The Summer Townet Survey

2023 Season Report

California Department of Fish and Wildlife

Bay Delta Region

Margaret W. Johnson

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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 of fish catch with 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-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 32 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. 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. Presently, 40 stations (31 index and 9 non-index stations) are sampled every other week June through early-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 at each station are to 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

(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 2023 season with Survey 1 on June 12th and completed the sixth and final survey on August 24th. Since 2020, the STN survey has not been able to sample at station 721 due to aquatic vegetation. An alternative station, 722, has been sampled in recent years. Station 722 is located 2 km down river from station 721 (Figure 1). 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.

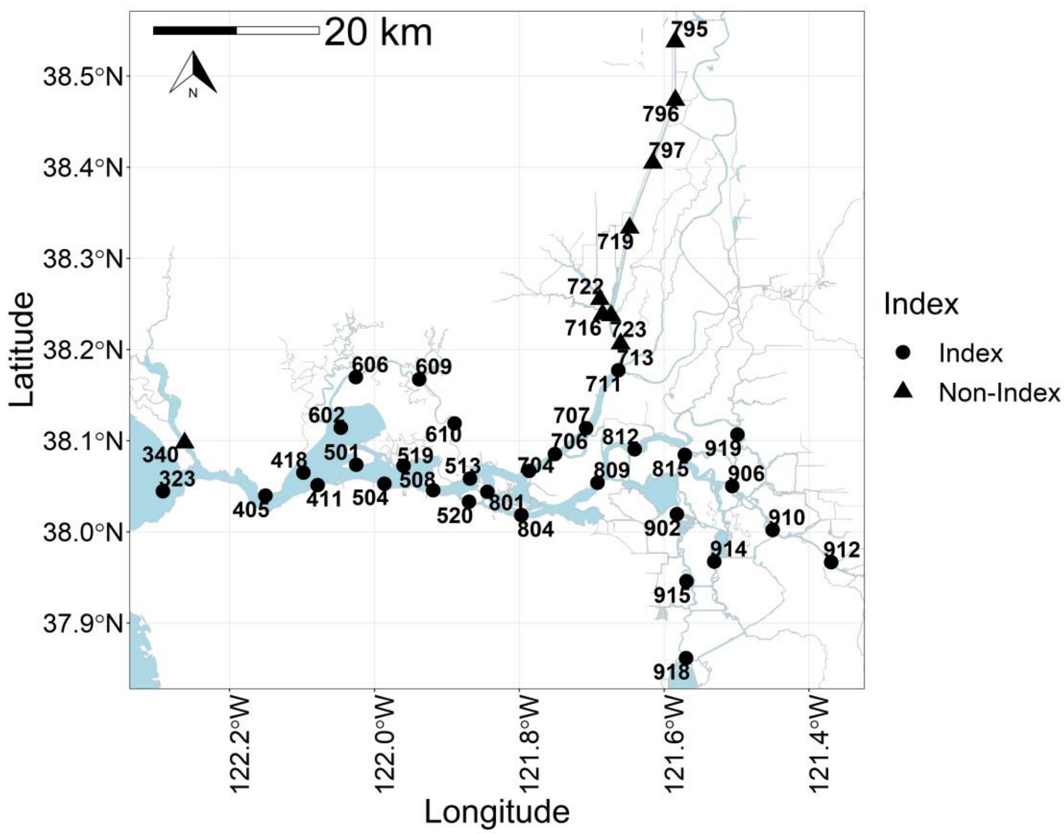

Figure 1. The Summer Townet Survey station map showing 31 index stations (circles) and 9 non-index stations (triangles). In 2021, we ceased to sample at station 721 and began to sample an alternative station labeled as 722.

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. Townet ready for deployment with meso-zooplankton (Clark-Bumpus) net mounted on top, and flowmeter attached to the center of the townet.

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 meso-zooplankton. 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 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 2023, STN successfully visited and sampled each index station in all six surveys. All non-index stations were also successfully sampled. Most surveys were completed within four days using one or two research vessels (Survey 1, June 12-15; Survey 2, June 26-29; Survey 3, July 10-14; Survey 4, July 24-27; Survey 5, Aug 7-10; Survey 6, Aug 21-24). The summary of tows for each station is presented in Table 1.

Table 1. Tows per station by survey and total tows over the 2023 Summer Townet season.

Station	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Survey 6	Total
323	3	3	3	3	3	3	**18**
340	3	3	3	2	3	3	**17**
405	3	2	3	2	3	3	**16**
411	3	2	3	2	2	2	**14**
418	3	3	3	3	3	3	**18**
501	3	3	3	2	2	3	**16**
504	3	3	3	2	2	2	**15**
508	3	3	3	3	3	2	**17**
513	3	3	3	3	3	3	**18**
519	3	2	3	2	3	2	**15**
520	2	2	3	3	3	2	**15**
602	3	3	3	3	3	3	**18**
606	3	3	3	3	3	3	**18**
609	3	3	3	3	3	3	**18**
610	3	3	3	3	3	3	**18**
704	3	3	3	3	3	3	**18**
706	3	3	3	3	3	3	**18**

Station	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Survey 6	Total
707	2	3	3	3	3	2	**16**
711	2	2	2	2	2	2	**12**
713	2	2	2	2	2	2	**12**
716	2	2	2	2	2	2	**12**
719	2	2	2	2	2	2	**12**
722	2	2	2	2	2	2	**12**
723	2	2	2	2	2	2	**12**
795	2	2	2	2	2	2	**12**
796	2	2	2	2	2	2	**12**
797	2	2	2	2	2	2	**12**
801	3	3	3	2	3	3	**17**
804	3	3	3	3	3	2	**17**
809	3	3	3	2	3	2	**16**
812	3	2	3	2	2	2	**14**
815	2	2	3	2	2	2	**13**
902	3	3	3	2	2	2	**15**
906	2	3	3	2	2	2	**14**
910	3	3	3	2	2	3	**16**
912	3	3	2	2	3	3	**16**
914	3	2	2	2	2	2	**13**
915	2	3	3	3	2	2	**15**
918	3	3	3	3	3	2	**17**
919	2	2	3	2	2	2	**13**
Total	**105**	**103**	**109**	**95**	**100**	**95**	**607**

Non-Routine Sampling

In addition to the routine monitoring, STN conducted additional sampling, starting in Survey 3 of 2023 (Table 2), as a collaborator with DWR on the Suisun Marsh Salinity

Control Gate (SMSCG) Action special study (IEP element 335). STN conducted additional zooplankton tows using a Mysid sled, as well as collected phytoplankton surface samples from the stations listed below. Phytoplankton samples were transferred at end of season to DWR for processing.

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. [1] indicates a station that is not part of the regular STN sampling schedule.

Survey	Station	Fish	Zooplankton	Phytoplankton
3	508	1	1	0
3	513	1	1	0
3	519	1	1	1
3	609	1	1	1
3	610	1	1	1
3	704	1	1	1
3	FMWT 605[1]	0	1	1
3	Mont[1]	0	1	1
4	508	1	1	0
4	513	1	1	0
4	519	1	1	1
4	602	1	1	1
4	606	1	1	1
4	609	1	1	1
4	610	1	1	1
4	704	1	1	1
4	706	1	1	1
4	801	1	1	1
4	FMWT 605[1]	0	1	1
4	Mont[1]	0	1	1
4	EMP NZS42[1]	0	1	1

Survey	Station	Fish	Zooplankton	Phytoplankton
5	508	1	1	0
5	513	1	1	0
5	519	1	1	1
5	602	1	1	1
5	606	1	1	1
5	609	1	1	1
5	610	1	1	1
5	704	1	1	1
5	706	1	1	1
5	801	1	1	1
5	FMWT 605[1]	0	1	1
5	Mont[1]	0	1	1
6	508	1	1	0
6	513	1	1	0
6	519	1	1	1
6	602	1	1	1
6	606	1	1	1
6	609	1	1	1
6	610	1	1	1
6	704	1	1	1
6	706	1	1	1
6	801	1	1	1
6	FMWT 605[1]	0	1	1
6	Mont[1]	0	1	1
6	EMP NZS42[1]	0	1	1

Environmental Variables

The STN 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.

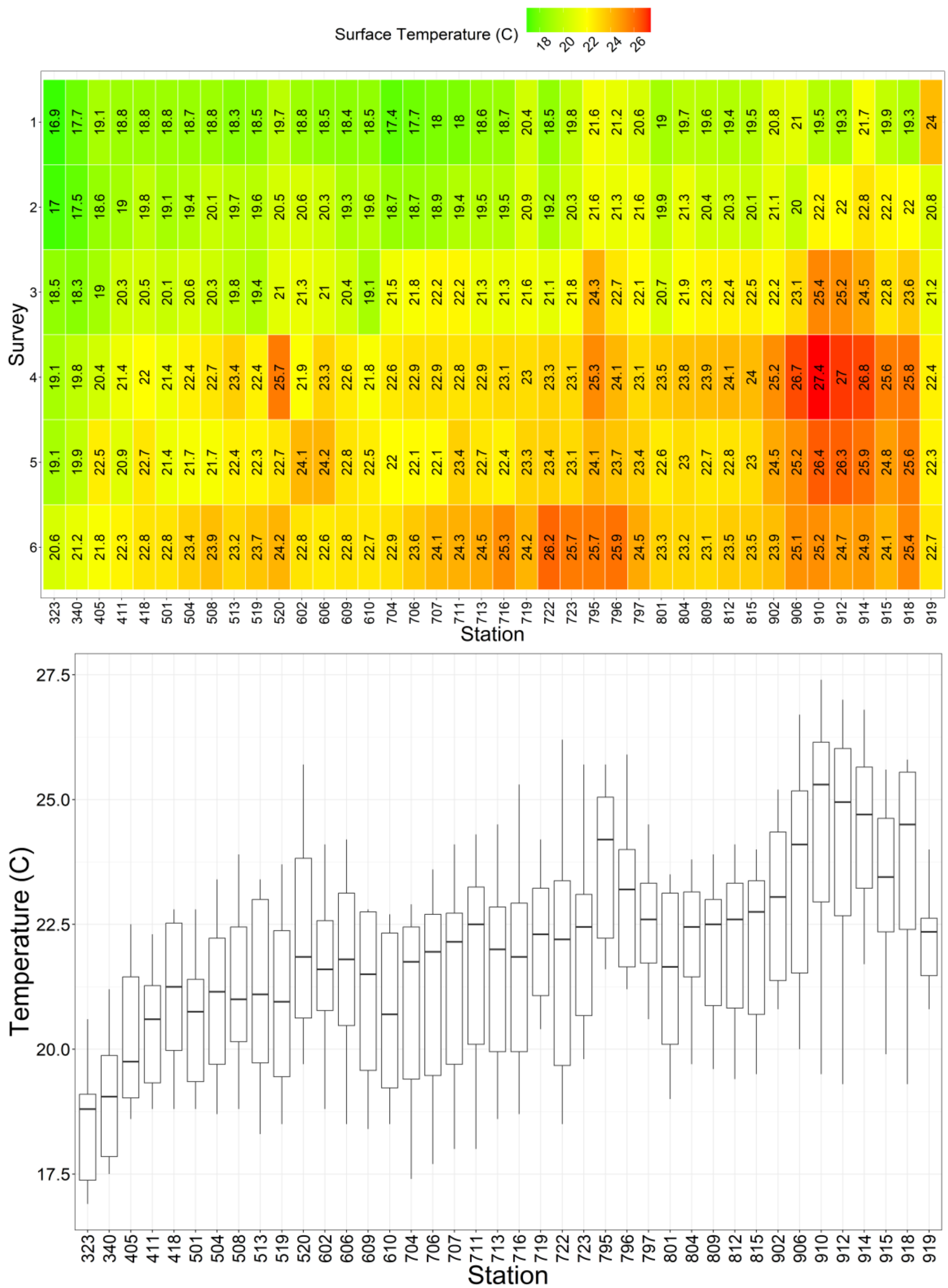

Figure 3. Surface temperature (°C) at each STN station by survey (top) and the distribution of temperature for each station across the season (bottom). Boxplots (bottom) show the median as a horizontal line, 1st and 3rd quartile by box, range by vertical line and outliers by point.

Temperatures (Figure 3) at the STN stations were generally cooler in June surveys (Surveys 1-2) and warmer from the end of July through late August (Surveys 4-6). Stations furthest from San Pablo Bay were generally warmer than downstream stations. Stations located in the South Delta (i.e. San Joaquin River and Old River) and the Sacramento Deep Water Ship Channel (SDWSC) were particularly warm. Stations 910 and 912, located at the eastern edge of the STN sampling range, reached the highest temperatures in mid-summer during Survey 4. 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 this comparison among stations.

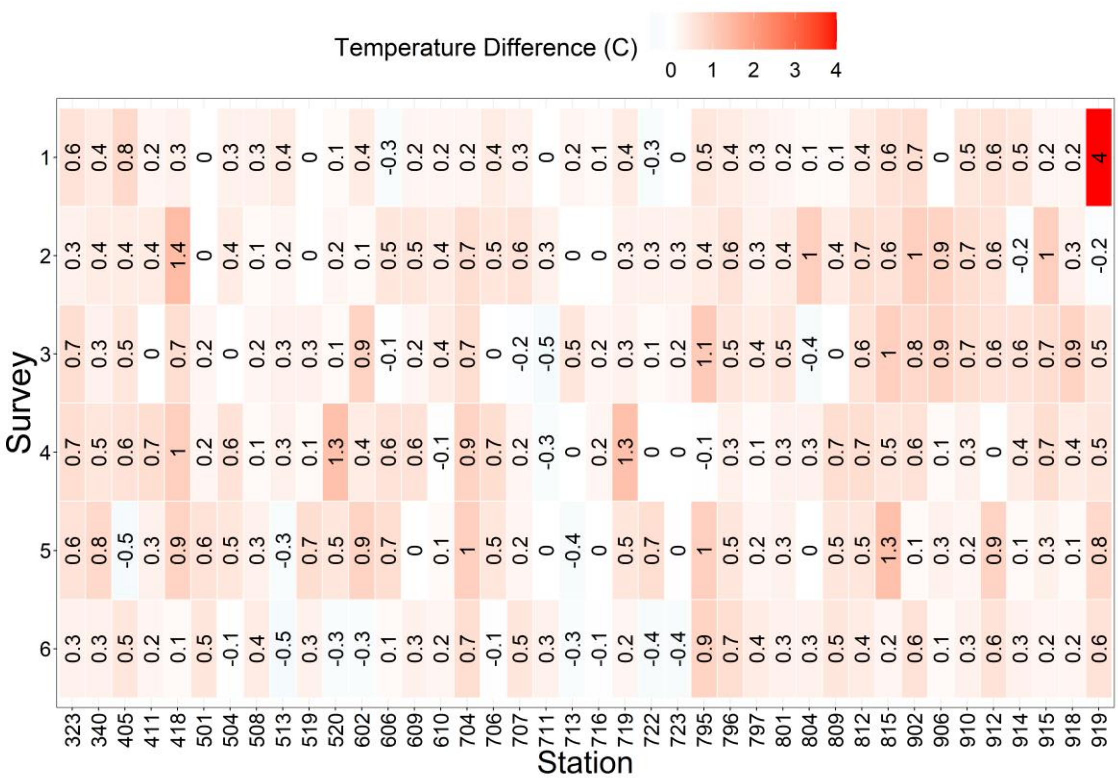

Figure 4. Temperature differences (°C) between the surface and bottom at each STN station (index and non-index). Red colors indicate greater temperatures at the surface and clear tiles indicate little to no difference in temperature.

Warmer surface temperatures were seen at most stations throughout the estuary (Figure 4), but not to the same degree as in 2022 and 2021. Slightly cooler surface temperatures were also observed at some stations. This may be due to currents 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 may rise in temperature while on the deck of the vessel during high air temperatures.

Overall, salinity was lower in 2023 than in the previous three years. Salinity was the highest in San Pablo Bay and decreased further upstream (Figure 5), with some variation in Suisun Bay due to tidal fluxes. Salinity reached zero parts per thousand (ppt) at stations in the San Joaquin River, as well as stations in the lower Sacramento River and the confluence of the two rivers.

Stations in Suisun Bay and Napa River showed the most extreme salinity differences between the surface and the bottom of the water column. At most other stations, differences in salinity values were smaller (Figure 6).

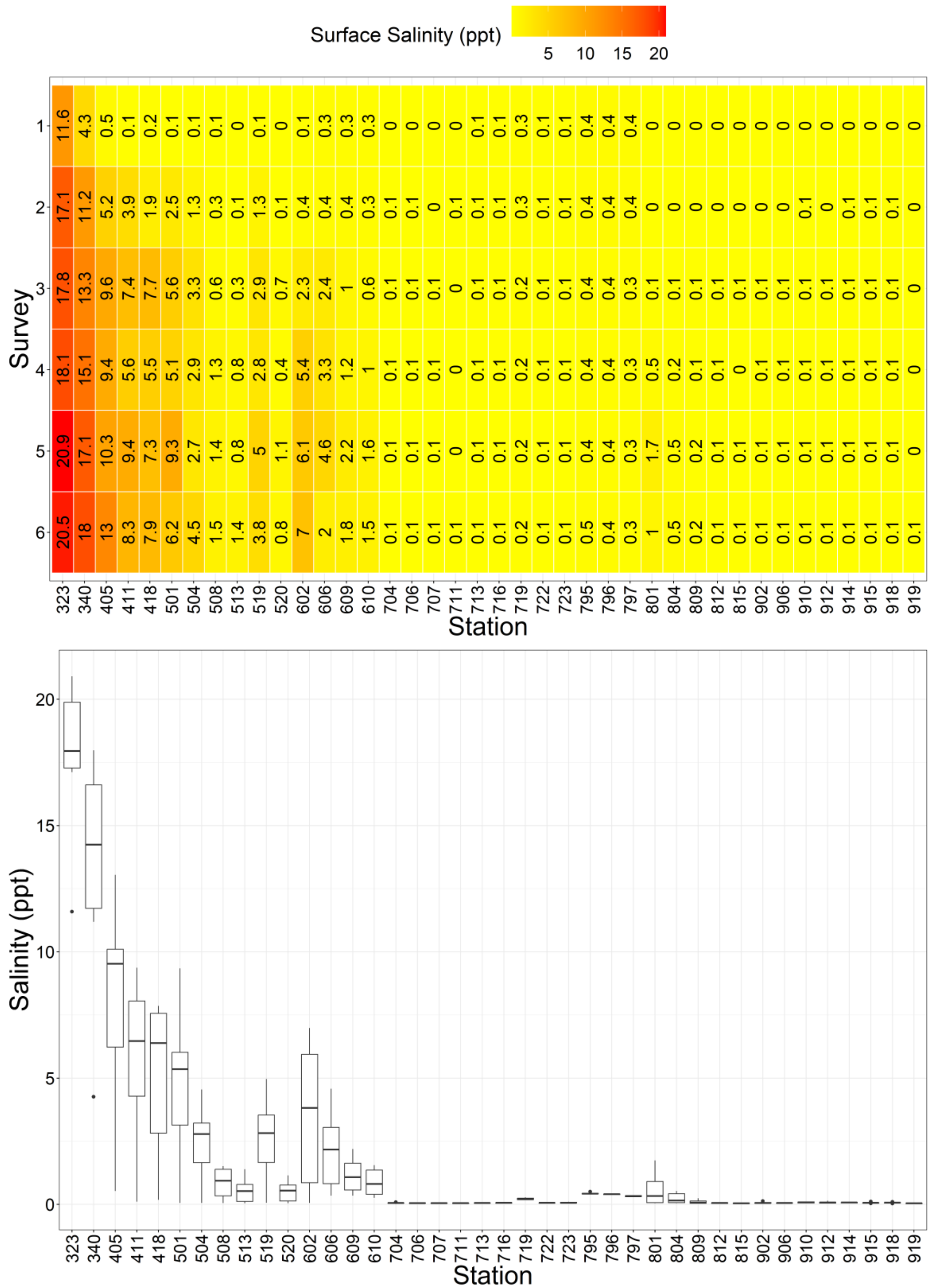

Figure 5. Surface salinity derived from specific conductance (µS/cm) measured at each STN station (index and non-index) in 2023. Red shading (top) transitioning to yellow indicates salinity decreasing further upstream.

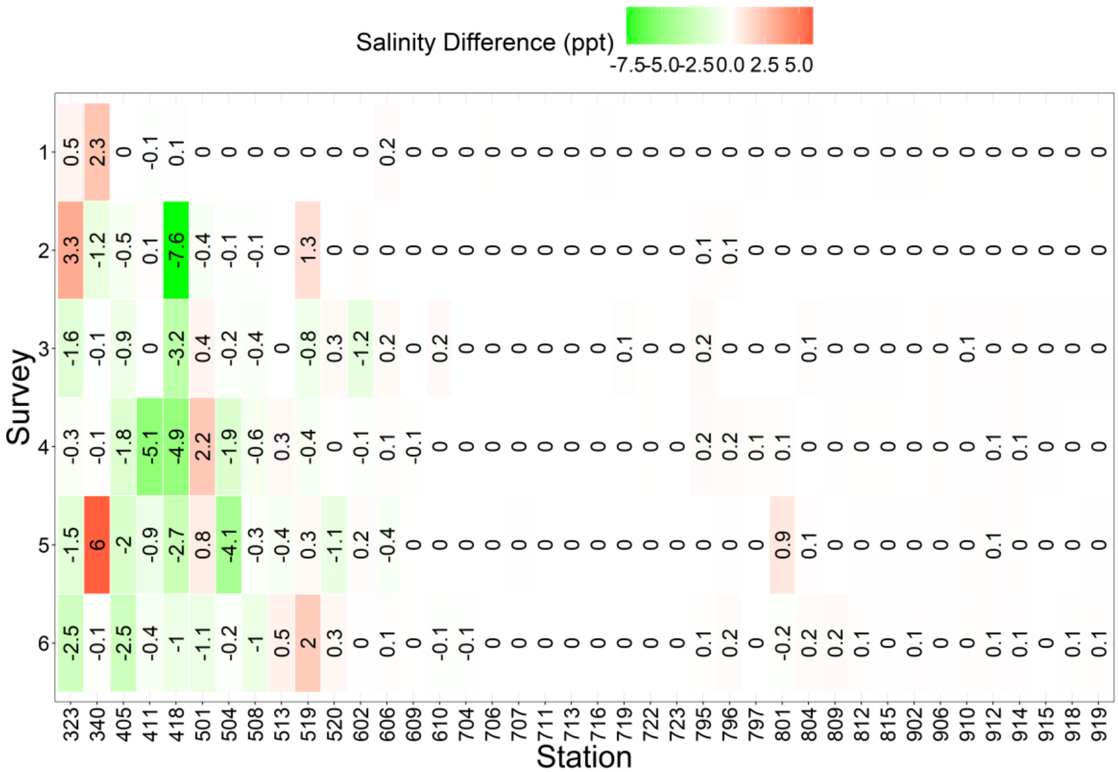

Figure 6. Salinity (ppt) differences within the water column between the surface and bottom. Negative (green) values indicate greater salinity lower in the water column while positive (red) values indicate greater salinity in the surface.

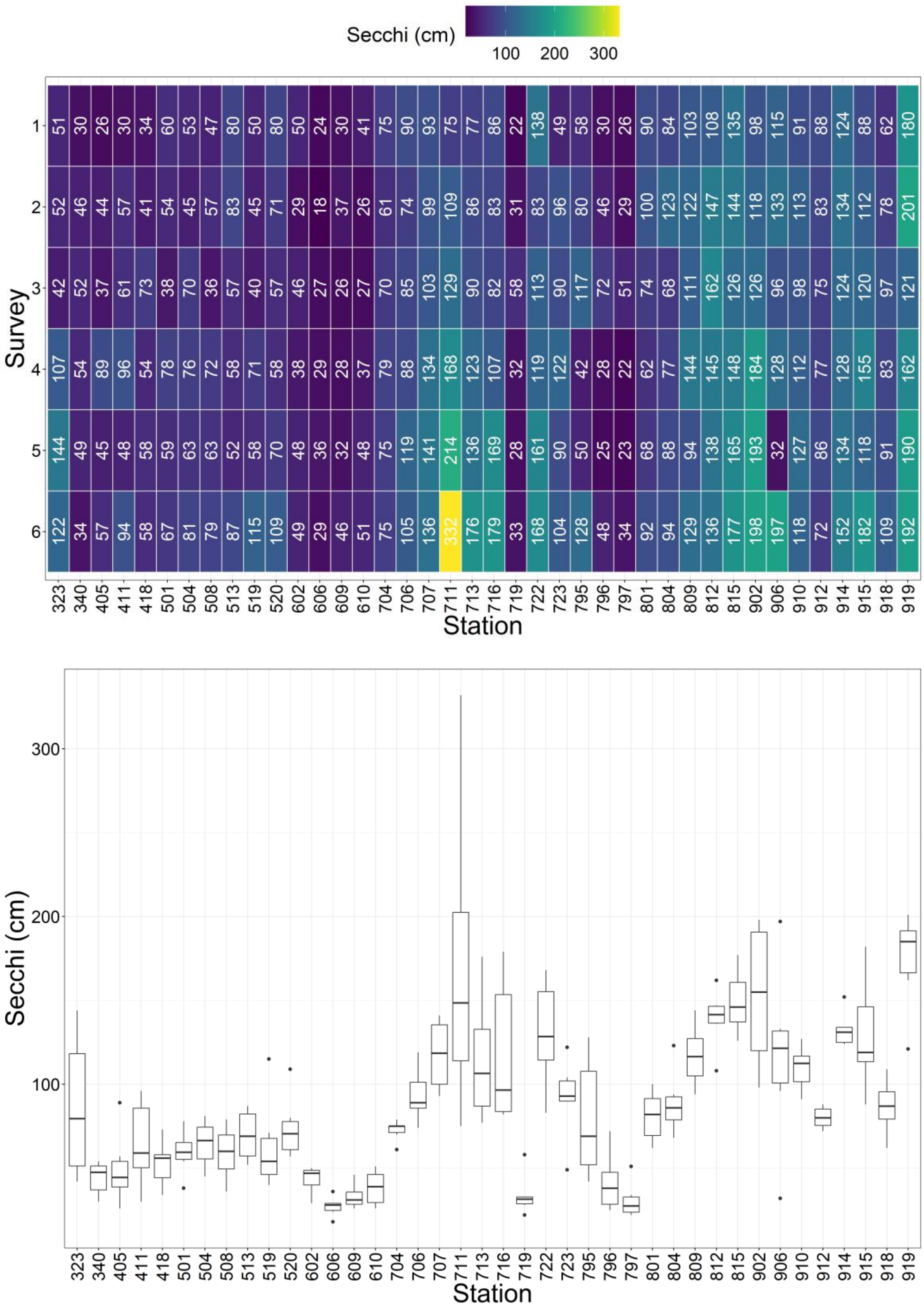

Figure 7. Water clarity as measured by Secchi disk depth (cm) for all stations and all surveys (top), and range of Secchi measurements for each station (bottom).

Secchi (Figure 7) and turbidity (Figure 8) values reflected regional variation in tidal mixing. Downstream stations generally showed higher turbidity than upstream stations, with a few exceptions. Station 323, the only station located in San Pablo Bay, showed lower turbidity than other stations nearby and slightly upstream. The Montezuma Slough (602-610) and SDWSC stations (719, 795-797) had the highest turbidity, while the Lower Sacramento River (704-716) and San Joaquin River (801-919) stations showed the lowest turbidity. This has been a regular pattern for stations within these subregions.

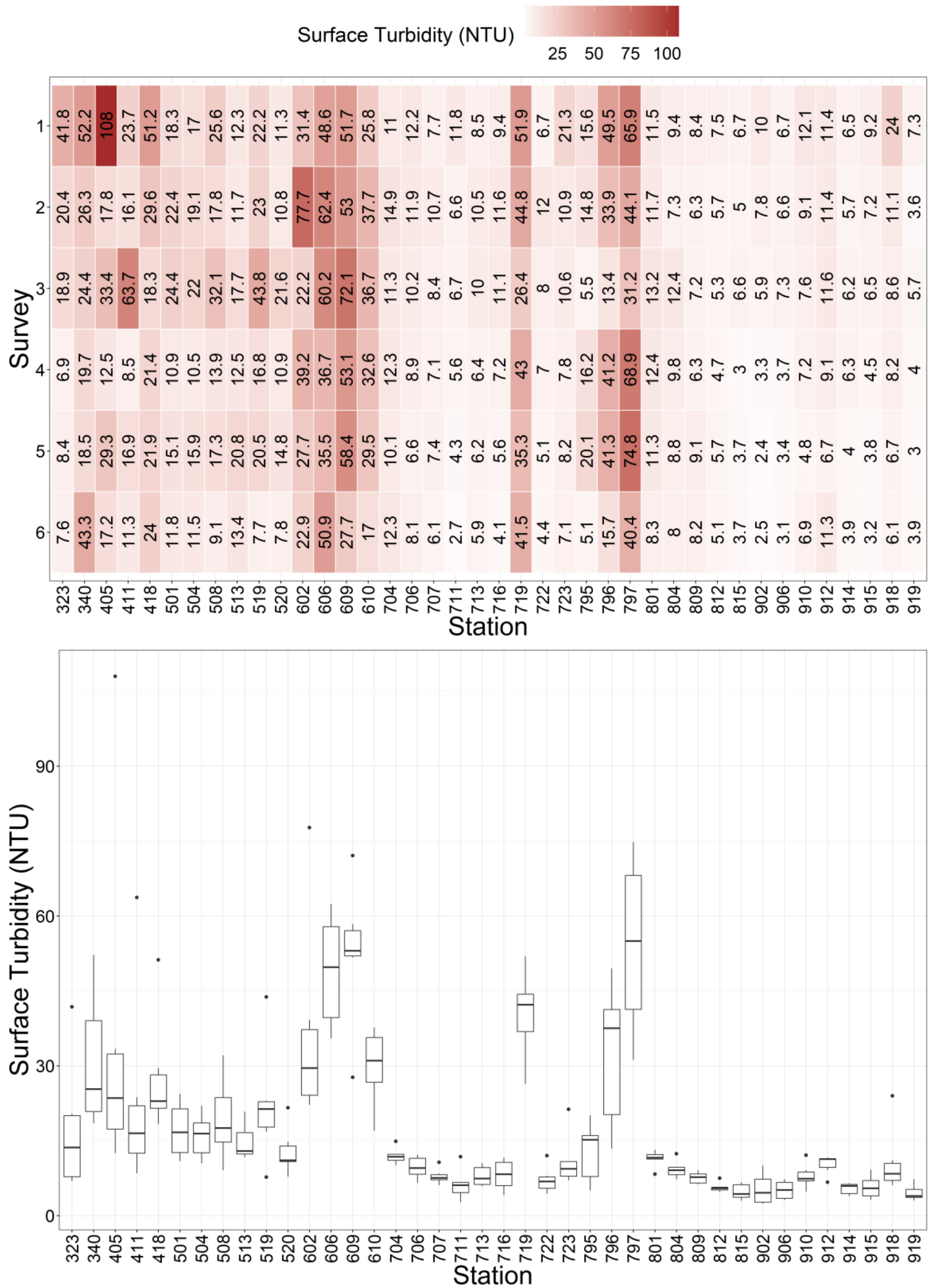

Figure 8. Surface turbidity (NTU) for all stations and all surveys (top), and range of turbidity measurements for each station (bottom).

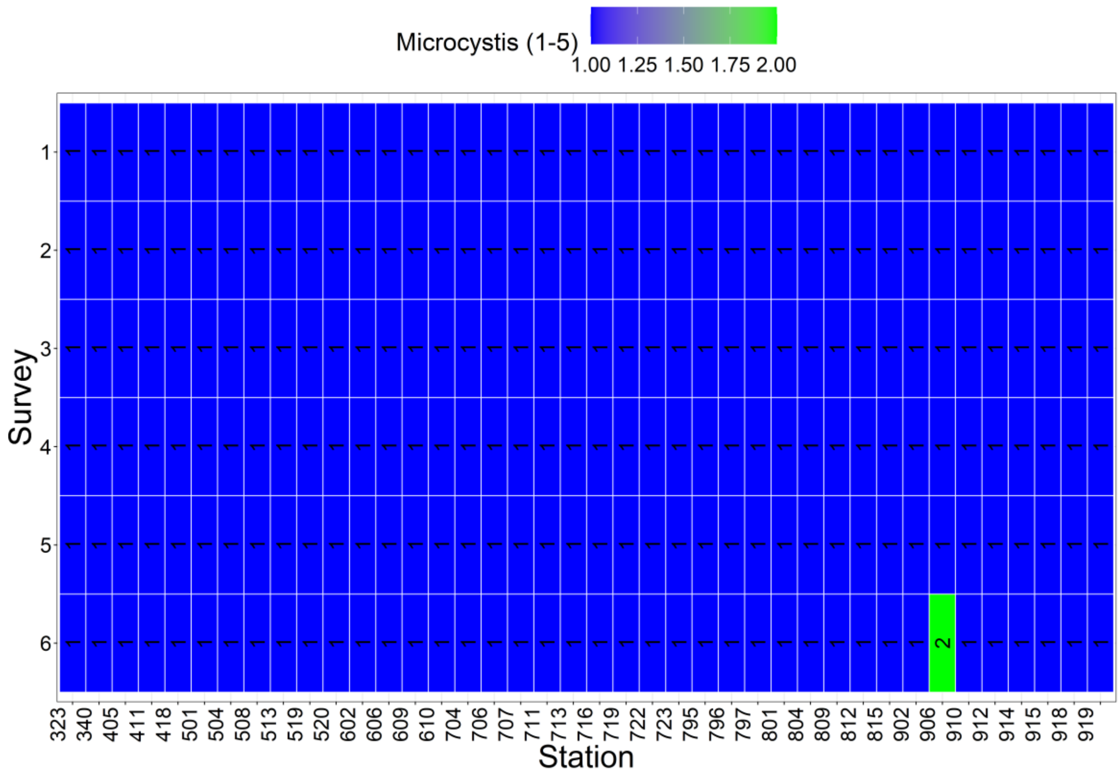

Figure 9. Ranking of Microcystis presence at each station, over each survey. 1 is an absence of Microcystis (blue) and 5 is the highest presence of Microcystis that can be reported (dark green).

Microcystis was not present, apart from station 906 during Survey 6 (Figure 9).

Catch Per Unit Effort

Fish

Total fish catch and catch-per-unit-effort (CPUE) were higher in 2023 than in 2022. The highest total fish catches were observed in Montezuma Slough and SDWSC, as well as station 704 in Lower Sacramento River (Figure 10). Fish catch in 2023 was dominated by *Tridentiger* spp., Shimofuri Goby (*Tridentiger bifasciatus*), and age-0 Striped Bass, all introduced species (Tables 3 & 4). *Tridentiger* spp. Goby larvae and small juveniles have a pelagic life stage prior to assuming the demersal life history of older juveniles and adults (Matern and Fleming 1995; Bennett et al. 2002). These small *Tridentiger* spp. Goby are difficult to identify to species. Despite being the most caught fish, *Tridentiger* spp. and Shokihaze Goby (*T. barbatus*) decreased in catch between 2022 and 2023, while Shimofuri Goby and age-0 Striped Bass catches increased. These changes may be attributed to the heavy storms and resultant river runoff that occurred in the beginning of that year. According to DWR, 2023 was a wet year which was preceded by two critical years and one dry year. Freshwater flow is associated with delayed spawning and increased abundance of young Striped Bass in the Delta (Turner and Chadwick 1972, Stevens 1977). The shifts in Shimofuri and Shokihaze Goby catches may reflect these two species' abilities to tolerate freshwater influxes. The

Shimofuri Goby are known to tolerate a wide range of temperatures and salinities (Matern 2001) yet are found mostly in the freshwater areas while the Shokihaze Goby tends to be found more in brackish estuarine habitats.

Other changes included an increase in Longfin Smelt (*Spirinchus thaleichthys*) total CPUE from 8 to 24, and a decrease in Northern Anchovy (*Engraulis mordax*) CPUE from 57 to 10. The Delta Smelt index remained at zero, but one Delta Smelt was caught at station 609 in Montezuma Slough during Survey 6. The fish was unmarked and retained for study.

Table 3. Total fish catch for each survey and the percent of total catch represented by each taxonomic category.

Organism	Native (N) or Intro-duced (I)	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Survey 6	Total Catch	Percent Catch
Tridentiger spp.	I	1389	392	202	168	331	434	2916	31.02
Age-0 Striped Bass	I	825	466	475	109	71	17	1963	20.88
Shimofuri Goby	I	576	355	395	288	53	258	1925	20.48
Threadfin Shad	I	35	26	77	252	193	189	772	8.21
Longfin Smelt	N	208	160	81	14	2	1	466	4.96
Northern Anchovy	N	3	2	31	4	35	134	209	2.22
Mississippi Silverside	I	2	5	36	109	85	52	289	3.07
American Shad	I	14	25	79	54	31	11	214	2.28
Shokihaze Goby	I	0	0	0	25	26	121	172	1.83
Splittail	N	51	53	12	5	0	0	121	1.29
Wakasagi	I	18	3	11	62	19	23	136	1.45
Plainfin Midshipman	N	0	0	0	0	0	25	25	0.27

Organism	Native (N) or Intro-duced (I)	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Survey 6	Total Catch	Percent Catch
White Catfish	I	1	12	1	2	4	14	34	0.36
Goldfish	I	0	0	0	21	0	0	21	0.22
Yellowfin Goby	I	18	3	5	3	1	0	30	0.32
Three Spine Stickleback	N	5	5	0	2	5	0	17	0.18
Channel Catfish	I	8	2	0	0	0	0	10	0.11
Pacific Herring	N	1	6	5	0	0	0	12	0.13
Starry Flounder	N	4	2	2	4	1	1	14	0.15
Carp	I	3	2	3	1	1	0	10	0.11
Prickly Sculpin	N	4	1	0	1	3	1	10	0.11
Longjaw Mudsucker	N	0	4	2	0	0	0	6	0.06
Largemouth Bass	I	0	0	2	0	2	0	4	0.04
Centrarchids (Unid)	-	0	2	0	0	2	1	5	0.05
Goby (Unid)	-	0	5	0	0	0	0	5	0.05
Unknown Damaged (UNID)	-	1	1	1	0	0	0	3	0.03
Lepomis (UNID)	I	0	0	0	1	1	0	2	0.02
Age-1 Striped Bass	I	0	0	0	0	1	1	2	0.02

Organism	Native (N) or Intro-duced (I)	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Survey 6	Total Catch	Percent Catch
Tridentiger-Striped Bass (UNID)	I	1	0	0	0	0	0	1	0.01
Arrow Goby	N	0	0	0	1	0	0	1	0.01
Black Crappie	I	0	0	0	1	0	0	1	0.01
Rainwater Killifish	I	0	0	0	1	0	0	1	0.01
Delta Smelt	I	0	0	0	0	0	1	1	0.01
Herring (Unid)	-	0	0	0	0	0	1	1	0.01
Staghorn Sculpin	I	0	0	0	0	0	1	1	0.01
Total Survey Catch		3167	1532	1420	1128	867	1286	9400	

Table 4. Fish CPUE (Catch per 10,000 m3 volume of water) for each survey, the total seasonal CPUE and the percent of catch represented by each taxonomic category.

Organism	Native (N) or Intro-duced (I)	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Survey 6	Total CPUE	Percent Total CPUE
Tridentiger spp.	I	270.96	78.8	39.63	41.01	94.49	140.37	112.44	29.04
Age-0 Striped Bass	I	238.37	136.78	131.98	29.26	19.92	4.37	98.22	25.37
Shimofuri Goby	I	113.06	72.78	77.98	64.85	9.2	82.78	70.9	18.31
Threadfin Shad	I	6.56	5.1	17.64	60.33	43.4	43.69	28.3	7.31
Longfin Smelt	N	60.5	47.57	21.5	4.52	0.22	0.11	23.62	6.10

Organism	Native (N) or Intro-duced (I)	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Survey 6	Total CPUE	Percent Total CPUE
Northern Anchovy	N	0.49	0.2	9.02	0.45	9.42	45.76	10.32	2.67
Mississippi Silverside	I	0.2	0.71	4.56	24.29	17.64	11.96	9.44	2.44
American Shad	I	3.03	6.43	19.12	15.14	7.58	1.95	8.93	2.31
Shokihaze Goby	I	0	0	0	6.44	4.87	39.09	7.77	2.01
Splittail	N	11.65	14.39	2.97	1.02	0	0	5.26	1.36
Wakasagi	I	3.43	0.31	1.88	14.01	4	4.94	4.59	1.19
Plainfin Midshipman	N	0	0	0	0	0	8.62	1.32	0.34
White Catfish	I	0.1	2.25	0.1	0.23	0.43	4.83	1.27	0.33
Goldfish	I	0	0	0	7.12	0	0	1.11	0.29
Yellowfin Goby	I	3.82	0.31	0.99	0.68	0.11	0	1.04	0.27
Three Spine Stickleback	N	0.49	1.33	0	0.45	0.54	0	0.47	0.12
Channel Catfish	I	2.15	0.2	0	0	0	0	0.42	0.11
Pacific Herring	N	0.1	1.43	0.5	0	0	0	0.35	0.09
Starry Flounder	N	0.59	0.2	0.2	0.45	0.11	0.11	0.28	0.07
Carp	I	0.59	0.2	0.5	0.11	0.11	0	0.26	0.07
Prickly Sculpin	N	0.59	0.1	0	0.11	0.32	0.11	0.21	0.05
Longjaw Mudsucker	N	0	0.82	0.2	0	0	0	0.18	0.05
Largemouth Bass	I	0	0	0.4	0	0.22	0	0.11	0.03

Organism	Native (N) or Intro-duced (I)	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Survey 6	Total CPUE	Percent Total CPUE
Centrarchids (Unid)	-	0	0.2	0	0	0.22	0.11	0.09	0.02
Goby (Unid)	-	0	0.51	0	0	0	0	0.09	0.02
Unknown Damaged (UNID)	-	0.1	0.1	0.1	0	0	0	0.05	0.01
Lepomis (UNID)	I	0	0	0	0.11	0.11	0	0.04	<0.01
Age-1 Striped Bass	I	0	0	0	0	0.11	0.11	0.04	<0.01
Trid.SB0 (UNID)	I	0.1	0	0	0	0	0	0.02	<0.01
Arrow Goby	N	0	0	0	0.11	0	0	0.02	<0.01
Black Crappie	I	0	0	0	0.11	0	0	0.02	<0.01
Rainwater Killifish	I	0	0	0	0.11	0	0	0.02	<0.01
Delta Smelt	I	0	0	0	0	0	0.11	0.02	<0.01
Herring (Unid)	-	0	0	0	0	0	0.11	0.02	<0.01
Staghorn Sculpin	I	0	0	0	0	0	0.11	0.02	<0.01

Invertebrates

The three most frequently caught invertebrates were shrimps *Exopalaemon modestus* and *Crangon* spp., and jellyfish *Maeotias marginata* (Tables 5 and 6). The shrimp *E. modestus* (Siberian prawn) represented 45% of the total CPUE, while the shrimp *Crangon* spp. represented 41%, both an increase from 2022. Twelve percent of the invertebrate CPUE consisted of the jellyfish *M. marginata*, a decrease from 2022's percentage of 43%. Shrimp catch strongly varied throughout the summer within stations, but surpassed totals of 1000 at stations 418 in western Suisun Bay and 797 in SDWSC (Figure 11). The highest jellyfish catch was observed at station 606 in Montezuma Slough during Survey 6, and high catches were also observed in Suisun and Honker bays in Surveys 5 and 6 (Figure 12).

The only jellyfish observed in 2023 were *M. marginata*, an introduced species that is native to the Black Sea and Sea of Azov (Naumov 1969). The presence of *M. marginata* was first recorded in San Francisco Estuary in 1981 but may have been present in the region as early as 1959 (Mills and Sommer 1995; Rees and Gershwin 2000; Schroeter 2008). It is limited to brackish waters of approximately 4-15 ppt, which may explain why it was only observed in large numbers later in the summer, during Surveys 5 and 6.

The shifts in shrimp abundances may be attributed to each genera's life history and salinity tolerance. The *E. modestus* was introduced from East Asia and first detected in the Lower Sacramento River by CDFW's San Francisco Bay Study in 2000 (Brown and Hieb 2014). This species can complete its lifecycle in freshwater, making it well-suited to the upstream regions of the San Francisco Estuary. The establishment of the Siberian prawn has thus been a threat to another introduced shrimp species, *Palaemon macrodactylus*, in the upper estuary (Brown and Hieb 2014). *Crangon 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). This could account for the high numbers of *Crangon* spp. observed in 2023, but our survey does not account for shrimp size and developmental stage.

Table 5. Invertebrate catch for each survey, the total seasonal catch and the percent of catch represented by each taxonomic category.

Organism	Native (N) or Intro-duced (I)	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Survey 6	Total Catch	Percent Total Catch
Exopalae-mon modestus	I	565	456	143	3065	1317	2070	7616	51.91
Crangon spp.	N	1695	45	421	451	408	2186	5206	35.48
Maeotias marginata	I	0	0	0	7	413	1162	1582	10.78
Palaemon macrodac-tylus	I	75	23	2	23	14	67	204	1.39
Cancer magister	N	0	0	0	0	0	64	64	0.44
Shrimp (UNID)	-	0	0	0	1	0	0	1	<0.01

Organism	Native (N) or Intro-duced (I)	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Survey 6	Total Catch	Percent Total Catch
Total Survey Catch		2335	524	566	3547	2152	5549	14673	

Table 6. Invertebrate CPUE (Catch per 10,000 m3 volume of water) for each survey, the total seasonal CPUE and the percent of catch represented by each taxonomic category.

Organism	Native (N) or Intro-duced (I)	Survey 1	Survey 2	Survey 3	Survey 4	Survey 5	Survey 6	Total CPUE	Percent Total CPUE
Exopalae-mon modestus	I	117.86	99.22	34.58	694.58	297.77	512.4	279.14	44.98
Crangon spp.	N	408.89	10.41	111.96	148.23	123.83	752.8	253.33	40.82
Maeotias marginata	I	0	0	0	1.13	124.69	370.77	77.11	12.42
Palaemon macrodac-tylus	I	17.42	6.84	0.2	2.82	2.81	16.67	7.79	1.26
Cancer magister	N	0	0	0	0	0	21.38	3.27	0.53
Shrimp (UNID)	-	0	0	0	0.11	0	0	0.02	<0.01

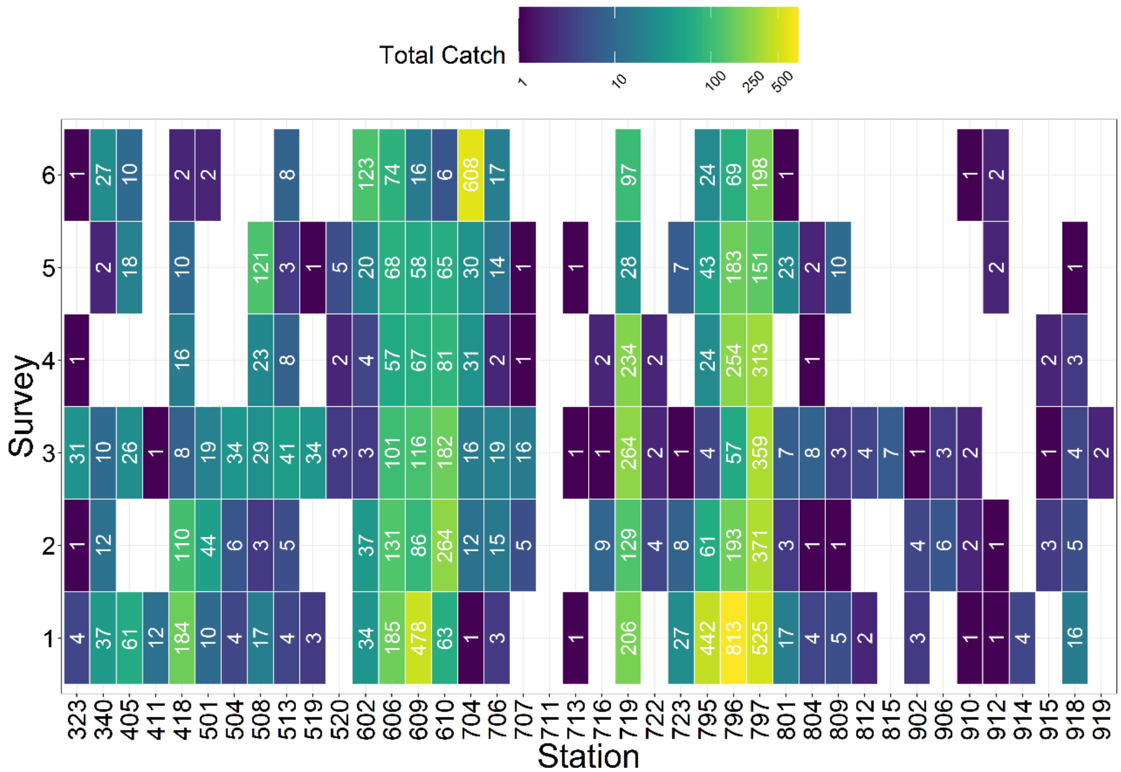

Figure 10. Total fish catch at each station across each survey.

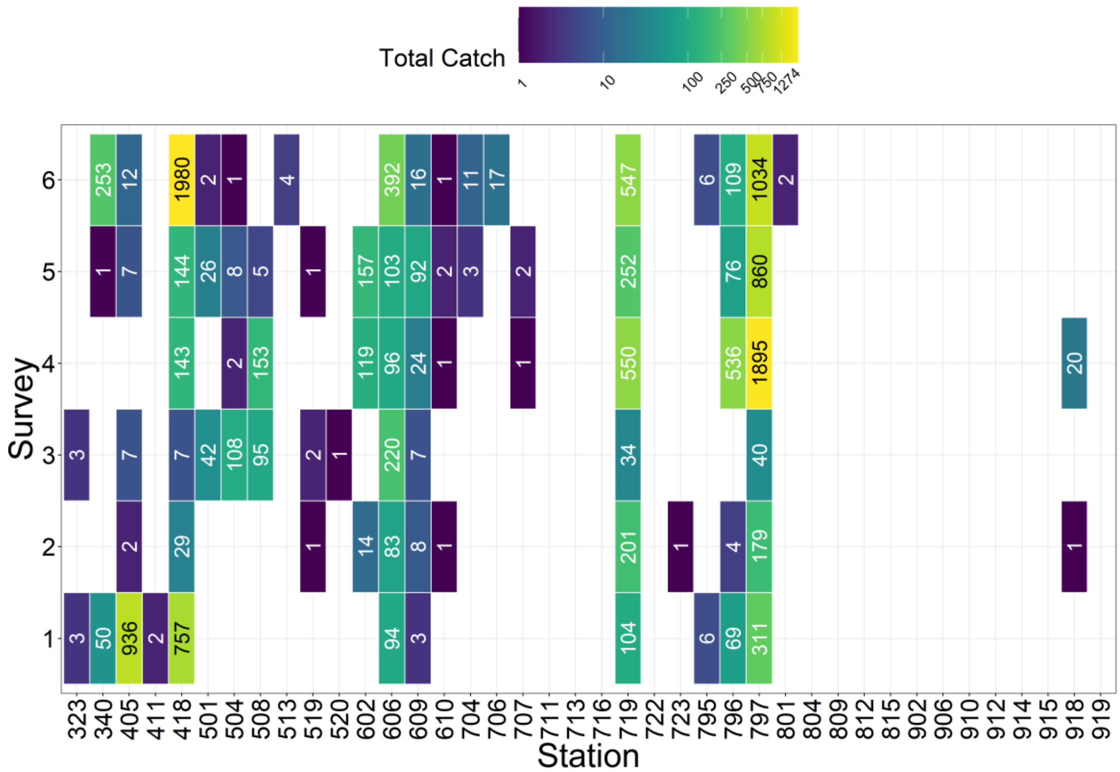

Figure 11. Total shrimp catch at each station across each survey.

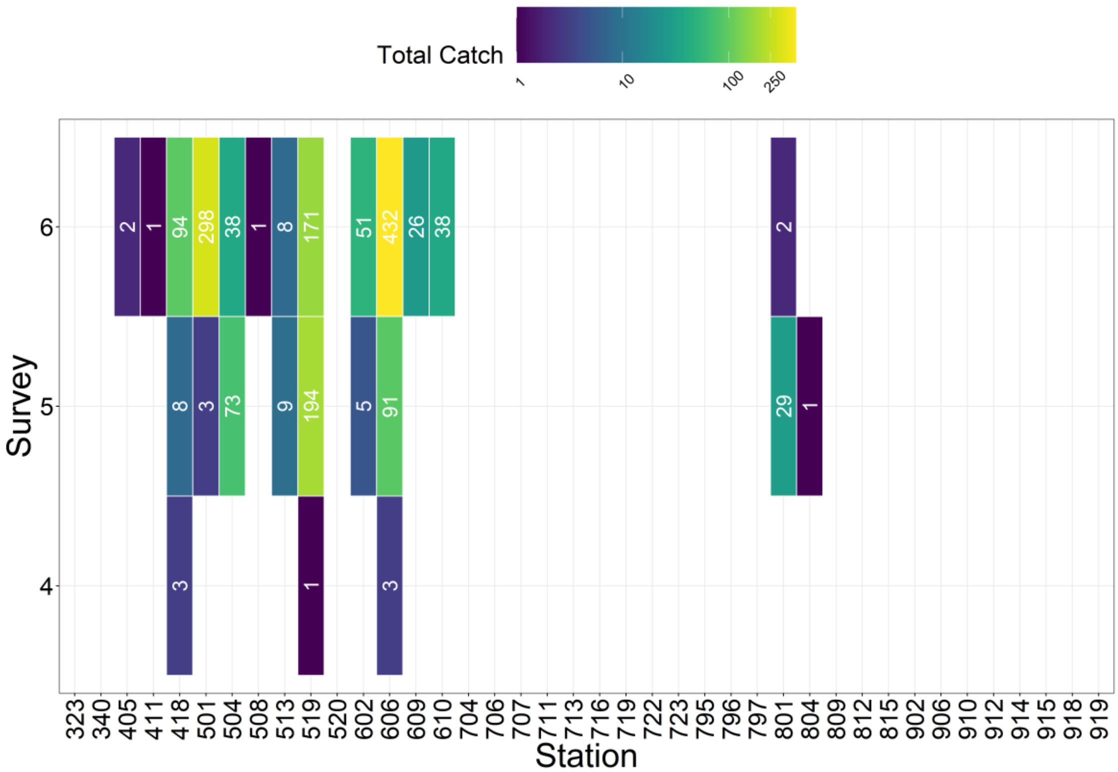

Figure 12. Total jellyfish catch at each station across Surveys 4-6. No jellyfish were caught in Surveys 1-3.

Length Frequency for species of Special Interest in 2023

American Shad

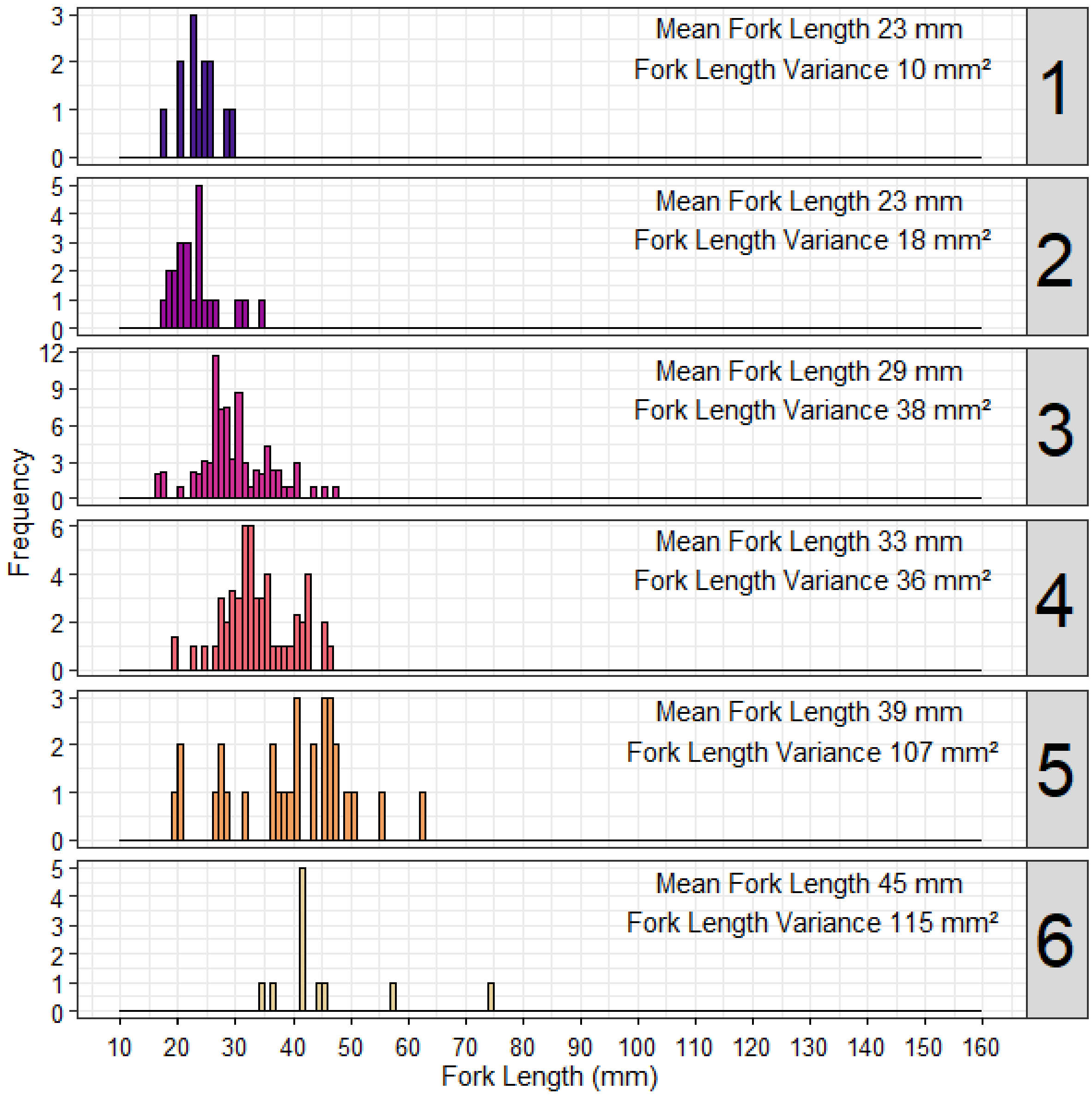

Figure 13. Fork length (mm) frequency histograms for American Shad collected during Summer Townet surveys 1-6. Mean fork length and fork length variance are displayed on each histogram.

American Shad (*Alosa sapidissima*) catch increased sharply in midsummer, peaking in Survey 3 at 79. Mean fork length of American Shad remained similar from Surveys 1 and 2, then gradually increased throughout the rest of the summer until reaching 47.29 mm in Survey 6 (Figure 13).

Delta Smelt

One Delta Smelt was caught during the 2023 STN survey season. The fish was caught in Montezuma Slough during Survey 6, and it had a 50 mm fork length and was unmarked. These fish are critically endangered and have not been caught in this survey since 2017.

Longfin Smelt

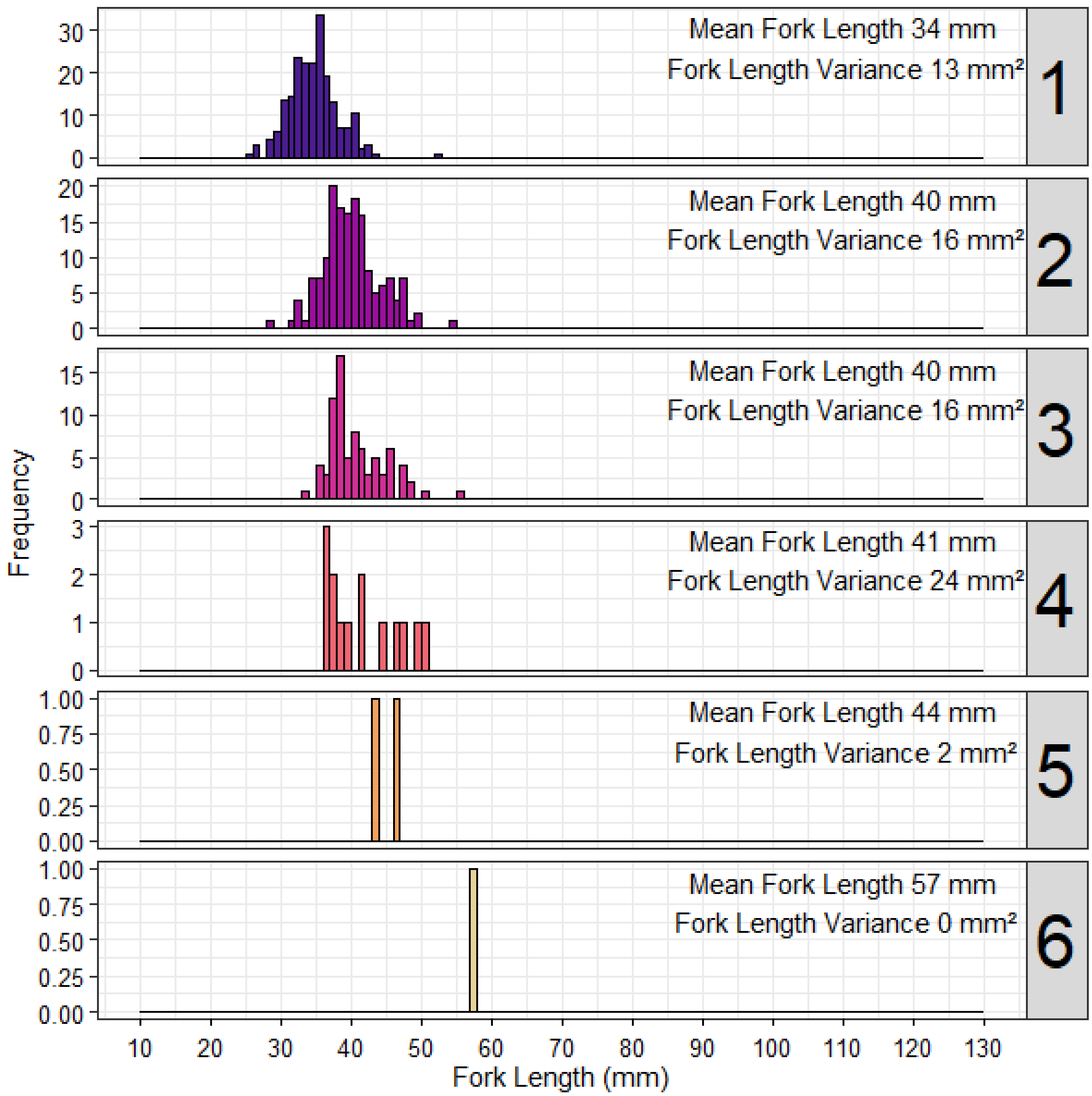

Figure 14. Fork length (mm) frequency histograms for Longfin Smelt collected during Summer Townet surveys 1-6. Mean fork length and fork length variance are displayed on each histogram.

Longfin Smelt catch was highest at the beginning of the summer at with survey 1 (N=208) and decreased to one individual in Survey 6. A downstream shift in distribution and decline in catch in the STN sample frame is a seasonal pattern during summer months as fish migrate to cooler waters. Mean fork length began at 34.24 mm and increased gradually until Survey 6, during which there was a steeper increase in fork length to 57 mm (Figure 14). Longfin Smelt were most abundant in downstream stations, in western Suisun Bay in particular.

Splittail

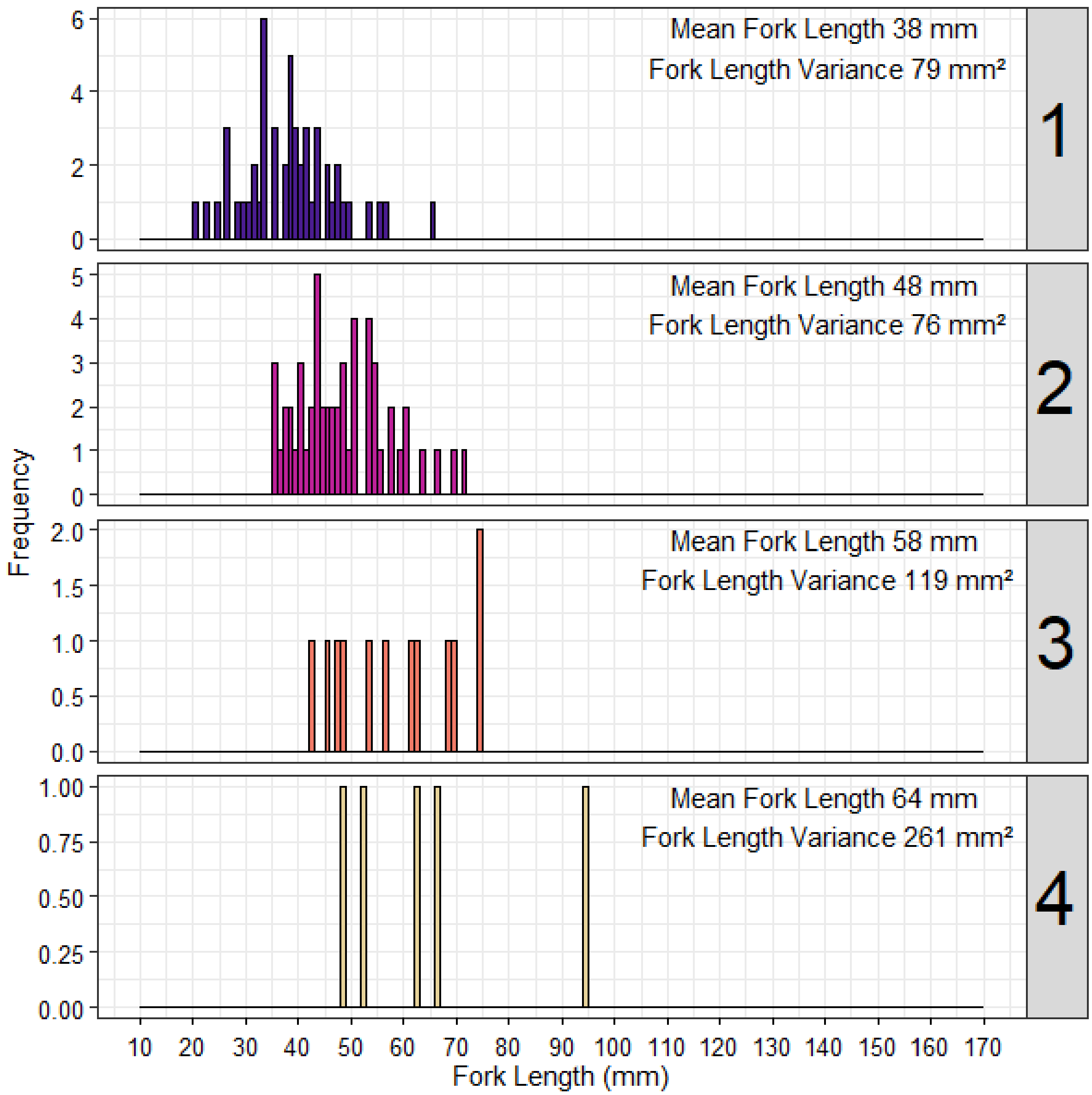

Figure 15. Fork length (mm) frequency histograms for Splittail collected during Summer Townet surveys 1-6. Mean fork length and fork length variance are displayed on each histogram.

Splittail catch was 104 and 106 for Surveys 1 and 2, then decreased to 24 and 10 during Surveys 3 and 4. No Splittail were caught in Surveys 5 or 6. Mean fork length increased steadily from 38.02 to 64.4 mm throughout the first four surveys (Figure 15).

Age-0 Striped Bass

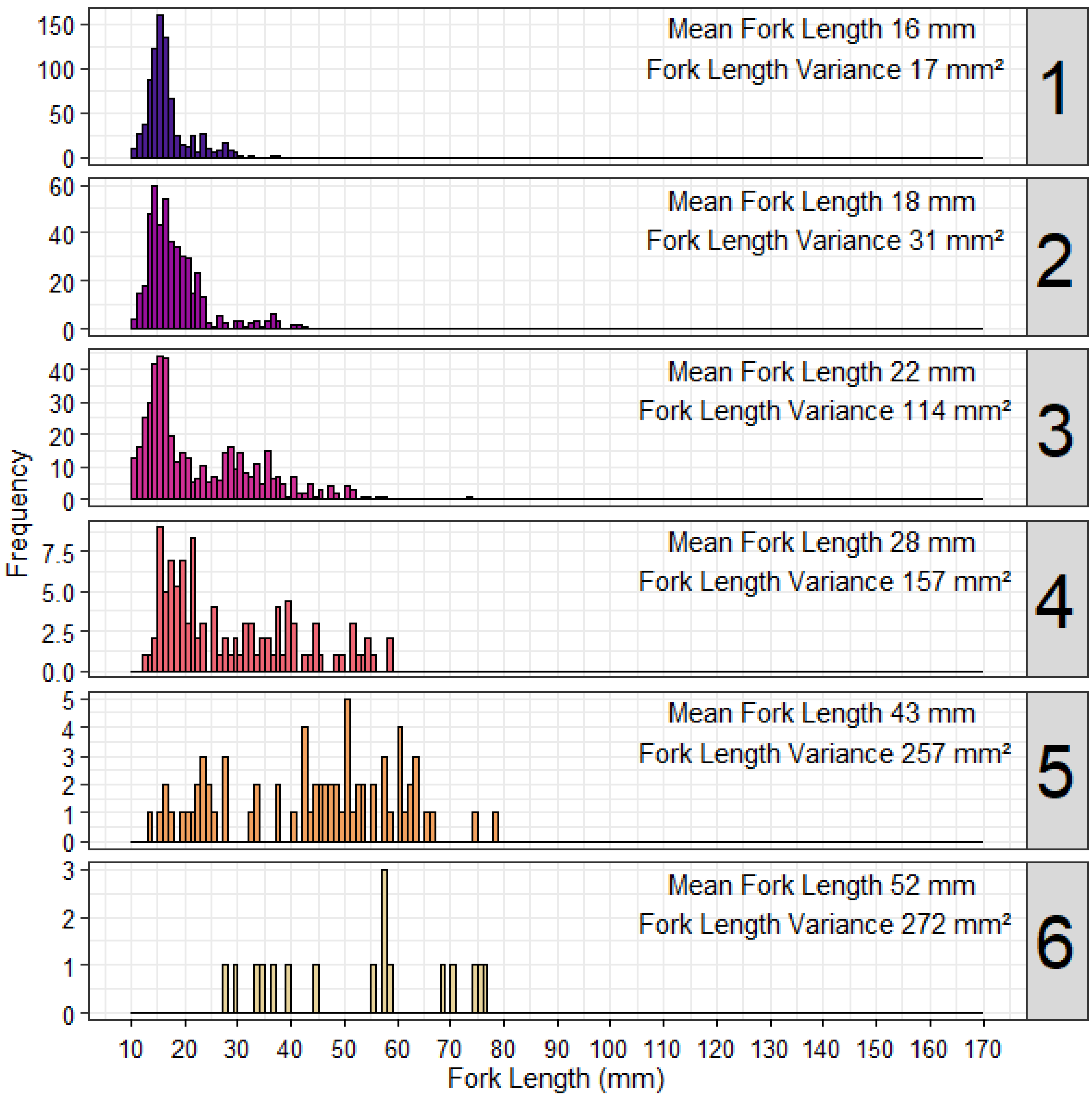

Figure 16. Fork length (mm) frequency histograms for age-0 Striped Bass collected during Summer Townet surveys 1-6. Mean fork length and fork length variance are displayed on each histogram.

Age-0 Striped Bass catch fluctuated between Surveys 1 through 3 but remained at high levels during those first three surveys. The catch sharply declined after Survey 3 and continued to decline through Survey 6. Mean fork length (Figure 16) began at 16.23 mm during Survey 1, increased gradually to 28.14 mm in Survey 4, then sharply increased to 43.42 mm in Survey 5 and 52.29 mm in Survey 6.

Threadfin Shad

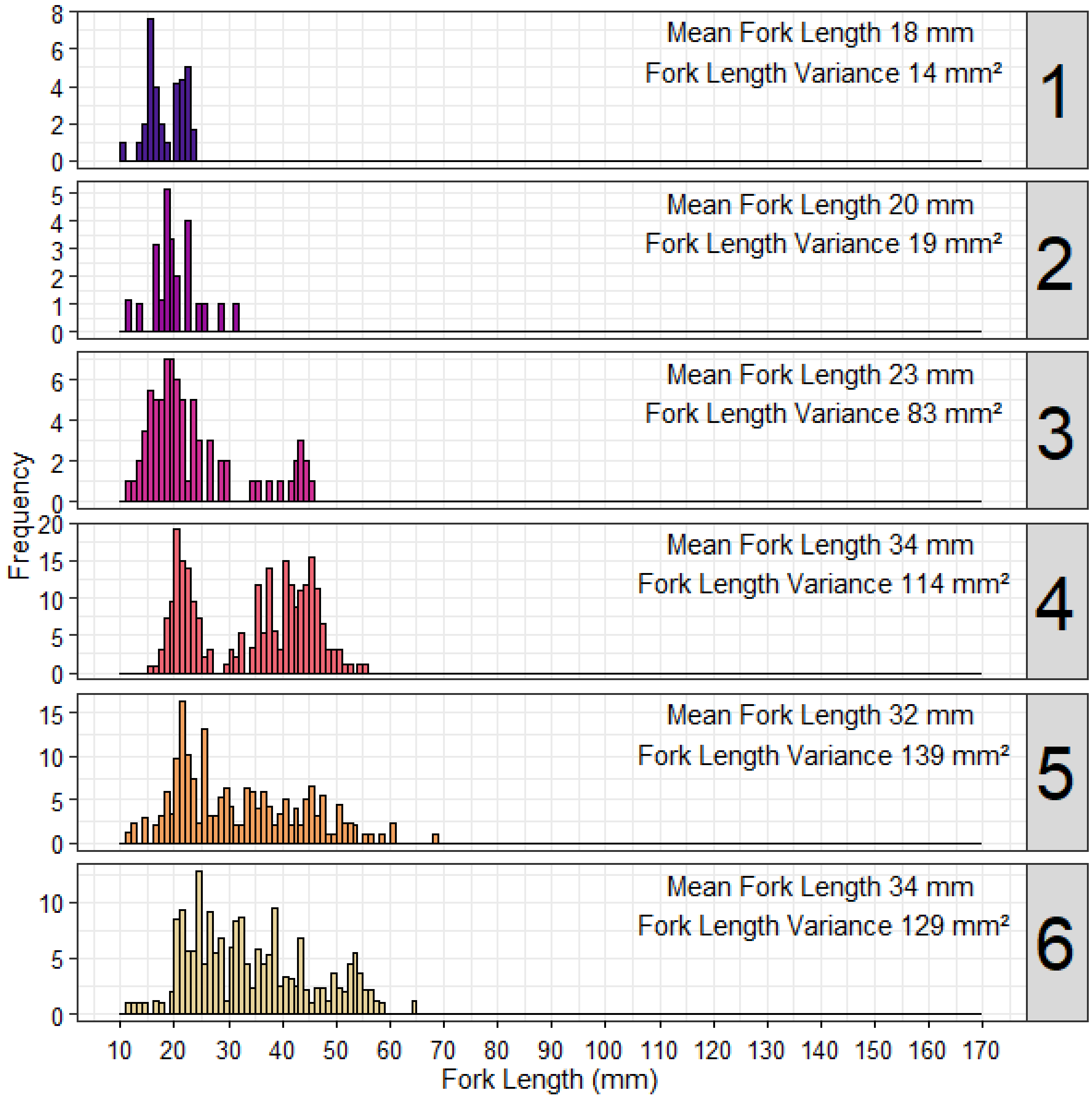

Figure 17. Fork length (mm) frequency histograms for Threadfin Shad collected during Summer Townet surveys 1-6. Mean fork length and fork length variance are displayed on each histogram.

Threadfin Shad catches began at 60 and 48 in Surveys 1 and 2, then increased greatly, peaking at 470 during Survey 4 and declining to 358 and 330 in the last two surveys. Mean fork length of Threadfin Shad (Figure 17) increased gradually throughout the summer, from 17.13 to 33.77 mm.

Acknowledgements

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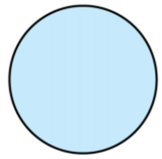
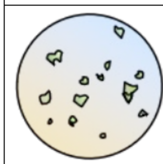
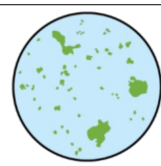
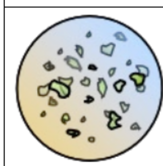
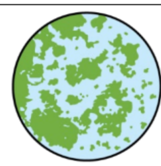
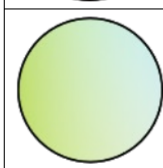
Appendix 1. Microcystis spp. ranking scale.

Update to Microcystis Scale Graphics
Revised 1/30/2020

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 *Mircrystis*.
		**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.

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