# The Summer Townet Survey

# 2024 Season Report

California Department of Fish and Wildlife

Bay Delta Region

Margaret W. Johnson

September 2025

Interagency Ecological Program

Cooperative Ecological Investigations Since 1970

# Table of Contents

## Introduction

The Summer Townet Survey (STN) is a long-term monitoring effort that samples for young pelagic fishes in the upper San Francisco Estuary (SFE), from San Pablo Bay upstream through the Sacramento-San Joaquin River Delta ("Delta"). This California Department of Fish and Wildlife (CDFW) survey has been conducted since 1959 and is one of the longest running pelagic fish sampling efforts in the United States. The study targets small fish (12-55 mm FL) during June – August using a small trawl net. Fish catch is used to determine the relative abundance and distribution of young fish to understand the annual recruitment success of fish populations that spawn in the late-winter and spring and rear during the summertime. The area sampled, Suisun Bay and Delta, is an important nursery for many species of young fish. Originally designed to determine the annual success of age-0 Striped Bass (*Morone saxatilis*), the study has evolved to inform on the State and Federally listed Delta Smelt (*Hypomesus transpacificus*) and other members of the pelagic community, including macro-invertebrates and zooplankton. Environmental data is collected during sampling to understand relationships between fish catch and water temperature, turbidity, salinity, and other measures of habitat conditions (e.g., harmful algal blooms).

STN has been of immense value to resource management in the SFE, having helped scientists better understand fish abundance and distribution relative to freshwater Delta outflow (Miller et al. 2012), and the decline of native fish and their need for protection by State and Federal Endangered Species Act listing (Tempel et al. 2021). This study has also helped determine the recruitment patterns of fish relative to loss by entrainment at water projects in the south Delta, and most recently, actions taken to improve summer and fall conditions for Delta Smelt and their habitat (Hammock et al. 2019). Summer Townet currently provides fish, zooplankton, and water quality information used to inform Water Rights Decisions (1485 and 1641), the Summer-Fall Habitat Action (STN Bibliography), modified operation of Suisun Marsh Salinity Control Gates (SMSCG), and tidal wetland restoration identified in the Delta Smelt Resiliency Strategy, federal biological opinions, and incidental take permit (ITP) issued by CDFW to Department of Water Resources (DWR) for long-term operation of the State Water Project (SWP).

Since its beginning, STN has sampled fixed locations from eastern San Pablo Bay to Rio Vista on the Sacramento River, and to Stockton on the San Joaquin River and a single station in the lower Napa River (Figure 1). Most stations are set in the channels of rivers, with additional locations in the shallow waters of Suisun, Grizzly, and Honker bays, to capture the movement of young fish as their distribution expanded throughout the season. These original 'index' stations are used to calculate relative abundance indices for Delta Smelt and Striped Bass and catch-per-unit-effort (CPUE) for all fishes. In 2011, the survey expanded to sample additional 'non-index' stations in the

Sacramento Deep Water Ship Channel (SDWSC) and Cache Slough complex. Presently, 40 stations (31 index and 9 non-index stations) are sampled every other week in June through August using a conical, fixed-frame net, which is pulled obliquely through the water column 2 to 3 times at each station. The repeated tows provide a greater water volume sample relative to the larger water volumes that occur in various river sections and bays and improve detection of fish. At each station environmental variables are measured including water temperature in degrees Celsius (°C), water clarity 4 (Secchi disk depth in cm & turbidity in NTU), and specific conductivity (µS/cm) converted to salinity parts-per-thousand (ppt) to help explain trends in catch and annual recruitment.

## Seasonal Overview

The STN began the 2024 season with Survey 1 on June 3rd and completed the sixth and final survey on August 16th. Relative abundance indices for Delta Smelt and age-0 Striped Bass were calculated and reported in separate memos, and can be accessed on the STN Bibliography. The following seasonal report is a supplement to the reported abundance indices. This report includes a summary of environmental trends, and the abundance and spatial patterns for fish and macro-invertebrate catch between June and August.

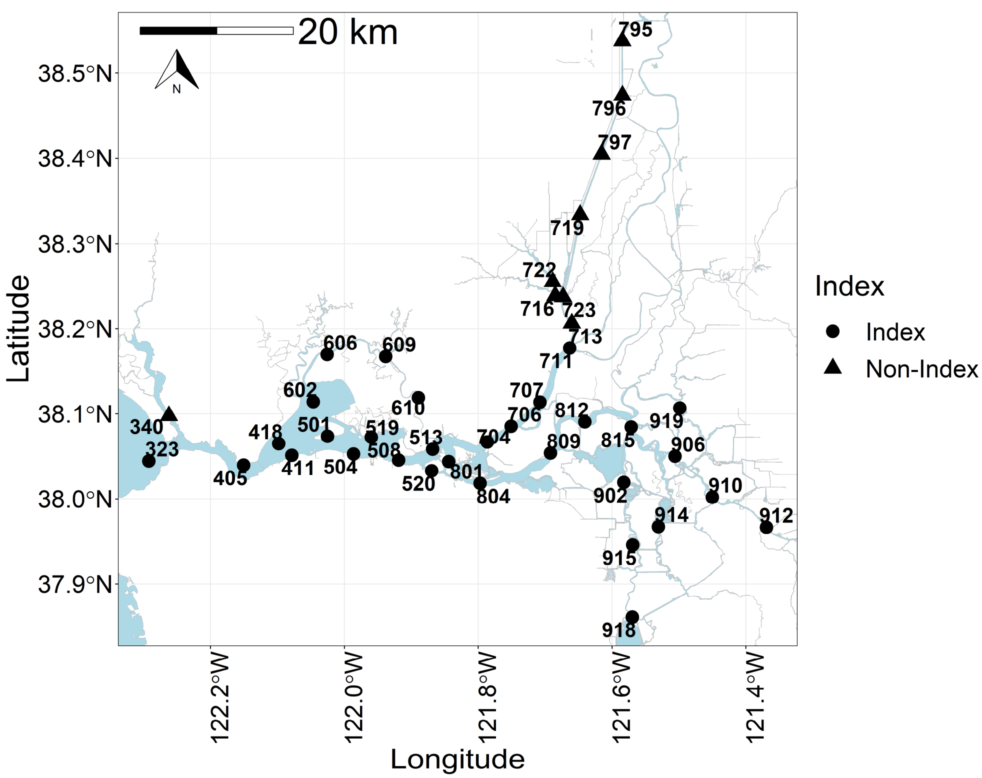



*Figure 1. The Summer Townet Survey station map showing 31 index stations (circles) and 9 non-index stations (triangles).*

## Methods and Gear

At each STN station, the net is towed for 10 minutes obliquely through the water. Each index station receives two tows and a third tow if at least one fish was collected in one of the first two tows. In the North Delta non-index stations, a maximum of two tows is conducted. The townet is a 5.64 m (18' 6") long cone (Figure 2) with a 1.49 $m^2$ (16.03 $ft^2$) opening at the mouth and a 30.48 cm (12") diameter opening at the end of the cod end (narrow end). It consists of four major components: 1) the collar, 2) the main body (1.27 cm (½") stretched knotted mesh), 3) the fyke (1.27 cm (½") knotless mesh) and 4) the cod-end (bobbinet with 8 holes per 2.54 cm (1 inch). A flowmeter (General Oceanics, model # 2030R) is suspended in the center of the net mouth during the tow (Figure 2).

*Figure 2. Left: Townet ready for deployment with meso-zooplankton (Clark-Bumpus) net mounted on top, and flowmeter attached to the center of the townet. Right: Townet during retrieval.*

Following each tow, the net is emptied, and all fish and macro-invertebrates (caridean shrimp, crabs, and jellyfish) are identified and enumerated. The first 50 representatives of each fish species have fork lengths (FL) recorded in millimeters (mm). Any fish that cannot be identified in the field, such as larval fish less than 25 mm FL, are preserved in ethanol or 10% buffered formalin to be identified later within our CDFW laboratory, Stockton, CA.

A modified Clark-Bumpus (CB) net is mounted at the top of the townet to collect mesozooplankton. The CB net targets zooplankton 0.5-3.0 mm long, including cladocerans, copepodids, and adult copepods. At each STN station, the CB sample is collected generally on the first tow, concurrent with fish sampling. Flowmeter counts for the CB net 6 are recorded at the start and end of each tow to calculate volume sampled. The CB sample is preserved using a concentrated, buffered formalin with rose-Bengal dye which is then diluted to a 10% buffered formalin solution.

Abiotic variables and a Microcystis spp. ranking metric are measured prior to sampling at each STN station (Appendix 1).

## Routine Sampling

In 2024, STN successfully visited and sampled each index station in all six surveys (Table 1). All non-index stations were also successfully sampled. Most surveys were completed within four days using one or two research vessels (Survey 1, June 3 - 6; Survey 2, June 17 - 21; Survey 3, July 1 - 5; Survey 4, July 15 - 19; Survey 5, Jul 29 - Aug 1; Survey 6, Aug 12-16). A summary of tows for each station is presented in Table 1.

*Table 1. Tows per station by survey and total tows over the 2024 STN season.*

| Station | Index | Survey 1 | Survey 2 | Survey 3 | Survey 4 | Survey 5 | Survey 6 | Total |
|---|---|---|---|---|---|---|---|---|
| 323 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | **18** |
| 340 | 0 | 3 | 3 | 2 | 3 | 3 | 3 | **17** |
| 405 | 1 | 3 | 3 | 3 | 3 | 3 | 2 | **17** |
| 411 | 1 | 3 | 2 | 2 | 3 | 3 | 2 | **15** |
| 418 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | **18** |
| 501 | 1 | 3 | 3 | 3 | 2 | 3 | 2 | **16** |
| 504 | 1 | 3 | 3 | 2 | 3 | 2 | 3 | **16** |
| 508 | 1 | 3 | 3 | 3 | 3 | 3 | 2 | **17** |
| 513 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | **18** |
| 519 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | **18** |
| 520 | 1 | 3 | 3 | 3 | 3 | 3 | 2 | **17** |
| 602 | 1 | 3 | 3 | 3 | 3 | 3 | 2 | **17** |
| 606 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | **18** |
| 609 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | **18** |
| 610 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | **18** |
| 704 | 1 | 2 | 2 | 3 | 3 | 3 | 2 | **15** |
| 706 | 1 | 2 | 3 | 3 | 3 | 2 | 3 | **16** |
| 707 | 1 | 3 | 3 | 3 | 2 | 3 | 2 | **16** |
| 711 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | **12** |
| 713 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | **12** |
| 716 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | **12** |
| 719 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | **12** |
| 722 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | **12** |
| 723 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | **12** |
| 795 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | **12** |
| 796 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | **12** |
| 797 | 0 | 2 | 2 | 2 | 2 | 2 | 2 | **12** |
| 801 | 1 | 3 | 3 | 3 | 3 | 3 | 2 | **17** |
| 804 | 1 | 2 | 3 | 3 | 2 | 3 | 2 | **15** |
| 809 | 1 | 3 | 3 | 3 | 3 | 3 | 2 | **17** |
| 812 | 1 | 2 | 3 | 3 | 3 | 3 | 2 | **16** |
| 815 | 1 | 2 | 3 | 3 | 2 | 2 | 2 | **14** |
| 902 | 1 | 3 | 3 | 2 | 2 | 2 | 2 | **14** |
| 906 | 1 | 2 | 3 | 3 | 2 | 2 | 2 | **14** |
| 910 | 1 | 2 | 3 | 3 | 3 | 3 | 2 | **16** |
| 912 | 1 | 2 | 3 | 3 | 3 | 3 | 3 | **17** |
| 914 | 1 | 3 | 3 | 2 | 2 | 2 | 2 | **14** |
| 915 | 1 | 2 | 3 | 2 | 2 | 2 | 2 | **13** |
| 918 | 1 | 3 | 3 | 2 | 2 | 2 | 2 | **14** |
| 919 | 1 | 2 | 3 | 3 | 2 | 2 | 2 | **14** |
| **Total** | | **101** | **109** | **104** | **101** | **102** | **91** | **608** |

## Non-Routine Sampling

In collaboration with DWR, STN conducted additional zooplankton sampling in Suisun Marsh for the modified operation of SMSCG special study (Table 2; Figure 3; IEP element 335). Starting in Survey 3 of 2024, STN conducted the additional zooplankton tows using a mysid sled with a CB net attached. As in the routine STN sampling, flowmeter counts for the CB net are recorded at the start and end of each tow to calculate volume sampled. The CB sample is preserved using a concentrated, buffered formalin with rose-Bengal dye which is then diluted to a 10% buffered formalin solution.

*Table 2. Summary of additional Summer Townet sampling effort (tow frequency) per survey and station conducted for the Suisun Marsh Salinity Control Gate (SMSCG) Action study. "0" indicates no sample collected and "1" indicates that a sample was collected.*

| Station | Survey 3 | Survey 4 | Survey 5 | Survey 6 | Total |
|---|---|---|---|---|---|
| FMWT 605 | 1 | 1 | 1 | 1 | **4** |
| Mont | 1 | 1 | 1 | 1 | **4** |
| EMP NZS42 | 1 | 0 | 1 | 0 | **2** |
| **Total** | **3** | **2** | **3** | **2** | **10** |

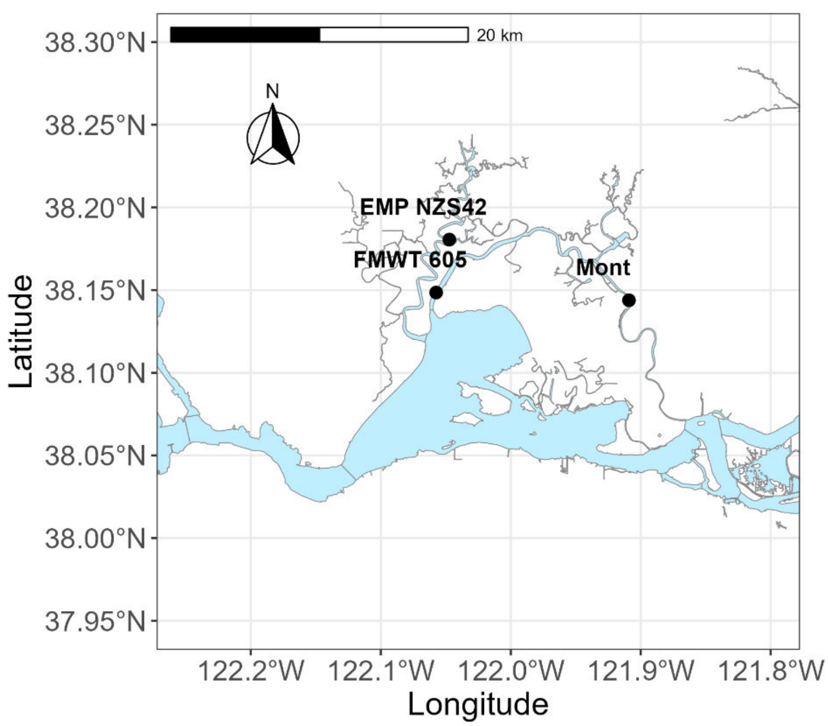
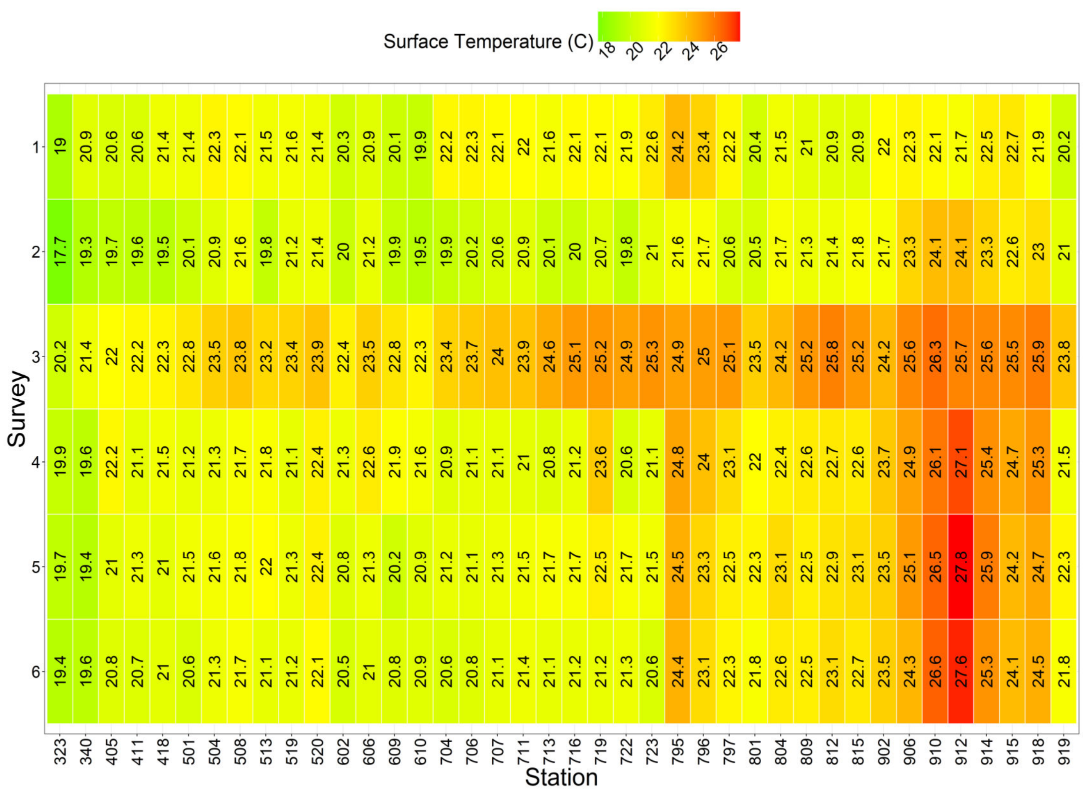



*Figure 3. Map of SMSCG sampling stations, where additional zooplankton tows were conducted during STN surveys in 2024.*

## Environmental Variables

The STN survey collects metrics for biotic and abiotic variables at each station. Summaries for temperature (C), salinity (ppt), water clarity (cm), turbidity (NTU), and Microcystis (1-5 qualitative rankings) are described below with corresponding figures.



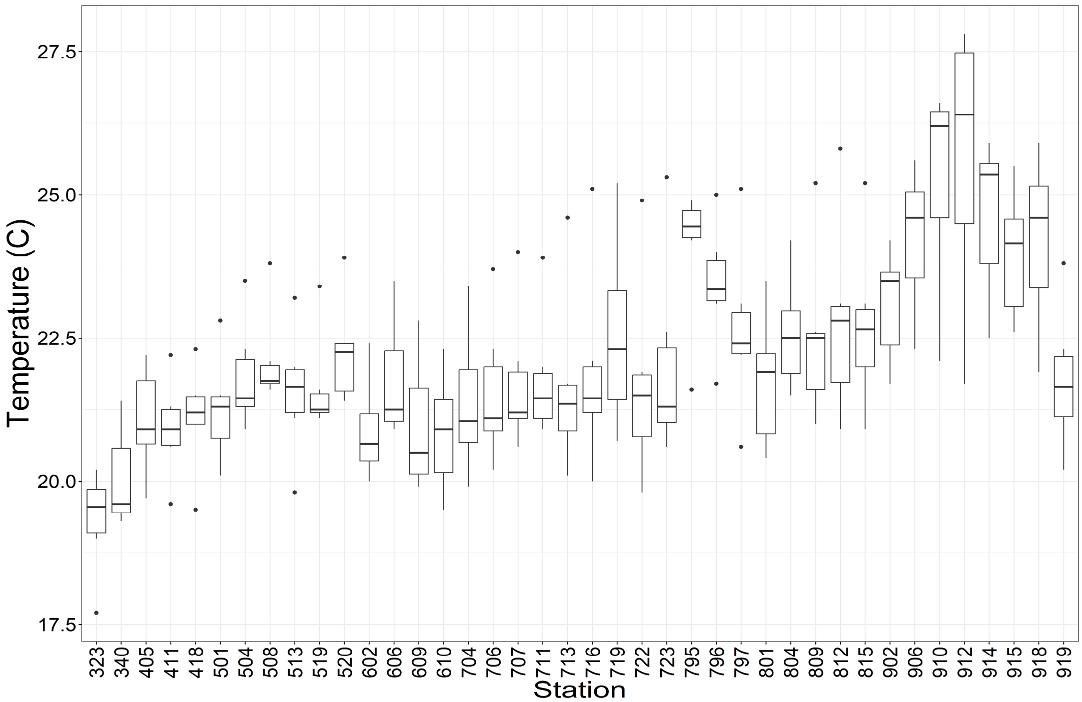



*Figure 4. Surface temperature (°C) at each STN station by survey (top) and the distribution of temperature for each station across the season (bottom). Boxplots (bottom) show the median as a horizontal line, 1st and 3rd quartile by box, range by vertical line and outliers by point.*

Temperatures (Figure 4) at the STN stations were generally cooler in June surveys (surveys 1-2) and warmest in early July, as well as August for some stations in the South Delta (i.e. San Joaquin River and Old River). In addition to temporal changes in temperature, stations furthest from San Pablo Bay were generally warmer than stations closer to the cooler ocean temperatures. The warmest stations were 910 and 912, located at the eastern edge of the STN sampling range outside of Stockton, CA.

Temperatures above 22°C result in stress and temperatures exceeding 25°C are known to increase mortality among Delta Smelt, which are more thermally sensitive than non-native species such as Wakasagi (*H. nipponensis*), Splittail (*Pogonichthys macrolepidotus*), and Mississippi Silverside (*Menidia audens*) (Swanson et al. 2000). Delta Smelt and other temperature sensitive fishes may therefore seek refuge in deeper, cooler parts of the water column in regions of the estuary where thermal stratification occurs (Mahardja et al. 2022). Although factors such as tide and time of day may affect surface temperatures, they were not considered in comparison among stations.

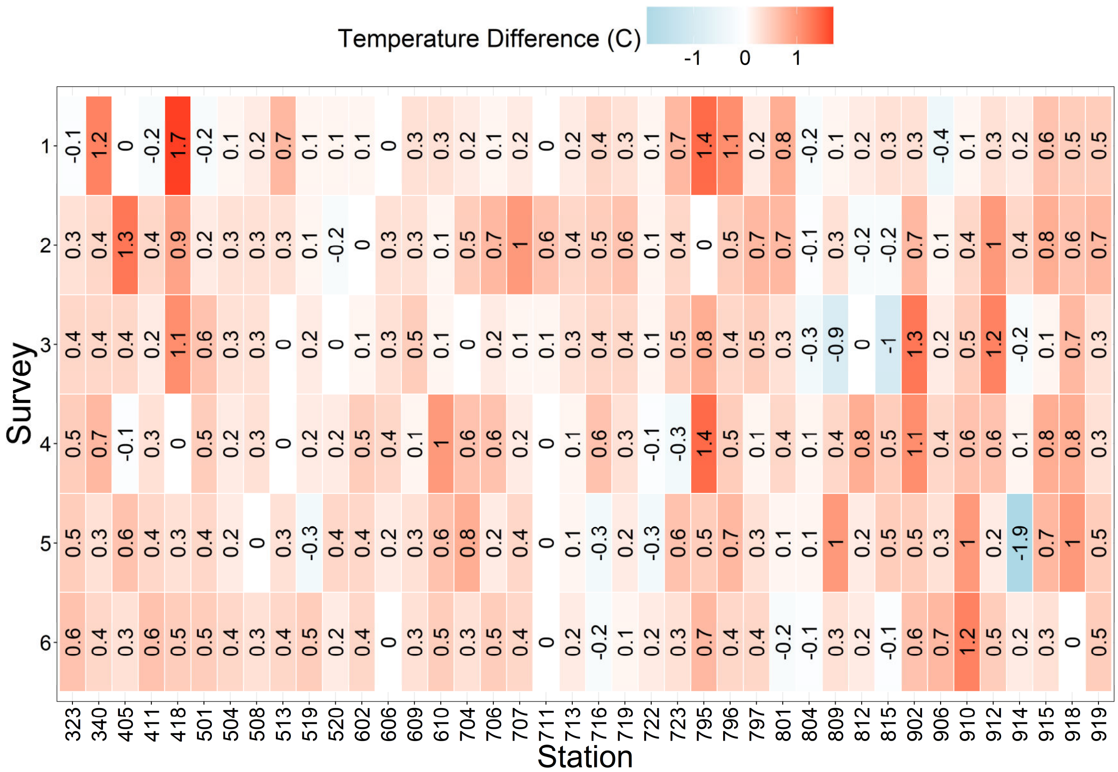



*Figure 5. Temperature differences (°C) between the surface and bottom at each STN station (index and non-index). Red colors indicate greater temperatures at the surface and blue colors indicate the opposite pattern. Clear tiles indicate little to no difference in temperature.*

Slightly warmer surface temperatures were seen at most stations throughout the estuary (Figure 5). A few slightly cooler surface temperatures were also observed at some stations. This may be due to current and water column mixing and possibly in part to methods used to measure bottom water temperatures. Bottom temperature is measured using a Van Dorn to collect a small sample of water just above the base of the water column. This small sample’s temperature may rise while on the deck of the vessel during periods of high air temperatures.

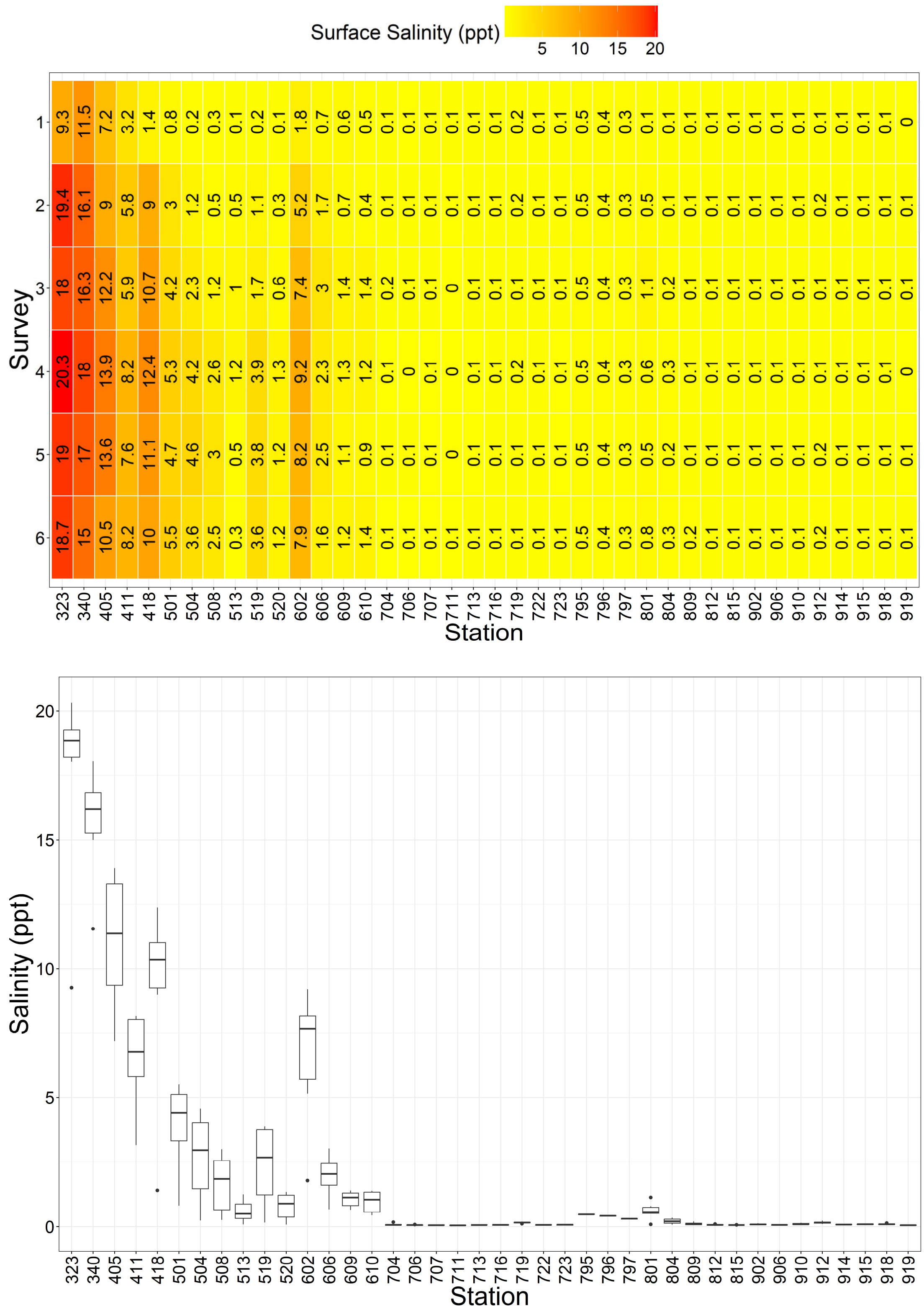



*Figure 6. Surface salinity derived from specific conductance (µS/cm) measured at each STN station (index and non-index) in 2024. Red shading (top) transitioning to yellow indicates salinity decreasing further upstream.*

Overall, salinity was higher in 2024 (“above normal” water year; available at [WSIHIST](WSIHIST)) than in 2023 (a “wet” year), but lower than in the critically Dry year of 2022. Salinity was the highest in San Pablo Bay and decreased further upstream (Figure 6), with some variation in Suisun Bay due to tidal fluxes. Salinity reached zero parts per thousand (ppt) at station 919 in the San Joaquin River, as well as stations 706 and 707 in the lower Sacramento River.

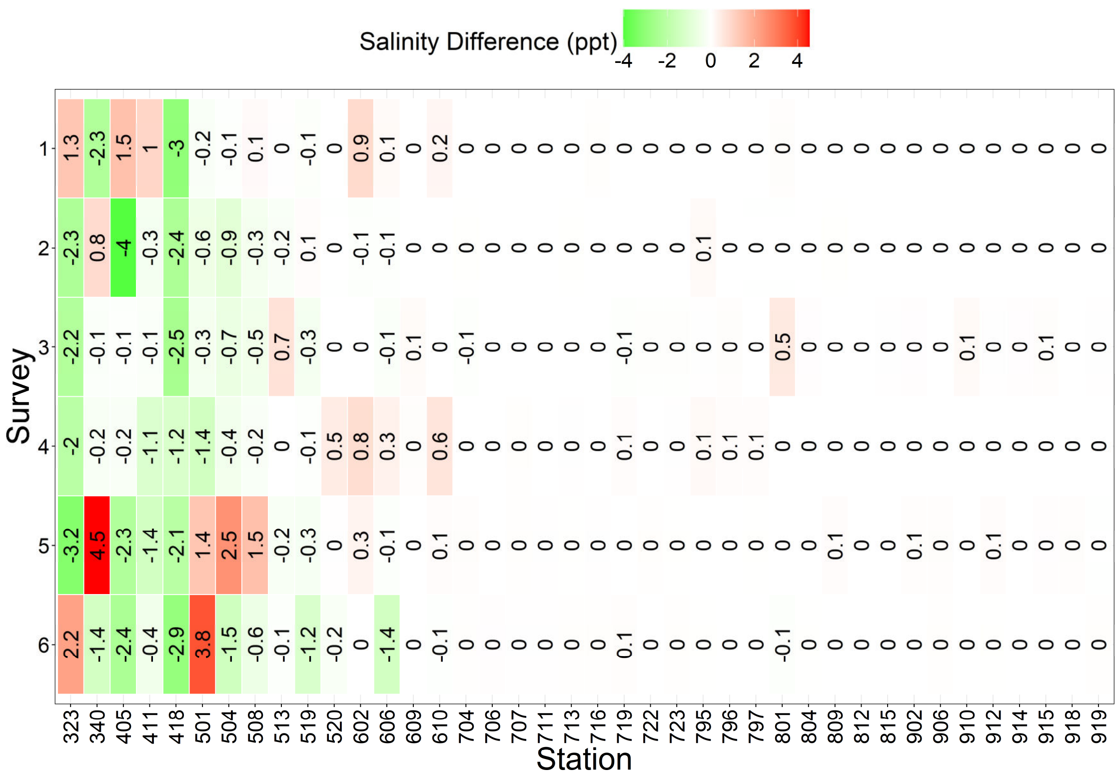



*Figure 7. Salinity (ppt) differences between the surface and bottom of the water column. Negative (green) values indicate greater salinity lower in the water column while positive (red) values indicate greater salinity in the surface.*

Stations in Suisun Bay and lower Napa River (Station 340) showed the most extreme differences in salinity between the surface and the bottom of the water column. At stations in the confluence and upstream in the Sacramento and San Joaquin rivers, differences in salinity values were smaller (Figure 7).

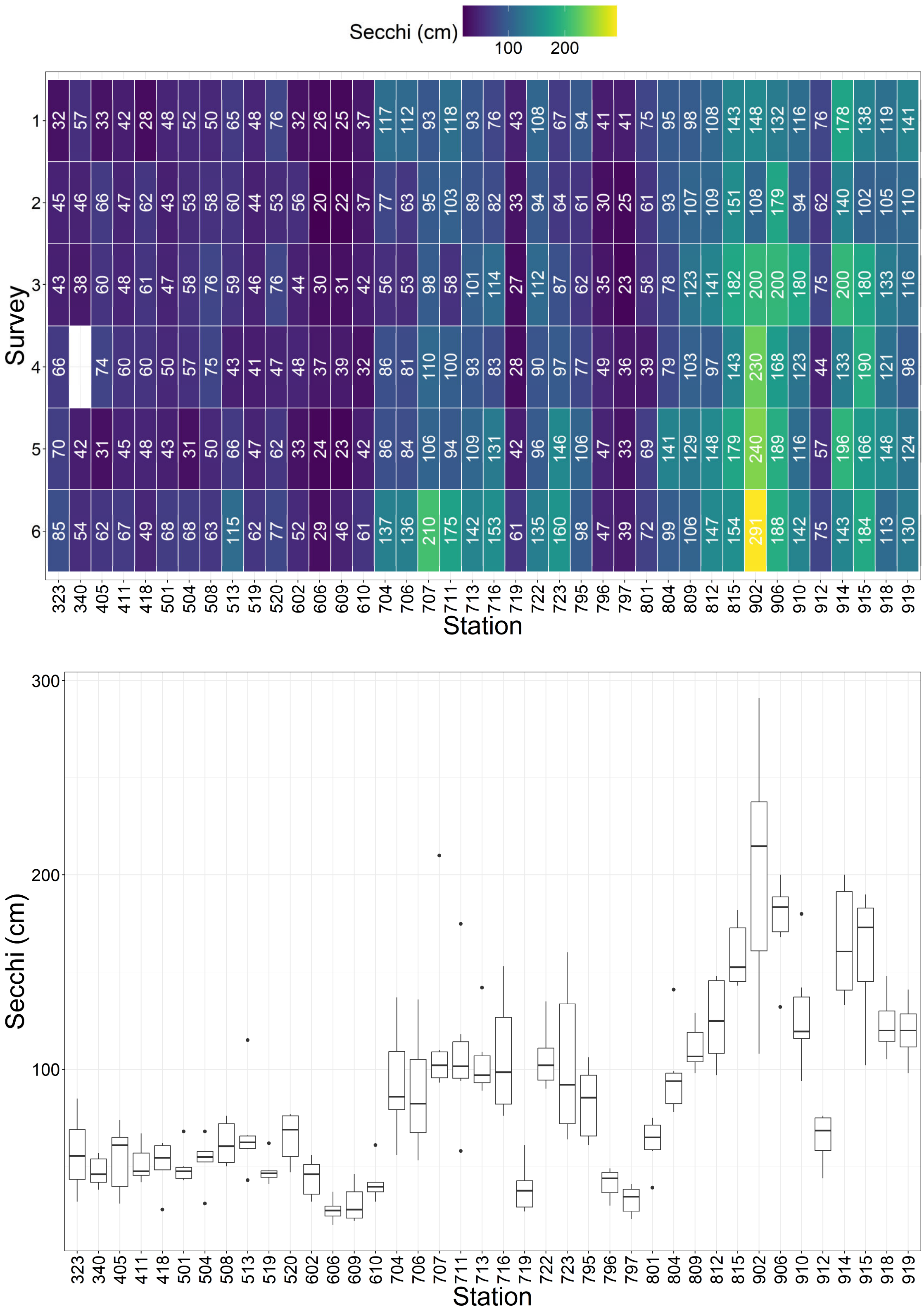
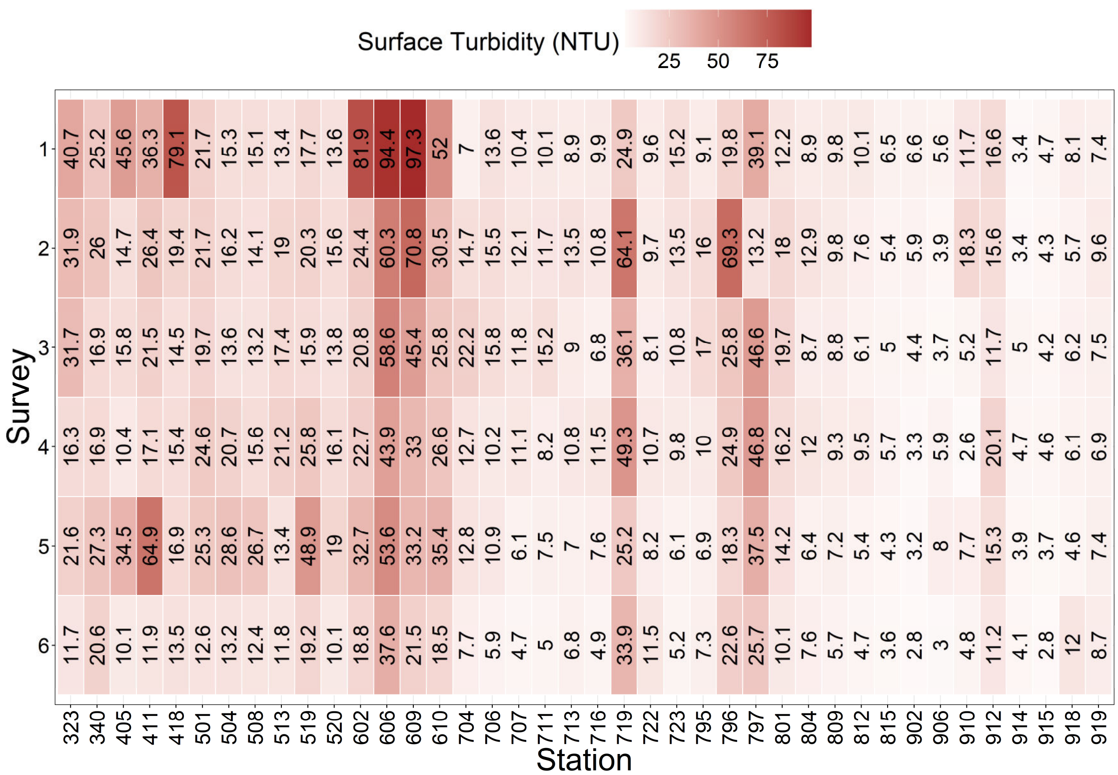



*Figure 8. Water clarity as measured by Secchi disk depth (cm) for all stations and all surveys (top), and range of Secchi measurements for each station (bottom).*

Secchi and turbidity values (Figures 8 & 9) reflected regional variation in tidal mixing. Upstream waters were generally clearer than they were downstream, with the exception of stations in the SDWSC (719, 795-797) and station 912 in the lower San Joaquin River, which showed slightly higher turbidity values. Stations in Suisun Marsh (606-610) also showed high levels of turbidity, while the lower San Joaquin River (809-919) stations showed the lowest turbidity. This has been a regular pattern for stations within these subregions.



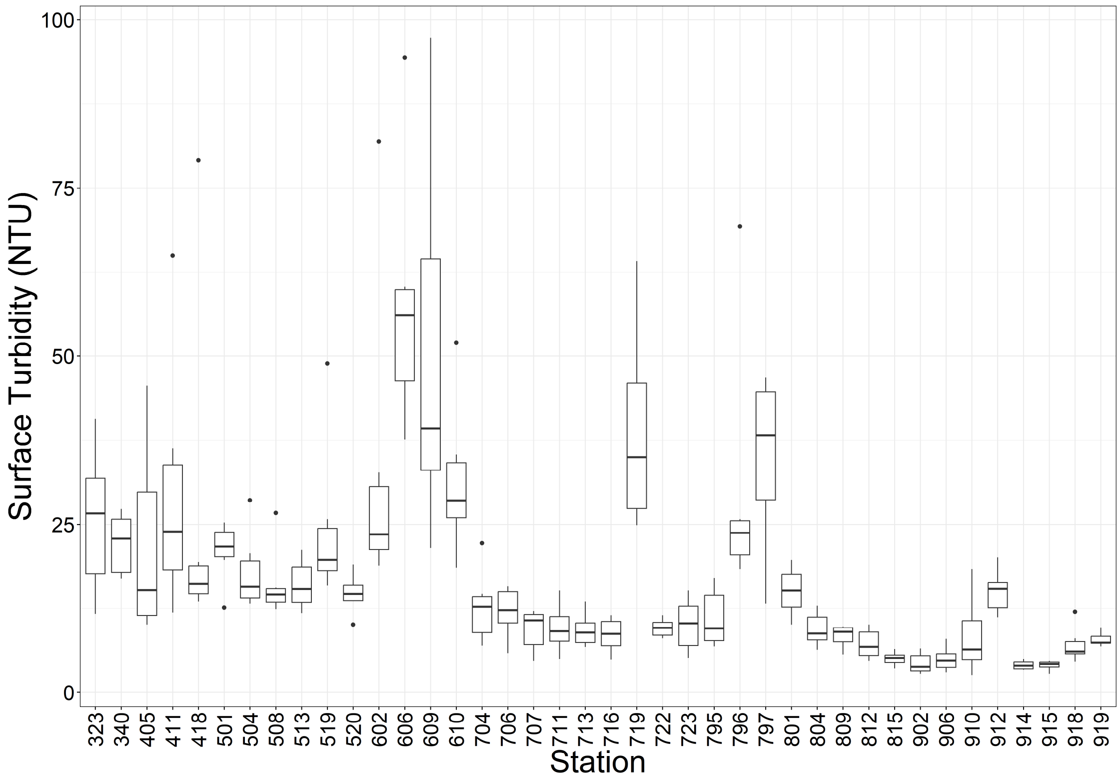



*Figure 9. Surface turbidity (NTU) for all stations and all surveys (top), and range of turbidity measurements for each station (bottom).*

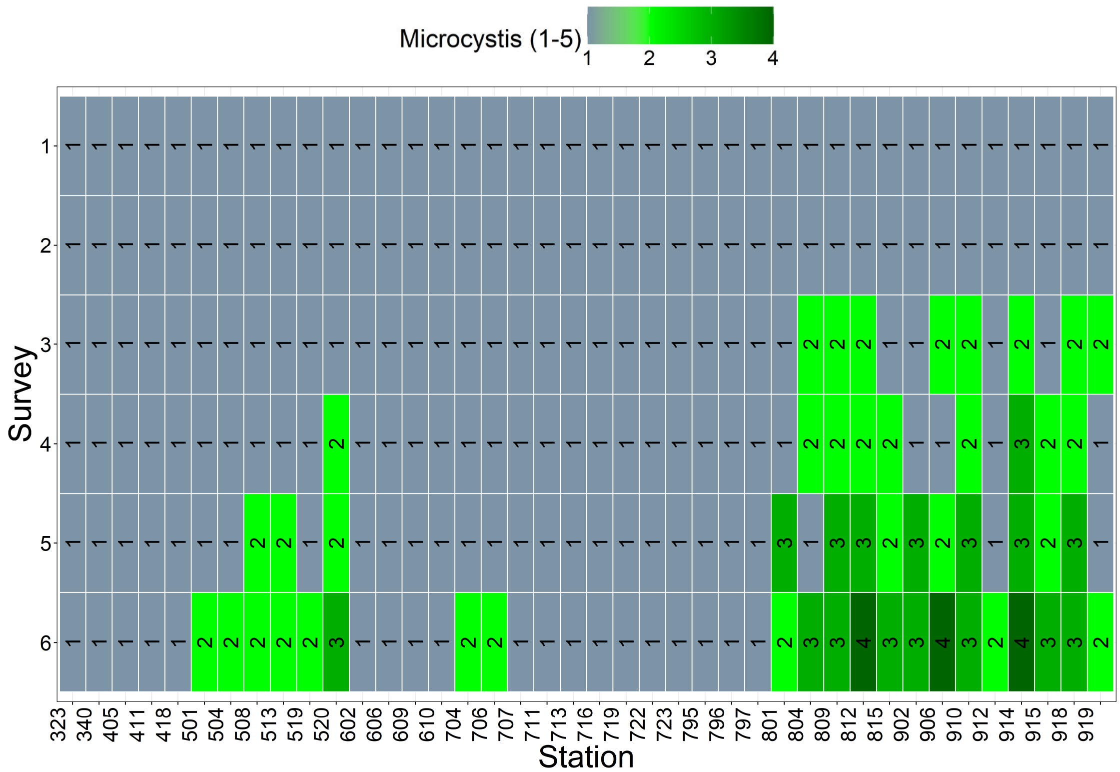



*Figure 10. Rankings of Microcystis spp. presence at each station, over each survey. 1 is an absence of Microcystis spp. (gray) and 5 is the highest presence of Microcystis spp. that can be reported (dark green). See Appendix 1 for ranking scale.*

*Microcystis* spp. (Figure 10) was detected during Surveys 3-6 in Suisun Bay, lower Sacramento River, the confluence, and the South Delta. *Microcystis* spp. presence increased over time, the highest rankings occurring in mid-August. The largest amount of *Microcystis* spp. was observed on August 12-13 at stations 812, 906, and 913 in the South Delta. Throughout the season, no *Microcystis* spp. was observed in the most western stations of Suisun Bay, nor was it observed at stations in Suisun Marsh or the SDWSC.

## Catch Per Unit Effort

### Fish

According to DWR, the 2024 water year was classified as “above normal”, receiving some freshwater outflow, but less than the previous wet year. Predictably, the total catch and CPUE of all species combined were lower in 2024 than in 2023. The majority of fish CPUE in 2024 consisted of non-native species (Table 4). STN observed the highest total fish catches during mid-summer in Suisun Marsh and the SDWSC (Figure 12). The majority of fish caught in 2024 were Tridentiger gobies (*Tridentiger* spp.), Threadfin Shad (*Dorosoma petenense*), Shimofuri Goby (*Tridentiger bifasciatus*), and age-0 Striped Bass, all introduced species (Tables 3 & 4).

Catch was dominated by *Tridentiger* spp., which includes Shimofuri Goby and Shokihaze Goby (*T. barbatus*). Within these groups, Shimofuri catch was the highest with a mean CPUE per survey of 18.4 (Table 3). Shimofuri and Shokihaze gobies are non-native, originating in fresh and brackish waters of East Asia (Ahito and Sakamoto, 1989). Although adult individuals of these species tend to inhabit benthic substrates (Young et al. 2017), *Tridentiger* spp. larvae and small juveniles have a pelagic life stage prior to assuming the demersal life stage of older juveniles and adults (Matern and Fleming 1995; Bennett et al. 2002). Shimofuri Goby are known to tolerate a wide range of temperatures and salinities (Matern 2001), yet are found mostly in freshwater areas while the Shokihaze Goby tends to be found more in brackish estuarine habitats. The increased outflow in 2023 and 2024 may have created more suitable habitat for Shimofuri Goby.

Threadfin Shad were the second most caught species, with a mean CPUE per survey of 30.5. This has been almost a two-fold increase since 2023. Threadfin Shad catch peaked in mid-July during Survey 4, and the majority were caught in the SDWSC. Smaller numbers of Threadfin Shad were also caught in the South Delta and Suisun Marsh.

There was a decrease in catch of species that depend on freshwater outflow during their spawning periods. Mean age-0 Striped Bass CPUE decreased from 29.2 in 2023 to 14.1 in 2024, but remained higher than in the dry years of 2020 – 2022. Other changes include a decrease in Longfin Smelt CPUE from 6.9 to 3.2 and a decrease in American Shad (*Alosa sapidissima*) CPUE from 3.6 to 2.4. These patterns indicate a return to catch levels similar to those observed during dry years of 2020 - 2022.

The Delta Smelt catch remained at zero, as no Delta Smelt were caught during the 2024 STN season.

*Table 3. Fish catch per survey, status (native or non-native), total seasonal catch, and the percent of total catch represented by each taxonomic category.*

| Organism | Status | Survey 1 | Survey 2 | Survey 3 | Survey 4 | Survey 5 | Survey 6 | Total Catch | % Total Catch |
|---|---|---|---|---|---|---|---|---|---|
| Tridentiger spp | Non-Native | 251 | 375 | 1,363 | 1,354 | 218 | 102 | 3,663 | 45.200 |
| Threadfin Shad | Non-Native | 137 | 293 | 338 | 327 | 296 | 180 | 1,571 | 19.385 |
| Age-0 Striped Bass | Non-Native | 559 | 254 | 122 | 35 | 17 | 2 | 989 | 12.204 |
| Shimofuri Goby | Non-Native | 177 | 247 | 241 | 221 | 42 | 12 | 940 | 11.599 |
| Longfin Smelt | Native | 173 | 38 | 14 | 3 | 2 | 1 | 231 | 2.850 |
| Shokihaze Goby | Non-Native | 0 | 0 | 63 | 97 | 26 | 14 | 200 | 2.468 |
| American Shad | Non-Native | 15 | 44 | 47 | 23 | 8 | 0 | 137 | 1.691 |
| Mississippi Silverside | Unknown | 0 | 1 | 2 | 8 | 39 | 15 | 65 | 0.802 |
| Wakasagi | Non-Native | 14 | 23 | 15 | 4 | 3 | 0 | 59 | 0.728 |
| White Catfish | Non-Native | 2 | 9 | 13 | 14 | 15 | 1 | 54 | 0.666 |
| Northern Anchovy | Native | 15 | 8 | 0 | 11 | 11 | 1 | 46 | 0.568 |
| Trid_SB0 (UNID) | Non-Native | 0 | 13 | 18 | 0 | 0 | 0 | 31 | 0.383 |
| Plainfin Midshipman | Native | 0 | 0 | 0 | 0 | 2 | 20 | 22 | 0.271 |
| Herring (Unid) | Unknown | 0 | 18 | 0 | 0 | 0 | 0 | 18 | 0.222 |
| Channel Catfish | Non-Native | 0 | 10 | 4 | 1 | 2 | 0 | 17 | 0.210 |
| Unknown Fish (UNID) | Unknown | 10 | 3 | 0 | 0 | 0 | 0 | 13 | 0.160 |
| Yellowfin Goby | Non-Native | 2 | 4 | 2 | 1 | 0 | 0 | 9 | 0.111 |
| Jacksmelt | Native | 5 | 0 | 0 | 0 | 2 | 0 | 7 | 0.086 |
| Three Spine Stickleback | Native | 3 | 1 | 1 | 1 | 0 | 0 | 6 | 0.074 |
| Tule Perch | Native | 3 | 1 | 0 | 0 | 0 | 0 | 4 | 0.049 |
| Bluegill | Non-Native | 2 | 0 | 0 | 0 | 1 | 0 | 3 | 0.037 |
| Prickly Sculpin | Native | 1 | 2 | 0 | 0 | 0 | 0 | 3 | 0.037 |
| Starry Flounder | Native | 0 | 0 | 1 | 2 | 0 | 0 | 3 | 0.037 |
| Centrarchids (Unid) | Non-Native | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0.025 |
| Largemouth Bass | Non-Native | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0.025 |
| Pacific Herring | Native | 1 | 0 | 0 | 0 | 1 | 0 | 2 | 0.025 |
| Splittail | Native | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0.025 |
| Hardhead | Native | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0.012 |
| Rainwater Killifish | Non-Native | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0.012 |
| Sacramento Sucker | Native | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0.012 |
| Silversides (Unid) | Unknown | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0.012 |
| Striped Bass Adult | Non-Native | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0.012 |
| Total | | 1,371 | 1,351 | 2,245 | 2,104 | 685 | 348 | 8,104 | 100.0 |

*Table 4. Summer Townet Survey 2024 season fish CPUE (Catch per 10,000 $m^3$ volume of water) for each survey, status (native or non-native), mean survey CPUE, and the percent of CPUE represented by each taxonomic category.*

| Organism | Status | Survey 1 | Survey 2 | Survey 3 | Survey 4 | Survey 5 | Survey 6 | Mean CPUE | % Total CPUE |
|---|---|---|---|---|---|---|---|---|---|
| Tridentiger spp | Non-Native | 27.98 | 44.50 | 127.53 | 131.69 | 22.88 | 11.51 | 61.01 | 43.88 |
| Threadfin Shad | Non-Native | 15.03 | 32.06 | 38.58 | 38.62 | 36.10 | 22.48 | 30.48 | 21.92 |
| Shimofuri Goby | Non-Native | 19.74 | 30.30 | 27.95 | 26.29 | 4.98 | 1.37 | 18.44 | 13.26 |
| Age-0 Striped Bass | Non-Native | 48.25 | 21.18 | 10.03 | 3.35 | 1.52 | 0.19 | 14.09 | 10.13 |
| Longfin Smelt | Native | 14.50 | 3.03 | 1.13 | 0.28 | 0.18 | 0.11 | 3.21 | 2.31 |
| Shokihaze Goby | Non-Native | 0.00 | 0.00 | 5.23 | 8.73 | 2.67 | 1.44 | 3.01 | 2.17 |
| American Shad | Non-Native | 1.47 | 4.73 | 5.26 | 2.40 | 0.68 | 0.00 | 2.42 | 1.74 |
| Mississippi Silverside | Non-Native | 0.00 | 0.08 | 0.24 | 0.86 | 4.92 | 1.84 | 1.32 | 0.95 |
| Wakasagi | Non-Native | 1.54 | 2.84 | 1.81 | 0.48 | 0.39 | 0.00 | 1.18 | 0.85 |
| White Catfish | Non-Native | 0.21 | 0.96 | 1.50 | 1.36 | 1.32 | 0.08 | 0.90 | 0.65 |
| Northern Anchovy | Native | 1.32 | 0.71 | 0.00 | 0.98 | 1.01 | 0.11 | 0.69 | 0.49 |
| Trid_SB0 (UNID) | Non-Native | 0.00 | 1.06 | 1.48 | 0.00 | 0.00 | 0.00 | 0.42 | 0.30 |
| Plainfin Midshipman | Native | 0.00 | 0.00 | 0.00 | 0.00 | 0.18 | 2.17 | 0.39 | 0.28 |
| Channel Catfish | Non-Native | 0.00 | 1.27 | 0.42 | 0.13 | 0.17 | 0.00 | 0.33 | 0.24 |
| Herring (Unid) | Unknown | 0.00 | 1.46 | 0.00 | 0.00 | 0.00 | 0.00 | 0.24 | 0.18 |
| Unknown Fish (UNID) | Unknown | 0.79 | 0.38 | 0.00 | 0.00 | 0.00 | 0.00 | 0.20 | 0.14 |
| Yellowfin Goby | Non-Native | 0.19 | 0.32 | 0.16 | 0.10 | 0.00 | 0.00 | 0.13 | 0.09 |
| Jacksmelt | Native | 0.41 | 0.00 | 0.00 | 0.00 | 0.18 | 0.00 | 0.10 | 0.07 |
| Three Spine Stickleback | Native | 0.27 | 0.08 | 0.08 | 0.08 | 0.00 | 0.00 | 0.09 | 0.06 |
| Tule Perch | Native | 0.27 | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.04 |
| Prickly Sculpin | Native | 0.10 | 0.19 | 0.00 | 0.00 | 0.00 | 0.00 | 0.05 | 0.04 |
| Bluegill | Non-Native | 0.19 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 | 0.05 | 0.03 |
| Starry Flounder | Native | 0.00 | 0.00 | 0.08 | 0.18 | 0.00 | 0.00 | 0.04 | 0.03 |
| Splittail | Native | 0.00 | 0.21 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.02 |
| Pacific Herring | Native | 0.08 | 0.00 | 0.00 | 0.00 | 0.09 | 0.00 | 0.03 | 0.02 |
| Largemouth Bass | Non-Native | 0.00 | 0.17 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.02 |
| Centrarchids (Unid) | Non-Native | 0.00 | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.02 |
| Silversides (Unid) | Unknown | 0.00 | 0.00 | 0.00 | 0.13 | 0.00 | 0.00 | 0.02 | 0.02 |
| Hardhead | Native | 0.00 | 0.00 | 0.00 | 0.12 | 0.00 | 0.00 | 0.02 | 0.01 |
| Sacramento Sucker | Native | 0.00 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.01 |
| Rainwater Killifish | Non-Native | 0.00 | 0.00 | 0.09 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |
| Striped Bass Adult | Non-Native | 0.08 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |

## Invertebrates

The highest invertebrate catches in 2024 were those of the jellyfish *Maeotias marginata* (Table 5) and shrimps *Exopalaemon modestus* and *Crangon* spp. (Table 6). Mean *Maeotias marginata* CPUE increased from 26.2 in 2023 to 98.6 in 2024, while *Crangon* spp. and *Exopalaemon modestus* CPUE respectively decreased from 77.6 to 53.7 and 161.8 to 90.3. The highest jellyfish catches occurred in Honker Bay and Suisun Marsh in July and August 2024 (Figure 13). Shrimp catches were lower but occurred at more stations, with the highest catches in Suisun Marsh and SDWSC during July surveys (Figure 14).

The increase in *M. marginata* catch may reflect a return to favorable salinity conditions for this jellyfish, which tend to thrive in brackish waters (Meek, 2010). The shifts in shrimp abundances may be also attributed to each genera's salinity tolerance and life history. *E. modestus* can complete its lifecycle in freshwater, making it well-suited to the upstream regions of the San Francisco Estuary (Brown and Hieb 2014). The majority of the *Crangon* spp. shrimp caught by STN are the species *C. franciscorum*. *C. franciscorum,* a native species, is less tolerant of low salinities and more often observed downstream in San Pablo and San Francisco Bay. However, they may be found throughout the estuary in their juvenile stages, and juvenile *C. franciscorum* abundance is strongly correlated with freshwater outflow (Baxter et al. 1999; Israel 1936). Other *Crangon* spp. shrimp, *C. nigricauda* and *C. nigromaculata* are distributed more downstream in the higher brackish and marine areas of the estuary.

*Table 5. Jellyfish catch per survey, status (native or non-native), total seasonal catch, and the percent of total catch represented by each taxonomic category.*

| Organism | Status | Survey 1 | Survey 2 | Survey 3 | Survey 4 | Survey 5 | Survey 6 | Total Catch | % Total Catch |
|---|---|---|---|---|---|---|---|---|---|
| Maeotias marginata | Non-Native | 0 | 6 | 55 | 1,998 | 1,756 | 2,645 | 6,460 | 99.969 |
| Jelly (UNID) | Unknown | 0 | 2 | 0 | 0 | 0 | 0 | 2 | 0.031 |
| Total | | 0 | 8 | 55 | 1,998 | 1,756 | 2,645 | 6,462 | 100.0 |

*Table 6. Crustacean (shrimp and crab) catch per survey, status (native or non-native), total seasonal catch, and the percent of total catch represented by each taxonomic category.*

| Organism | Status | Survey 1 | Survey 2 | Survey 3 | Survey 4 | Survey 5 | Survey 6 | Total Catch | % Total Catch |
|---|---|---|---|---|---|---|---|---|---|
| Exopalaemon modestus | Non-Native | 288 | 748 | 769 | 1,479 | 729 | 690 | 4,703 | 54.383 |
| Crangon spp | Native | 432 | 537 | 1,386 | 530 | 799 | 32 | 3,716 | 42.969 |
| Palaemon macrodactylus | Non-Native | 7 | 81 | 10 | 80 | 39 | 2 | 219 | 2.532 |
| Macrobrachium spp | Non-Native | 3 | 1 | 0 | 1 | 0 | 0 | 5 | 0.058 |
| Cancer magister | Native | 0 | 0 | 0 | 2 | 0 | 0 | 2 | 0.023 |
| Shrimp (UNID) | Unknown | 1 | 0 | 0 | 0 | 0 | 1 | 2 | 0.023 |
| Crab (UnID) | Unknown | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0.012 |
| Total | | 731 | 1,367 | 2,166 | 2,092 | 1,567 | 725 | 8,648 | 100.0 |

*Table 7. Jellyfish CPUE per survey, status (native or non-native), mean survey CPUE, and the percent of total CPUE represented by each taxonomic category.*

| Organism | Status | Survey 1 | Survey 2 | Survey 3 | Survey 4 | Survey 5 | Survey 6 | Mean CPUE | % Total CPUE |
|---|---|---|---|---|---|---|---|---|---|
| Maeotias marginata | Non-Native | 0 | 0.50 | 4.61 | 184.44 | 163.52 | 238.42 | 98.58 | 99.97 |
| Jelly (UNID) | Unknown | 0 | 0.16 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.03 |

*Table 8. Crustacean (shrimp and crab) CPUE per survey, status (native or non-native), mean survey CPUE, and the percent of total CPUE represented by each taxonomic category.*

| Organism | Status | Survey 1 | Survey 2 | Survey 3 | Survey 4 | Survey 5 | Survey 6 | Mean CPUE | % Total CPUE |
|---|---|---|---|---|---|---|---|---|---|
| Exopalaemon modestus | Non-Native | 31.26 | 82.40 | 84.70 | 182.39 | 76.56 | 84.67 | 90.33 | 61.16 |
| Crangon spp | Native | 36.74 | 45.01 | 112.75 | 48.94 | 75.55 | 3.14 | 53.69 | 36.35 |
| Palaemon macrodactylus | Non-Native | 0.71 | 7.99 | 0.82 | 7.73 | 3.66 | 0.22 | 3.52 | 2.38 |
| Macrobrachium spp | Non-Native | 0.31 | 0.09 | 0.00 | 0.09 | 0.00 | 0.00 | 0.08 | 0.05 |
| Shrimp (UNID) | Unknown | 0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.03 | 0.02 |
| Cancer magister | Native | 0.00 | 0.00 | 0.00 | 0.19 | 0.00 | 0.00 | 0.03 | 0.02 |
| Crab (UnID) | Unknown | 0.00 | 0.00 | 0.08 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 |

In 2024, STN also observed, for the first time, catch of the recently introduced shrimp, *Macrobrachium* spp. (Figure 11). This group of shrimp originates in fresh-brackish waters of the Indo-Pacific region (Wowor and Ng, 2007), and five individuals were caught in the South Delta at stations 910, 914, and 918.

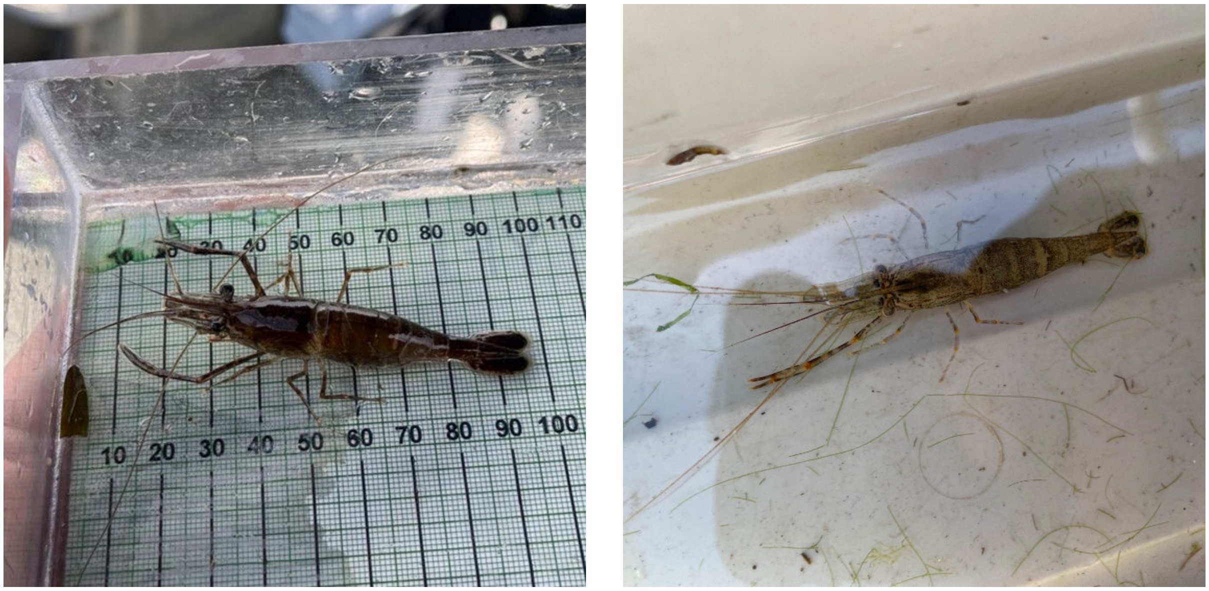


*Figure 11. Macrobrachium spp. caught at stations 918 during Survey 1 (left) and 914 during Survey 2 in 2024 (right). Photo credits: Spencer Breining-Aday and Taylor Rohlin.*

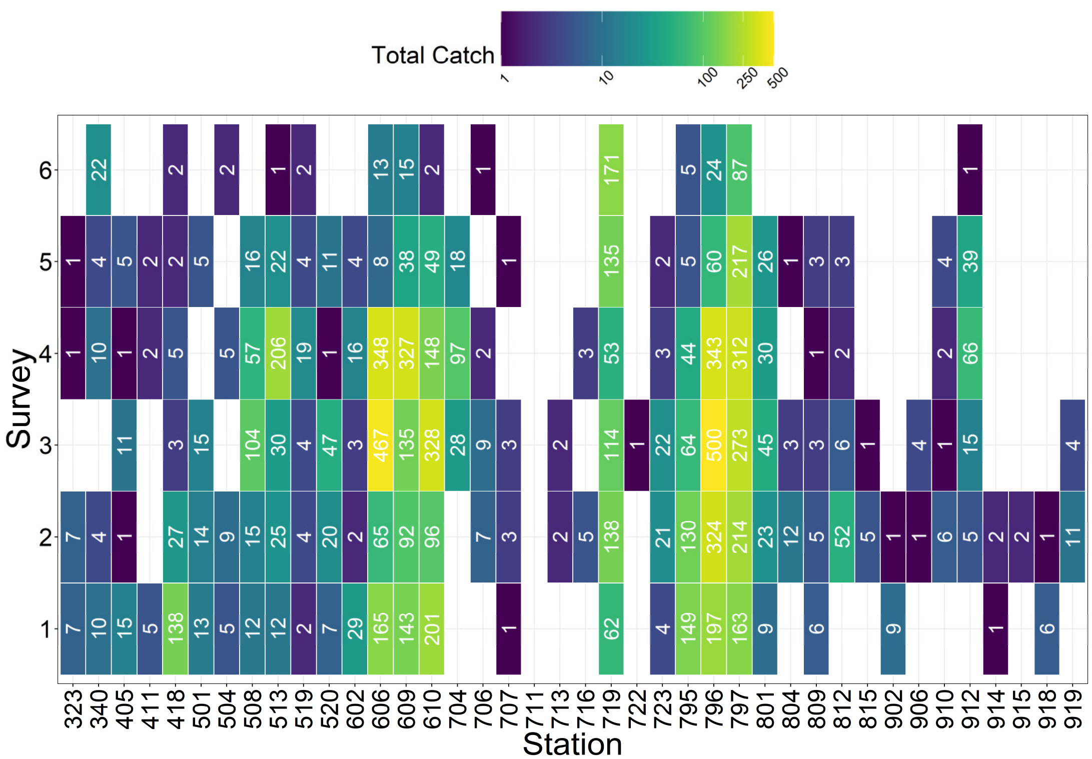



*Figure 12. Total fish catch at each station across each survey.*

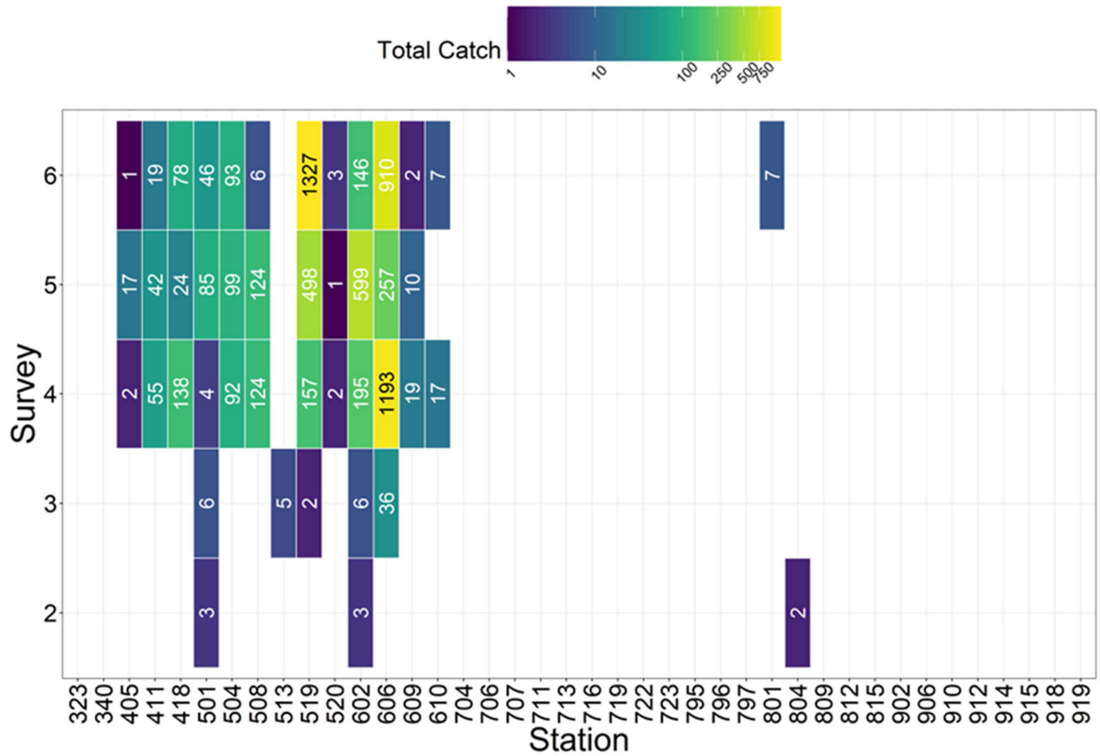



*Figure 13. Total jellyfish catch at each station across each survey.*

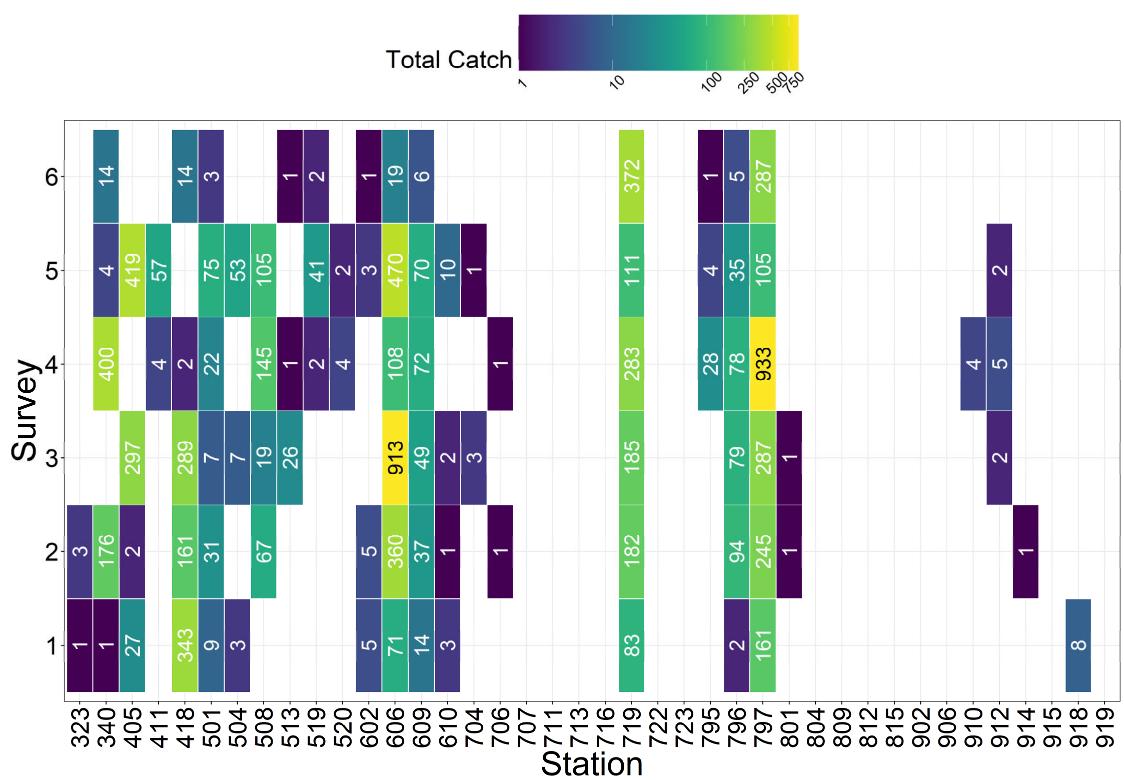



*Figure 14. Total shrimp catch at each station across each survey.*

## Design-Based Abundance Indices

Below are draft design-based abundance (DBA) indices for select species of fish caught by STN. CDFW has developed DBA indices for fish trawl surveys during an ongoing Monitoring Design Review effort in collaboration with staff from Applied Marine Sciences, ICF, and other State and Federal agencies (Monitoring Survey Design Team 2022). CDFW DBA indices were developed, expanding on methods created by the U.S. Fish and Wildlife Service (Polansky et al. (2019). The following DBA indices are set within 9-10 regions spaced throughout the San Francisco Estuary (Slater et al. 2023). Fish catch per unit effort is expanded by sub-regional volumetric expansions and summed across all sub-regions. The variance of the index is based upon 9-10 regions (dependent on years and stations sampled). Additional information on variance calculations can be found in Polansky et al. (2019). These alternative estimates are based on a recently developed standardized sampling frame that takes into account the spatial and vertical stratification of the San Francisco Estuary (Polansky et al., 2019; Slater et al., 2023). Larval and juvenile fish CPUE is extrapolated by sub-regional volumetric expansions and summed across all sub-regions in order to give broader and more accurate estimates of fish populations in the estuary system. Abundance values reported in this summary may be higher than previously reported, however the overall trends remain consistent.  Regional data that was previously excluded from long-term index calculations (i.e. “non-index” stations) is now included. DBA data is derived from all 40 stations; common species captured are plotted below (Figures 15-26).

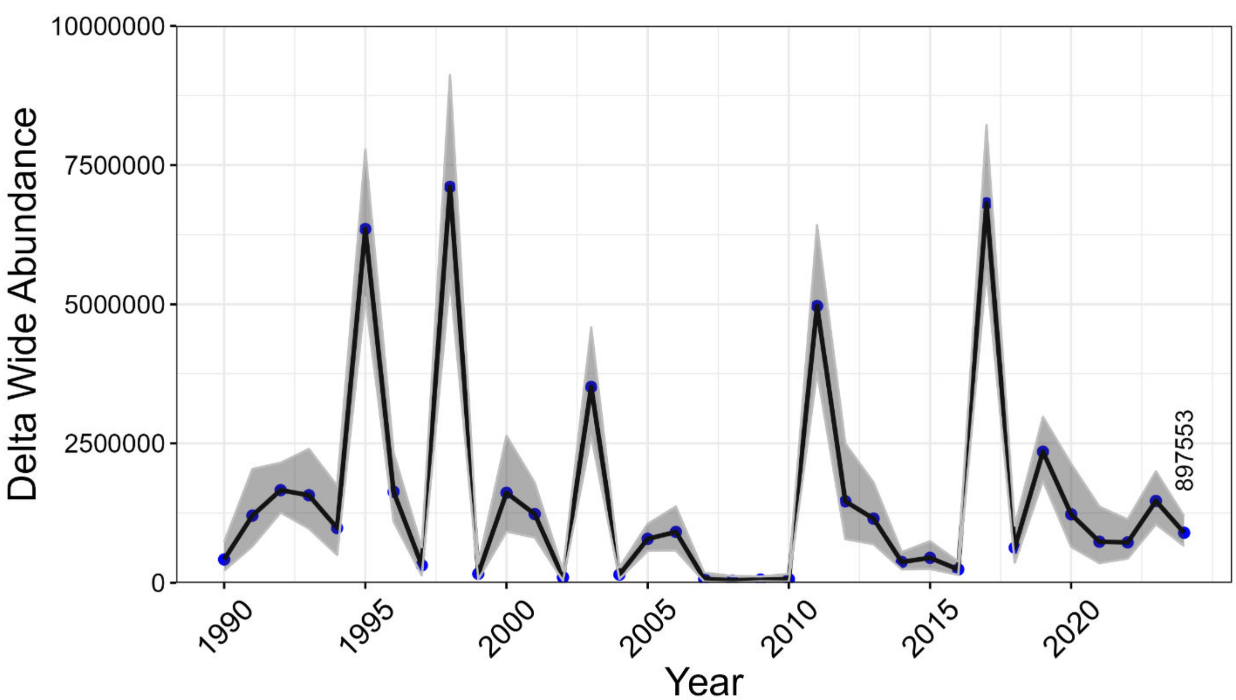



*Figure 15. American Shad design-based abundance estimates for the years 1990 – 2024.*

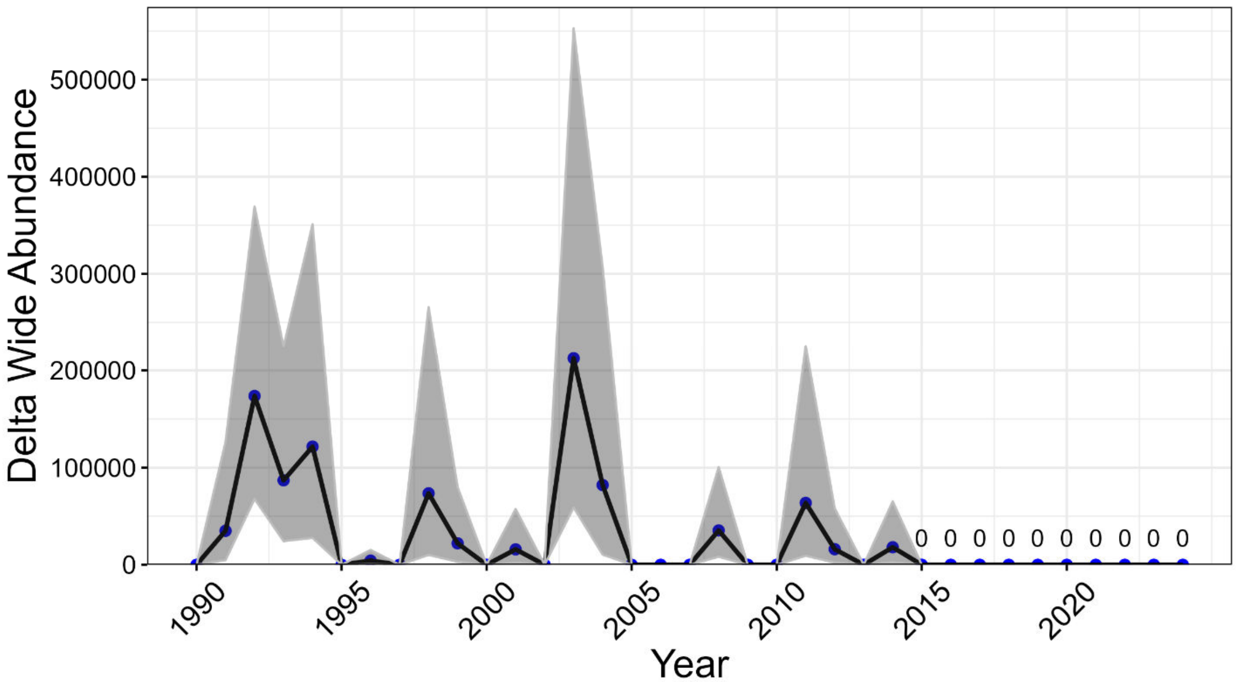



*Figure 16. Chinook Salmon design-based abundance estimates for the years 1990 – 2024.*

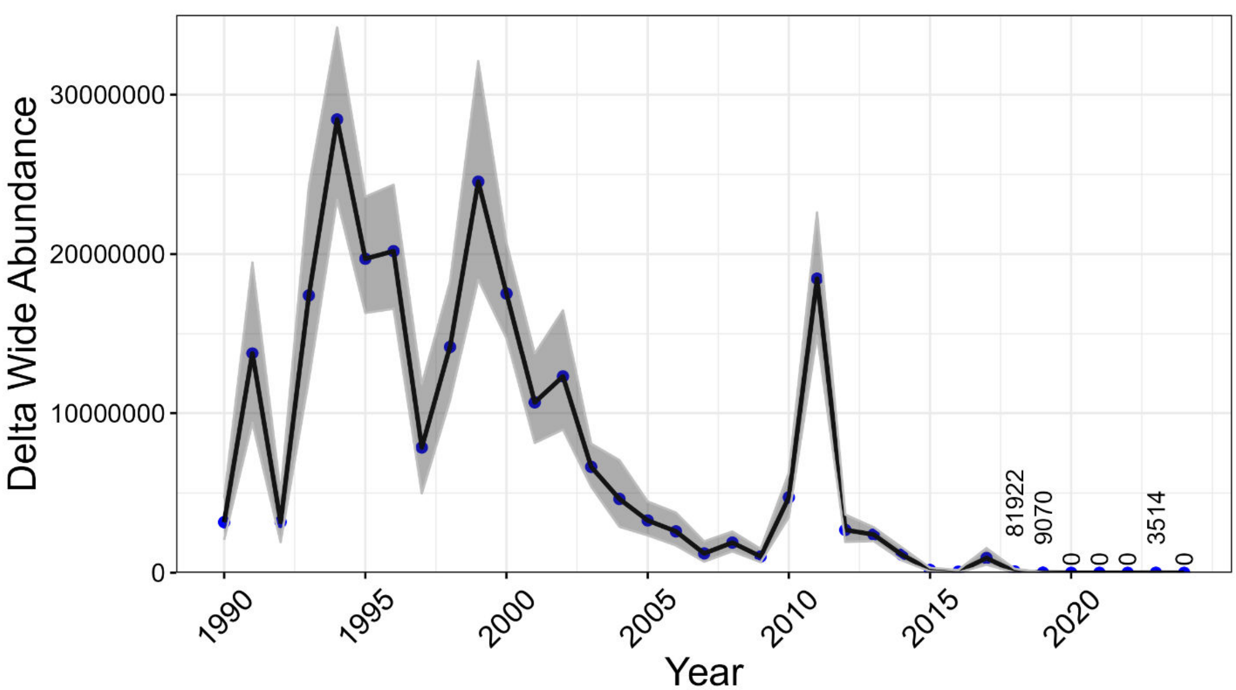



*Figure 17. Delta Smelt design-based abundance estimates for the years 1990 – 2024.*

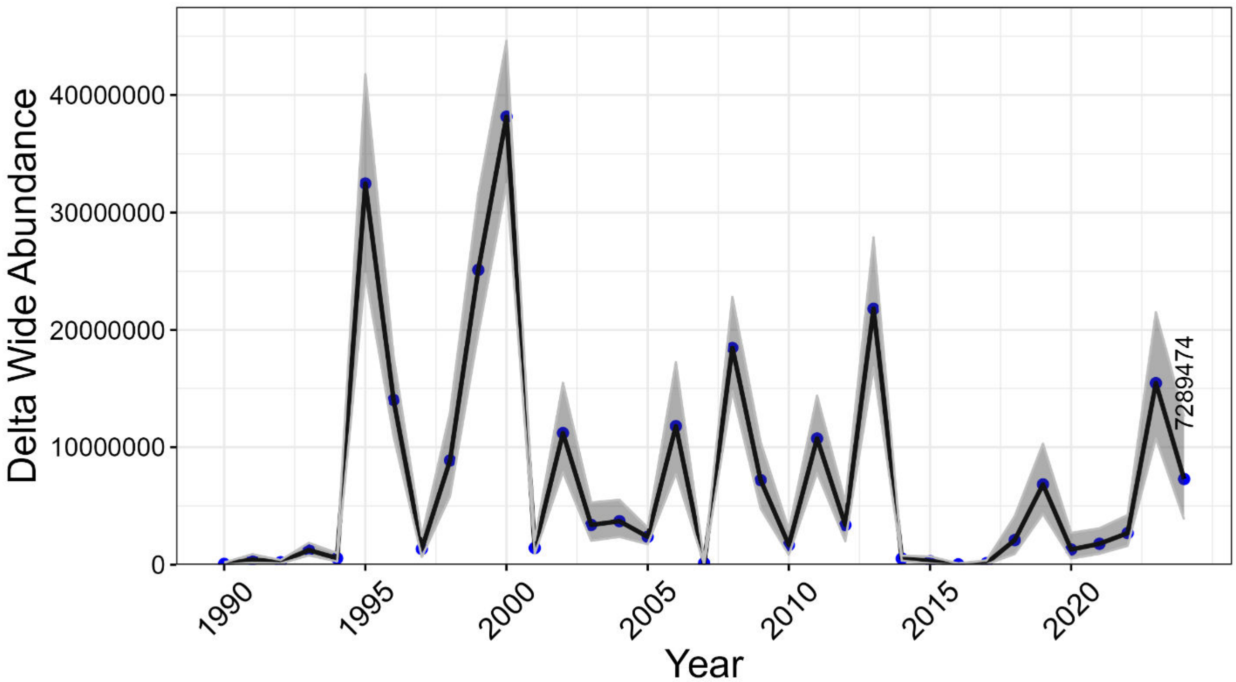



*Figure 18. Longfin Smelt design-based abundance estimates for the years 1990 – 2024.*

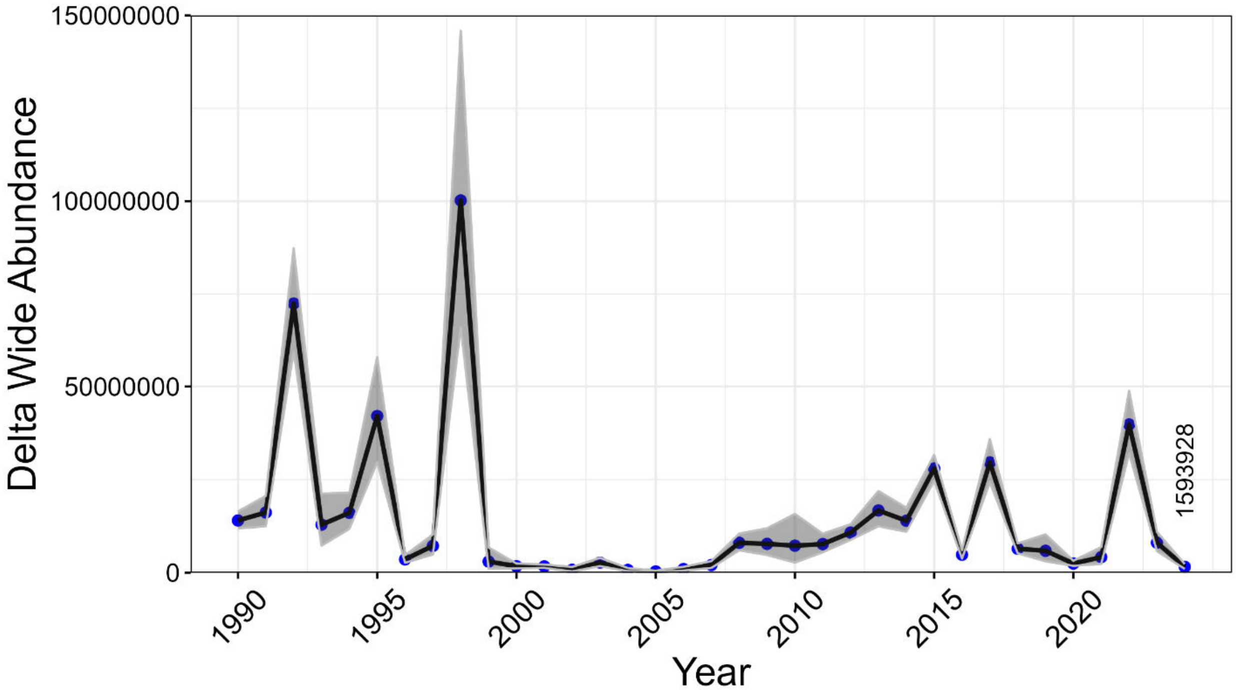



*Figure 19. Northern Anchovy design-based abundance estimates for the years 1990 – 2024.*

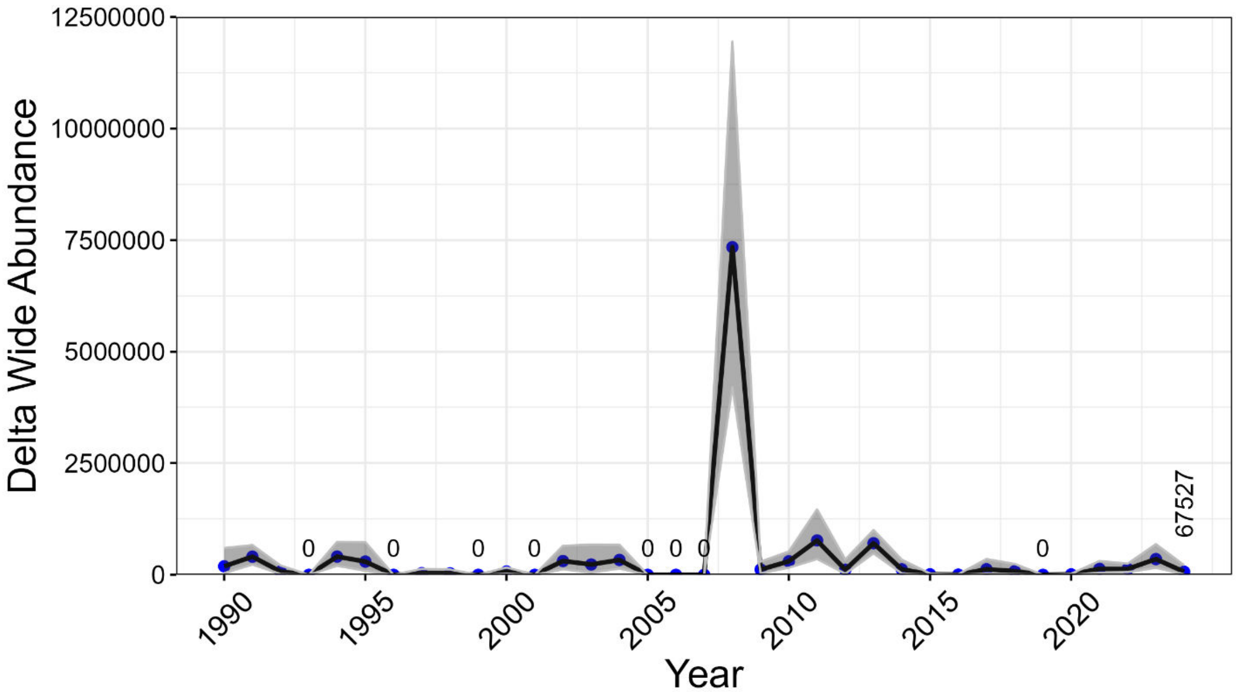



*Figure 20. Pacific Herring design-based abundance estimates for the years 1990 – 2024.*

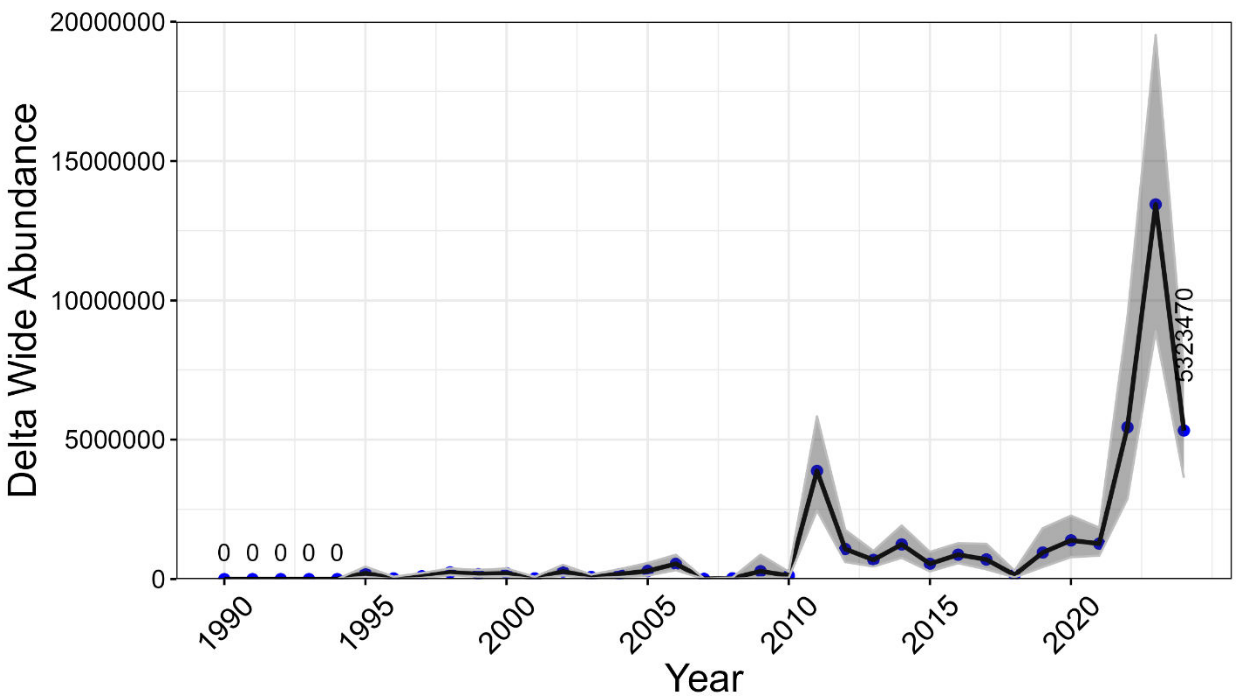



*Figure 21. Shimofuri Goby design-based abundance estimates for the years 1990 – 2024.*

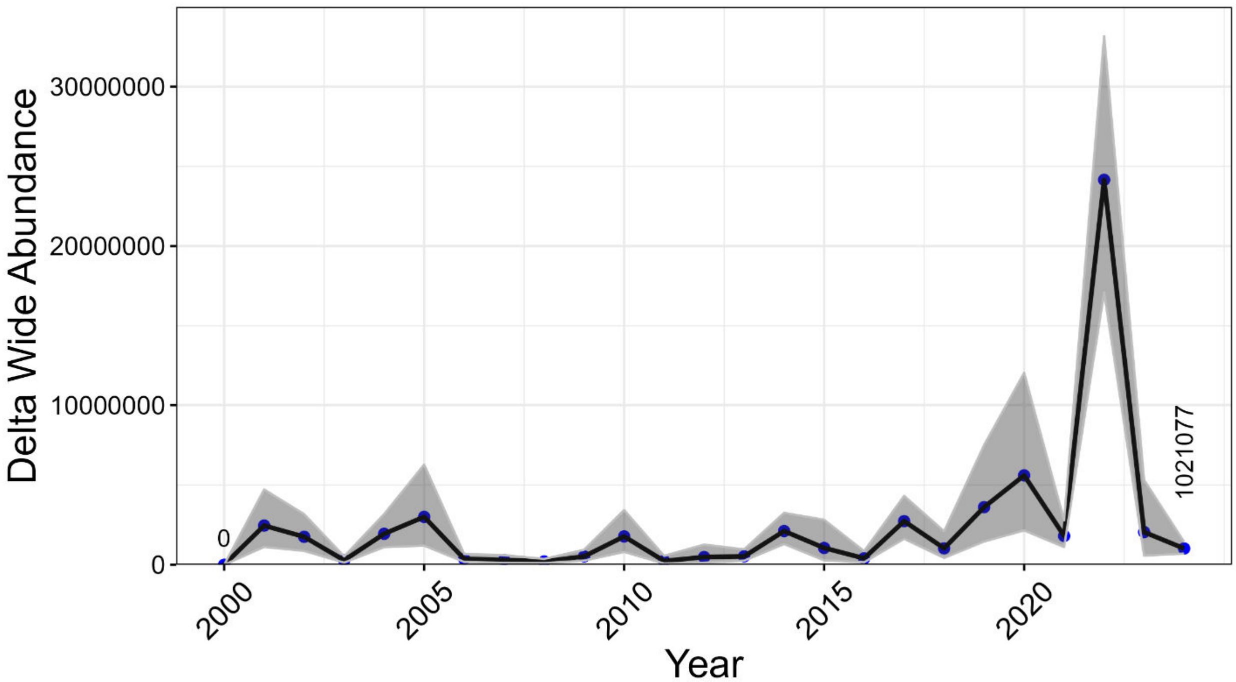



*Figure 22. Shokihaze Goby Smelt design-based abundance estimates for the years 2000 – 2024.*

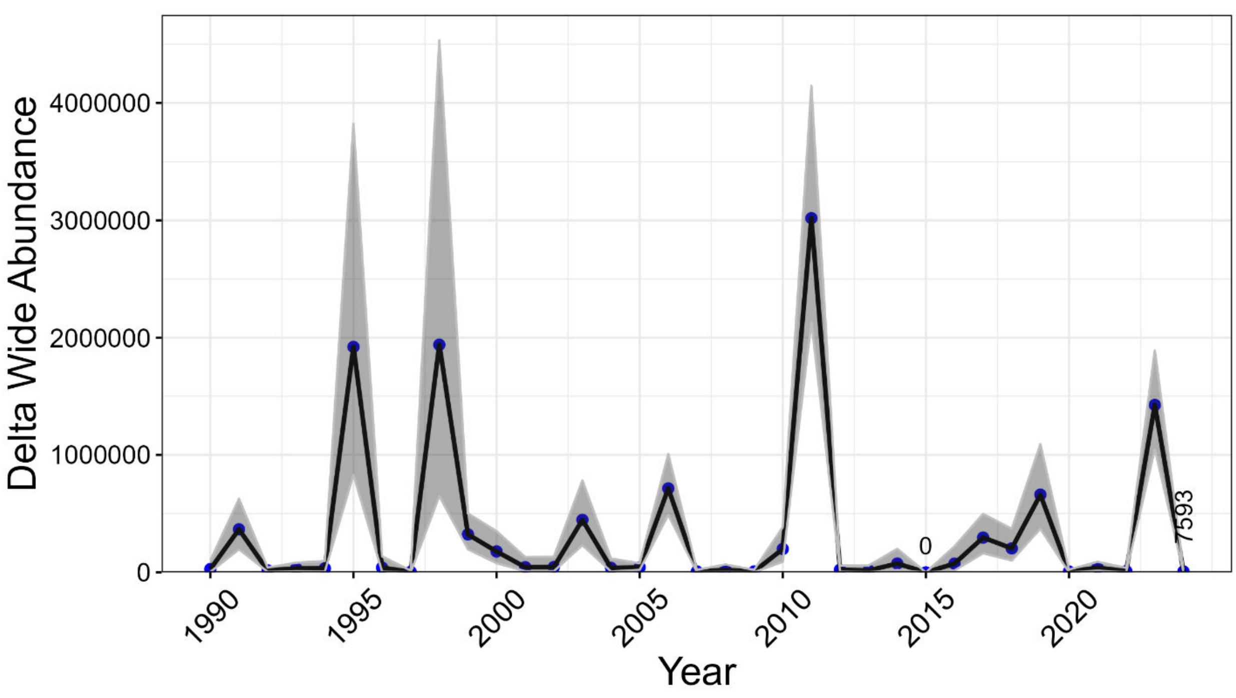



*Figure 23. Splittail design-based abundance estimates for the years 1990 – 2024.*

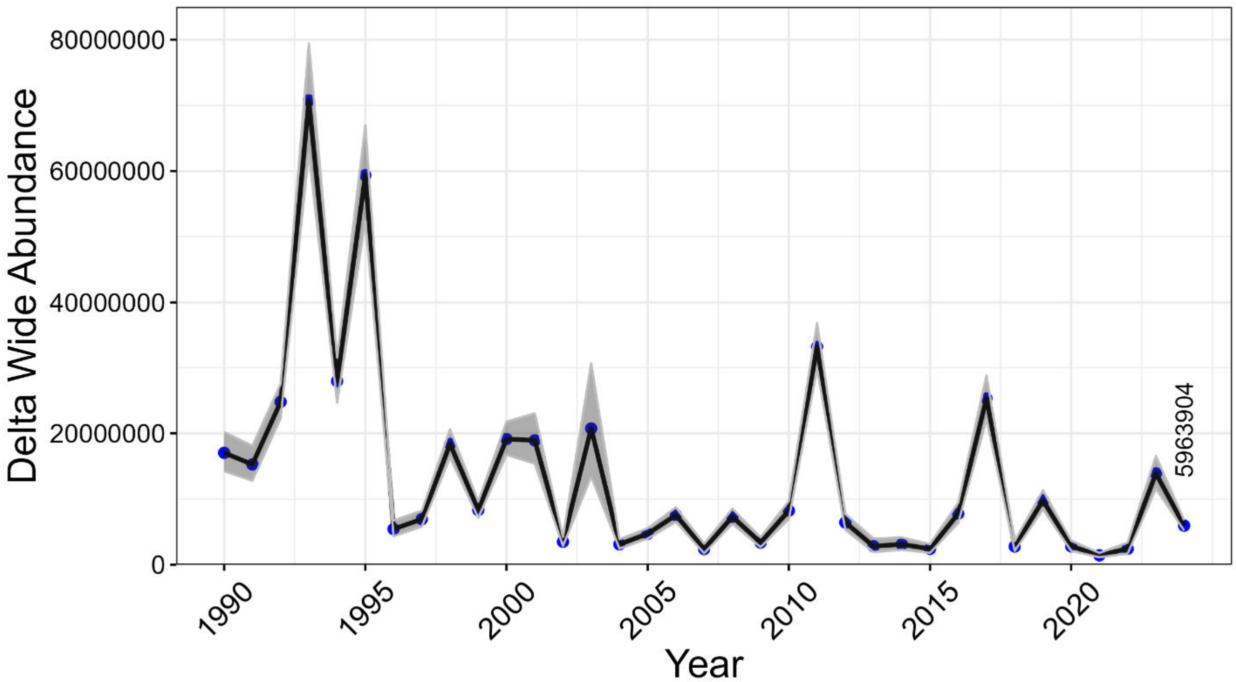



*Figure 24. Age-0 Striped Bass design-based abundance estimates for the years 1990 – 2024.*

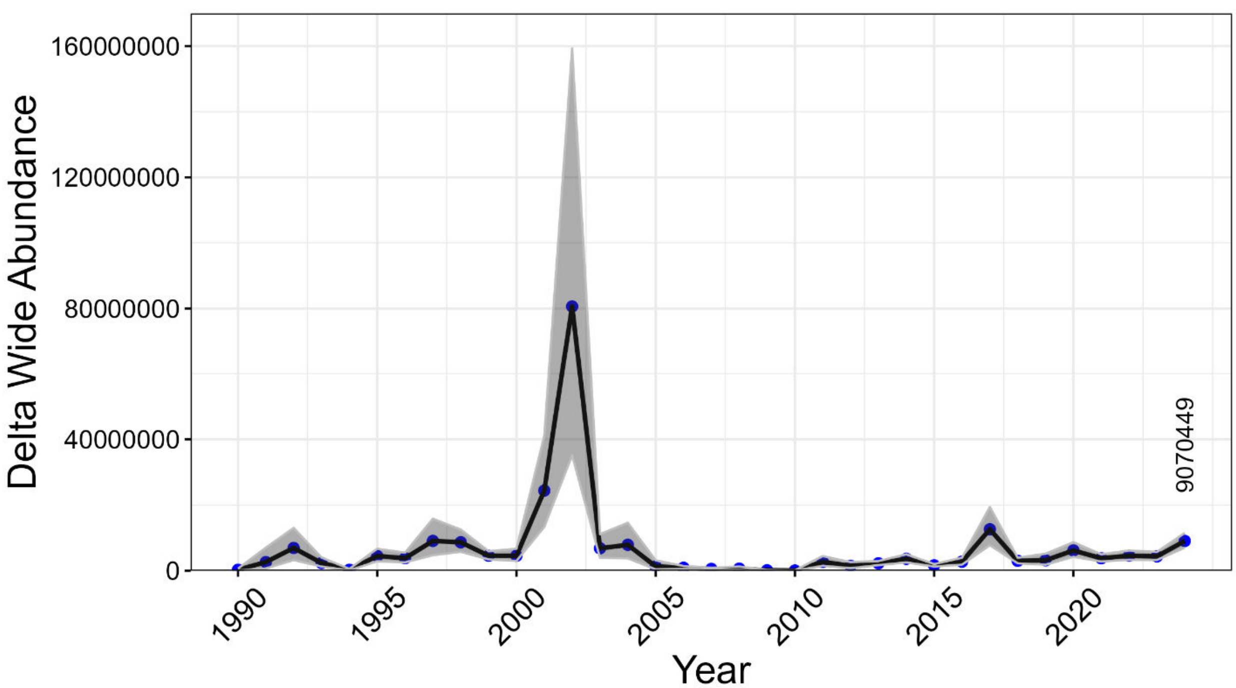



*Figure 25. Threadfin Shad design-based abundance estimates for the years 1990 – 2024.*

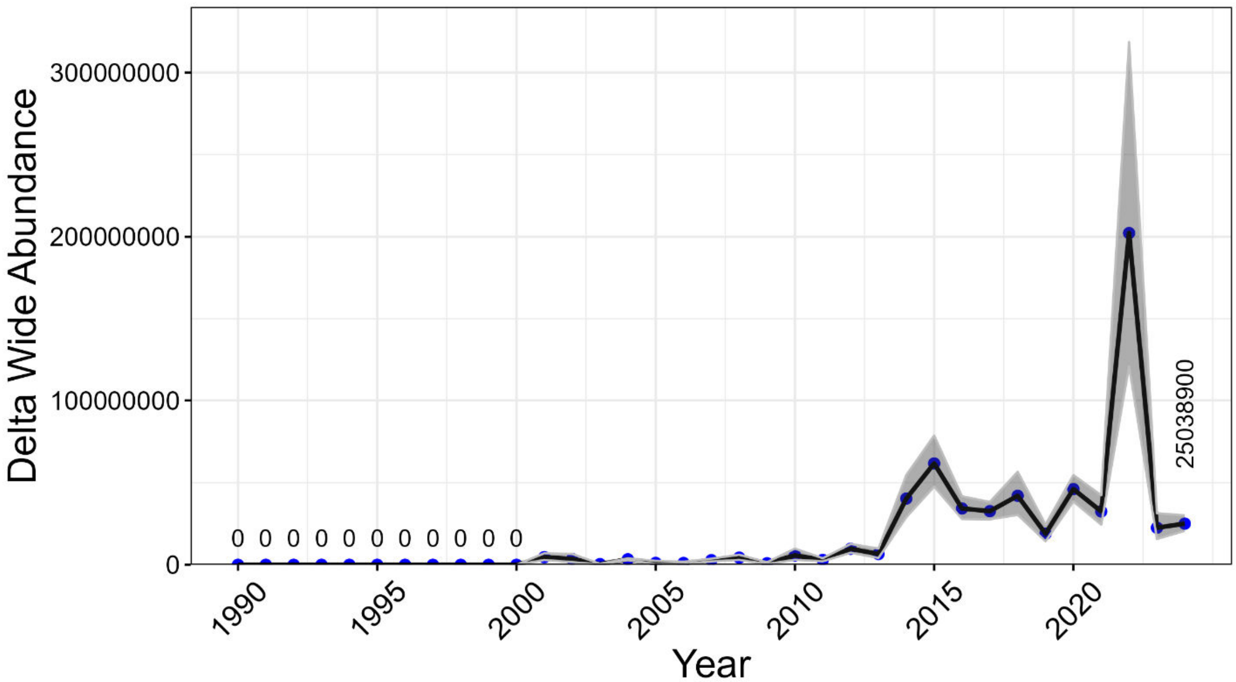



*Figure 26.* Tridentiger spp*. design-based abundance estimates for the years 1990 – 2024.*

## Length Frequencies for Species of Special Interest in 2024

Below are adjusted fork length frequency histograms for American Shad, Longfin Smelt, age-0 Striped bass, and Threadfin Shad. A maximum of 50 lengths is recorded for each species per tow. Available length data is then extrapolated to assign adjusted frequency of fish per 1 mm fork length intervals. Most of these species caught were young-of-the-year fish.

### American Shad

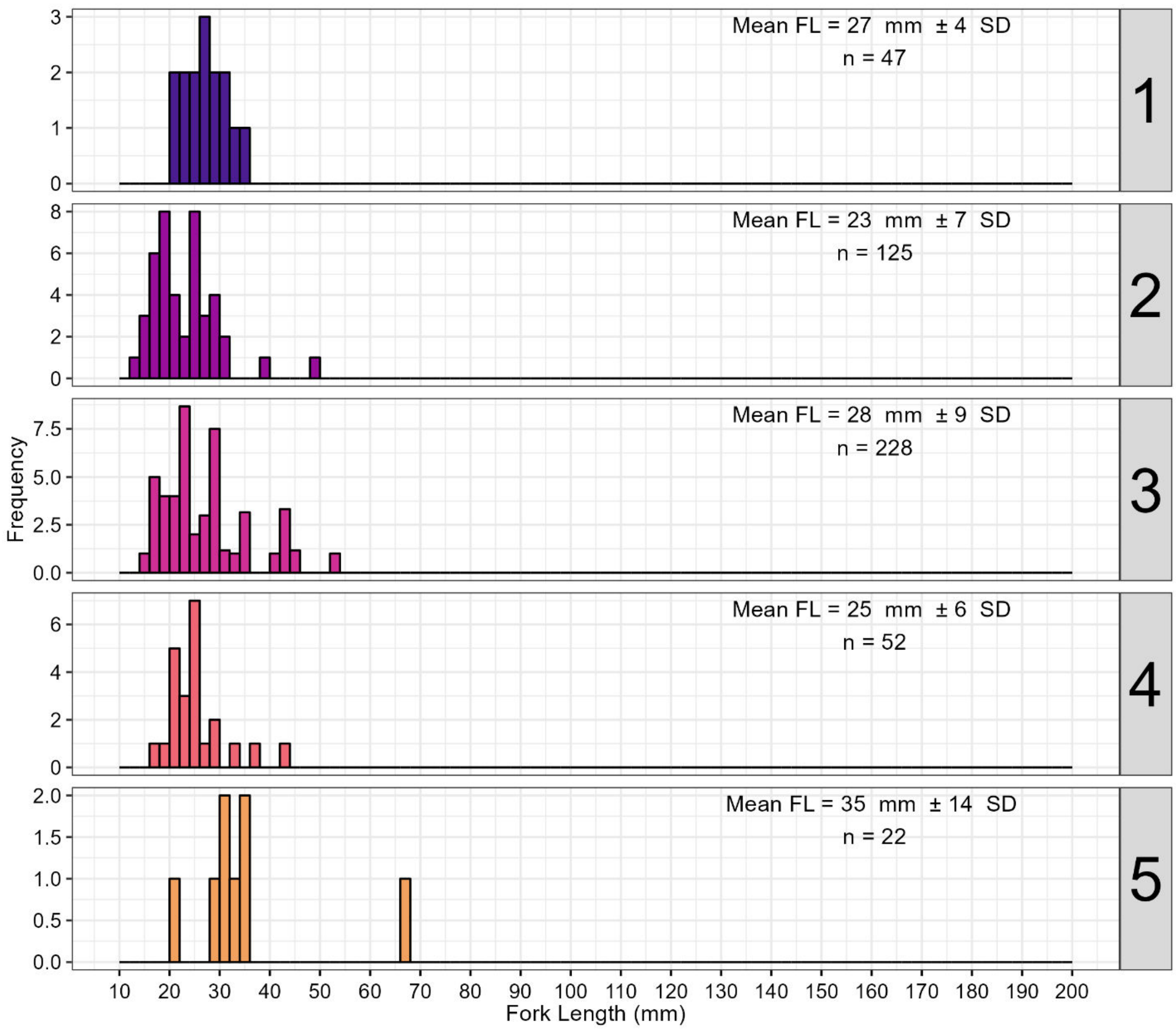



*Figure 27. Adjusted length (mm) frequency histograms for American Shad collected during Summer Townet surveys 1-5; Survey 6 = 0 catch. Mean fork length, standard deviation, and fish catch values (n) are displayed on each histogram.*

## Longfin Smelt

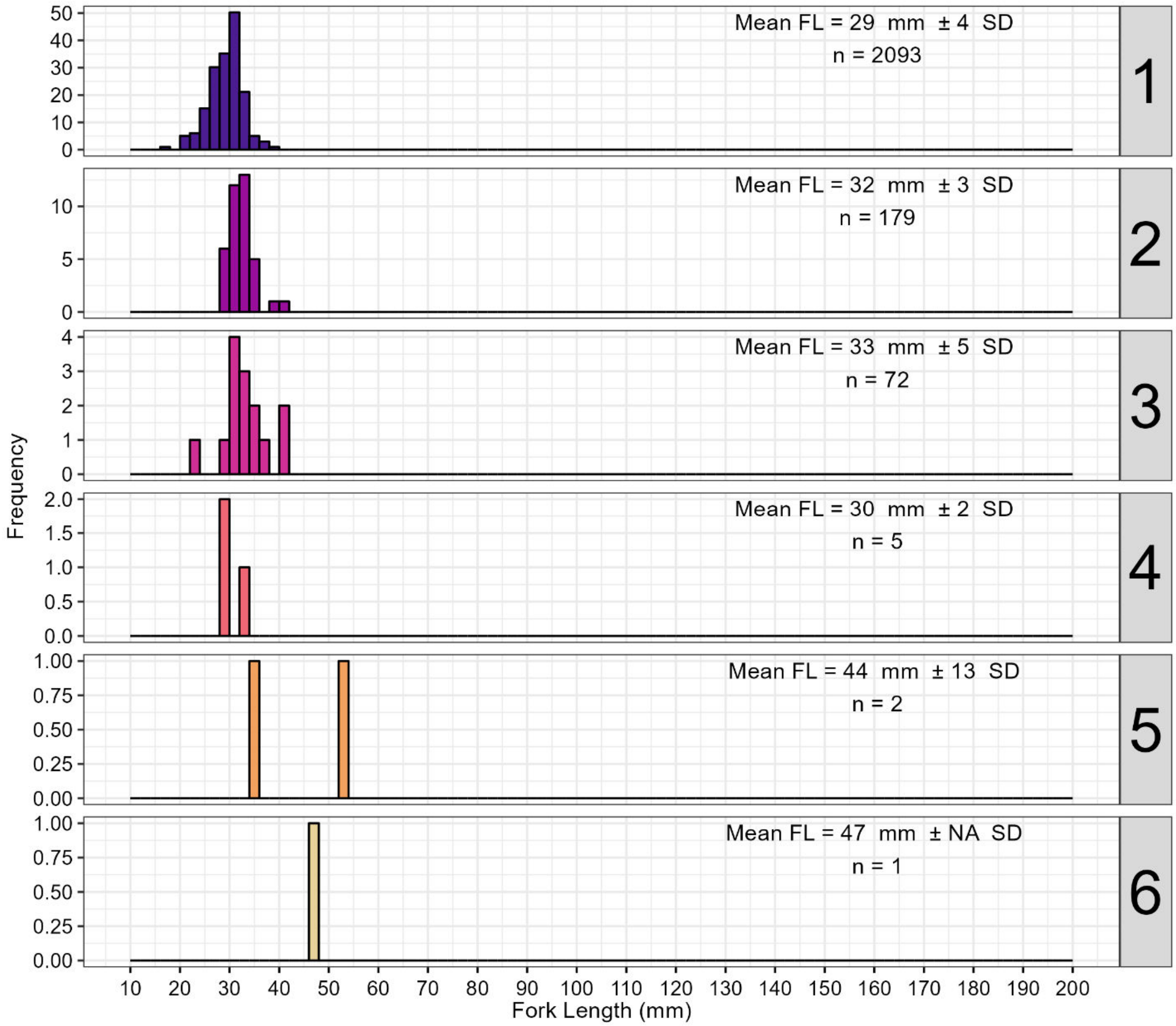



*Figure 28. Adjusted length (mm) frequency histograms for Longfin Smelt collected during Summer Townet surveys 1-6. Mean fork length, standard deviation, and fish catch values (n) are displayed on each histogram.*

## Age-0 Striped Bass

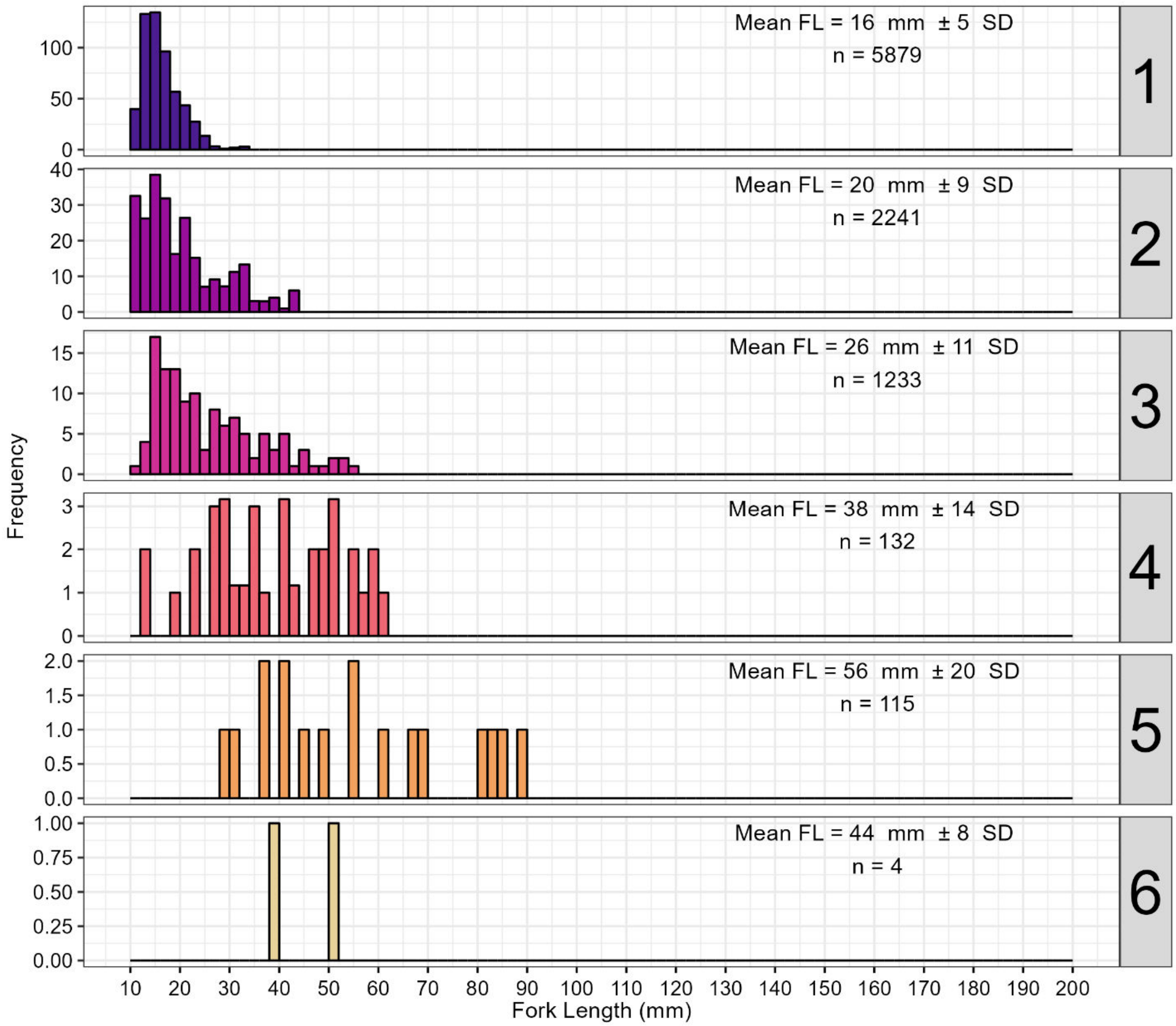



*Figure 29. Adjusted length (mm) frequency histograms for age-0 Striped Bass collected during Summer Townet surveys 1-6. Mean fork length, standard deviation, and fish catch values (n) are displayed on each histogram.*

**Threadfin Shad**

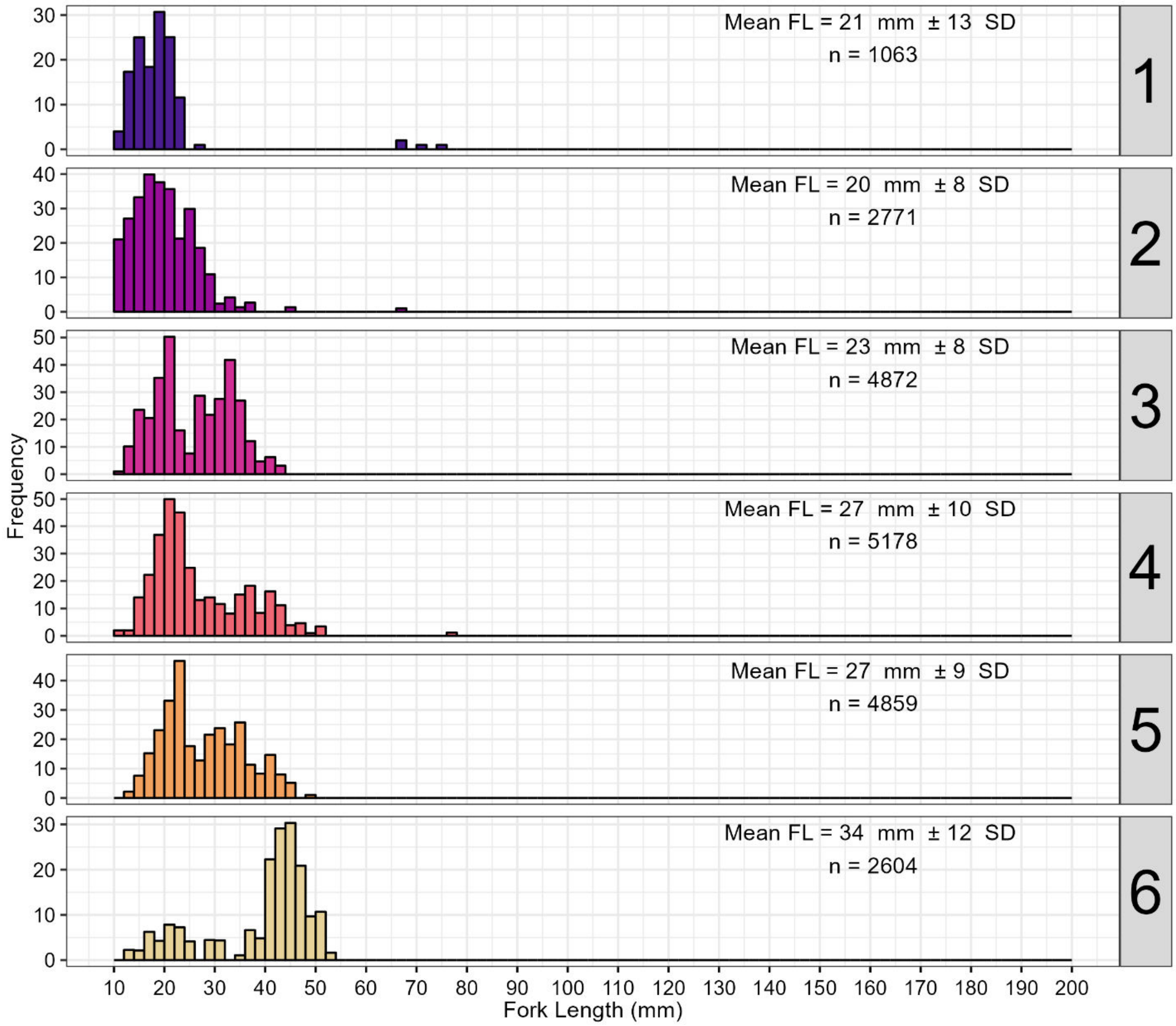



*Figure 30. Adjusted length (mm) frequency histograms for Threadfin Shad collected during Summer Townet surveys 1-6. Mean fork length, standard deviation, and fish catch values (n) are displayed on each histogram.*

## Acknowledgements

This work was conducted under the auspices of the Interagency Ecological Program. Funding for the Fall Midwater Trawl survey was supported by contracts with the Department of Water Resources and the US Bureau of Reclamation. We would like to acknowledge all the individuals involved with the success of the 2024 Summer Townet Survey, Including: Steven Slater, Taylor Rohlin, Spencer Breining-Aday, Nene Ugbah, Allegra Rocha, Caitlin Schuh, Denisse Anaya, Libby Cruz, Erica Steen, Mike Grady, Spencer Lewis, Paul Macias, Dave Hull, Michael Barcelos, Sara Douglas, Zach Liddle, Trevin Li, Kevin Juranek, and Tricia Bippus.

## References

Akihito and K. Sakamoto. 1989. Reexamination of the status of the striped goby. Japanese Journal of Ichthyology 36(1):100-112.

Baxter R, Hieb K, DeLeon S, Fleming K, Orsi J.1999. Report on the 1980-1995 fish, shrimp, and crab sampling in the San Francisco Estuary, California. California Department of Fish and Game Technical Report, 63. 503 p.

Bennett WA, Kimmerer WJ, Burau JR. 2002. Plasticity in vertical migration by native and exotic estuarine fishes in a dynamic low-salinity zone. Limnology and Oceanography, 47(5):1496–1507. https://doi.org/10.4319/lo.2002.47.5.1496

Brown T and Hieb K. 2014. Status of the Siberian Prawn, Exopalaemon modestus, in the San Francisco Estuary. San Francisco Estuary and Watershed Science, 12(1). https://doi.org/10.15447/sfews.2014v12iss1art4

Hammock BG, Hartman R, Slater SB, Hennessy A, Teh SJ. 2019. Tidal Wetlands Associated with Foraging Success of Delta Smelt. Estuaries and Coasts, 42(3):857-867. https://doi.org/10.1007/s12237-019-00521-5

Israel HR. 1936. A contribution toward the life history of two California shrimps, Crago franciscorum (Stimpson) and Crago nigricauda (Stimpson). California Department of Fish and Game, Fish Bulletin, 46. 28 p.

Mahardja B, Bashevkin SM, Pien C, Nelson M, Davis BE, Hartman R. 2022. Escape from the heat: thermal stratification in a well-mixed estuary and implications for fish species facing a changing climate. Hydrobiologia 849, 2895–2918. https://doi.org/10.1007/s10750-022-04886-w

Matern SA, Fleming KJ. 1995. Invasion of a third Asian Goby, Tridentiger bifasciatus, into California. California Fish and Game, 81:71–76.

Matern SA. 2001. Using temperature and salinity tolerances to predict the success of the Shimofuri Goby, a recent invader into California. Transactions of the American Fisheries Society, 130:592–599. https://doi.org/10.1577/1548-

8659(2001)130<0592:UTASTT>2.0.CO;2

Miller WJ, Manly BFJ, Murphy DD, Fullerton D, Ramey RR. 2012. An investigation of factors affecting the decline of Delta Smelt (Hypomesus transpacificus) in the 36 Sacramento-San Joaquin Estuary. Reviews in Fisheries Science, 20(1):1-19. https://doi.org/10.1080/10641262.2011.634930

Meek, M. H. (2010). The invasion biology of three species of invasive hydrozoans in the upper San Francisco Estuary. University of California, Davis.

Leo Polansky, Lara Mitchell, Ken B. Newman, Using Multistage Design-Based Methods to Construct Abundance Indices and Uncertainty Measures for Delta Smelt, *Transactions of the American Fisheries Society*, Volume 148, Issue 4, July 2019, Pages 710–724, https://doi.org/10.1002/tafs.10166

Slater, S. B., A. Barros, and A. R. Melwani. 2023. CDFW Methods for Defining Sample Frame, Stratification, and Volumes for Juvenile Pelagic Fishes Studies in the Upper San Francisco Estuary. Monitoring Survey Design Technical Note #1. FINAL DRAFT FOR 6-AGENCY REVIEW. January 12, 2023. California Department of Fish and Wildlife.

Stevens DE. 1977. Striped Bass (Morone saxatilis) year class strength in relation to river flow in the Sacramento-San Joaquin Estuary, California. Transactions of the American Fisheries Society. 106(1): 34-42. https://doi.org/10.1577/1548-8659(1977)106<34:SBMSYC>2.0.CO;2

Swanson C, Reid T, Young PS, Cech JJ. 2000. Comparative Environmental tolerances of threatened Delta Smelt (Hypomesus transpacificus) and introduced Wakasagi (H. nipponensis) in an altered California estuary. Oecologia 123:384–390. https://doi.org/10.1007/s004420051025

Tempel TL, Malinich TD, Burns J, Barros A, Burdi CE, Hobbs JA. 2021. The value of long-term monitoring of the San Francisco Estuary for Delta Smelt and Longfin Smelt. California Fish and Wildlife Journal. https://doi.org/10.51492/cfwj.cesasi.7

Turner JL, Chadwick HK. 1972. Distribution and abundance of young-of-the-year Striped Bass, Morone saxatilis, in relation to river flow in the Sacramento-San Joaquin Estuary. Transactions of the American Fisheries Society, 101(3): 442–452. https://doi.org/10.1577/1548-8659(1972)101<442:DAAOYS>2.0.CO;2

Young, Matthew & Berridge, Kathleen & O’Rear, Teejay & Moyle, Peter & Durand, John. (2017). Habitat partitioning by native and alien fishes and decapods in novel habitats of the upper San Francisco Estuary. Biological Invasions. 19. 1-18. 10.1007/s10530-017-1477-2.

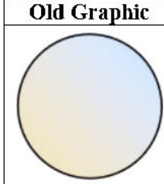
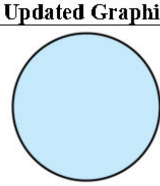
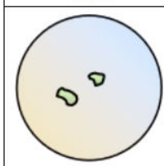
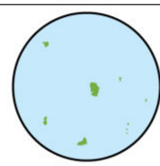
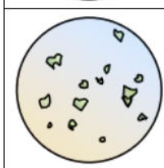
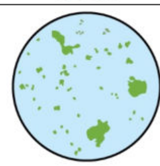
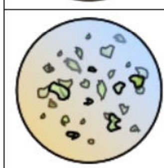
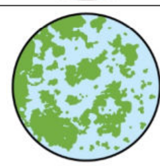
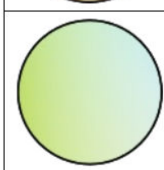
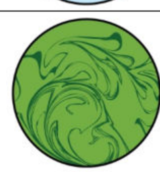
Wowor, D., and P. K. Ng. 2007. The giant freshwater prawns of the Macrobrachium rosenbergii species group (Crustacea: Decapoda: Caridea: Palaemonidae). The Raffles Bulletin of Zoology 55(2):321-336.

## Appendix

*Appendix 1. Microcystis spp. ranking scale.*

**Update to Microcystis Scale Graphics**

*Revised 1/30/2020*

| Old Graphic | Updated Graphic | Score |
|---|---|---|
|  |  | **1 – Absent**<br>No visible *Microcystis* colonies |
|  |  | **2 – Low**<br>Visible but widely scattered *Microcystis* colonies. |
|  |  | **3 - Medium**<br>Adjacent colonies of *Microcystis*. |
|  |  | **4 - High**<br>Contiguous colonies of *Micrcystis*. |
|  |  | **5. Very High**<br>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/.