The Fall Midwater Trawl Survey

Season Report: 2024

California Department of Fish and Wildlife

Bay Delta Region (Stockton)

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Interagency Ecological Program

Cooperative Ecological Investigations Since 1970

Contents

Introduction

The Fall Midwater Trawl (FMWT) is an ecological monitoring survey that has been conducted by the California Department of Fish and Wildlife (CDFW) annually since 1967. Due to the creation of the federal and state water projects, concern over ecological impacts on the San Francisco Estuary (estuary) and its fisheries drove the creation of this survey. At its inception, the FMWT was focused primarily on determining relative abundance and distribution of age-0 Striped Bass (*Morone saxatilis*) (Stevens 1977) due to the popularity of the sport fishery in the state. The survey proved to be adept at monitoring pelagic fishes as well as recording associated environmental parameters. As such, it became an integral piece to the framework of compliance monitoring necessary to determine impacts from water exports, habitat degradation, and ecological shifts in the largest estuarine habitat in western North America.

The original sampling range and station placement of the survey occurred from San Pablo Bay upstream to the lower Sacramento River and the lower San Joaquin River, respectively. Station placement and range effectively covered the estuary, which was a known nursery habitat for young Striped Bass (Turner and Chadwick 1972). This spatial and temporal coverage allowed for a more accurate calculation of young-of-the-year (age-0) Striped Bass relative abundance indices. FMWT also developed abundance and distribution information for other pelagic fishes that utilize part, or all of the estuary. These species include Delta Smelt (*Hypomesus transpacificus*), Longfin Smelt (*Spirinchus thaleichthys*), Splittail (*Pogonichthys macrolepidotus*), American Shad (*Alosa sapidissima*), and Threadfin Shad (*Dorosoma petenense*). The anadromous, and estuarine life histories of these species make them excellent indicators of watershed health due to their integration throughout the system. Low outflow conditions led to the creation of "non-index" stations in upstream areas of the Delta in the early 1990s, as well as an expansion into the north Delta in 2009 to increase Osmerid habitat sampling. Subsequent station additions were created in 2021 and 2023 to further broaden FMWT spatial sampling coverage in upstream habitats. This upstream station expansion has facilitated increased detection of pelagic fishes (White and Baxter 2022). Currently, FMWT samples 130 stations monthly from September through December (Figure 1). Sampling ranges from San Pablo Bay upstream to West Sacramento in the Sacramento River Deep Water Ship Channel (SDWSC), and south to Stockton on the San Joaquin River. Since 2009, the survey has also conducted meso- and macro-zooplankton sampling at a subset of stations to track food web dynamics integral to recruitment of young fishes. This additional sampling helps inform if reduced or altered prey abundance is a contributing factor in fish population declines.

The FMWT has been sampling annually for over half a century. The data collected has been fundamental in creating a baseline for fish abundance and distribution within the estuary and continues to be a key asset for understanding changes within this highly dynamic system. The FMWT is one of many long-term monitoring surveys conducted within the estuary (Tempel et al 2021) and is a monitoring element of the Interagency Ecological Program (IEP; see: Interagency Ecological Program 2024 Annual Work Plan). Long-term monitoring studies like the FMWT are important in recognizing and quantifying changes in the environment, linking biological patterns to environmental variability, and informing anthropogenic impacts on ecosystems (McGowan 1990; Cody and Smallwood 1996; Ducklow et al. 2009; Clutton-Brock and Sheldon 2010; Magurran et al. 2010; Nelson et al. 2011; Likens 2012; Lindenmayer et al. 2012; Hofmann et al. 2013; Hughes et al. 2017). For example, FMWT data has helped highlight a striking and sweeping decline in fish populations throughout the estuary (Sommer et al. 2007; Baxter et al. 2010; Mac Nally et al. 2010; Thomson et al. 2010), as well as underscoring resilience abilities of fish communities to long term drought cycles in the estuary (Mahardja et al. 2021).

The FMWT also collaborates with other agency efforts, such as the CDFW Diet and Condition Study, the Department of Water Resources (DWR) Suisun Marsh Salinity Control Gate (SMSCG) Action, and U.S. Bureau of Reclamation (USBR) Directed Outflow Project (DOP) to inform summer and fall resource management actions. Also, the FMWT works collaboratively with the UC Davis Aquatic Health Program laboratory to address measures of fish condition.

The objective of this report is to summarize environmental variables and catch patterns that are not reported in the FMWT Annual Fish Abundance and Distribution Memorandum (Bibliography). The goal of the 2024 field season was to sample all stations safely and efficiently, identifying and counting all fishes and macro-invertebrates, and measuring the fork lengths (FL) of the first 50 randomly selected individuals of each fish species from each station. Meso- and macro-zooplankton samples were also collected at 35 stations to help inform food availability for young fish. A suite of environmental data was also recorded at each station. The first survey began September 3rd, 2024, and the final survey was completed on December 20th, 2024.

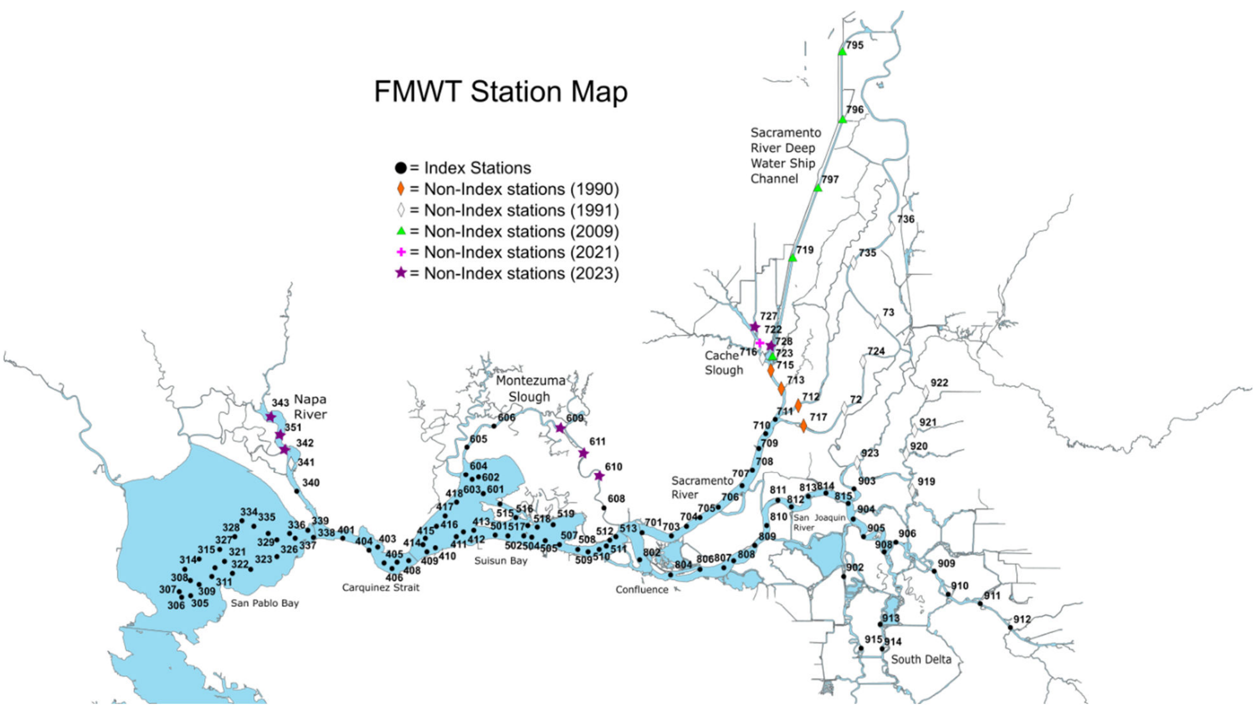


Figure 1. Map of Fall Midwater Trawl station locations, and station index designations.

Methods and Gear

The FMWT trawl net consists of a 12 ft x 12 ft mouth (3.6576 m x 3.6576 m), is 58 ft long (17.68 m), and made of 9 mesh panels starting with 8-inch (203.2 mm) stretched mesh openings near the mouth tapering down mesh sizes to ½-inch (12.7 mm) stretched knotted mesh at the cod end. The net is deployed and allowed to sink up to 36 ft (10.97 m) of depth with up to 300 ft (91.4 m) of cable let out then retrieved obliquely through the water column according to a cable out tow schedule which varies with water depth. Metal planing doors fixed at each corner of the mouth of the net assist in keeping the net open during sampling. Further details on sampling methods and gear can be found in the FMWT protocol document. Each oblique tow is 12 minutes long and each of the 130 FMWT stations receives one tow. The survey currently takes 12-14 days to cover the FMWT spatial range each month (September-December).

2024 Field Season

The 2024 field season had its challenges but was completed successfully. Each monthly survey began in San Pablo Bay and stations were sampled upstream to and through the Delta. For the initial San Pablo days, crew members stayed overnight in Solano County. This added to personnel safety and increased scheduling efficiency by eliminating extraneous commutes before and after long days in the field. The U.S. Bureau of Reclamation (USBR) lent the survey the research vessel (R/V) Compliance, which served as the primary sampling vessel for the month of December. Routine sampling of 130 fish tows and 35 zooplankton tows (Clark-Bumpus (CB) and Mysid nets) were completed for all months (September-December) in 2024. In all, 520 midwater tows were completed, along with 142 CB/Mysid zooplankton tows. Overall, 2024 sampling contributed to the FMWT annual abundance indices and additional zooplankton tows for the DWR SMSCG special study.

Figure 2. Crew sets up planing doors in preparation for net deployment on the Sacramento River.

Outflow

The 2024 water year classification based on unimpaired runoff in the Sacramento Valley was "above normal" (available from the Department of Water Resources (DWR) at WSIHIST). This sequential above average water year (2023 was "wet") has served to bolster California's estuarine habitats and the species that depend on them. The majority of the state's watersheds drain via the Sacramento and San Joaquin rivers into the upper San Francisco Estuary. Freshwater outflow is the most influential factor in the overall water quality of the estuary. It influences water clarity, temperature, dissolved oxygen, and salinity, which impacts fish and plankton communities by association (Kimmerer et al. 1998, Kimmerer 2002 a; Kimmerer 2002 b; Bennett 2005). Variability in freshwater outflow regulates the position of the "low salinity zone" (LSZ), a highly productive zone where freshwater transitions to brackish water (Jassby et al. 1995; Hobbs et al. 2006), which can occur as far west as San Pablo Bay under high outflow or as far east as the Delta under low outflow conditions. X2 is a measurement of kilometers from the Golden Gate Bridge where water salinity is 2 parts per thousand (ppt) near the bottom and used to inform the location, roughly at the center, of the LSZ (FLOAT MAST 2022). The 2024 water year provided good outflow through the first half of the year (Figure 3). This pushed and kept the LSZ in wide open areas like Suisun Bay. By keeping the LSZ downstream of the confluence, this created a broader area of mixing and a larger nursery habitat as a whole. All of this was occurring during crucial winter to spring spawning and spring to fall rearing months. The abiotic and biotic trends discussed in this seasonal summary were impacted by this outflow relationship. Outflow and X2 data for Figure 3 were provided by the Dayflow program (DWR 2024).

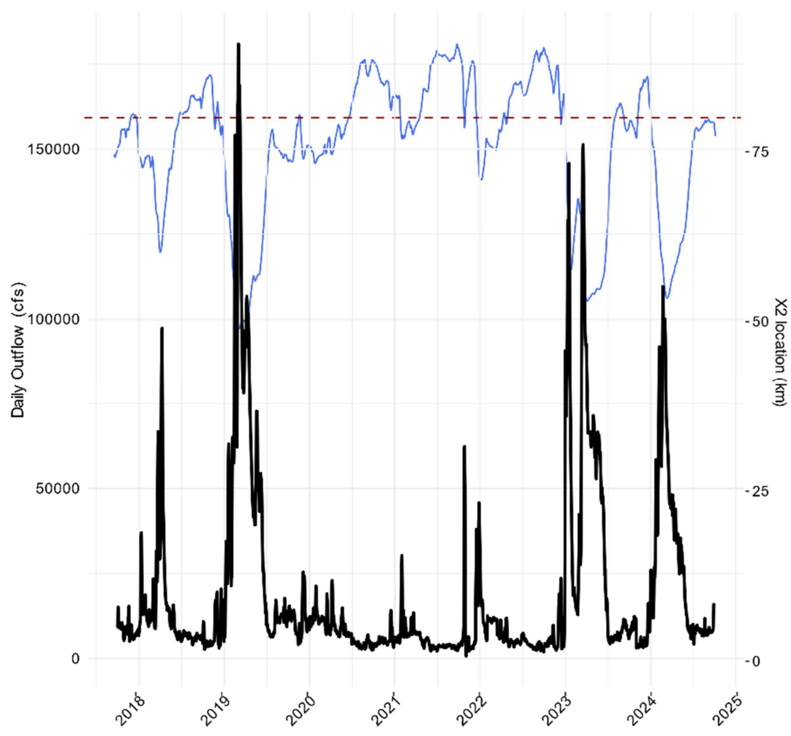


Figure 3. Line plot showing daily net Delta Outflow values (black line) and X2 location (blue line) for water years 2018 to 2024. Outflow is measured on the left y-axis in cubic feet per second

(cfs). X2 location is conveyed on the right y-axis as river kilometers upstream from the Golden Gate Bridge. The red dashed line represents the confluence of the Sacramento and San Joaquin rivers, the LSZ is substantially reduced in surface area when positioned at or upstream of this location.

Environmental Variables

Water clarity

Due to the spatial range and seasonality of the survey, Secchi disc depth (cm) varied considerably across stations (Figure 4). Water clarity was greatest in late fall with low flows into November at stations on the mainstem Sacramento River upstream of Rio Vista. Clarity was reduced in San Pablo Bay, Carquinez Strait, Suisun Bay, Montezuma Slough (stations in 300-700 range), and the stations in the middle/upper section of the SDWSC (stations 719, 795-797), notably in December with onset of winter rainstorms. Previous studies have documented a negative correlation between fish catch and high Secchi values (Mac Nally et al. 2010, Latour 2016), which varies between species. For example, larval Longfin Smelt are more likely to be caught in the Secchi depth range of 0-80 cm (Grimaldo et al. 2017) and adult Longfin Smelt catch is greatest at depths less than 50 cm (Lewis et al. 2019). Historically, 75% of FMWT Longfin Smelt catch occurred when Secchi depth was ≤90 cm.

Turbidity is a more accurate measurement of water clarity or lack thereof. It is measured in Nephelometric Turbidity Units (NTU). Higher turbidity values coincide with decreased water clarity. The heatmap and boxplot of turbidity values during the 2024 FMWT survey (Figures 5 & 6) show a similar pattern to the Secchi values. Despite monthly variability, turbidity was consistently higher in Suisun Bay, Montezuma Slough, and the middle/upper section of the SDWSC. Turbidity was highest during the December survey. These higher values coincided with increased precipitation, and by association greater sediment expulsion from watershed tributaries. Many fishes within the estuary depend on a certain level of turbidity, for instance Delta Smelt persist within a specific turbidity window (12–80 NTU) (Hasenbein et al. 2016).

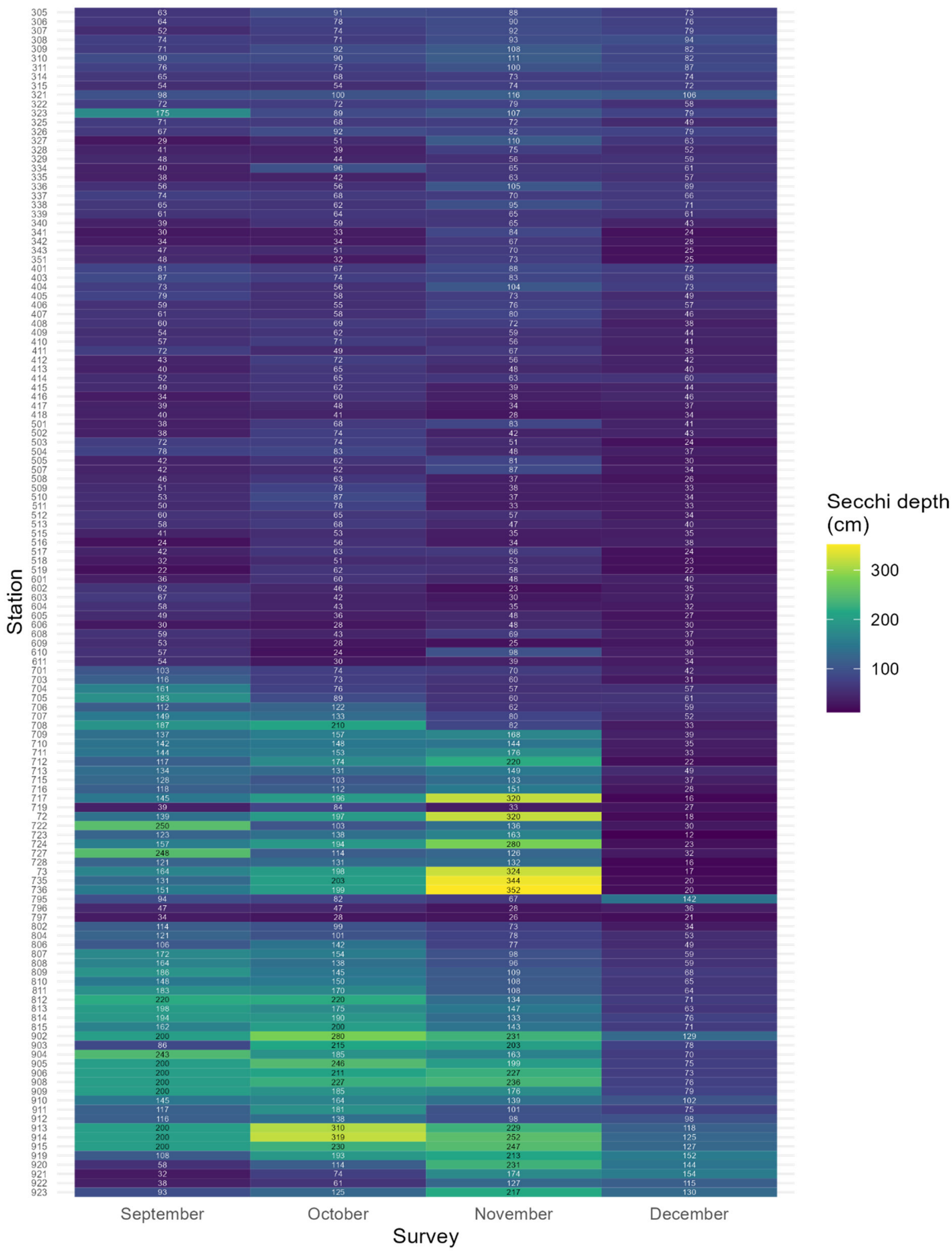


Figure 4. Heatmap of monthly Secchi disk depth values (cm) recorded during the 2024 FMWT season. Dark purple values represent less clarity and more suitable conditions for fishes with a preference for turbidity.

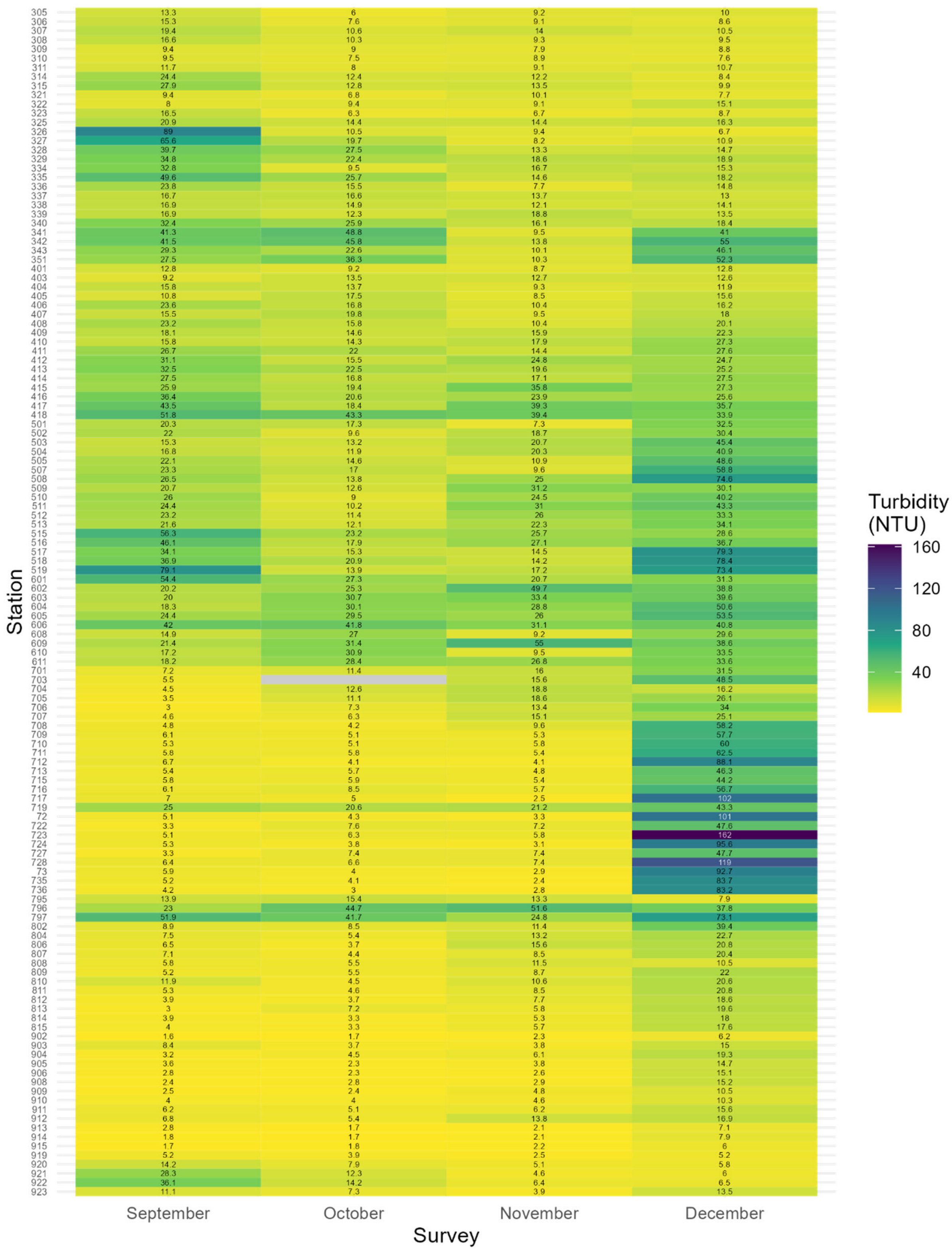


Figure 5. Heatmap of surface water turbidity (NTU) recorded during the 2024 FMWT season. Grey values indicate missing data. The northern part of the SDWSC, western and northern Suisun Bay, and Sacramento River were the most turbid regions which varied among months.

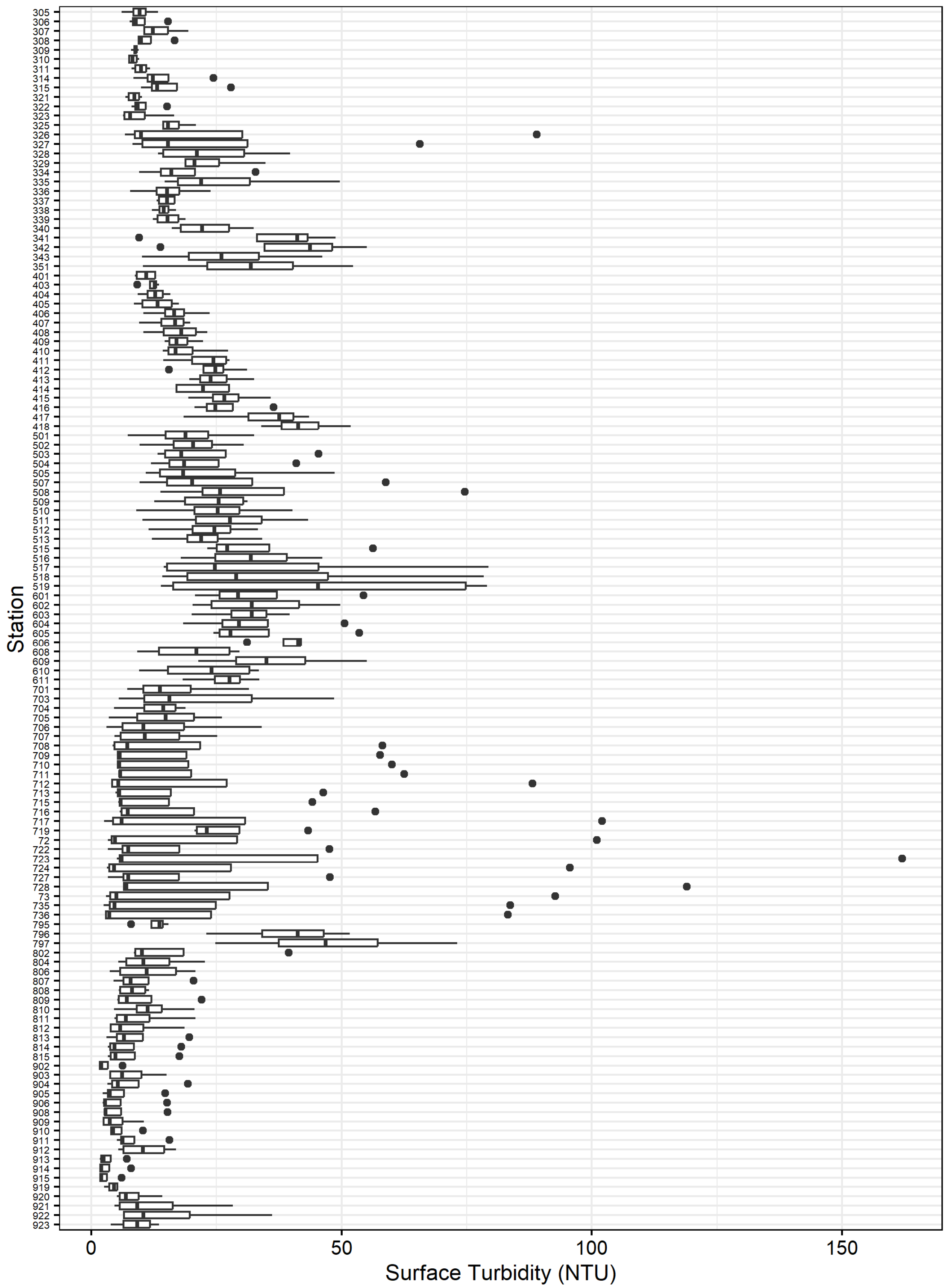


Figure 6. Distribution of monthly surface turbidity (NTU) recorded during the 2024 FMWT season. Boxplots show the median as a vertical line, 1st and 3rd quartile by a box, range by a horizontal line, and outliers by points.

Temperature

Temperature is a vital factor in fish life history (i.e. metabolism, growth, initiation and cessation of spawning, stress, etc.) and influences fish survival within the estuary. Many pelagic estuarine species have thermal tolerances that limit survivorship (Baker et al.1995; Swanson et al. 2000; Moyle et al. 2004; Bennett 2005). Previous studies have connected long term seasonal Delta Smelt detection with changes in environmental parameters like temperature (Feyrer et al. 2007; Nobriga et al. 2008; Feyrer et al. 2011). Research has also shown that thermal tolerance is reduced in native species compared to ecologically overlapping introduced species (Komoroske et al. 2021). Other research has shown adult Longfin Smelt prefer temperatures under 17.8°C (Hobbs and Moyle 2015), larval Longfin Smelt are most abundant in the 8-12°C range (Grimaldo et al. 2017) and adults are most abundant in water 12-16°C (Lewis et al. 2019). Longfin Smelt typically spawn between 7-14.5°C (Moyle 2002), and Delta Smelt have been shown to stop spawning when water temperature increases past 20°C (Swanson et al. 2000). Research has documented physiological thermal limitations for some anadromous and estuarine species. For example, Jeffries et al. (2016) found Longfin Smelt show a cellular stress response once water temperature is greater or equal to 20°C, Bennett (2005) showed Delta Smelt experience mortality at temperatures above 25°C, and Marine et al. (2003) found that juvenile Chinook Salmon reared at 17–20°C experienced decreased growth rates, variable smoltification impairment, and higher predation vulnerability compared with fish reared at 13–16°C. Historically, 75% of FMWT Longfin Smelt catch has occurred when water temperature is ≤ 19°C and ≥ 4.3°C.

The heatmap of surface water temperature (Figure 7) shows how temperature throughout the estuary changed over the course of the 2024 survey. This season had some interesting temperature patterns. A heat wave occurred at the beginning of October and limited seasonal cooling across most all stations sampled that month. In several instances, surface temperatures were higher in October than they were in September. Cooling then occurred very rapidly, and in November a multitude of stations had surface water temperatures that were almost half of what they were in October. Temperatures ranged from 18-25°C in September, 16-24°C in October, 12-17°C in November, and 9-13°C in December. Stations upstream of Prisoners Point on the lower San Joaquin River experienced the greatest variation in temperature over the course of the 2024 season (Stations 905-912, Figure 8). Temperatures were usually warmer at the surface compared to bottom water samples (Figure 9). The most extreme differences were found at Stations in San Pablo Bay in September and October. However, these temperature differences do not necessarily indicate stratification at these stations since these differences may not be consistent or prolonged across tides.

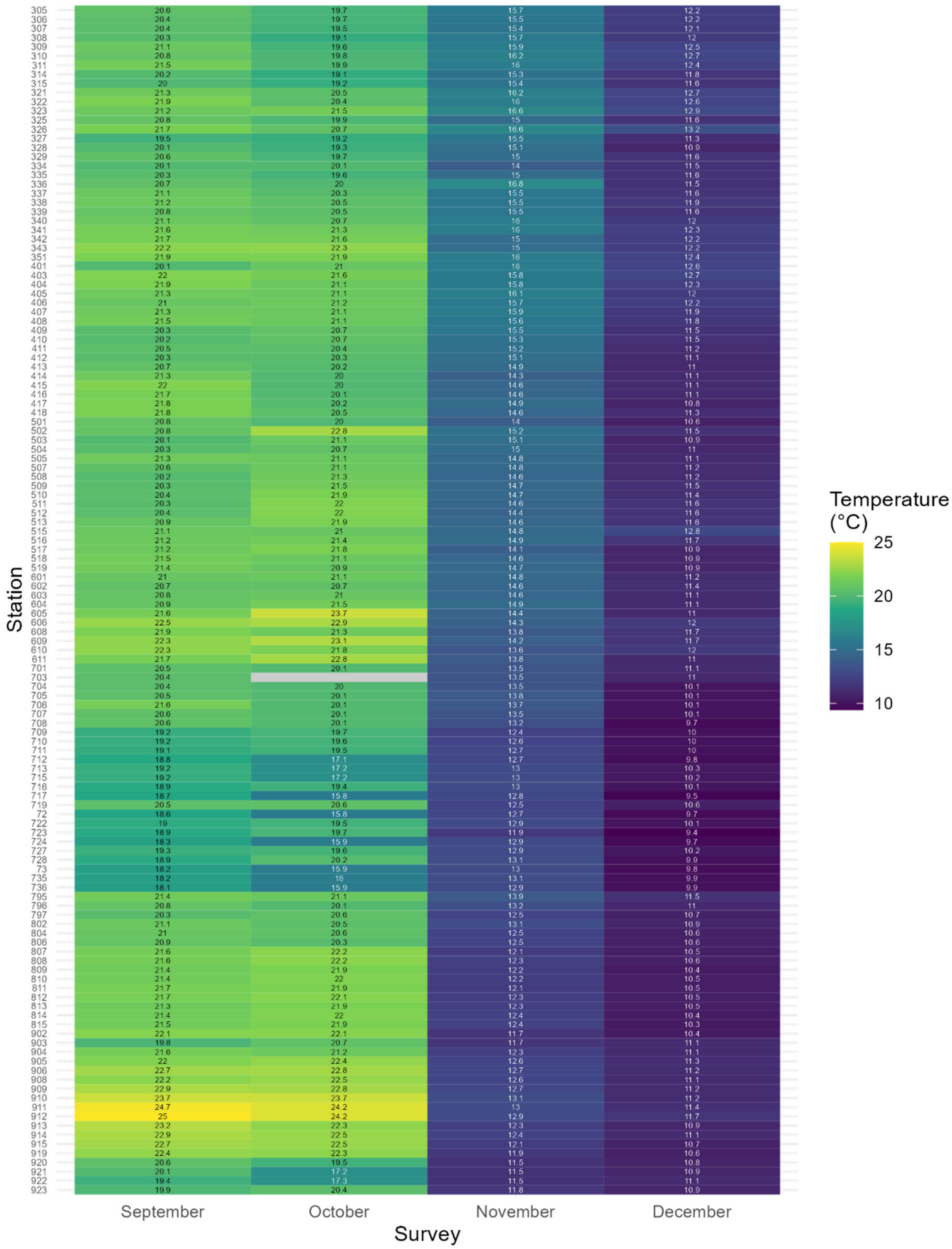


Figure 7. Heatmap of monthly surface water temperature (°C) recorded during the 2024 FMWT season. Grey values indicate missing data. Temperature values at 20 °C or greater induce cellular stress in Longfin Smelt and values above 25 °C induce Delta Smelt stress and mortality, therefore stations in the purple and blue ranges are most suitable. Stations in the green to yellow range are potentially unsuitable for many species.

Figure 8. Distribution of monthly surface water temperature (°C) recorded during the 2024 FMWT season. Boxplots show the median as a vertical line, 1st and 3rd quartile by a box, range by a horizontal line, and outliers by points.

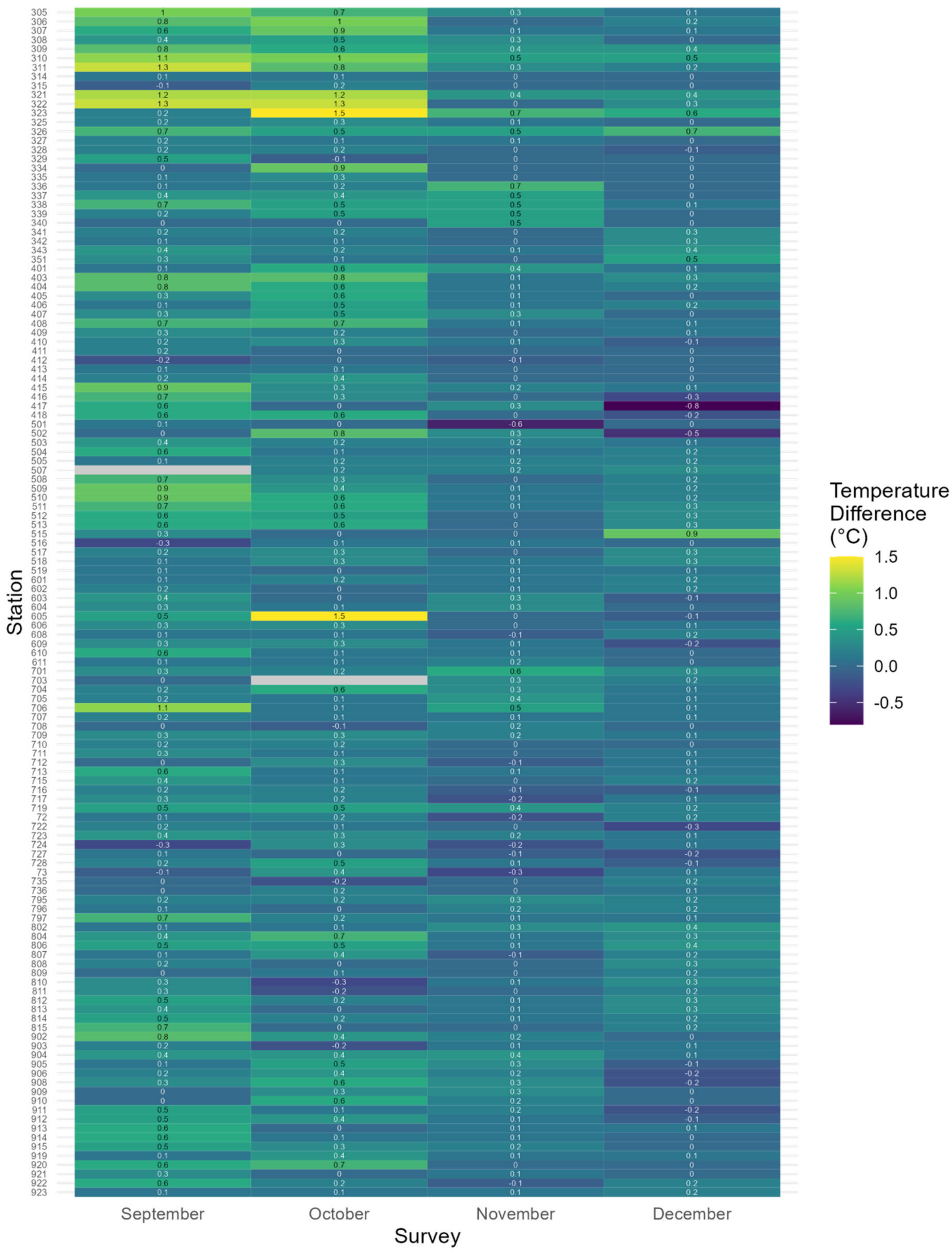


Figure 9. Heatmap of temperature (°C) differences between surface and bottom water recorded during the 2024 FMWT season. Grey values indicate missing data. Negative (blue to purple) values are warmer bottom temperature compared to the surface. Positive (green to yellow) values indicate greater temperatures on the surface.

Salinity

Salinity is an important environmental parameter in determining where pelagic organisms are located and distributed throughout the estuary. In the upper estuary, the LSZ (salinity 0.5-6 ppt) is recognized as a critical variable in the creation of nursery habitat for young fishes. This dynamic well-mixed zone is highly productive and facilitates increased bottom-up ecological processes (Kimmerer 2002 a; Kimmerer 2002 b; Bennett 2005), which correlates with increased turbidity (Kimmerer et al. 1998; Schoellhamer 2000).

The FMWT measures specific conductance at each station, values are converted to salinity (ppt) for better visual analysis and to inform habitat relative to the LSZ and X2. The heatmap and boxplot of salinity values observed during the 2024 FMWT season show in September that the LSZ persisted downstream of Chipps Island; and was fluid through most of eastern Suisun Bay (Figures 10 & 11). Salinity did not encroach too far upstream this season. November saw the most upstream movement of the salinity field, with station 802 in Broad Slough and station 701 in the lower Sacramento River reaching around 3 ppt (Figure 10). It is worth noting that salinity was slightly higher in the SDWSC (Stations 795-797, Figures 10 & 11) compared to surrounding freshwater stations. Most stations did not have extreme salinity differences between surface and bottom sections of the water column (Figure 12).

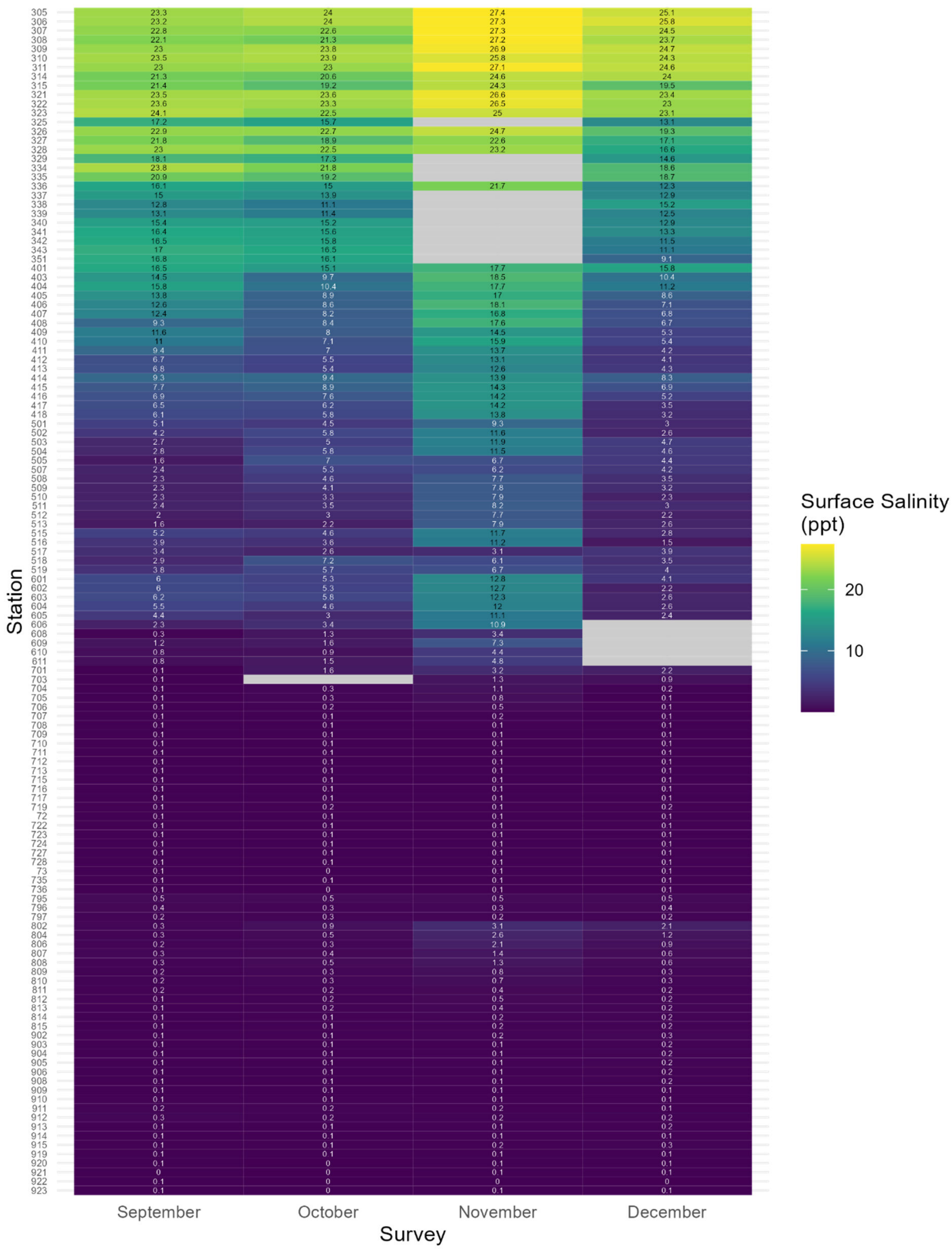


Figure 10. Heatmap of monthly surface water salinity (ppt) recorded during the 2024 FMWT season. Grey values indicate missing data. The low salinity zone (0.5-6 ppt, dark purple stations).

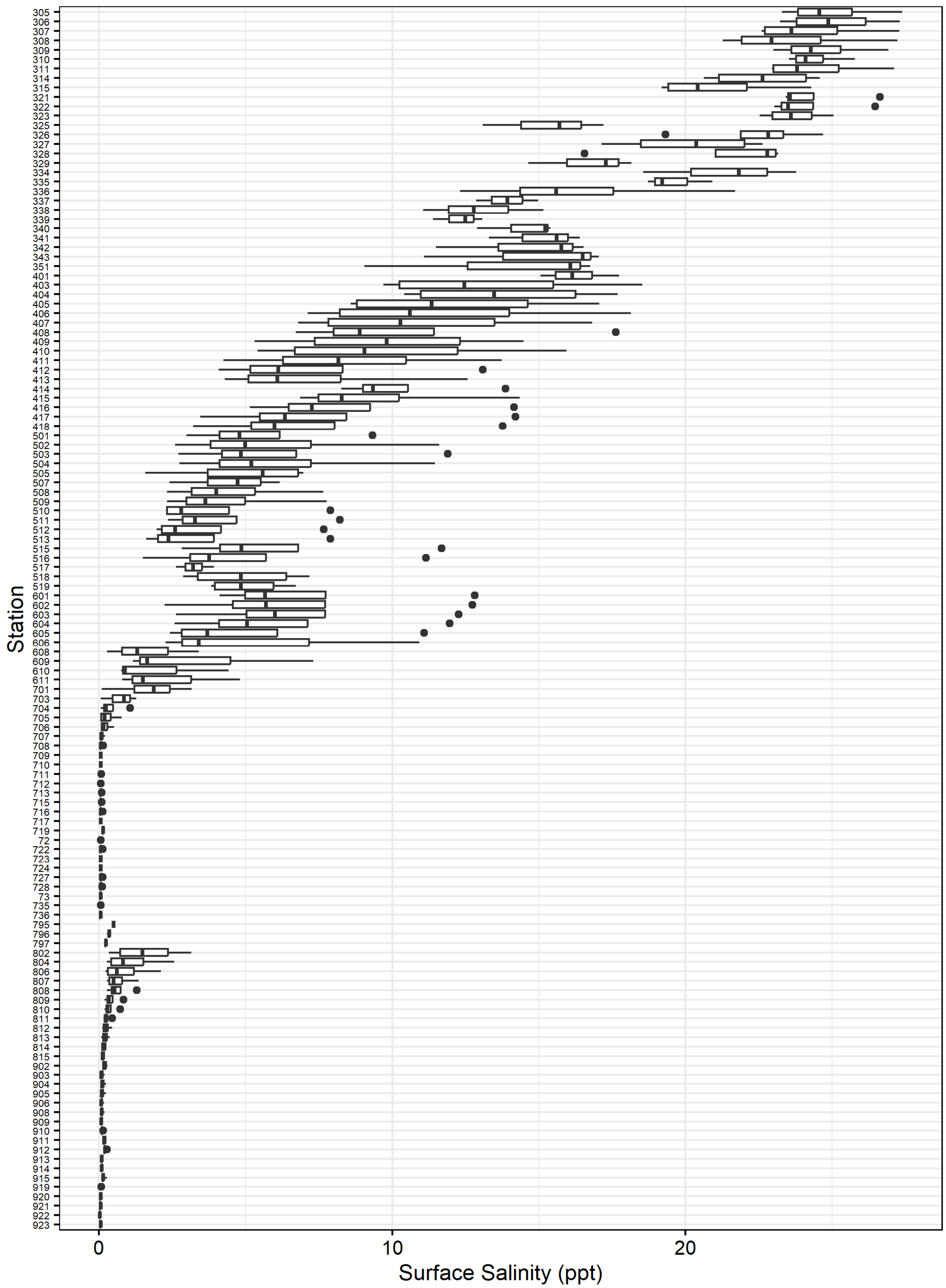


Figure 11. Distribution of monthly surface salinity (ppt) recorded during the 2024 FMWT season. Boxplots show the median as a vertical line, 1st and 3rd quartile by a box, range by a horizontal line, and outliers by points.

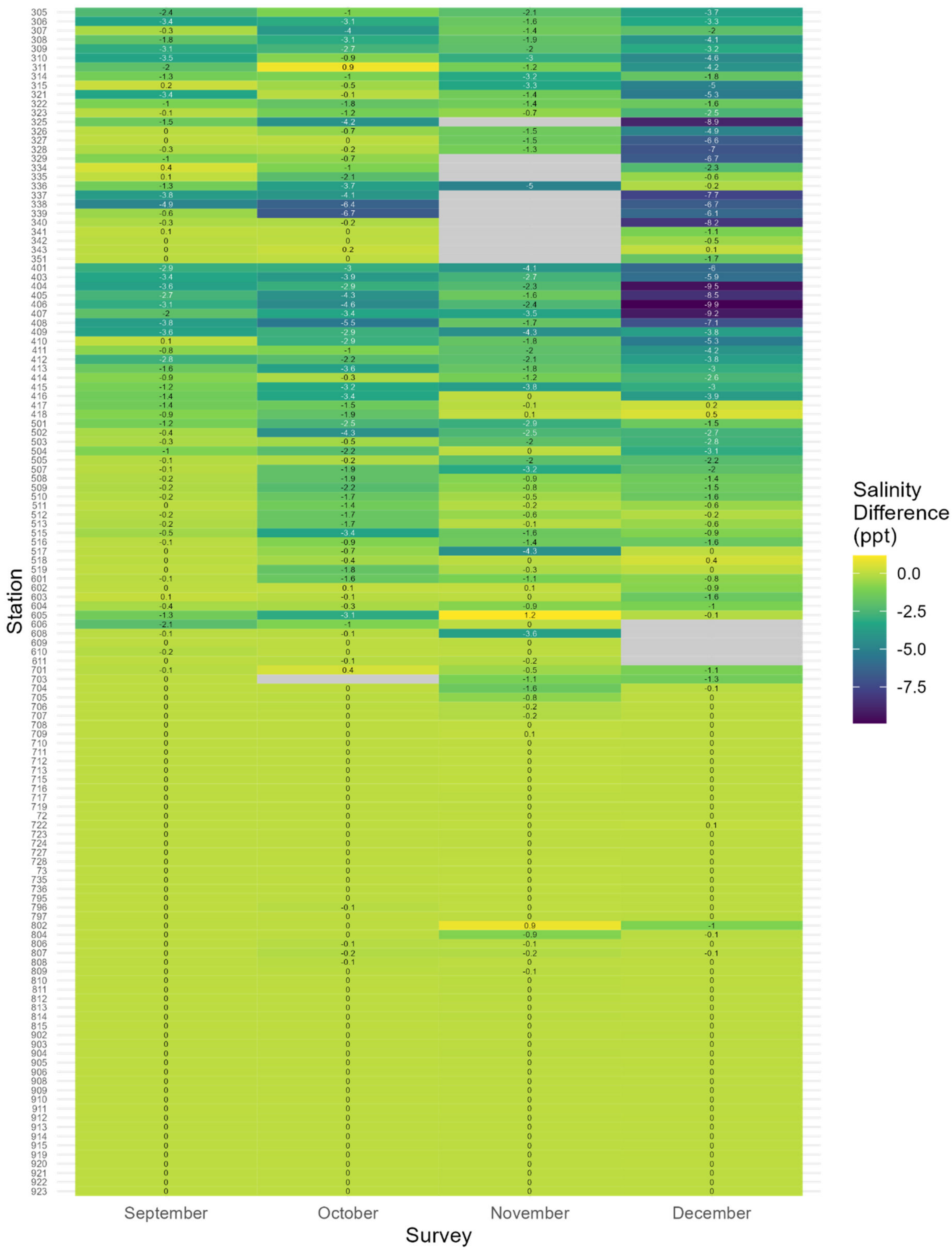


Figure 12. Heatmap of salinity (ppt) differences between surface and bottom water recorded during the 2024 FMWT season. Grey values indicate missing data. Negative (blue to purple) values are higher salinity on the bottom compared to the surface. Positive (yellow) values indicate higher salinity at the surface.

Microcystis

The colonial cyanobacteria *Microcystis aeruginosa* (“Microcystis”) was first discovered in the estuary in the early 2000s (Lehman et al. 2005). Microcystis in high abundance has toxic effects on the local food web, accumulating in dominant zooplankton species (Ger et al. 2010) and bioaccumulating up the trophic levels (Lehman et al. 2010). Microcystis becomes seasonally abundant during periods of low water flow and high-water temperatures (Lehman et al. 2008). FMWT assigns a qualitative rank of 1-5 based on visual inspection for flakes (Figure 13; Morris and Civiello (2013)). In 2024 during the September survey Microcystis was found in low abundance at three stations in Montezuma Slough and three stations in the South Delta (Figure 14). During the October survey it was found in low to medium abundance at 13 stations in South Delta. The heatwave that occurred at the start of October may have been a contributor to the Microcystis spike seen that month. By November, Microcystis was no longer detected at any stations.

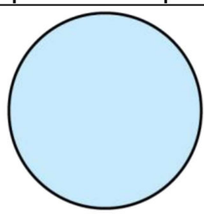
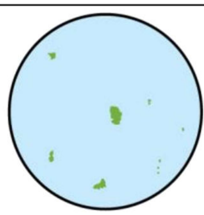
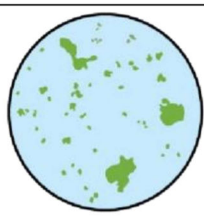
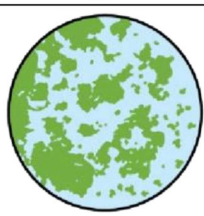
Updated Graphic	Score
	**1- Absent** No visible *Microcystis* colonies.
	**2- Low** Visible but widely scattered *Microcystis* colonies.
	**3- Medium** Adjacent colonies of *Microcystis*.
	**4 - High** Contiguous colonies of *Microcystis*.
	**5 - Very High** Concentrated contiguous colonies of *Microcystis*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

Figure 13. Qualitative rankings are used to assess Microcystis aeruginosa blooms on the water surface.

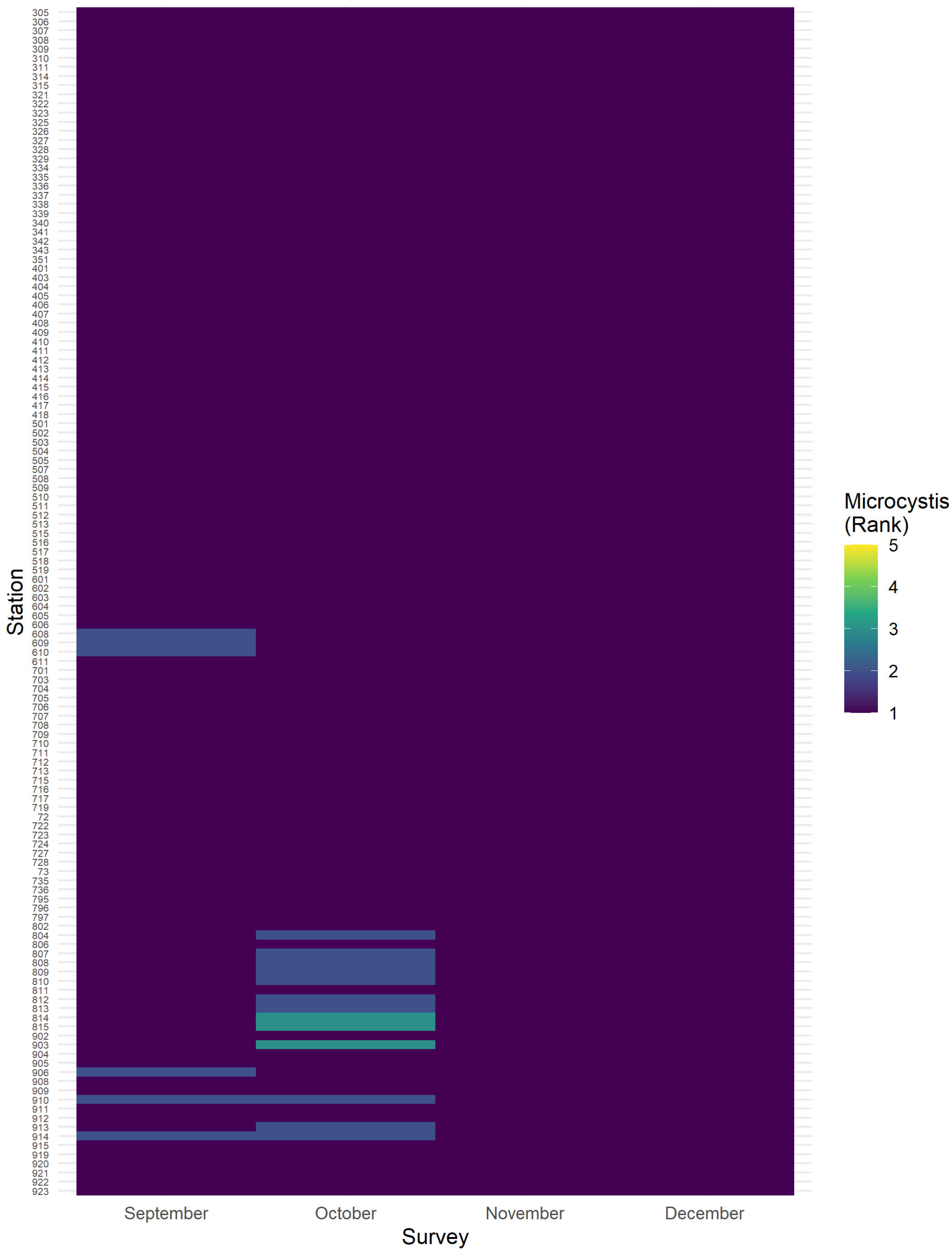


Figure 14. Heatmap of Microcystis spp. rankings recorded during the 2024 FMWT season. Scale is a qualitative assessment of Microcystis density.

Biotic Variables

Fish

The FMWT survey records all species of fish and macro-invertebrates (i.e. shrimps, crabs, and jellyfish) caught in the trawl net. No Delta Smelt were captured this season. The typical unit for reporting catch (used below, Tables 1-2, Figure 15), is catch per tow or per unit effort (CPUE). CPUE is calculated as:(([Total species catch]/[Volume])*10,000) or catch per cubic hectare (see CPUE Calculation Instructions).

Generally, CPUE by region matches with the life histories of the species captured (Figure 15). Log10(x+1) transformed fish catch data (Figure 16) shows the variation in catch by station and survey. The top six species caught this season will be discussed in detail below. A variety of other benthic, demersal, littoral, and pelagic fishes were captured this season but constitute less than 1% of total catch (Tables 1-2).

During 2024, Northern Anchovy (*Engraulis mordax*) constituted the majority of total catch (Figure 15, Tables 1-2). Northern Anchovy are marine opportunists with occasional juvenile presence in brackish waters (Moyle 2002). They are the most abundant anchovy species in California (Miller & Lea 1972) and are an important forage fish for a wealth of animals. As such, they were the most caught species of the survey. During the latter half of the 2024 survey, anchovies were detected at stations farther upstream. The farthest upstream detection was at station 509 near Chipps Island in November.

Threadfin Shad were the second most caught species in 2024. Catch of this species was highest in September (Table 1). Threadfin Shad were introduced as a forage fish and quickly expanded throughout the state. These fish had a greater presence at stations associated with freshwater and had the highest CPUE at stations in the SDWSC (Figure 15). While these fish can tolerate a wide range of salinities, they prefer freshwater, and their spawning abilities are limited by salinity (Hendricks 1961). Like American Shad, they have rapid growth and reproductive abilities. Threadfin Shad are planktivorous as well as opportunistic detritivores. These characteristics have allowed them to spread in California very quickly after their initial introduction.

American Shad were the third most caught species (Table 1). Catch was consistent throughout the months, with a slight peak in December. The FMWT typically catches out-migrating juveniles. American Shad were detected at a wide range of stations, most likely due to their anadromous life history and euryhaline osmoregulatory abilities. American Shad were initially introduced into California in 1871 as forage fish (Dill and Cordone 1997). Historically, the lower San Joaquin River was a stronghold for Clupeids; the FMWT has recorded reduced presence in this area over the last couple decades.

In an interesting twist this year, Plainfin Midshipman (*Porichthys notatus*) were the fourth most caught species (Table 1). This was due to consistent catch of juveniles throughout San Pablo and Western Suisun Bay stations in September. This mass of juveniles was most likely the result of a mid-summer spawning event. This species is traditionally demersal, so finding them in abundance throughout the water column was an ichthyological treat for the crew on board. Detection of this species diminished to two individuals in October, and there was no observed catch in November and December.

Age-0 Striped Bass were the fifth most caught fish. After hatching, larvae and young juveniles rely on zooplankton crustaceans with transition from copepods to larger amphipods and mysids.

Individuals become more piscivorous as they grow into adults. Adult fish are hardy, but cool and consistent flows are required to keep their eggs and larvae suspended in the water column and off the benthos. Detection of the age-0 portion of this species was lower this year than in 2023. Catch was lowest in October and highest in November.

Longfin Smelt were the sixth most abundant species captured on survey this year. Longfin Smelt in the estuary are considered a distinct population segment (DPS). Populations of this native anadromous Osmerid have been declining in the estuary for decades. Young-of-the-year fish typically migrate upstream during the fall and winter with adults following suit as environmental conditions transition to winter parameters. Catch this season was lower than in 2023. A fair amount of seasonal fish were caught in September (Table 1) the majority being age-0 (Figure 29). However, catch dropped off in October. This was possibly due in part to the heatwave that engulfed California that month. Detection increased in November and peaked in December.

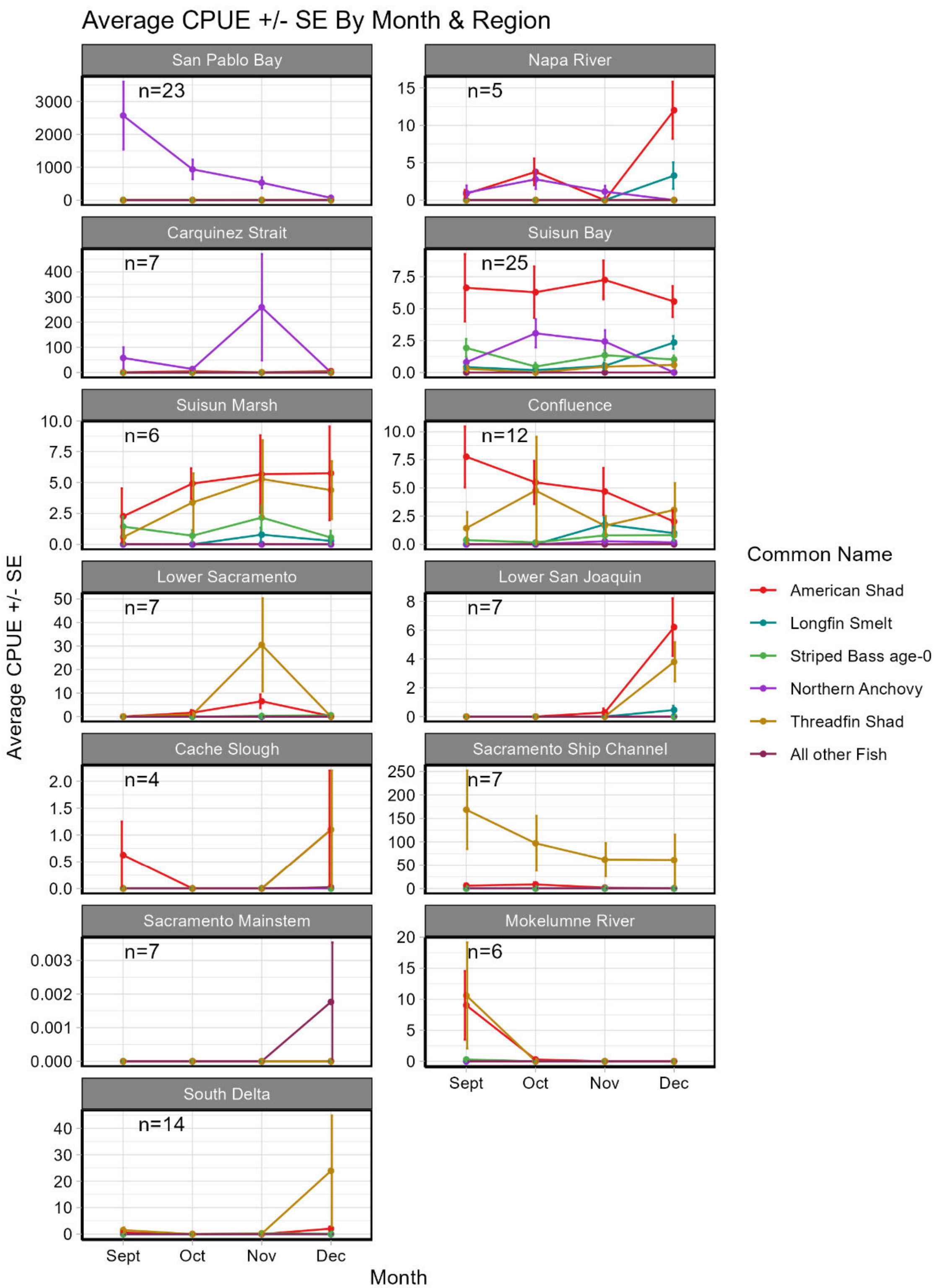


Figure 15. Regional fish catch for the 2024 FMWT survey organized by species used for index calculations. Lines represent monthly average catch per unit effort (CPUE) values and error bars represent +/- standard error. Number of stations per region is denoted in each plot as n = #.

Table 1: Total monthly fish catch during the 2024 FWMT season.

Species	Origin	September	October	November	December	Total	Total %
Northern Anchovy	Native	23572	12753	7808	1004	45137	92.7
Threadfin Shad	Introduced	721	412	358	472	1963	3.9
American Shad	Introduced	234	232	237	312	1015	2.1
Plainfin Midshipman	Native	150	2	0	0	152	0.3
Striped Bass age-0	Introduced	38	15	41	32	126	0.3
Longfin Smelt	Native	22	10	26	55	113	0.2
Striped Bass age-1	Introduced	6	5	10	8	29	0.1
Wakasagi	Introduced	13	8	2	4	27	0.1
White Catfish	Introduced	1	0	12	0	13	<0.1
Chinook Salmon	Native	1	0	0	9	10	<0.1
Bat Ray	Native	7	1	1	0	9	<0.1
Mississippi Silverside	Introduced	3	2	1	3	9	<0.1
Striped Bass age-2	Introduced	2	4	0	2	8	<0.1
California Grunion	Native	3	0	3	1	7	<0.1
Pacific Herring	Native	1	1	0	5	7	<0.1
Starry Flounder	Native	4	1	1	1	7	<0.1
Bluegill	Introduced	1	0	1	4	6	<0.1
Striped Bass age-3+	Introduced	0	0	4	2	6	<0.1
California Halibut	Native	2	1	0	2	5	<0.1
Hitch	Native	0	0	0	5	5	<0.1
Jacksmelt	Native	3	1	1	0	5	<0.1
Shimofuri Goby	Introduced	2	0	0	2	4	<0.1
Yellowfin Goby	Introduced	3	0	0	0	3	<0.1
Shokihaze Goby	Introduced	2	0	0	0	2	<0.1
White Sturgeon	Native	1	0	1	0	2	<0.1
Bay Goby	Native	1	0	0	0	1	<0.1
Black Crappie	Introduced	0	0	0	1	1	<0.1
Common Carp	Introduced	0	0	1	0	1	<0.1
Largemouth Bass	Introduced	1	0	0	0	1	<0.1
Total		24794	13448	8508	1924	48674	

Table 2: Total monthly fish CPUE during the 2024 FWMT season.

Species	Origin	September	October	November	December	Total CPUE	% CPUE
Northern Anchovy	Native	59,570.3	21,737.1	14,095.0	1,543.1	96,945.5	93.8
Threadfin Shad	Introduced	1,292.1	762.1	716.1	879.8	3,650.1	3.5
American Shad	Introduced	407.3	408.9	384.7	532.0	1,732.9	1.7
Plainfin Midshipman	Native	306.0	2.7	0.0	0.0	308.7	0.3
Striped Bass age-0	Introduced	64.8	24.4	66.3	53.1	208.6	0.2
Longfin Smelt	Native	34.9	15.5	45.5	95.2	191.1	0.2
Striped Bass age-1	Introduced	13.5	9.0	15.8	13.5	51.8	0.1
Wakasagi	Introduced	23.8	14.0	4.4	7.8	50.0	<0.1
White Catfish	Introduced	1.8	0.0	23.6	0.0	25.4	<0.1
Bat Ray	Native	15.1	1.5	1.7	0.0	18.3	<0.1
Chinook Salmon	Native	2.0	0.0	0.0	15.6	17.6	<0.1
Mississippi Silverside	Introduced	5.5	3.6	1.2	5.6	15.9	<0.1
Striped Bass age-2	Introduced	3.7	6.1	0.0	3.3	13.1	<0.1
Pacific Herring	Native	3.2	1.9	0.0	7.9	13.0	<0.1
Starry Flounder	Native	5.8	1.4	1.7	1.7	10.6	<0.1
California Grunion	Native	4.0	0.0	4.2	1.7	9.9	<0.1
Bluegill	Introduced	1.3	0.0	1.9	6.6	9.8	<0.1
Striped Bass age-3+	Introduced	0.0	0.0	6.6	2.7	9.3	<0.1
Hitch	Native	0.0	0.0	0.0	9.2	9.2	<0.1
Jacksmelt	Native	5.4	1.4	1.6	0.0	8.4	<0.1
Shimofuri Goby	Introduced	3.7	0.0	0.0	4.4	8.1	<0.1
California Halibut	Native	3.1	1.5	0.0	3.3	7.9	<0.1
Yellowfin Goby	Introduced	4.7	0.0	0.0	0.0	4.7	<0.1
White Sturgeon	Native	2.0	0.0	1.8	0.0	3.8	<0.1
Shokihaze Goby	Introduced	3.4	0.0	0.0	0.0	3.4	<0.1
Black Crappie	Introduced	0.0	0.0	0.0	1.9	1.9	<0.1
Common Carp	Introduced	0.0	0.0	1.5	0.0	1.5	<0.1
Bay Goby	Native	1.3	0.0	0.0	0.0	1.3	<0.1
Largemouth Bass	Introduced	1.3	0.0	0.0	0.0	1.3	<0.1

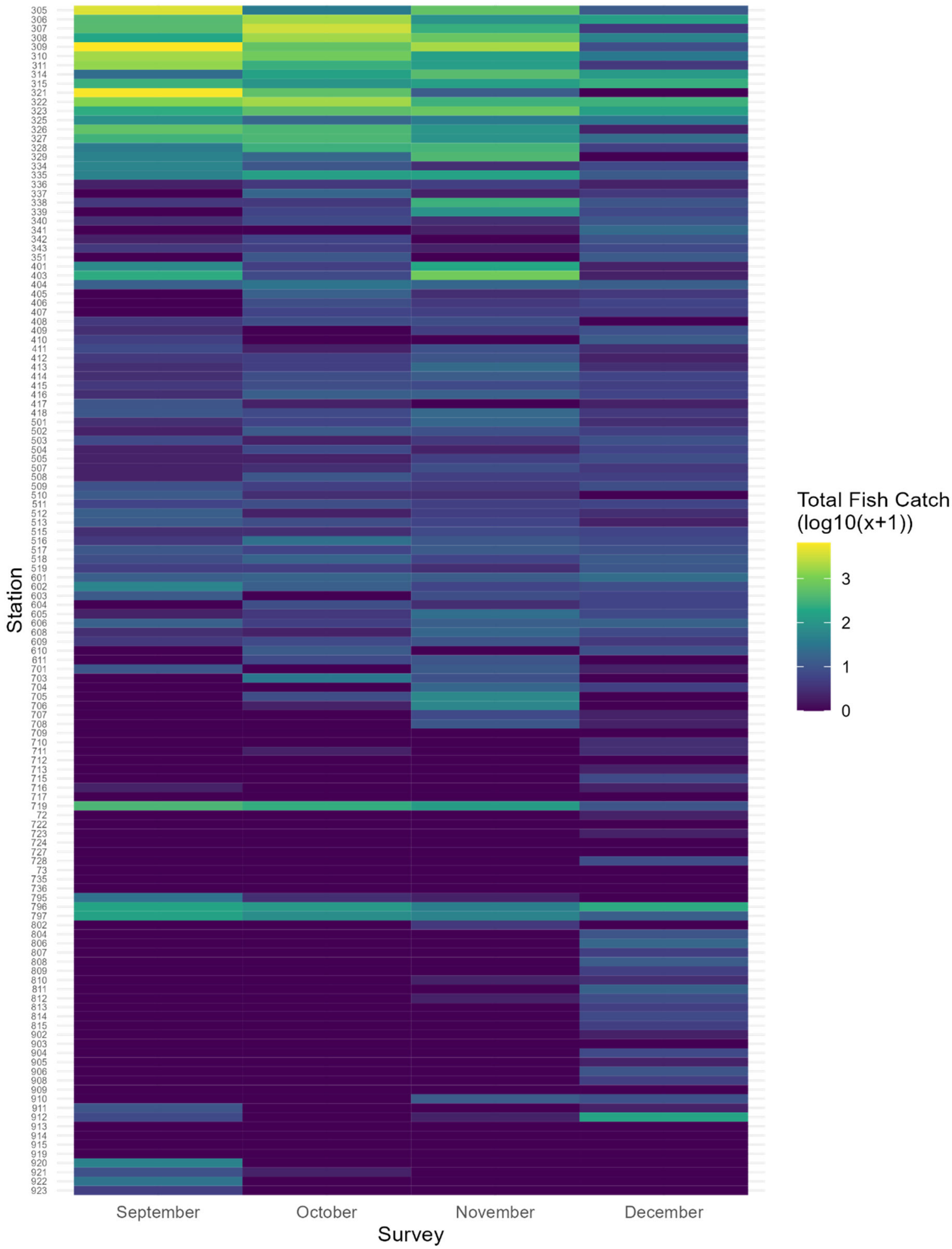


Figure 16. Heatmap of Log10(x+1) total fish catch by station recorded during the 2024 FMWT season. San Pablo Bay and the middle section of the SDWSC had the highest fish catch.

Design-Based Abundance Indices

This summary will report draft design-based abundance (DBA) indices for the FMWT. 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). Abundance values reported in this summary may be higher than previously reported, however the overall trends remain consistent. This is due to an enhancement of the variance calculation. Specifically, 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 130 FMWT stations; common species captured by the FMWT are plotted below (Figures 17-26).

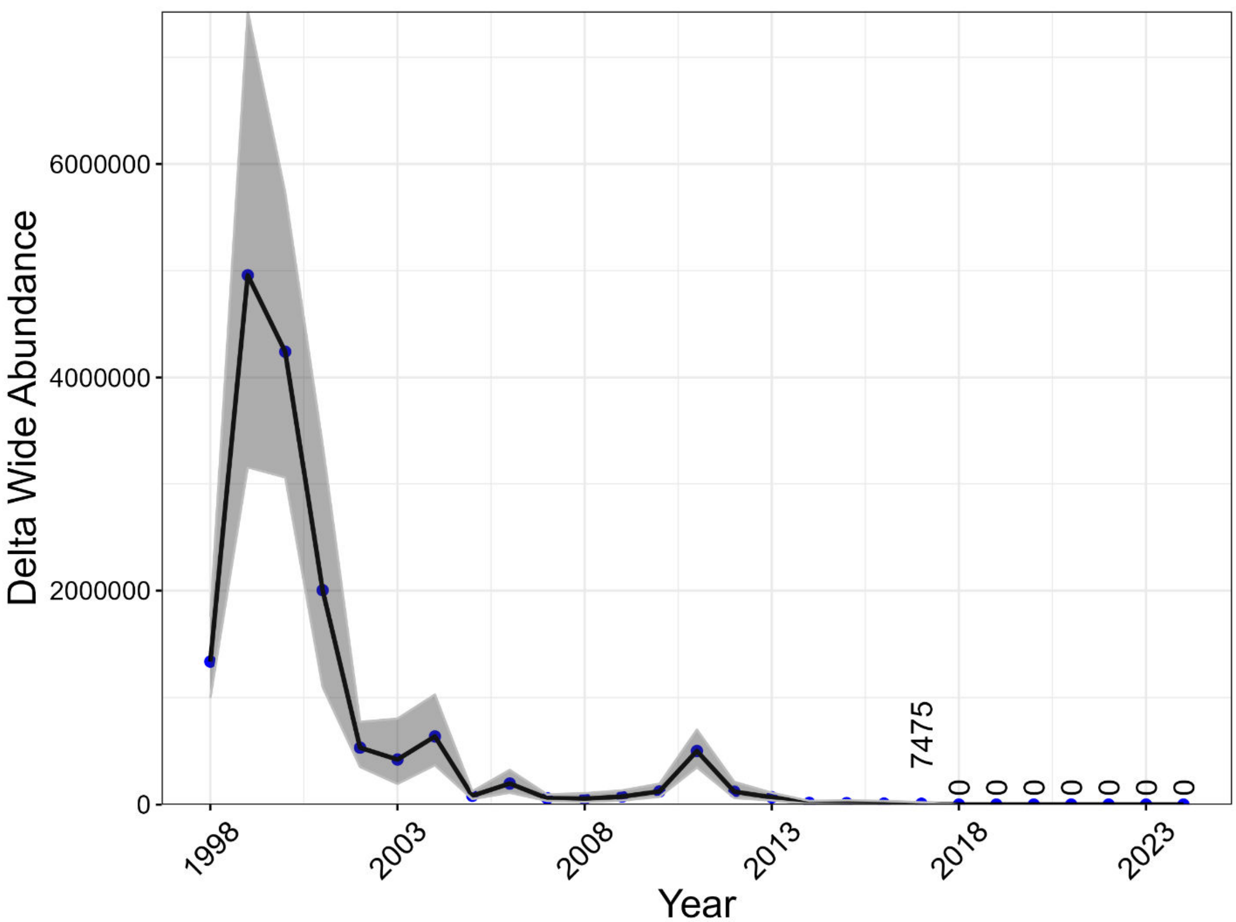


Figure 17. FMWT design-based abundance indices for Delta Smelt. Delta wide abundance is plotted for survey years 1998-2024. Blue points denote the abundance value for a given year,

with the eight most recent annual values denoted by text above the point. The grey ribbon indicates upper and lower confidence intervals.

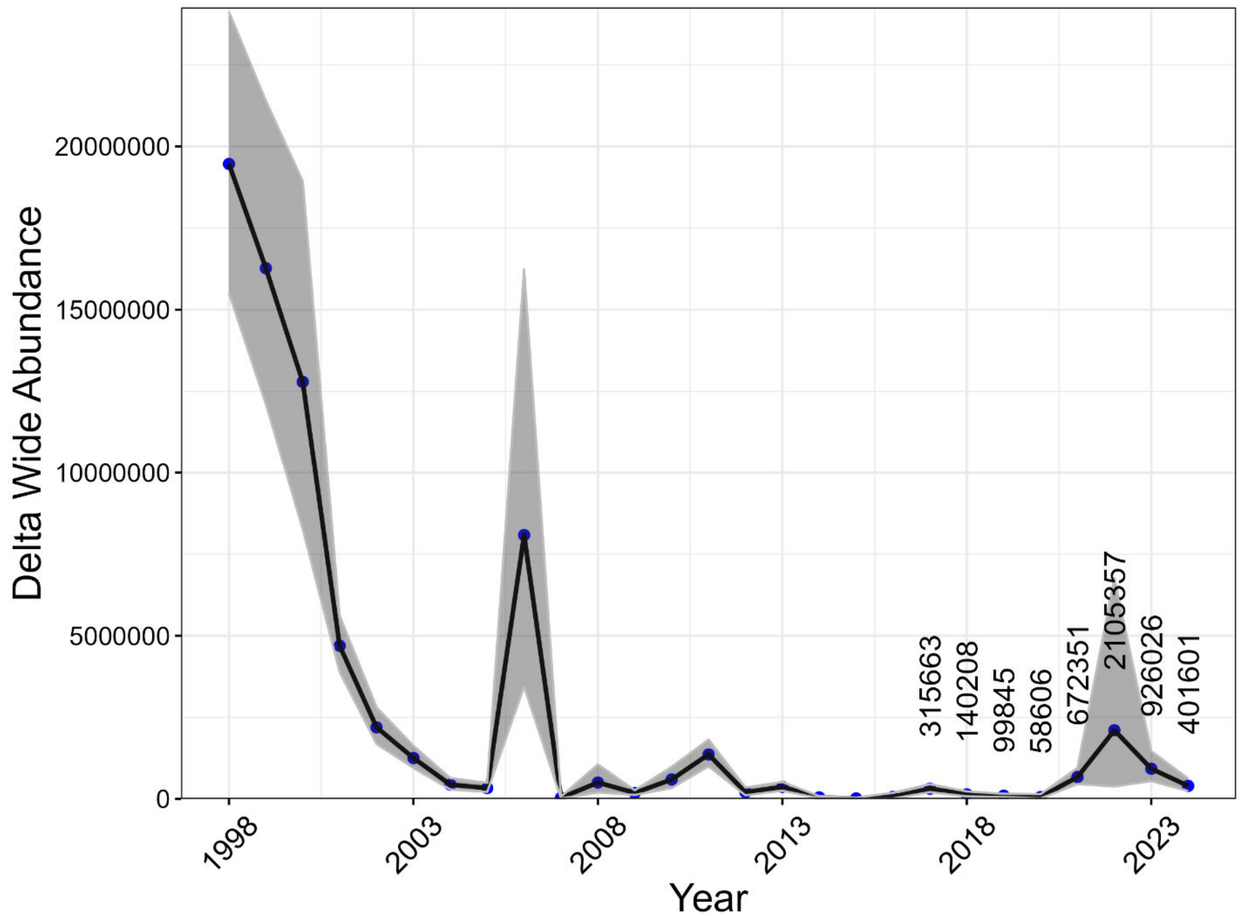


Figure 18. FMWT design-based abundance indices for Longfin Smelt. Delta wide abundance is plotted for survey years 1998-2024. Blue points denote the abundance value for a given year, with the eight most recent annual values denoted by text above the point. The grey ribbon indicates upper and lower confidence intervals.

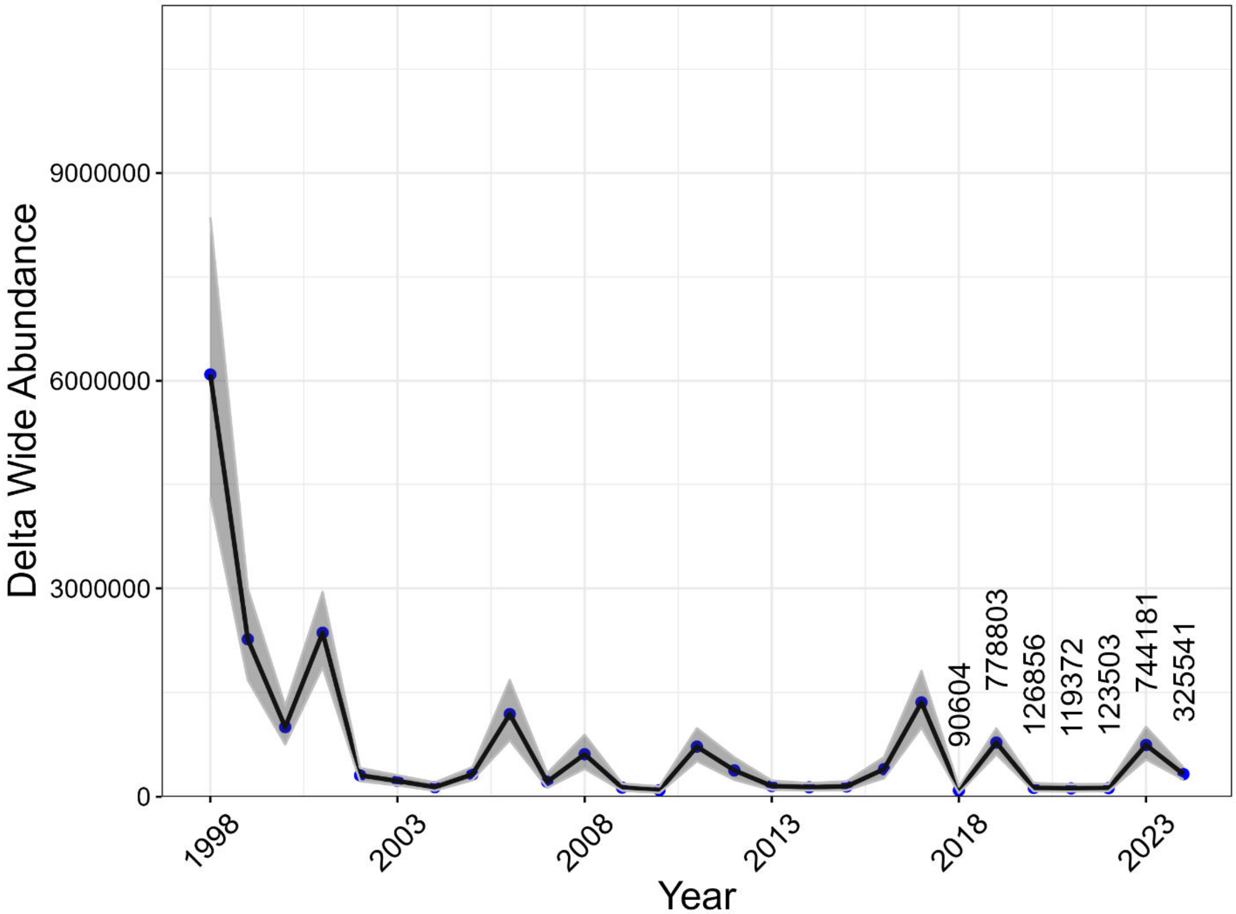


Figure 19. FMWT design-based abundance indices for age-0 Striped Bass. Delta wide abundance is plotted for survey years 1998-2024. Blue points denote the abundance value for a given year, with the eight most recent annual values denoted by text above the point. The grey ribbon indicates upper and lower confidence intervals.

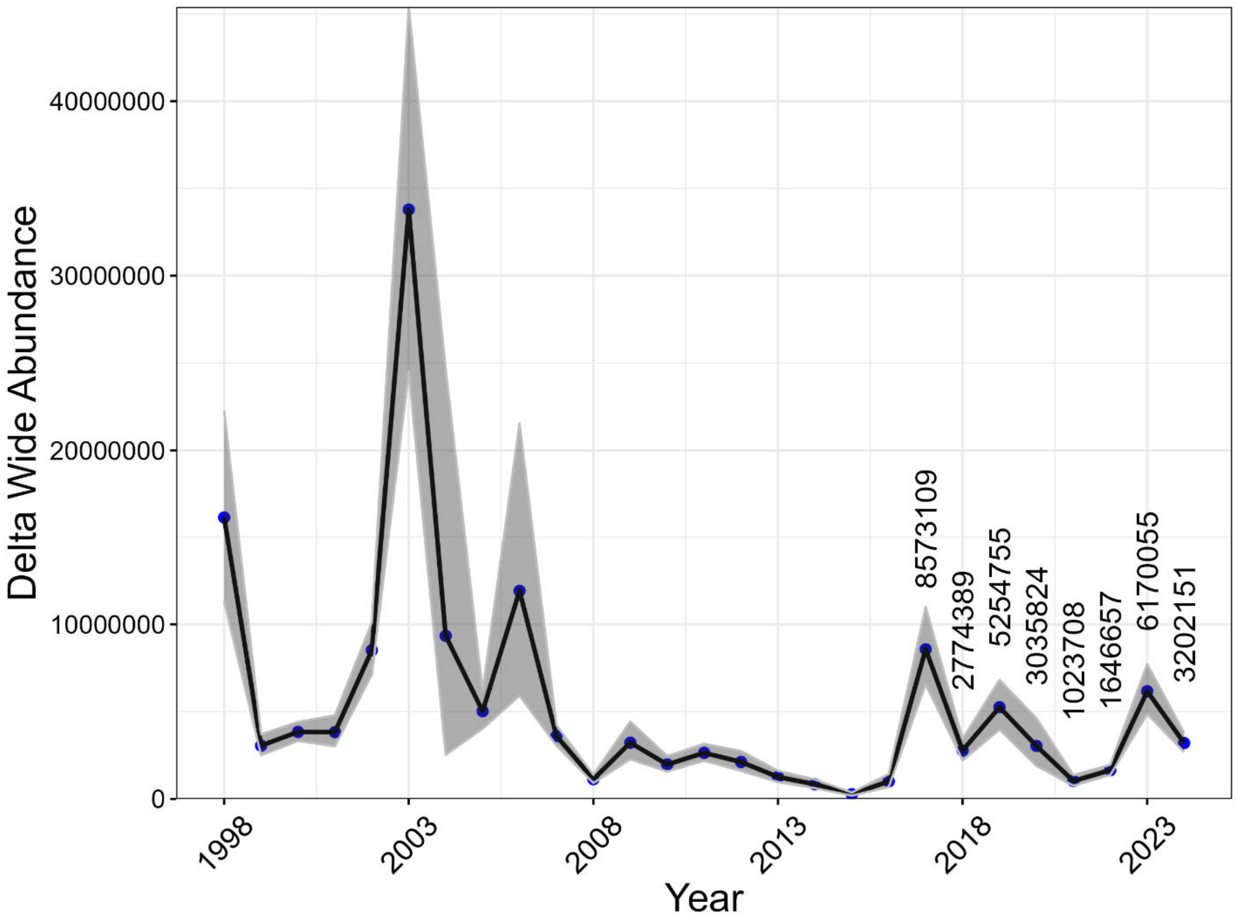


Figure 20. FMWT design-based abundance indices for American Shad. Delta wide abundance is plotted for survey years 1998-2024. Blue points denote the abundance value for a given year, with the eight most recent annual values denoted by text above the point. The grey ribbon indicates upper and lower confidence intervals.

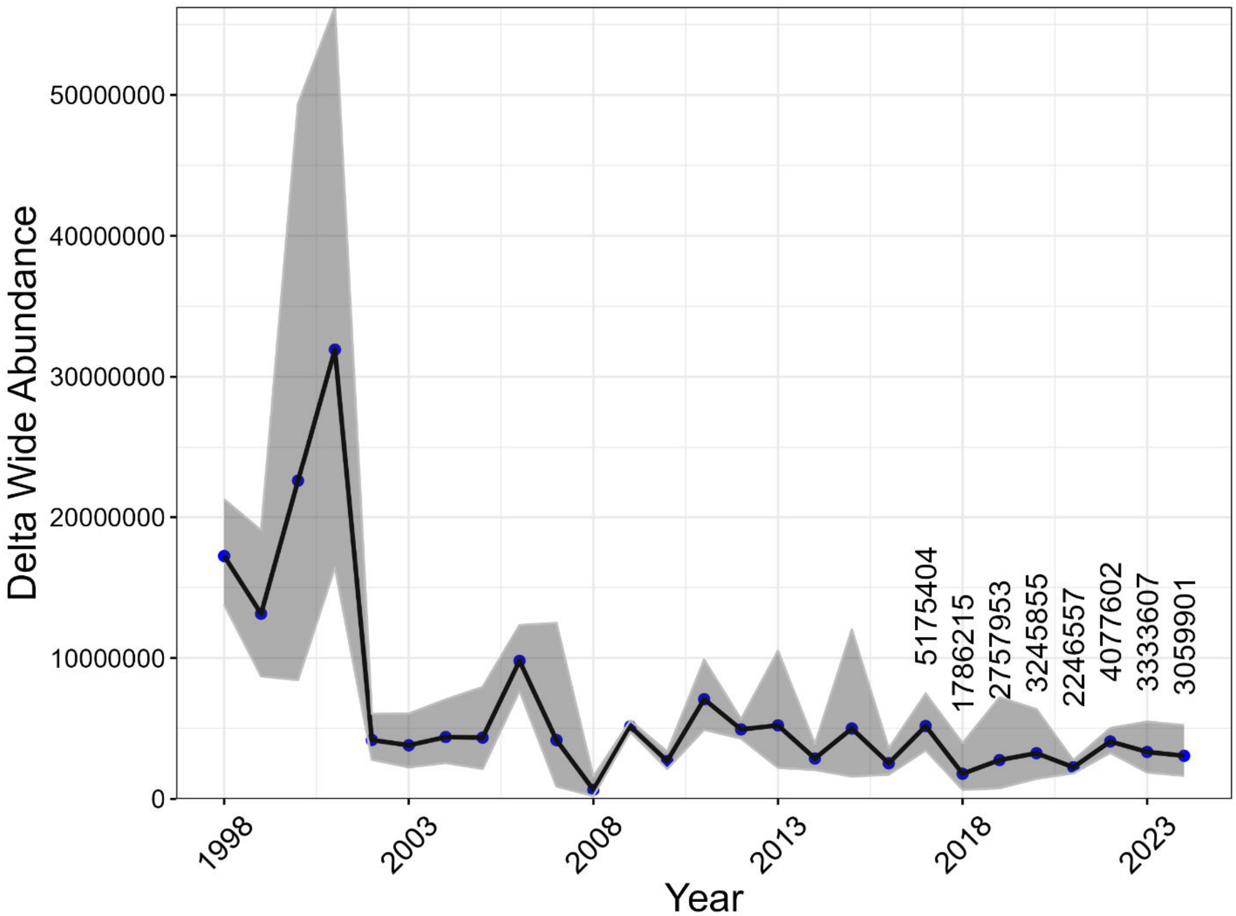


Figure 21. FMWT design-based abundance indices for Threadfin Shad. Delta wide abundance is plotted for survey years 1998-2024. Blue points denote the abundance value for a given year, with the eight most recent annual values denoted by text above the point. The grey ribbon indicates upper and lower confidence intervals.

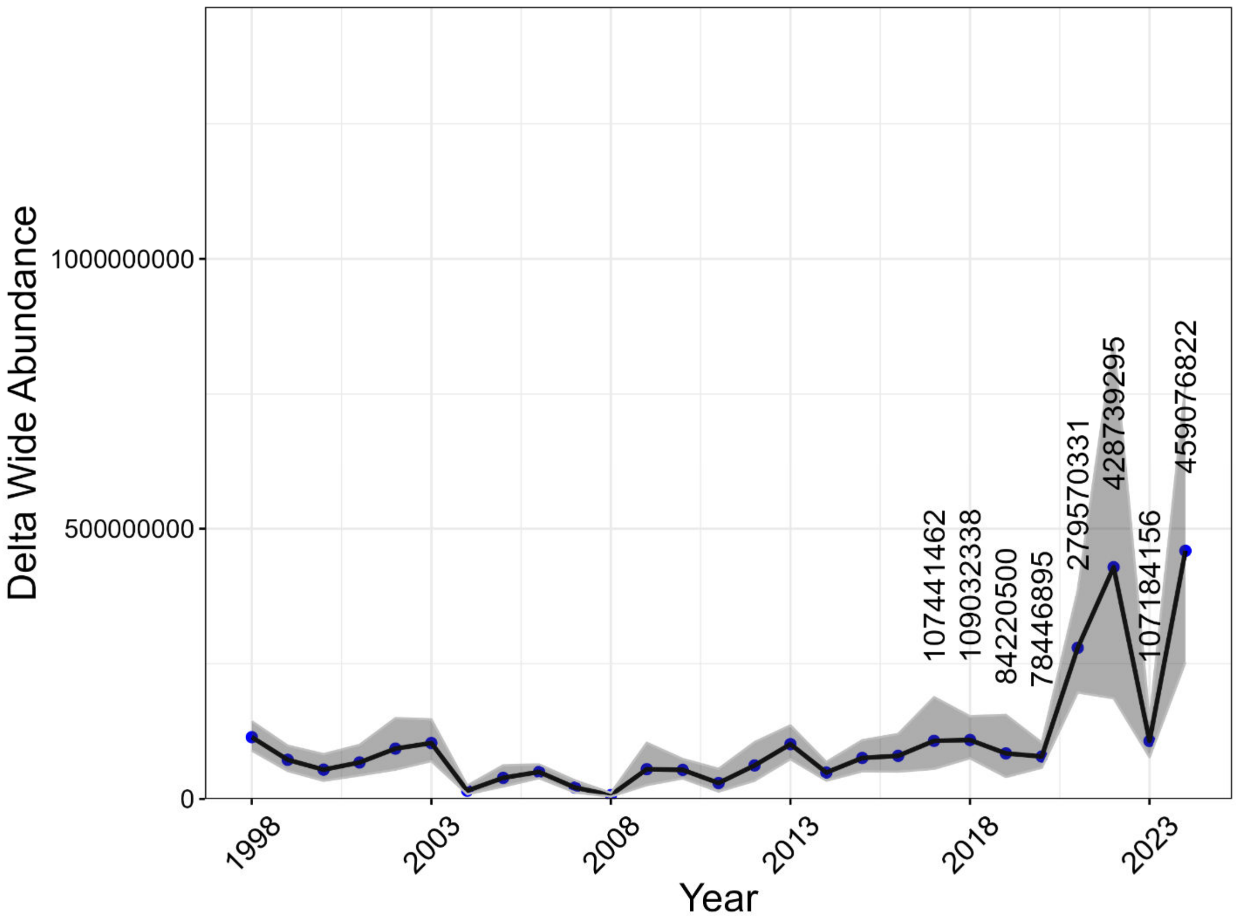


Figure 22. FMWT design-based abundance indices for Northern Anchovy. Delta wide abundance is plotted for survey years 1998-2024. Blue points denote the abundance value for a given year, with the eight most recent annual values denoted by text above the point. The grey ribbon indicates upper and lower confidence intervals.

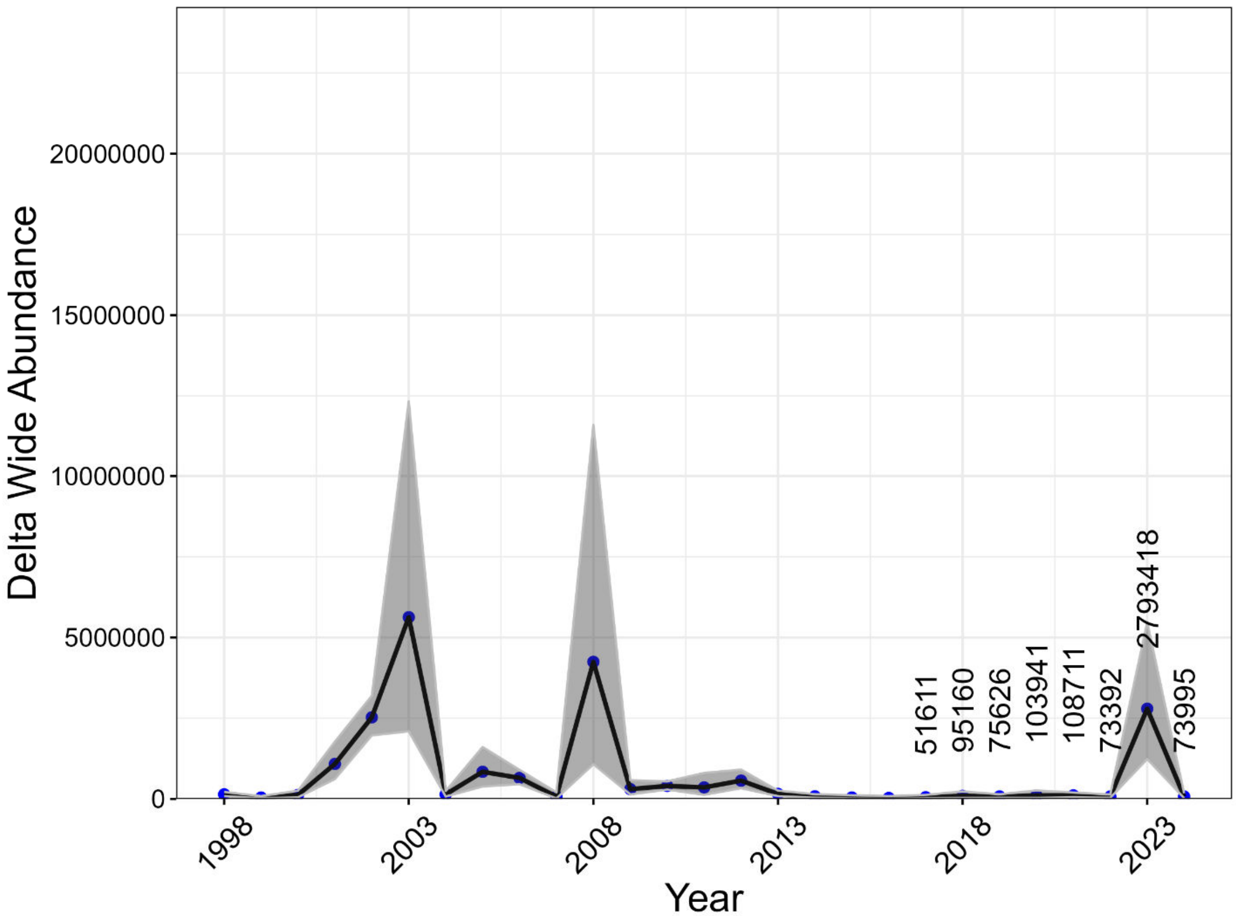


Figure 23. FMWT design-based abundance indices for Pacific Herring. Delta wide abundance is plotted for survey years 1998-2024. Blue points denote the abundance value for a given year, with the eight most recent annual values denoted by text above the point. The grey ribbon indicates upper and lower confidence intervals.

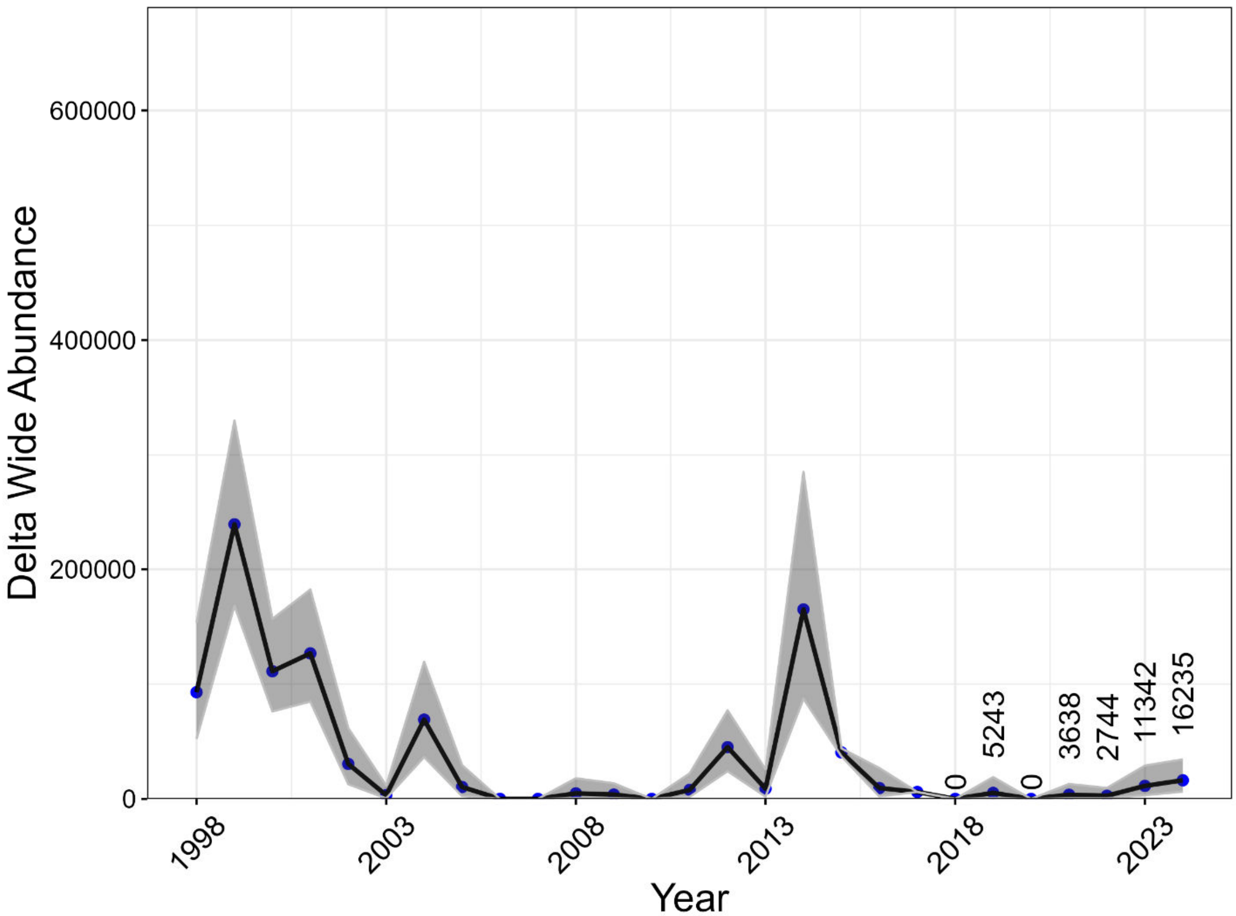


Figure 24. FMWT design-based abundance indices for Chinook Salmon. Delta wide abundance is plotted for survey years 1998-2024. Blue points denote the abundance value for a given year, with the eight most recent annual values denoted by text above the point. The grey ribbon indicates upper and lower confidence intervals.

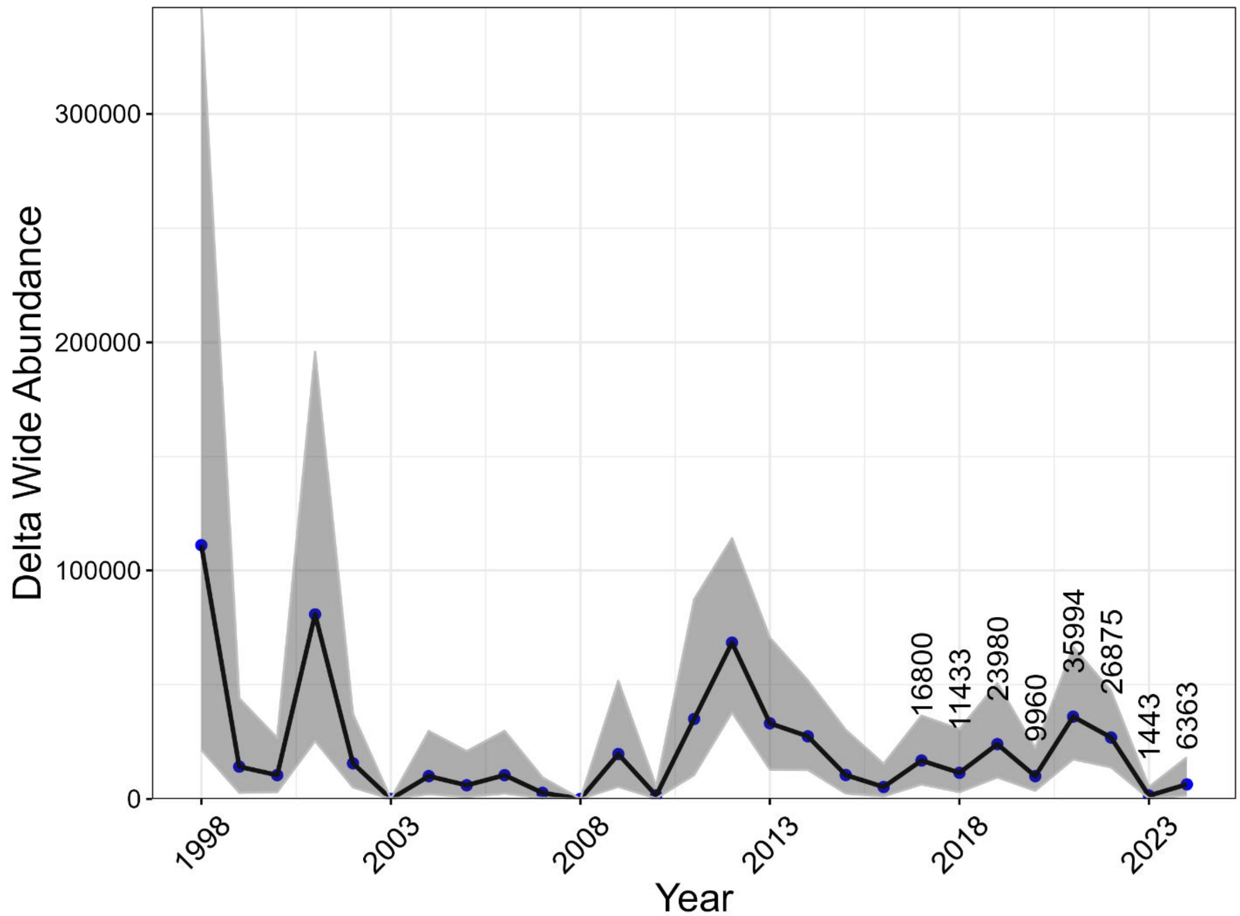


Figure 25. FMWT design-based abundance indices for Shimofuri Goby. Delta wide abundance is plotted for survey years 1998-2024. Blue points denote the abundance value for a given year, with the eight most recent annual values denoted by text above the point. The grey ribbon indicates upper and lower confidence intervals.

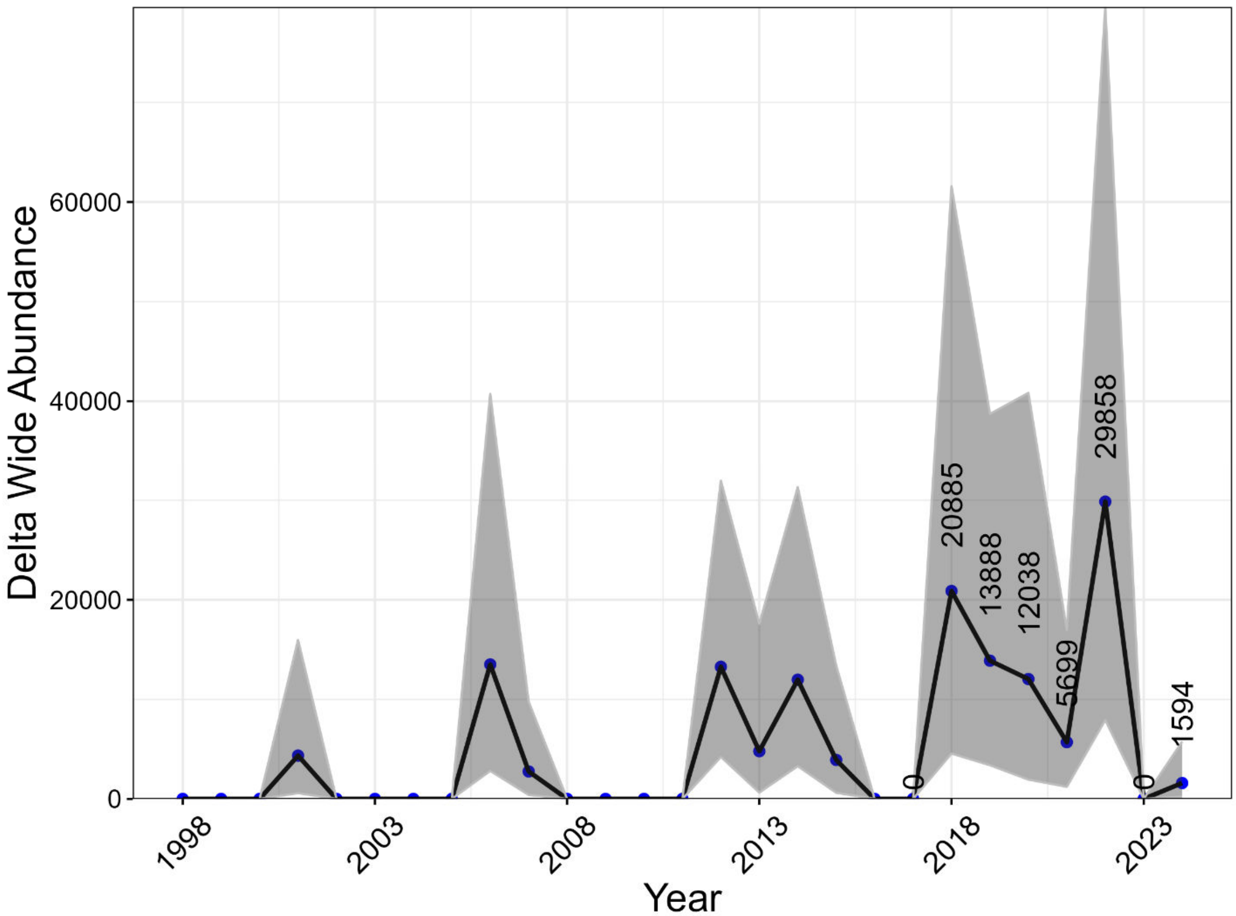


Figure 26. FMWT design-based abundance indices for Shokihaze Goby. Delta wide abundance is plotted for survey years 1998-2024. Blue points denote the abundance value for a given year, with the eight most recent annual values denoted by text above the point. The grey ribbon indicates upper and lower confidence intervals.

Fork Length Frequencies

Fork length frequency histograms from the 2024 season for the six most caught species are plotted below (Figures 27-32). The FMWT only measures the first 50 randomly selected fish of each species per tow, anything beyond that is plus counted. An adjusted fork length frequency is calculated for fish not measured, or if a fish length cannot be determined for a damaged specimen. This is done by calculating the ratio of total catch to the number of fish measured multiplied by the length frequency. The plots below utilize adjusted fork length frequencies to better quantify the size range of each species. The fork length frequency histograms are grouped and colored according to the survey number, beginning with survey 3 (September) and ending with survey 6 (December). The bin size for fork lengths was set to one mm. Note that the scale for frequency (y-axis) and fork length (x-axis) in each figure varies between survey and species. The mean fork length and standard deviation as well as number of fish captured are labeled on each histogram. In 2024 the FMWT mostly detected young-of-the-year fish. However, age-class varies by species and month captured. The bimodal distribution of Longfin Smelt fork lengths for survey six illustrates that age-class distinction quite well (Figure 29).

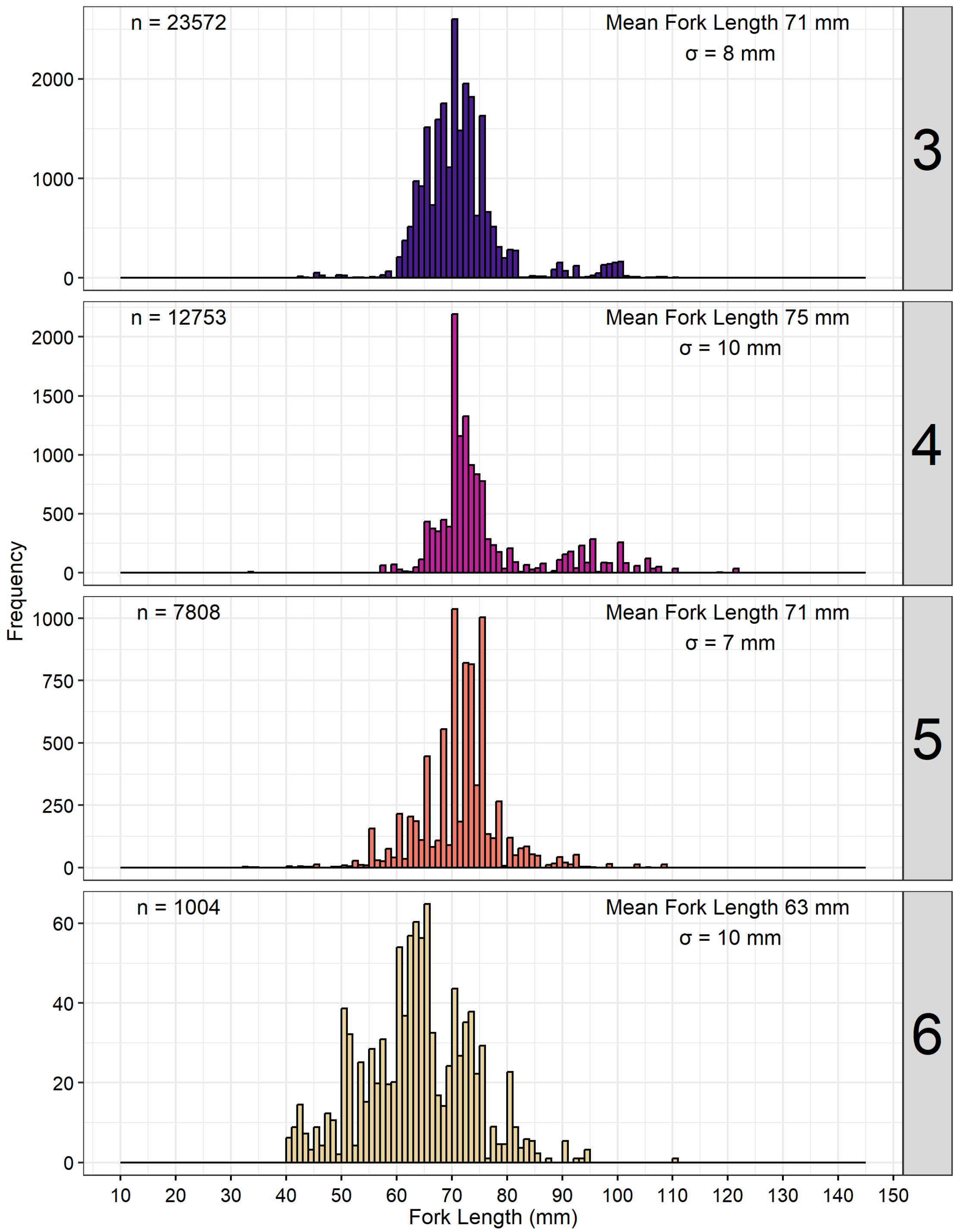


Figure 27. Fork length (mm) frequency histograms for Northern Anchovy among monthly surveys in 2024. Survey number (right panel), number of fish (n), mean fork length (mm), and fork length standard deviation (σ), are displayed on each histogram.

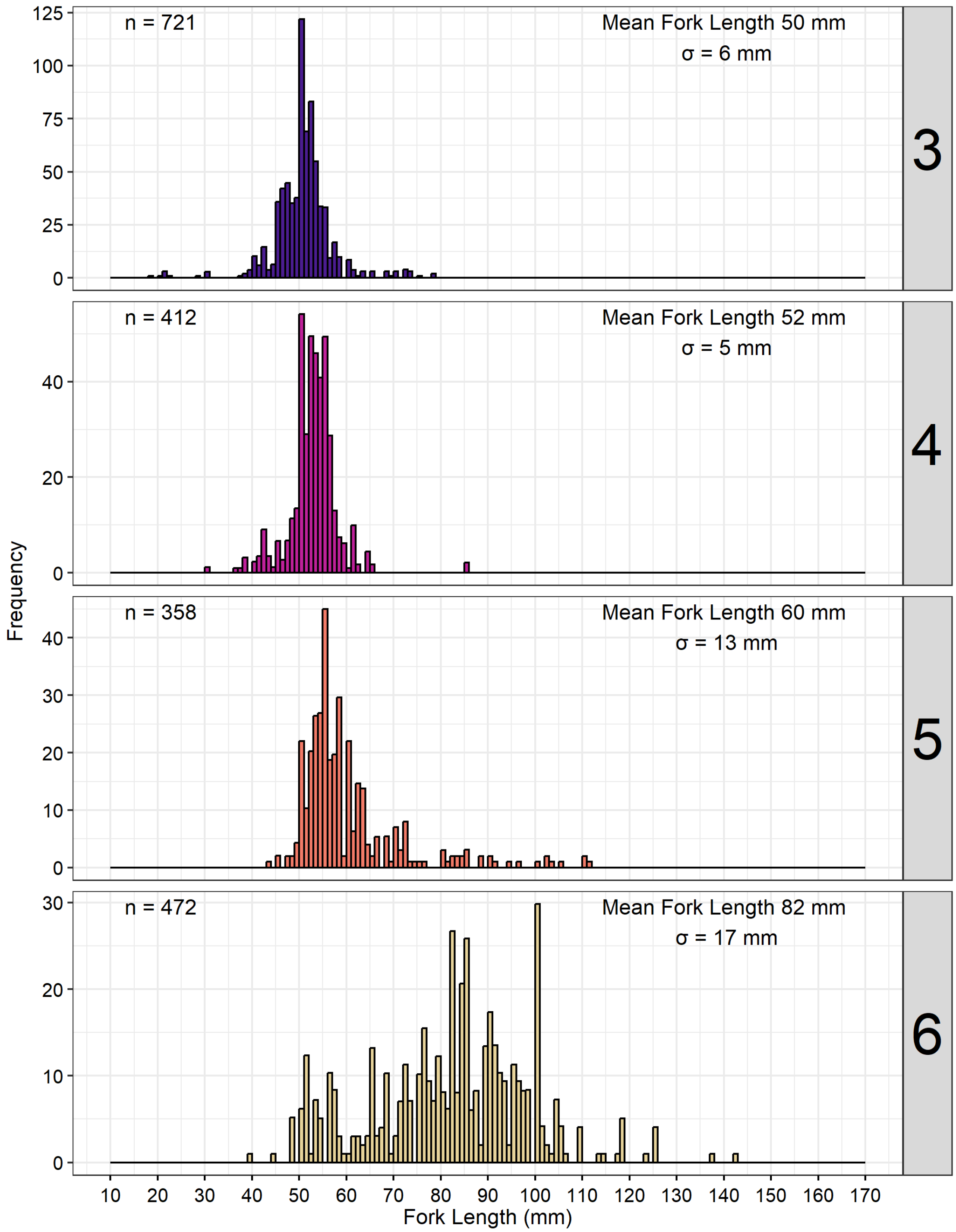


Figure 28. Fork length (mm) frequency histograms for Threadfin Shad among monthly surveys in 2024. Survey number (right panel), number of fish (n), mean fork length (mm), and fork length standard deviation (σ), are displayed on each histogram.

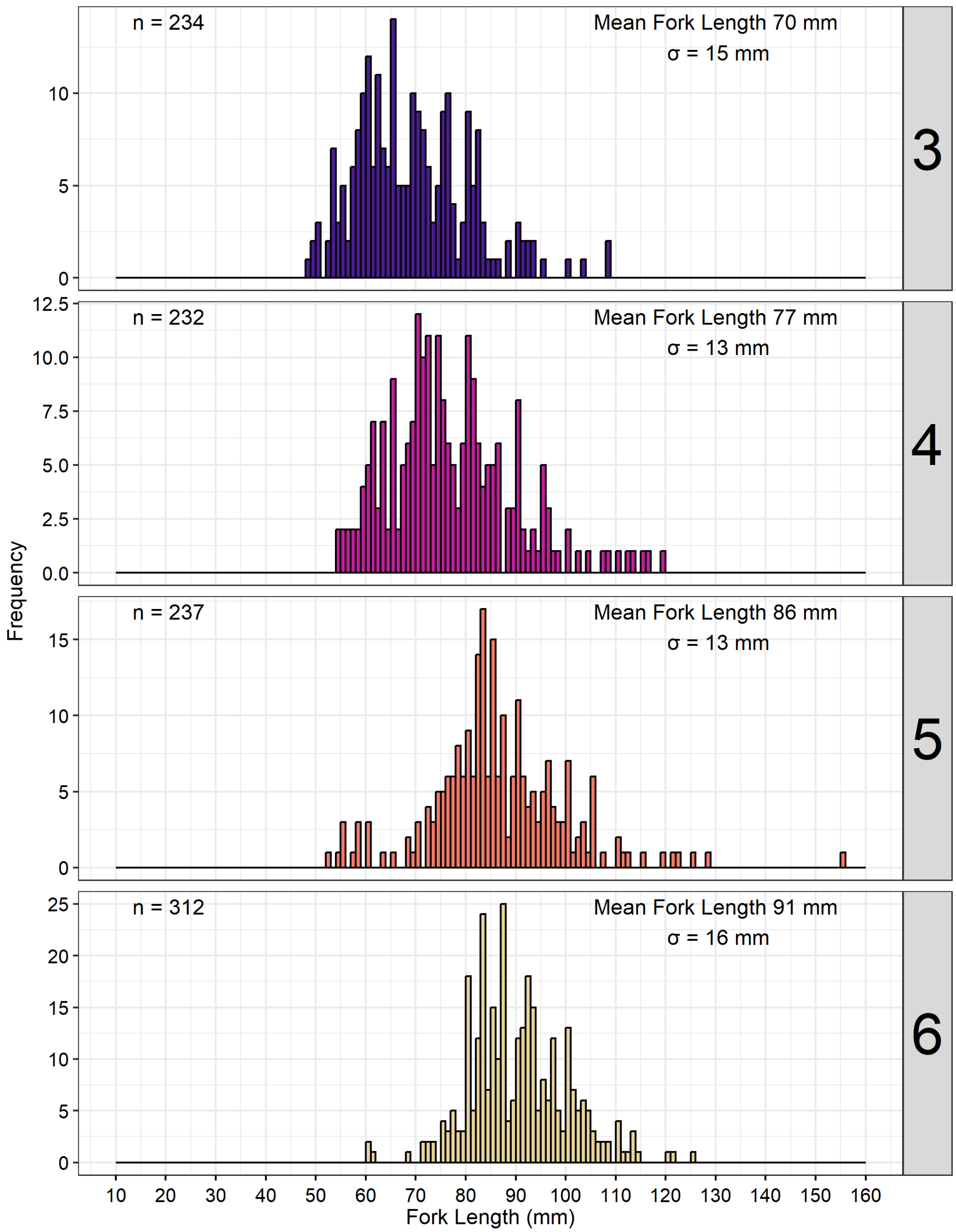


Figure 29. Fork length (mm) frequency histograms for American Shad among monthly surveys in 2024. Survey number (right panel), number of fish (n), mean fork length (mm), and fork length standard deviation (σ), are displayed on each histogram.

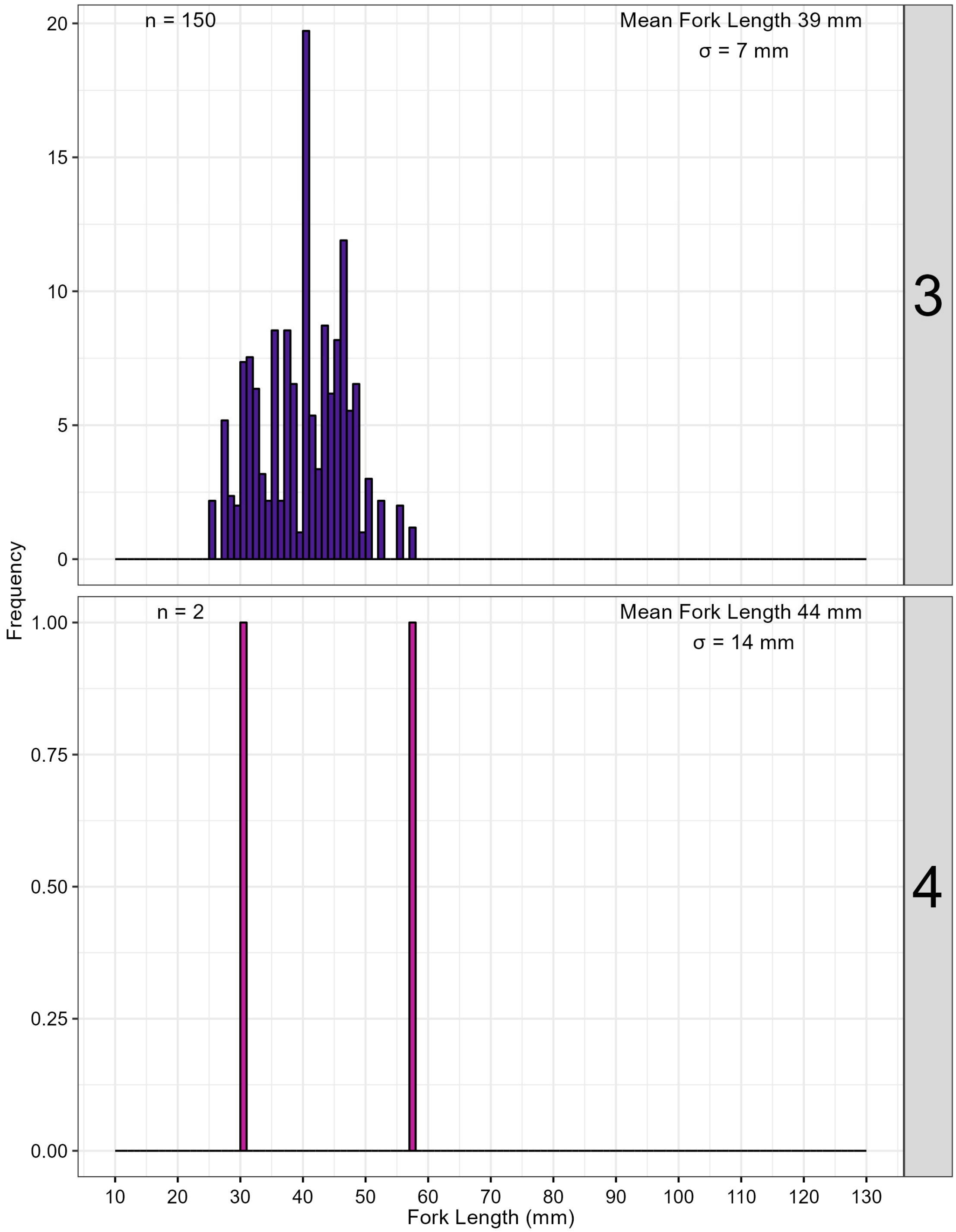


Figure 30. Fork length (mm) frequency histograms for Plainfin Midshipman among monthly surveys in 2024. Survey number (right panel), number of fish (n), mean fork length (mm), and fork length standard deviation (σ), are displayed on each histogram. This species was only caught during Survey’s three and four in 2024.

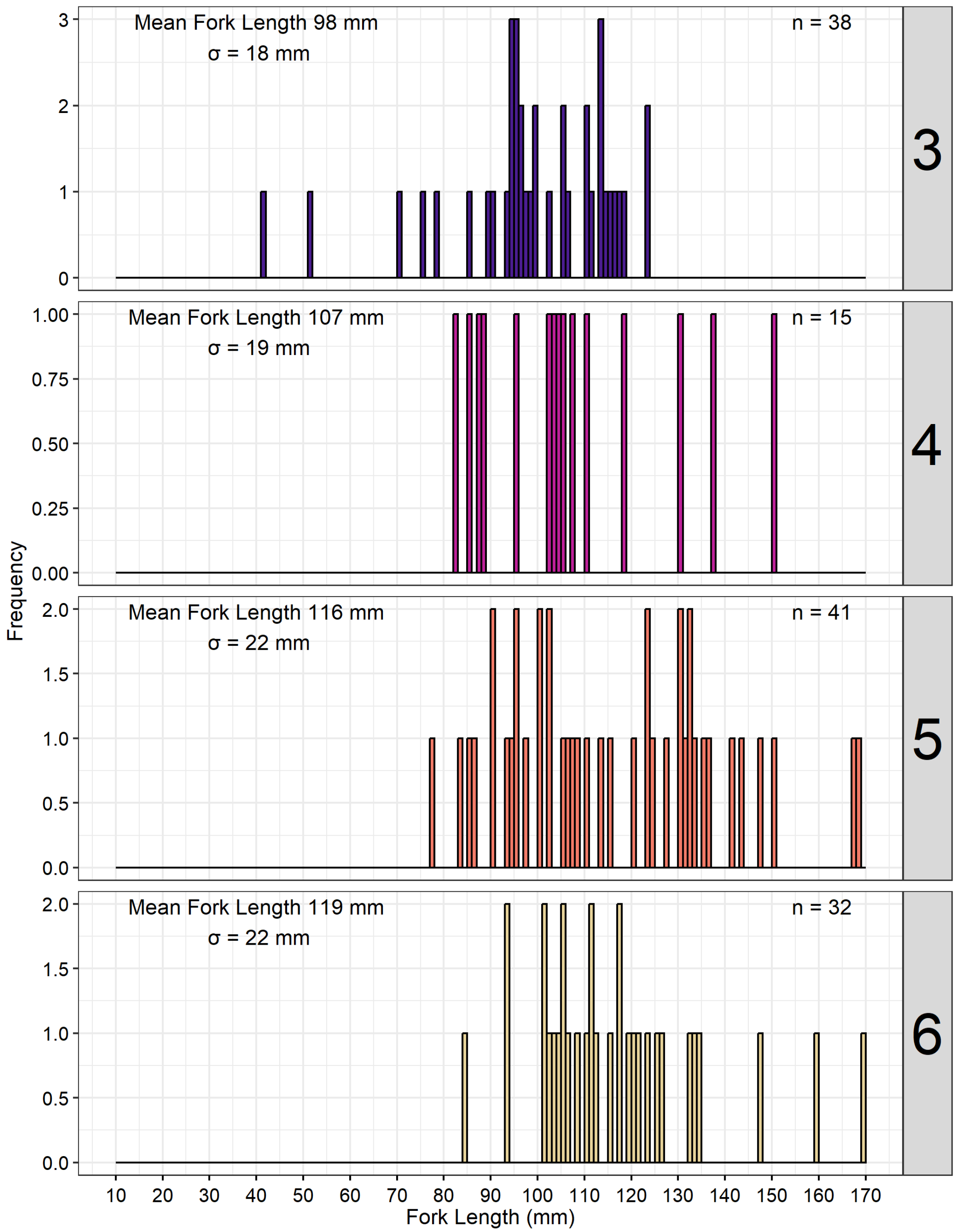


Figure 31. Fork length (mm) frequency histograms for age-0 Striped Bass among monthly surveys in 2024. Survey number (right panel), number of fish (n), mean fork length (mm), and fork length standard deviation (σ), are displayed on each histogram.

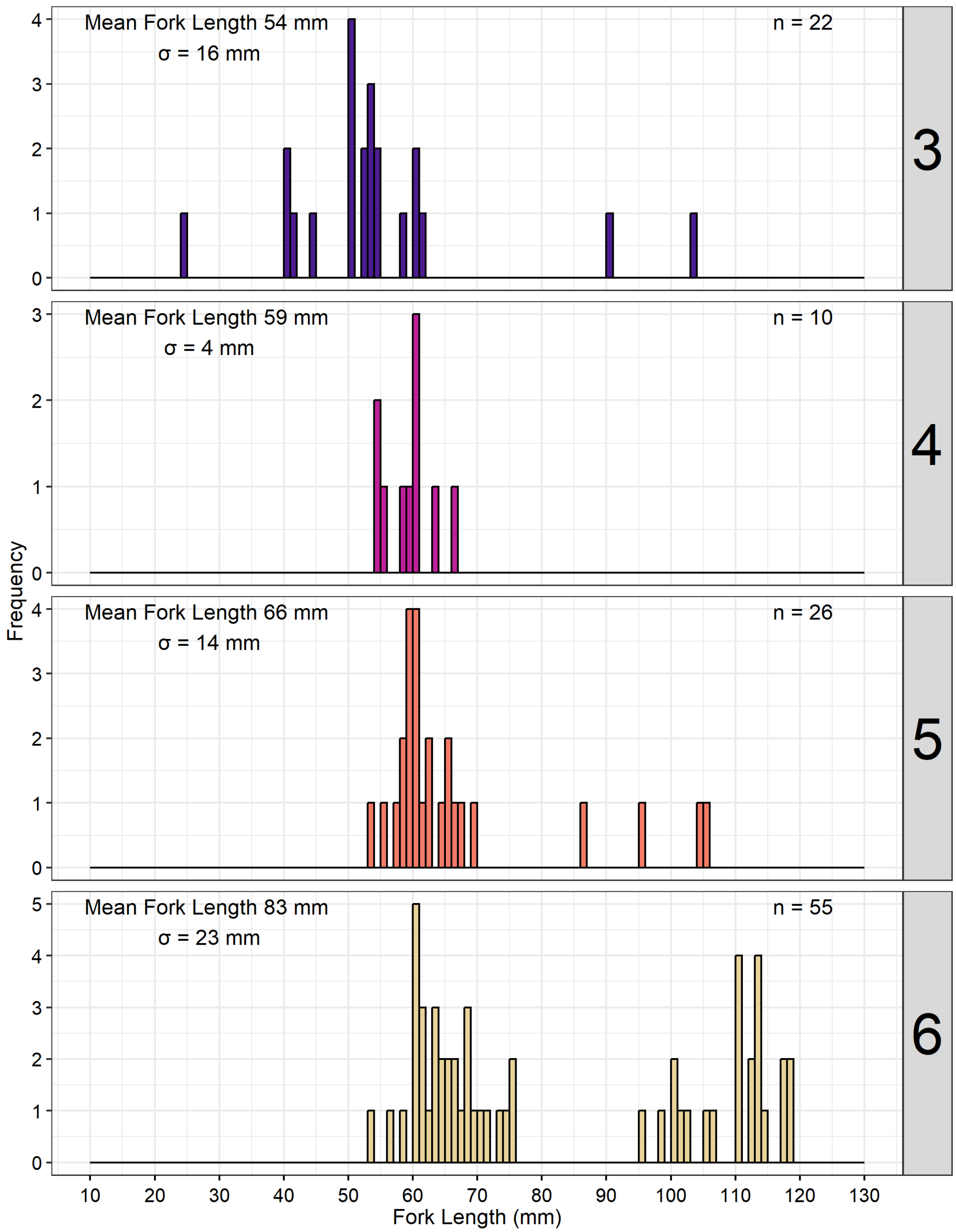


Figure 32. Fork length (mm) frequency histograms for Longfin Smelt among monthly surveys in 2024. Survey number (right panel), number of fish (n), mean fork length (mm), and fork length standard deviation (σ), are displayed on each histogram.

Invertebrates

For analysis and data visualization purposes, macro-invertebrate catch is divided into two groups. The first group being jellyfish (phyla: Cnidaria & Ctenophora) and the second group being crustaceans (subphylum Crustacea). *Maeotias marginata* constituted the largest amount of total catch for the jellyfish (Table 3, Figure 33). This introduced species prefers lower salinities and warmer water. Catch numbers tapered off in November and there was no detection in December. Native *Polyorchis penicillatus* (red-eye jellyfish) and *Pleurobrachia bachei* (Pacific sea gooseberry) were caught in low abundance during the December survey. Two moon jellies (*Aurelia aurita*) were caught in 2024 as well, much to the delight of the crew onboard.

Among crustaceans, native *Crangon* spp. shrimp were the most caught crustaceans (Table 4), the FMWT only identifies to Genus for these shrimps. These shrimps typically have a distribution that is limited to marine and brackish environments. The highest *Crangon* spp. catch occurred at station 335 (East San Pablo Bay) in September (Figure 34). *Exopalaemon modestus* (Siberian Prawn) constituted the second largest total catch for shrimp. This introduced species prefers lower salinities and was the dominant crustacean at most FMWT freshwater to brackish stations (Figure 34). The highest catch for this species occurred at station 797 in the SDWSC in September. *Palaemon macrodactylus* shrimp, another introduced species, were the third most captured crustacean. The detection of these shrimps was highest during the September survey and was lowest during the November survey (Table 4). Two *Upogebia pugettensis* were captured in September survey this year, a welcome surprise to crew onboard. No crabs were collected in 2024.

Table 3: Total monthly jellyfish catch during the 2024 FWMT season.

Species	Origin	September	October	November	December	Total	Total %
Maeotias marginata	Introduced	4372	1942	26	0	6340	99.5
Polyorchis spp.	Native	0	0	0	21	21	0.3
Pleurobrachia spp.	Native	0	0	0	11	11	0.2
Aurelia aurita	Native	0	1	0	1	2	<0.1
Total		4372	1943	26	33	6374	

Table 4: Total monthly crustacean catch during the 2024 FWMT season.

Species	Origin	September	October	November	December	Total	Total %
Crangon spp.	Native	6490	216	381	146	7233	53.4
Exopalaemon modestus	Introduced	3117	1811	995	351	6274	46.3
Palaemon macrodactylus	Introduced	37	2	0	9	48	0.4
Upogebia pugettensis	Native	2	0	0	0	2	<0.1
Total		9646	2029	1376	506	13557	

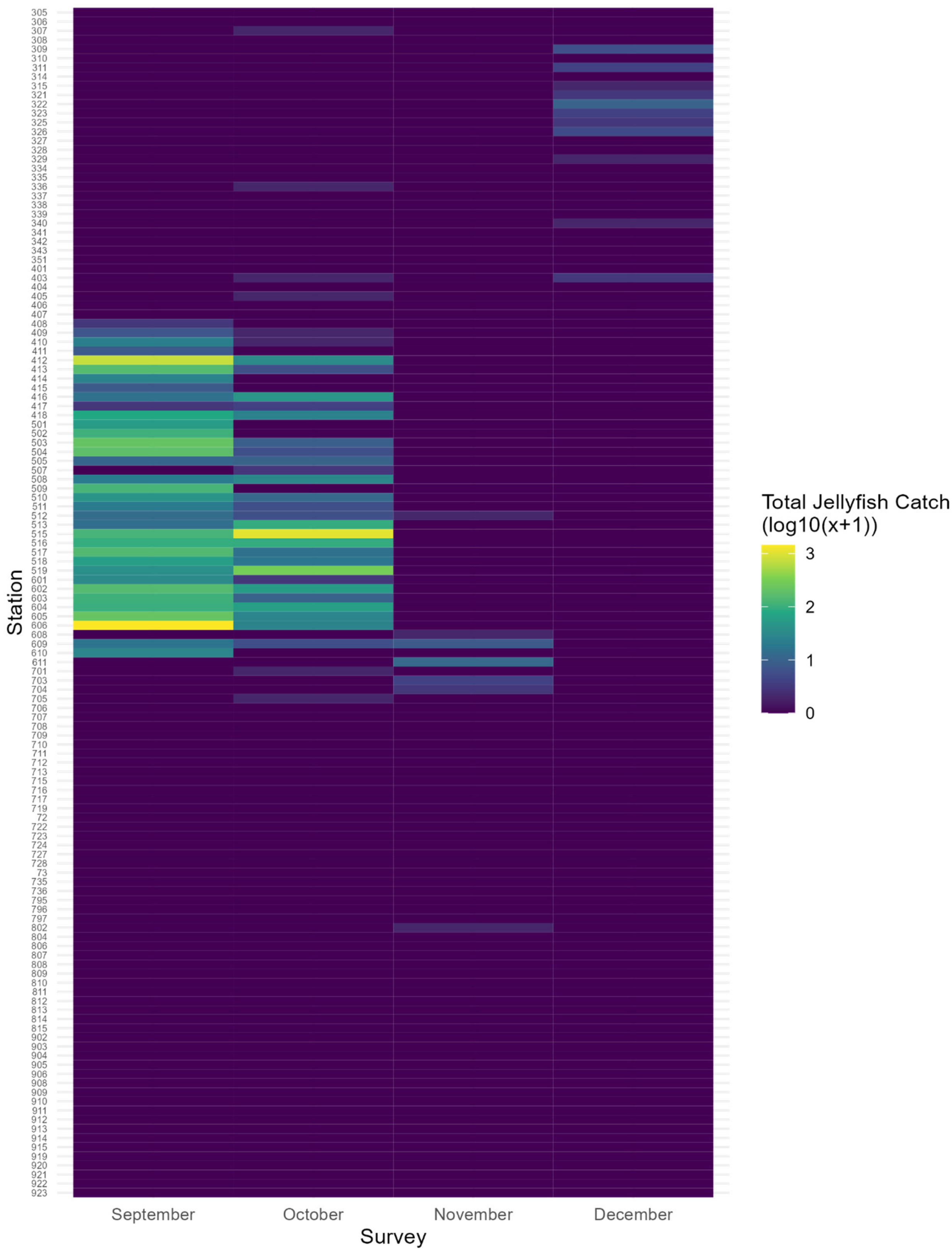


Figure 33. Heatmap of Log10(x+1) total jellyfish catch by station recorded during the 2024 FMWT season.

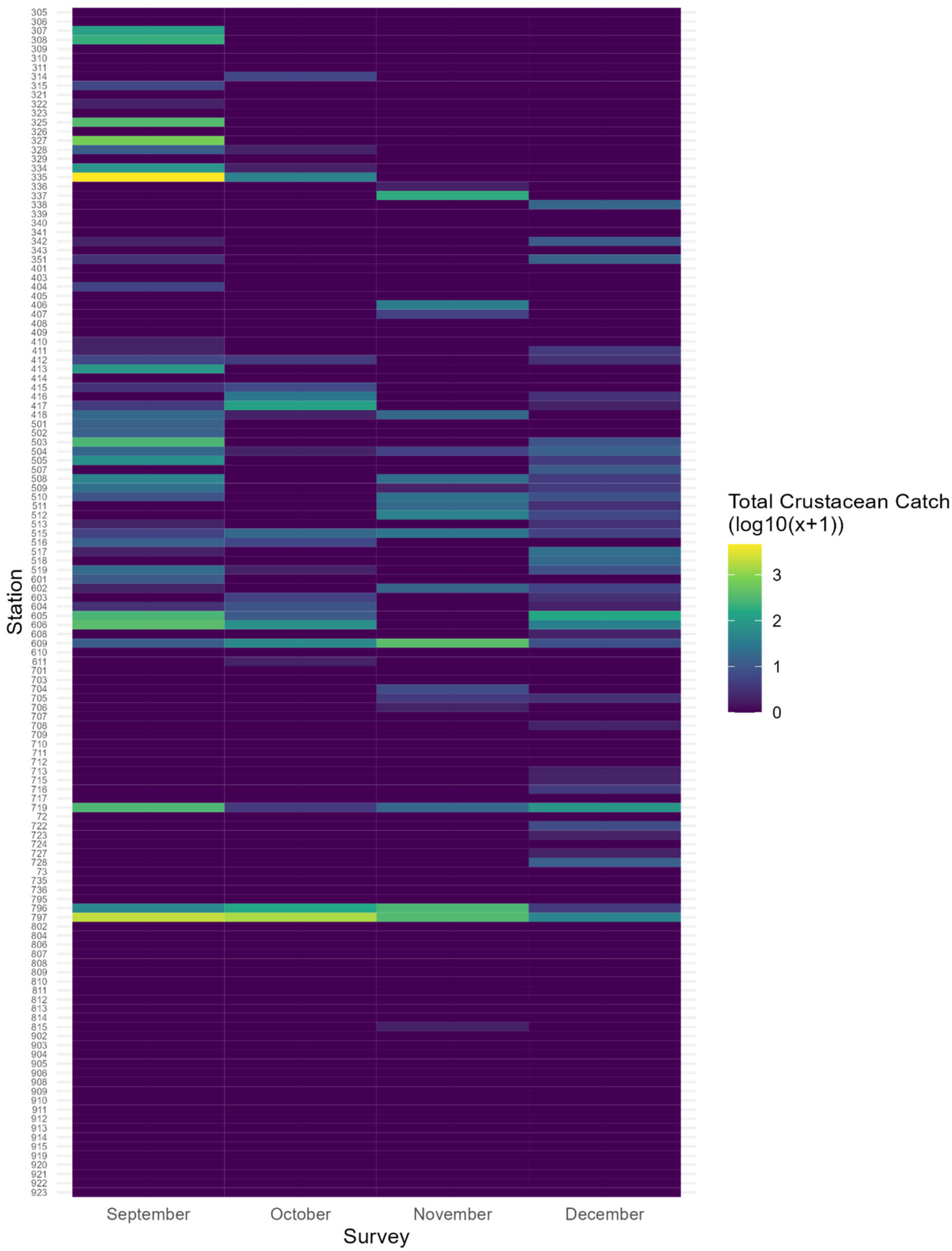


Figure 34. Heatmap of Log10(x+1) total crustacean catch by station recorded during the 2024 FMWT season.

Acknowledgments

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