Morro Bay Watershed Creek Health Memo
For Water Year 2024

Date Range: Water Year 2024 (October 1, 2023 to September 30, 2024)
Analytes: Temperature, Nitrate as Nitrogen (NO_3-N), Orthophosphate as Phosphorus (PO_4-P), Dissolved Oxygen, pH

1. Background

The Morro Bay National Estuary Program (Estuary Program) conducts monitoring in the Morro Bay estuary and surrounding watershed to track ambient water quality trends and to assess the impacts of specific implementation projects.

Estuary Program staff and volunteers collect data under the guidance of a Quality Assurance Project Plan (QAPP) which is reviewed and approved by EPA and the Central Coast Regional Water Quality Control Board (CCRWQCB). This QAPP document contains the monitoring locations, protocols, equipment specifications, and other details that allow users to assess the quality of the collected data. The full QAPP document is available at https://www.mbnep.org/qapp/.

2. Water Temperature

Water temperature plays a critical role in aquatic ecosystem health. For sensitive wildlife like the South-Central California Coast steelhead (*Oncorhynchus mykiss*), temperature has a direct impact on growth, reproduction, and survival potential. Elevated temperatures, especially those that are sustained for long periods of time, may impede the ability of *O. mykiss* to complete their lifecycle.

The Estuary Program monitors continuous water temperature in the Chorro Creek subwatershed to assess how frequently water temperature conditions are supportive of *O. mykiss*.

2.1 Equipment Specifications

The Estuary Program deploys HOBO TidbiT MX 2203 temperature data loggers at sites throughout the watershed (Section 2.2). These loggers monitor daily fluctuations and seasonal trends of creek water temperature. Loggers are deployed year-round and are programmed to collect readings at 30-minute intervals.

Specifications for the TidbiT temperature loggers are as follows:

Specification	Value
Measurement/Operating Range	-20° to 70 °C in air -20° to 50 °C in water
Accuracy	±0.25°C from -20° to 0 °C ±0.2°C from 0° to 70 °C
Resolution	0.01°C

While the TidbiT temperature loggers do not require calibration, staff collect independent temperature measurements from a secondary meter during deployment and retrieval. Additional measurements are collected periodically throughout deployments for quality assurance.

2.2 Monitoring Locations

The Estuary Program monitored continuous temperature at six sites in the Chorro Creek subwatershed (Figure 1) during WY2024. Three of the six monitoring sites are located along the mainstem of Chorro Creek, which is known to support *O. mykiss*. Historical data indicates elevated temperatures on Chorro Creek above levels preferred by these sensitive fish. The remaining sites were chosen along three tributaries to Chorro Creek: Pennington Creek, San Luisito Creek, and Dairy Creek. These tributaries have historically provided spawning grounds for *O. mykiss*.

Continuous Temperature Monitoring Sites for WY2024

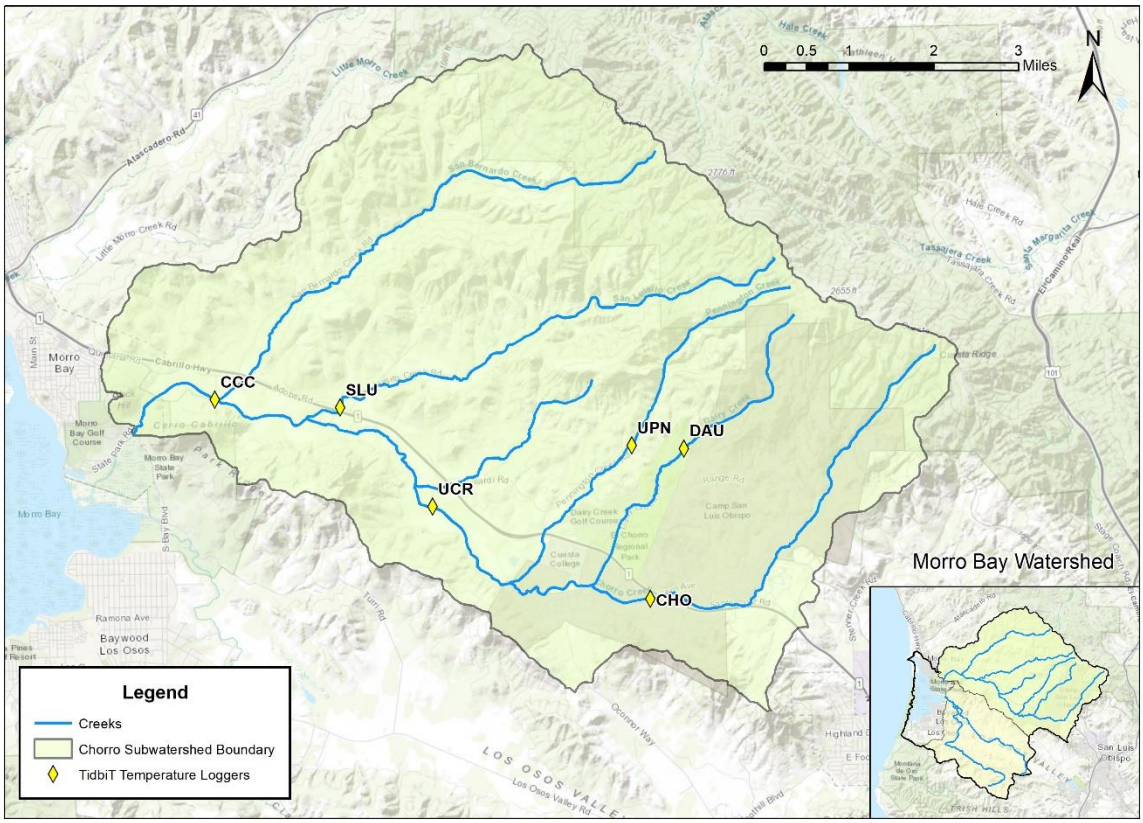

Figure 1. *Continuous temperature monitoring sites in the Chorro Creek subwatershed during WY2024.*

2.3 Results

Research has shown that prolonged exposure to temperatures above 18 °C can negatively impact *O. mykiss* reproduction, growth, migration timing, stress levels, and survival (Moyle 2002). This 18 °C temperature threshold was selected based on research that identified the optimal temperature range for *O. mykiss* as between 13 and 21 °C.

The following graphs illustrate water temperatures for the entire water year, color coded by season[1]. The multi-colored line indicates water temperature in degrees Celsius (°C) recorded at 30-minute intervals, and the horizontal red line indicates the 18 °C threshold protective of sensitive species.

Chorro Creek

Water temperature data was collected at three sites along Chorro Creek:

- Chorro Creek at Camp San Luis Obispo (site code CHO): This is the uppermost monitoring site, located at Camp San Luis Obispo at the Highway 1 bridge.

[1] Dates used to define the WY2024 seasons can be found in Appendix B.

- Chorro Creek at Upper Chorro Reserve (UCR): This site is downstream of the California Men's Colony wastewater treatment plant outfall and just upstream of the Chorro Creek Ecological Reserve.
- Chorro Creek at Chorro Creek Road (CCC): This is the furthest downstream site, located immediately upstream of Chorro Flats. It is above the zone of tidal influence from the bay.

Camp San Luis Obispo

The following graph (Figure 2) shows water temperature at Chorro Creek near Camp San Luis Obispo (CHO). After experiencing technical issues with the temperature logger at the start of the water year, it was deployed on October 30, 2023 and remained active until April 24, 2024. Persistent technical issues prevented further data collection with this logger. However, an InSitu Level TROLL 700 pressure transducer and temperature sensor is co-located with the logger and had been used to fill in data gaps from the prior water year.

Specifications for the InSitu Level TROLL 700 are as follows:

Specification	Value
Measurement/Operating Range	-20 ° to 80 °C
Accuracy	±0.1 °C
Resolution	0.01 °C

Because the pressure transducer's specifications met the need of the project[2], temperature readings from this device were used to fill in missing data from October 1, 2023 to October 29, 2023 and from April 25, 2024 through the end of WY2024 (September 30, 2024). Nearly five months of overlapping readings between the two loggers were compared to verify that the temperature results were significantly similar before combining the two datasets. The overlapping readings were significantly correlated ($p<0.001$, $R^2=0.954$) and exhibited an average relative percent difference under 1.5% between the sensors.

[2] The InSitu Level TROLL 700 and Level TROLL 500 have a temperature accuracy of ±0.1 °C and a resolution of 0.01 °C, while the TidbiT MX2203 loggers have a temperature accuracy of ±0.2 °C and a resolution of 0.01 °C.

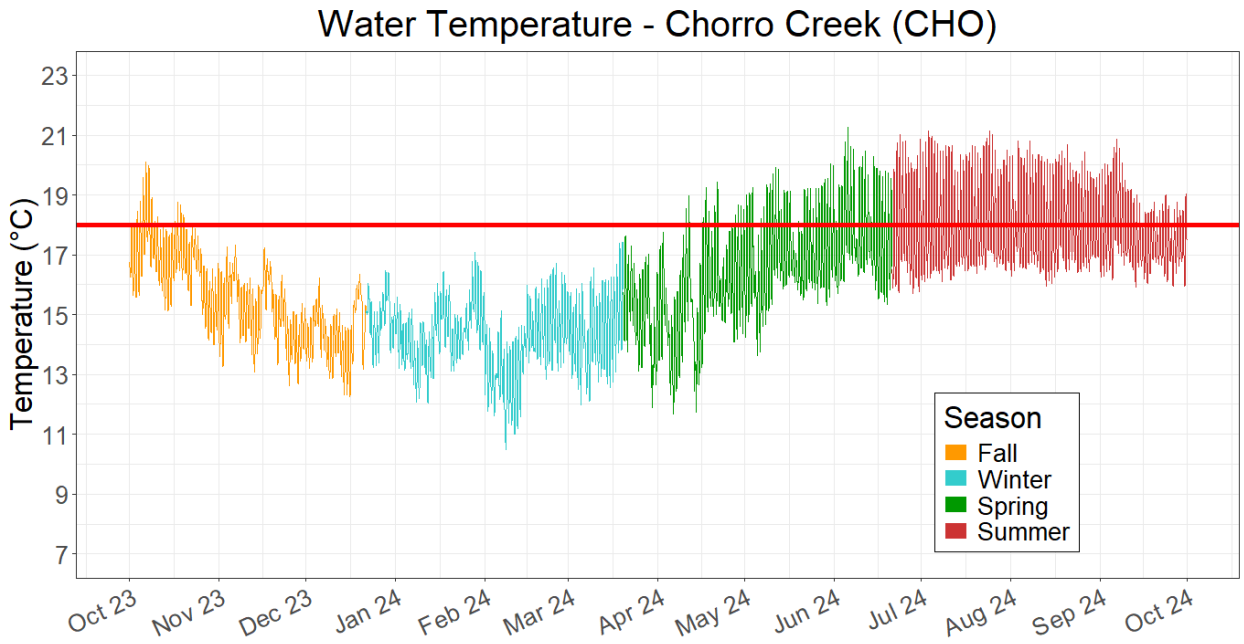

Figure 2. *Water temperature at Chorro Creek (CHO) during WY2024, colored by season. Missing TidbiT data was supplemented with data from an InSitu Level TROLL 700 pressure transducer located at the same site from October 1, 2023 to October 29, 2023 and April 25, 2024 through the end of WY2024.*

Upper Chorro Reserve

The following graph (Figure 3) shows water temperature at Chorro Creek upstream of the Chorro Creek Ecological Reserve (UCR). The temperature logger at UCR was deployed for the entirety of WY2024 (October 1, 2023 - September 30, 2024).

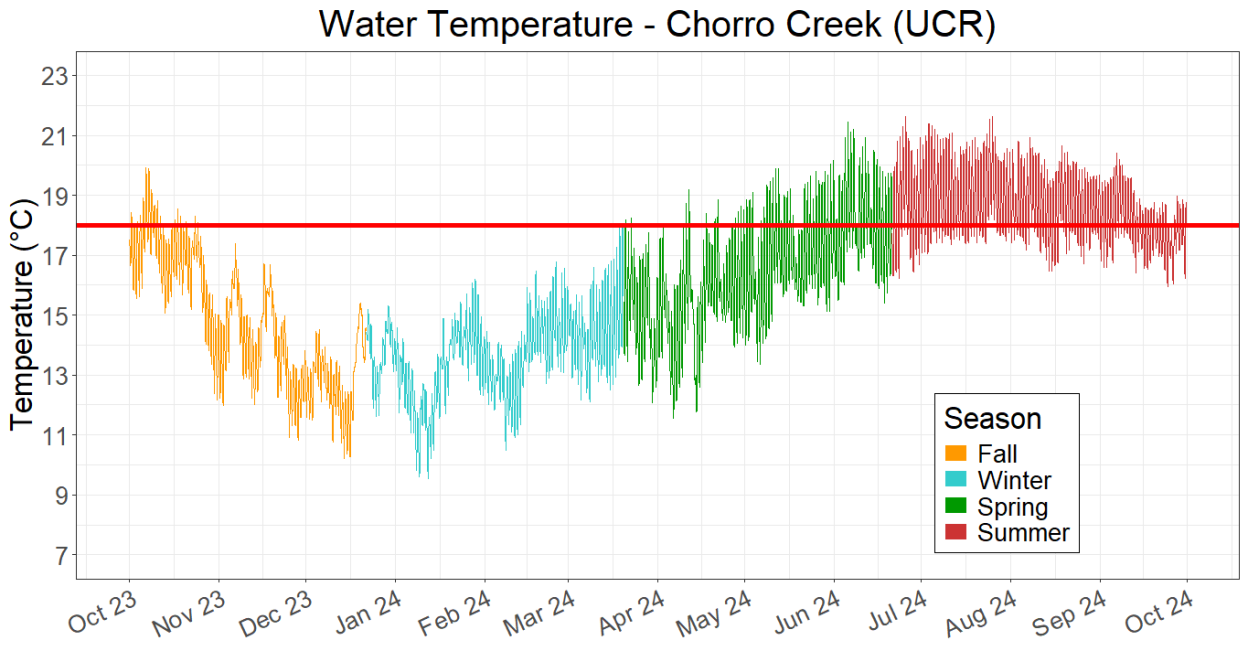

Figure 3. *Water temperature at Chorro Creek (UCR) during WY2024, colored by season.*

Chorro Creek Road

The following graph (Figure 4) shows water temperature at Chorro Creek near Chorro Creek Road (CCC). The temperature logger at CCC experienced three short data gaps, all due to rainfall events that had displaced the logger, leaving it exposed to the air as the water level in the creek returned to its typical height. The logger was interrupted from October 3, 2023 to October 25, 2023, from February 20, 2024 to February 28, 2024, and from March 30, 2024 to April 13, 2024. After this last storm event, the logger remained active until the end of WY2024 (September 30, 2024). All data gaps were filled with temperature data from an Insitu Level TROLL 500 pressure transducer located near the logger. The Level TROLL 500 model has the same specifications as those listed for the Level TROLL 700 model. Nearly seven months of overlapping readings between the two loggers were compared to verify that the temperature results were significantly similar before combining the two datasets. The overlapping readings were significantly correlated ($p<0.001$, $R^2=0.961$) and exhibited an average relative percent difference of 1.8% between the sensors.

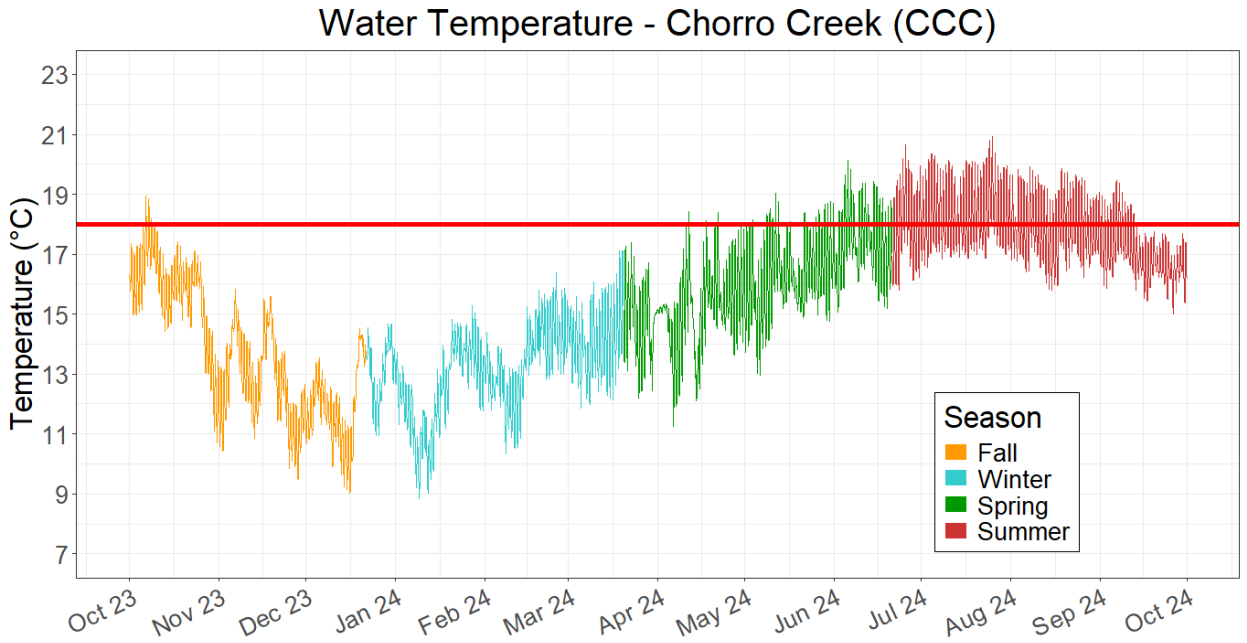

Figure 4. *Water temperature at Chorro Creek (CCC) during WY2024, colored by season. Missing TidbiT data was supplemented with data from an InSitu Level TROLL 500 pressure transducer located at the same site from October 3, 2023 to October 25, 2023 and February 20, 2024 to February 28, 2024 and March 30, 2024 to April 13, 2024.*

Chorro Creek Tributaries

Water temperature data was collected from three tributaries to Chorro Creek:

- San Luisito Creek (SLU): This site is located on Adobe Road, about 0.5 miles upstream of the confluence with Chorro Creek.
- Pennington Creek (UPN): This site is located about 2.5 miles upstream of the confluence with Chorro Creek, upstream of the former Rancho El Chorro Outdoor School campus and near the Cal Poly Beef Center at Escuela Ranch.
- Dairy Creek (DAU): This site is located within El Chorro Regional Park, approximately 2 miles upstream of the confluence of Dairy and Chorro Creeks.

San Luisito Creek

The following graph (Figure 5) shows water temperature at San Luisito Creek at Adobe Road (SLU) during WY2024. The temperature logger at SLU was deployed from the start of WY2024 (October 1, 2023) until February 21, 2023. Due to two storm events that displaced the logger, leaving it on the creek bank as water levels fell, there are data gaps from February 22, 2024 to February 26, 2024 and from March 9, 2024 to March 26, 2024. After the logger was replaced on March 26, 2024, it was active until the end of WY2024 (September 30, 2024).

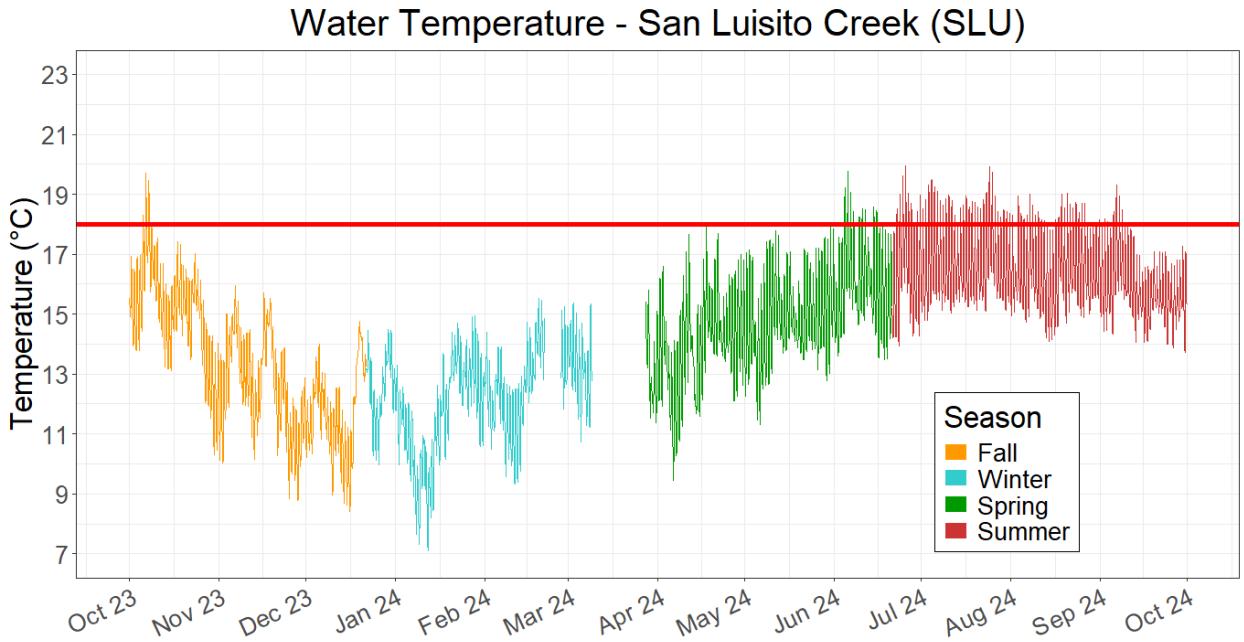

Figure 5. *Water temperature at San Luisito Creek (SLU) during WY2024, colored by season. Data was not available from February 22, 2024 to February 26, 2024 and March 9, 2024 to March 26, 2024.*

Pennington Creek

The following graph (Figure 6) shows water temperature at Pennington Creek on Escuela Ranch (UPN) during WY2024. The temperature logger at UPN was deployed for the entirety of WY2024 (October 1, 2023 - September 30, 2024).

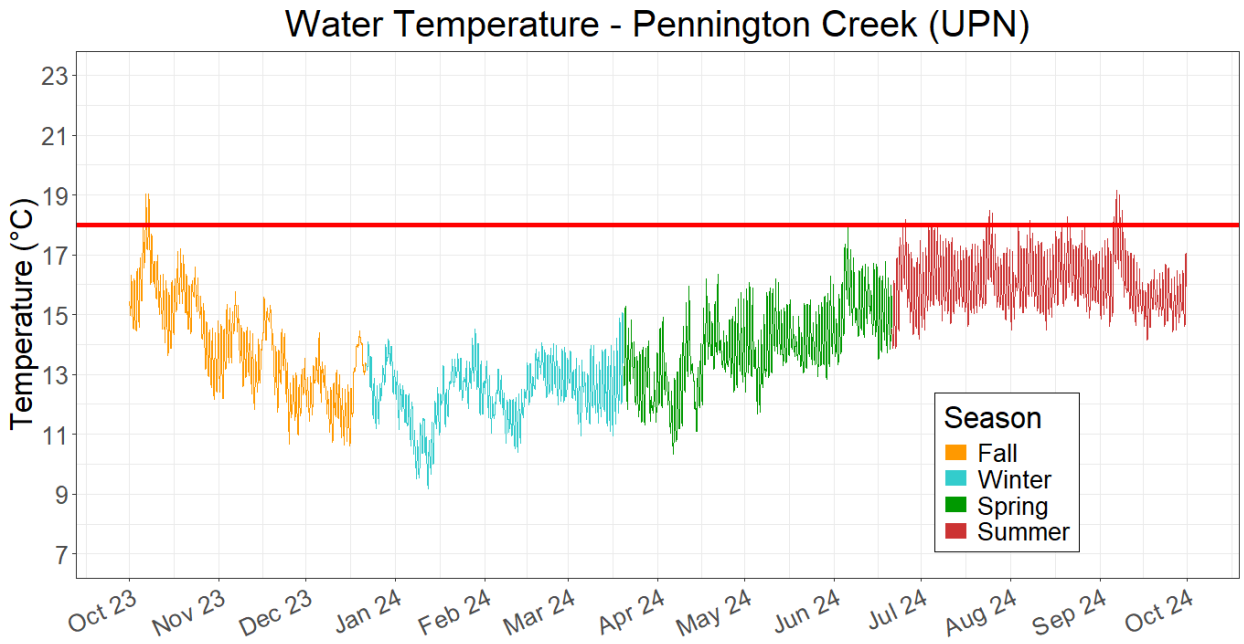

***Figure 6**. Water temperature at Pennington Creek (UPN) during WY2024, colored by season.*

Dairy Creek

The following graph (Figure 7) shows water temperature at upper Dairy Creek above El Chorro Regional Park (DAU) during WY2024. The temperature logger at DAU was deployed for the entirety of WY2024 (October 1, 2023 - September 30, 2024). This is the first time we have a full year of temperature data at DAU since its initial deployment in 2018. Higher than average rainfall during WY2023 and WY2024 prevented this site from becoming dry and disconnected.

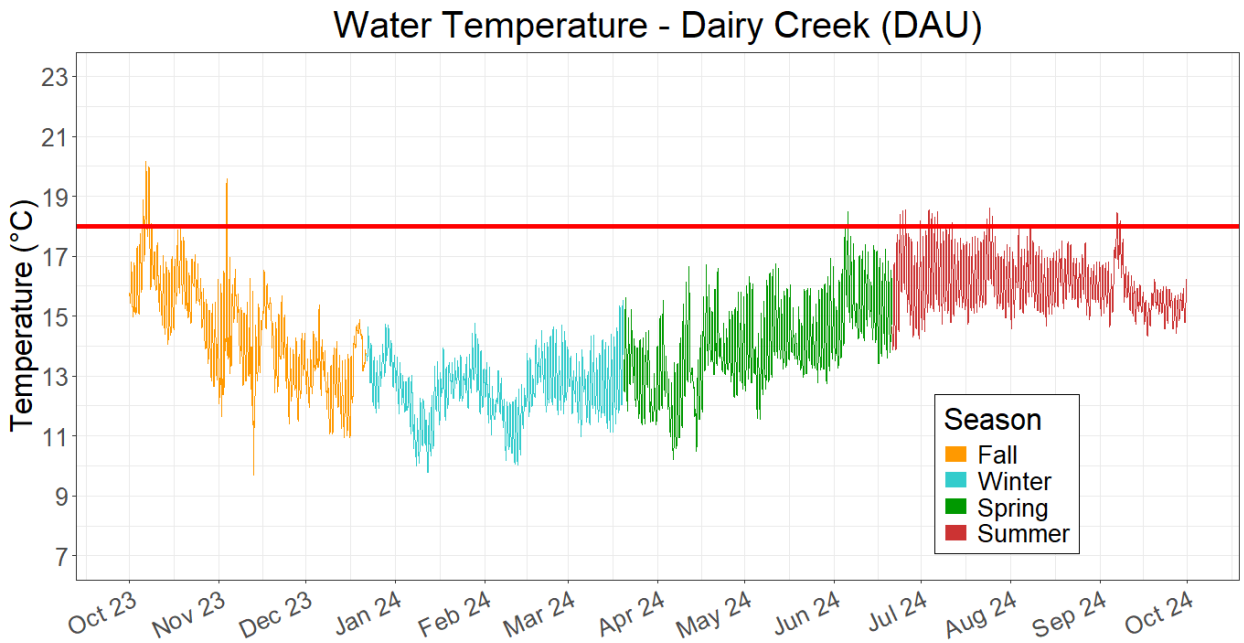

***Figure 7.** Water temperatures at Dairy Creek (DAU) during WY2024, colored by season.*

2.4 Discussion

Water temperature results from WY2024 were analyzed using a variety of metrics. First, percent exceedance was calculated to see how frequently water temperature was higher than 18 °C at each site. Exceedance was calculated for the entire deployment period of the logger, which varied by site, and on a seasonal basis (Table 1). Because deployment periods for each logger varied, percent exceedance for each site cannot be directly compared between sites. Deployment periods for each temperature logger are outlined in Appendix A.

Table 1. Percent exceedance of the 18 °C threshold for sensitive species at each monitoring site for WY2024. The deployment periods vary based on site locations.

Timeframe	CHO	UCR	CCC	UPN	DAU	SLU
Full Deployment Period	16.2%	24.6%	13.2%	0.8%	1.2%	4.3%
Fall	4.4%	6.3%	1.0%	1.0%	2.0%	1.3%
Winter	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
Spring	16.7%	20.0%	9.7%	0.0%	0.2%	2.0%
Summer	39.5%	65.1%	37.5%	2.1%	2.6%	11.9%
Total days deployed in WY2024	337[2]	366	322[2]	366	366	343

The U.S. Environmental Protection Agency (EPA) set forth water temperature criteria in the 1986 Quality Criteria for Water (also known as the "Gold Book"), where it recommends the use of a maximum weekly average temperature (MWAT) as an index for assigning protective temperature standards for fisheries. The MWAT is the highest single temperature value of the seven-day moving average. This index is calculated relative to an upper limit, such as the 18 °C threshold mentioned previously.

Despite being a standard outlined by the EPA, several case studies have found the MWAT to be inadequately protective (McCullough, 2010). Because high daily maximum temperatures are often accompanied by low daily minimums, averages may remain relatively constant even if the daily maxima are much higher than ideal (Beschta et al. 1987). For a more protective metric, the maximum weekly maximum temperature (MWMT), also known as the seven-day average of the daily maximum temperatures (7-DADM), has been adopted more recently in some watersheds for assessing temperature regimes. The MWMT is defined as the maximum seasonal or yearly value of the daily maximum temperatures over a running seven-day consecutive period (Welsh et al., 2001).

In addition to percent exceedance of the 18 °C threshold, both MWAT and MWMT were calculated monthly to further assess thermal suitability for sensitive species. These values were compared to thermal thresholds for salmon and trout life stages, as designated by the EPA (Table 2).

Table 2. *Maximum weekly average temperatures (MWAT) and maximum weekly maximum temperatures (MWMT) for monitoring sites during WY2024. Salmon and trout life stage thresholds adapted from EPA, 2003.*

Maximum Weekly Average Temperature (MWAT) - WY 2024												
Site	Oct '23	Nov '23	Dec '23	Jan '24	Feb '24	Mar '24	Apr '24	May '24	Jun '24	Jul '24	Aug '24	Sep '24
CHO	17.7	15.8	15.1	15.1	14.8	15.5	16.3	17.3	18.0	18.3	18.2	18.2
UCR	18.0	15.1	14.2	14.4	14.6	15.6	16.1	17.4	18.8	19.3	19.0	18.7
CCC	17.0	13.9	13.4	13.9	14.5	15.2	15.8	16.8	18.1	18.6	18.1	17.7
UPN	16.8	14.3	13.4	13.0	13.2	13.3	14.2	14.4	16.0	16.5	16.5	16.8
DAU	17.2	14.8	13.8	13.0	13.1	13.4	14.2	14.5	16.2	16.6	16.3	16.6
SLU	16.7	13.8	13.1	13.2	13.9	13.3	14.9	15.2	16.7	17.0	16.7	16.6

Maximum Weekly Maximum Temperature (MWMT) - WY 2024												
Site	Oct '23	Nov '23	Dec '23	Jan '24	Feb '24	Mar '24	Apr '24	May '24	Jun '24	Jul '24	Aug '24	Sep '24
CHO	19.1	16.8	15.8	16.3	16.3	17.2	18.4	19.5	20.5	20.8	20.4	20.3
UCR	19.1	16.0	14.8	15.6	16.1	17.8	18.1	19.8	20.9	21.1	20.5	19.9
CCC	18.1	14.7	13.9	14.7	15.8	17.0	17.5	18.5	19.9	20.3	19.7	19.0
UPN	17.8	15.1	13.9	13.7	13.9	14.7	15.4	15.7	17.4	17.8	17.8	18.2
DAU	18.5	16.8	14.4	14.0	14.4	15.1	15.8	16.3	17.9	18.2	17.5	17.5
SLU	18.2	15.0	13.8	14.3	15.1	14.7	16.6	17.5	19.0	19.1	18.7	18.5

	> 20°C, Exceeds EPA Threshold for Salmon/Trout Migration
	> 18°C, Exceeds EPA Threshold for Salmon/Trout Migration plus Non-Core Juvenile Rearing
	> 16°C, Exceeds EPA Threshold for Salmon/Trout "Core" Juvenile Rearing
	> 14°C, Exceeds EPA Threshold for Steelhead Smoltification
	> 13°C, Exceeds EPA Threshold of Salmon/Trout Spawning and Egg Incubation
	< 13°C, EPA Optimal Range for Salmon/Trout Egg Incubation
-	= insufficient data

Table 2 illustrates how MWMT is a more protective metric than MWAT. All temperature monitoring sites show elevated summer temperatures that exceeded a MWMT of 18 °C for at least one month, including the tributaries to Chorro Creek. The MWAT table similarly shows elevated temperatures during this time, however only the mainstem sites crossed the 18 °C threshold. For the first time since tracking of MWAT and MWMT began in WY2021, none of the sites had values that could support all salmonid life stages (<13 °C) during the winter months. This is likely due to the 2023 to 2024 El Niño event, regarded as the fifth most powerful on record, which lasted from June 2023 to March 2024 (WMO 2024). El Niño events are characterized by warm and wet conditions, which would have contributed to a notably warmer winter in WY2024 than in previous years (Figure 8).

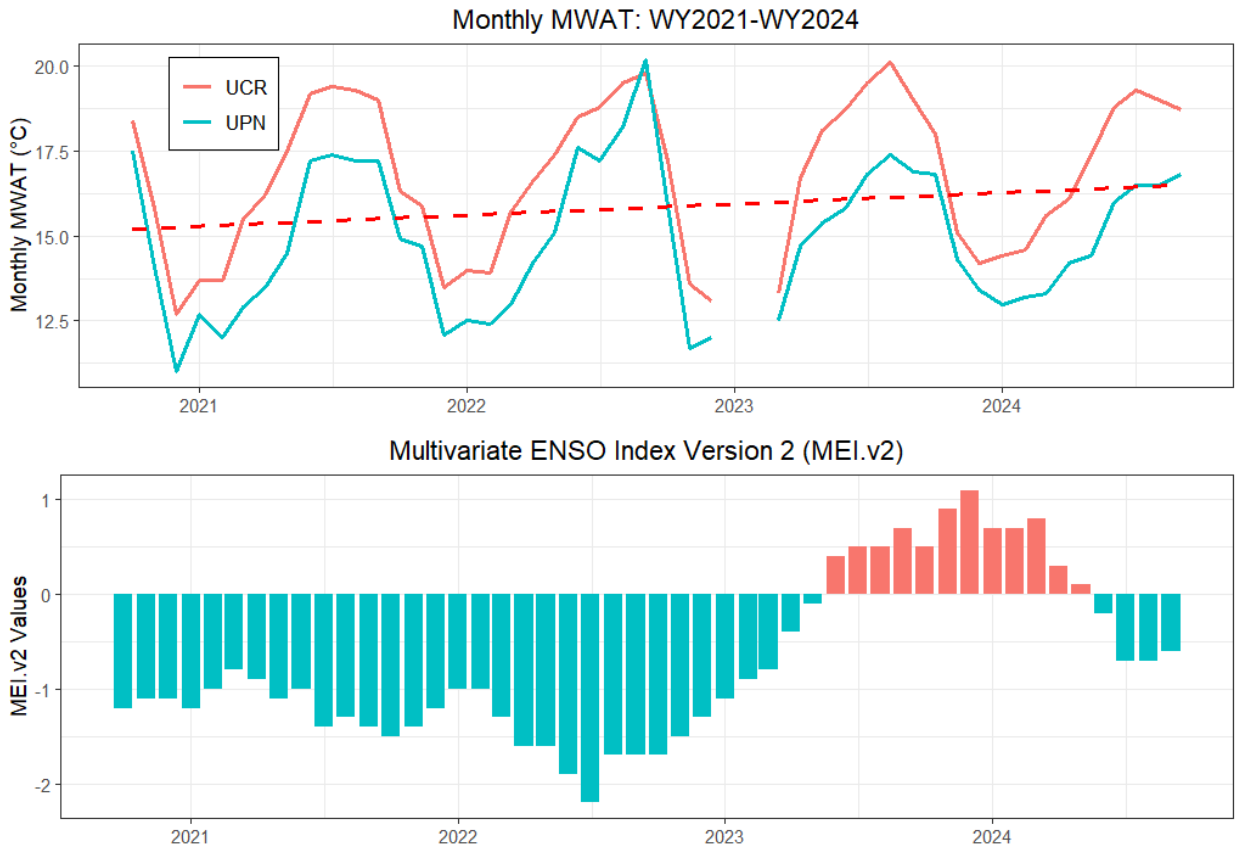

Figure 8. *(Top) Monthly MWAT values from WY2021 to WY2024 for the UCR (Chorro Creek mainstem) and UPN (Chorro Creek tributary) TidbiT temperature logger deployment sites. The dashed red line represents the regression line for MWAT over time. (Bottom) Monthly Multivariate ENSO Index version 2 (MEI.v2) values, representing El Niño severity by accounting for changes in temperature, pressure, and wind across the Pacific Ocean (NOAA 2025). Higher values (red bars) represent higher intensity El Niño events and lower values (blue bars) are more indicative of La Niña conditions.*

The highest MWAT and MWMT values from WY2024 occurred on Chorro Creek at UCR, which is located upstream of the Chorro Creek Ecological Reserve. This site has had frequent and sustained issues with elevated temperatures, potentially due to treated effluent from the wastewater treatment plant discharged upstream of the site.

3. Bimonthly Nutrient Monitoring

Nutrient impairment can lead to degraded water quality conditions and eutrophication, which can harm aquatic life and compromise ecosystem function. The Estuary Program assesses ambient nutrient concentrations throughout the Morro Bay watershed to identify long-term trends and prioritize restoration and conservation efforts. Staff collect samples for laboratory analysis for nitrate as nitrogen and orthophosphate as phosphorus every other month, or six times per year.

3.1 Analytical Specifications

The Estuary Program collects samples using standard sampling techniques. The samples are stored in the dark on ice and then delivered to a certified laboratory for analysis within the specified hold time. The analysis specifications are as follows:

Nitrate as Nitrogen (NO_3-N, mg/L):

Specification	Value
Method Number	SM 4500-NO3 F
Minimum Detection Limit	0.11 mg/L
Reporting Limit	0.4 mg/L
Hold Time	48 hours
Sample storage conditions	6 °C in the dark

Orthophosphate as Phosphorus (PO_4-P, mg/L):

Specification	Value
Method Number	EPA 365.1
Minimum Detection Limit	0.031 mg/L
Reporting Limit	0.1 mg/L
Hold Time	48 hours
Sample storage conditions	6 °C in the dark

The laboratory occasionally dilutes the sample prior to analysis if the nutrient concentrations are elevated, which impacts the minimum detection limit (MDL) and reporting limit (RL) for the results. For each result that is less than the RL, a random number between zero and the RL is generated and used for analysis[3].

3.2 Monitoring Locations

Eight sites were selected to represent Chorro and Los Osos Creeks and their respective tributaries (Figure 9). The sites include upper Chorro Creek (site code CHO), middle Chorro Creek (UCR), lower Chorro Creek (TWB), middle Dairy Creek (DAM), Pennington Creek (UPN), San Luisito Creek (SLU), Warden Creek (TUR), and upper Los Osos Creek (CLV).

[3] This is the same method utilized by the CCRWQCB to manage non-detects in their own analysis.

Morro Bay Watershed Bimonthly Nutrient Monitoring Sites

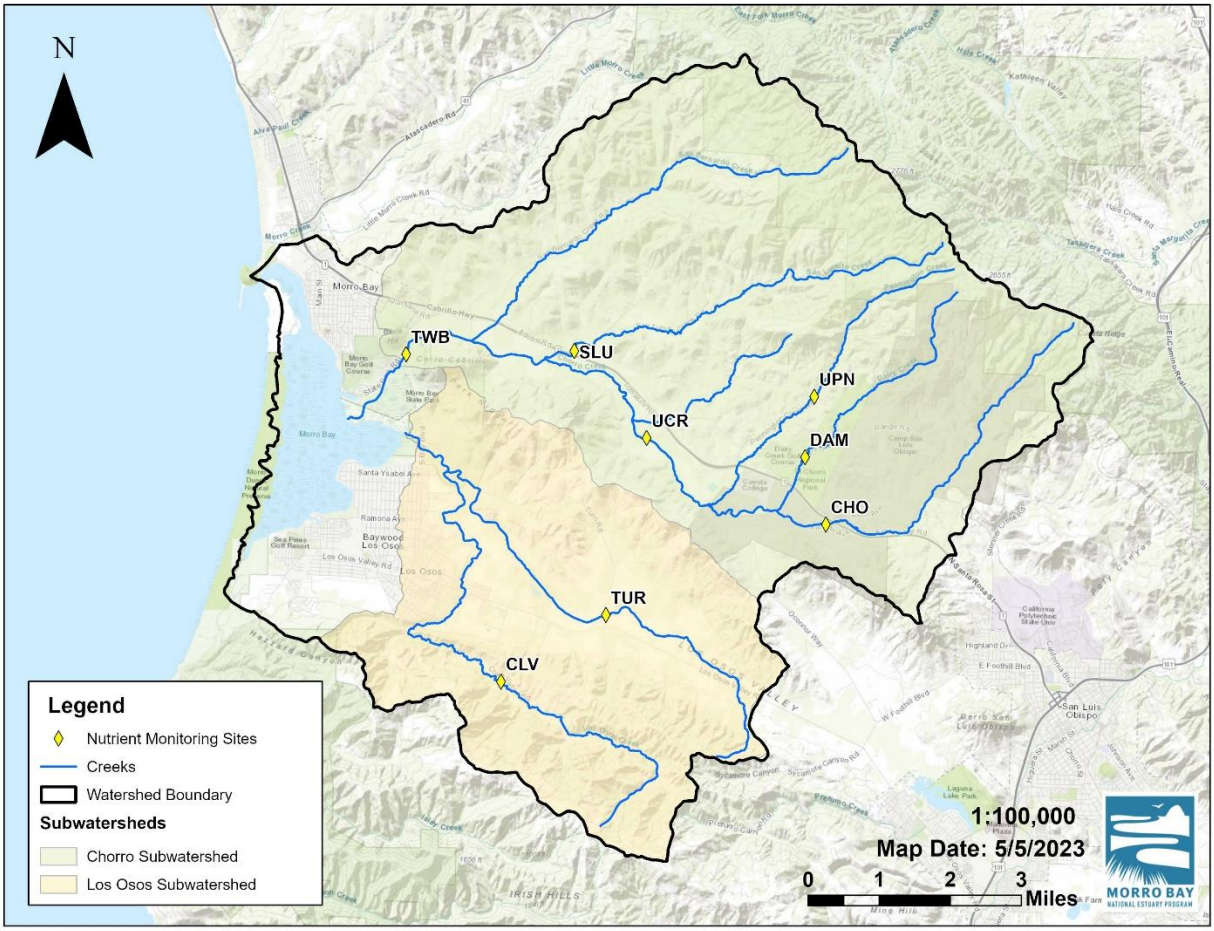

Figure 9. *Bimonthly nutrient monitoring locations in the Morro Bay watershed.*

3.3 Results

Nitrate as Nitrogen

Nitrate results are compared to two standards. In freshwater systems, a water body is considered to likely be impaired by nitrates if concentrations are greater than or equal to 1 mg/L as N. This is a 303(d) Listing Guidance Value utilized by the CCRWQCB and others to assess potential impairment when accompanied by other signs of ecological impact, such as widespread algal growth and excessively low or high dissolved oxygen concentrations. The EPA has a maximum contaminant level (MCL) of 10 mg/L NO_3-N for drinking water for protection of human health.

The Estuary Program assessment utilized the following scores:

Good	- for NO_3-N concentrations < 1 mg/L (protective of aquatic and human health)
Fair	- for NO_3-N concentrations ≥ 1 mg/L and < 10 mg/L
Poor	- for NO_3-N concentrations ≥ 10 mg/L (exceeds level protective of human health)

Figure 10 shows the average NO_3-N concentration for sites monitored in WY2024. The number of samples varies by site, as some sites go dry during the summer. For sites with year-round flow, this represents six readings.

Average Nitrate as Nitrogen (mg/L) Concentrations for WY2024

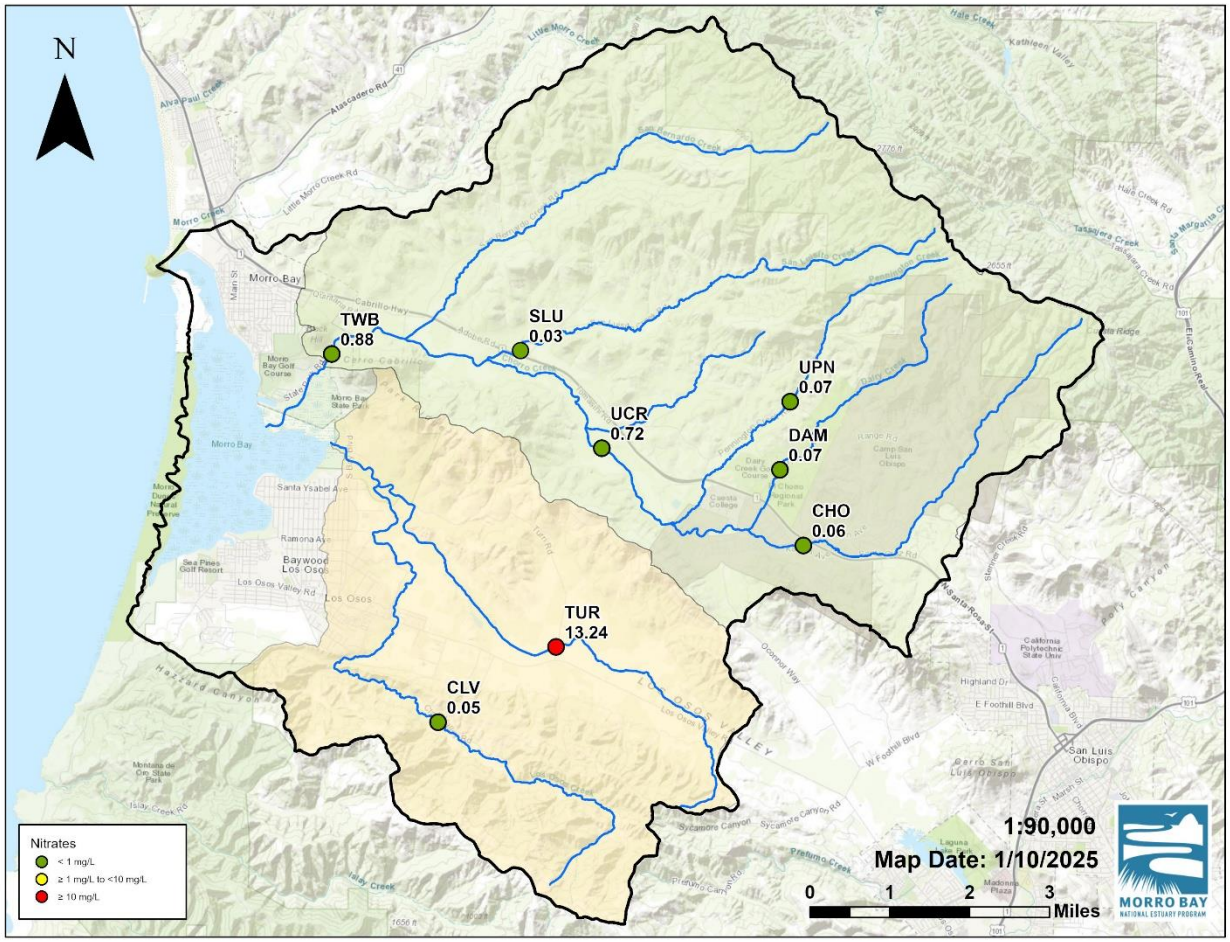

Figure 10. *Average NO_3-N concentrations for WY2024 at eight representative monitoring locations.*

Historical NO_3-N averages were compared to results from WY2024 (Table 3). Historical data includes nutrient monitoring data from WY2016 through WY2024. Values highlighted in green indicate concentrations which are protective of aquatic and human health (< 1 mg/L NO_3-N). Values highlighted in yellow indicate values that fall under the EPA MCL but are greater than CCRWQCB's level of protection of aquatic life (≥ 1 mg/L and < 10 mg/L NO_3-N). Values highlighted in red exceed the drinking water level protective of human health (≥ 10 mg/L NO_3-N). The relative percent difference (RPD) was then calculated to compare WY2024 data to historical data. Sites with higher RPDs indicate greater differences between WY2024 and historical data.

Table 3. *Historical NO3-N averages compared to WY2024 averages.*

	CHO	CLV	DAM	SLU	TUR	TWB	UCR	UPN
Historical Average, NO_3-N (mg/L)	0.11	0.08	0.06	0.12	12.17	0.76	1.91	0.08
WY2024 Average, NO_3-N (mg/L)	0.06	0.05	0.07	0.03	13.24	0.88	0.72	0.07
Relative Percent Difference (%)	50.6%	37.4%	20.6%	115%	8.4%	14.3%	90.8%	13.5%

Orthophosphate as Phosphorus

Orthophosphate as phosphorus (PO_4-P) results are compared to targets outlined in the Pajaro River nutrient objectives guidance document (Williamson 1994). A value of 0.12 mg/L is used for comparison since freshwater systems with concentrations less than 0.12 mg/L are considered to be at low risk for eutrophication, although there is no established value for the Morro Bay watershed. To date, there is no standard protective of human health for orthophosphates.

The Estuary Program assessment utilized the following scores:

Good	- for PO_4-P concentrations < 0.12 mg/L
Fair	- for PO_4-P concentrations ≥ 0.12 mg/L

Figure 11 shows the average PO_4-P concentrations for sites monitored in WY2024. The number of samples varies by site, as some sites go dry during the summer. For sites with year-round flow, this represents six readings.

Average Orthophosphate as Phosphorus (mg/L) Concentrations for WY2024

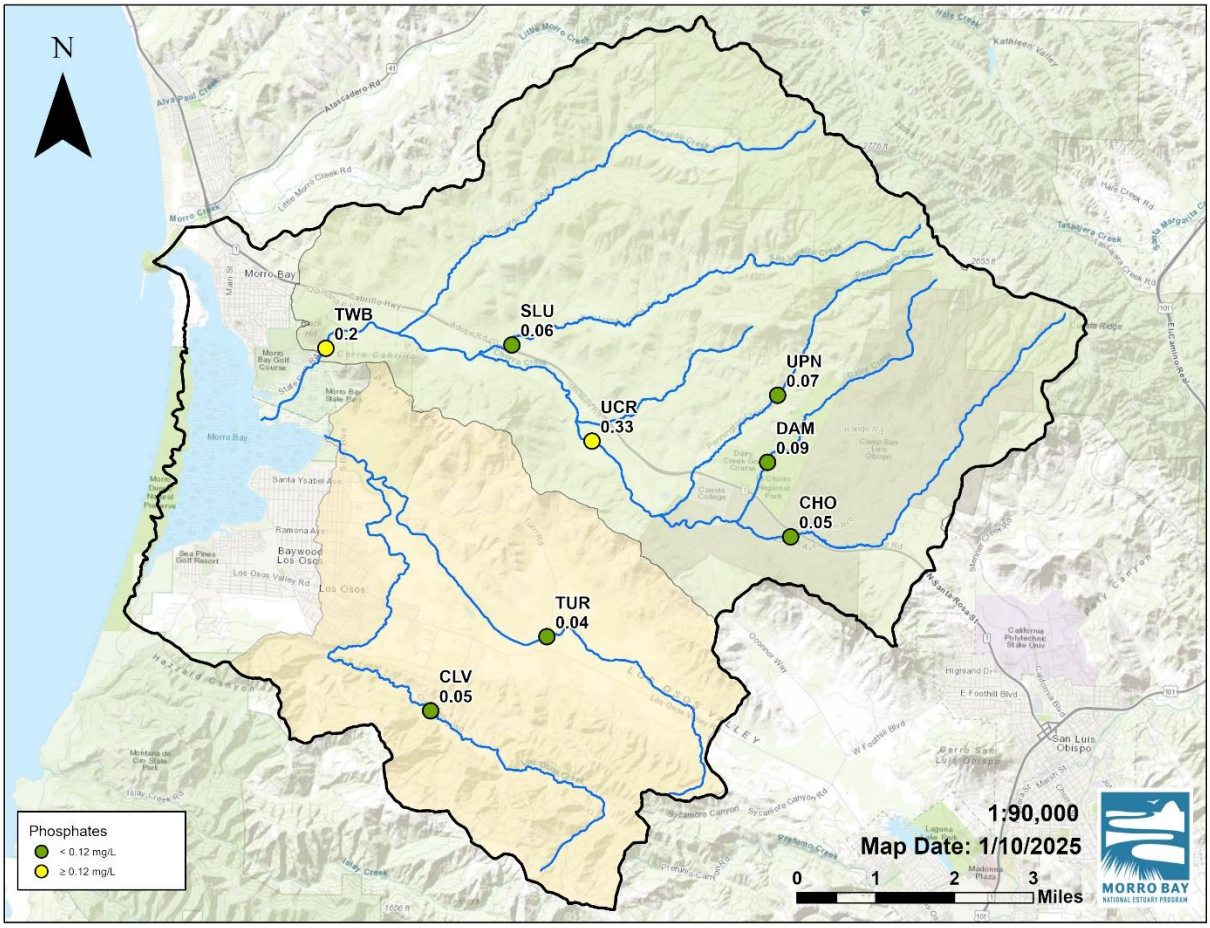

Figure 11. *Average PO_4-P concentrations for WY2024 at eight representative monitoring locations*

Historical PO_4-P averages were compared to results from WY2024 (Table 4). Historical data includes nutrient monitoring data from WY2016 through WY2024. Values highlighted in green indicate those that are at a low risk for eutrophication (< 0.12 mg/L PO_4-P). Values highlighted yellow are at a higher risk for eutrophication (≥ 0.12 mg/L PO_4-P). The RPD was then calculated to compare WY2024 data to historical data. Sites with higher RPDs indicate greater differences between WY2024 and historical data.

Table 4. *Historical PO_4-P averages compared to WY2024 averages.*

	CHO	CLV	DAM	SLU	TUR	TWB	UCR	UPN
Historical Average, PO_4-P (mg/L)	0.04	0.04	0.08	0.09	0.04	0.38	0.85	0.05
WY2024 Average, PO_4-P (mg/L)	0.05	0.05	0.09	0.06	0.04	0.20	0.33	0.07
Relative Percent Difference (%)	36.3%	20.3%	14.1%	44.1%	4.6%	63.2%	86.8%	40.9%

3.4 Discussion

Concentrations of PO_4-P are typically higher in the Chorro Creek subwatershed than in the Los Osos Creek subwatershed. Sites located along the mainstem of Chorro Creek, especially those downstream of the CA Men's Colony wastewater treatment plant, tend to exhibit higher PO_4-P concentrations than the surrounding tributaries. Chorro Creek at UCR, located approximately two miles downstream of the treatment plant, represents the higher end of PO_4-P concentrations in the watershed, followed by lower Chorro Creek at TWB.

The highest NO_3-N values in the Morro Bay watershed have consistently been detected on Warden Creek at TUR, which is heavily impacted by surrounding agricultural cropland. Elevated NO_3-N values at TUR have consistently exceeded the level of protection for both human and aquatic health (≥ 10 mg/L NO_3-N). In WY2024, average NO3-N concentrations at TUR remained high at 13.24 mg/L, indicating persistent nutrient loading issues at this site.

Data collected from Chorro Creek at UCR and TWB have also indicated elevated NO_3-N concentrations relative to upstream and downstream levels. These concentrations have historically exceeded the level of protection for aquatic health (≥ 1.0 mg/L NO_3-N) but not the level of protection for human health (≥ 10 mg/L NO_3-N). In WY2024, average concentrations decreased at both sites compared to WY2023, indicating some improvement in water quality. UCR improved by 67% (from 2.18 mg/L in WY2023 to 0.72 mg/L in WY2024) and TWB improved by 19% (from 1.09 mg/L in WY2023 to 0.88 mg/L in WY2024).

In WY2023, several sites within the Chorro Creek subwatershed experienced higher than normal average NO_3-N concentrations, with SLU and UPN showing significant increases from historical levels. While the exact cause of these elevated NO_3-N concentrations is unknown, the high flows of WY2023 likely contributed, potentially through bank erosion or increased leaching. In WY2024, NO_3-N concentrations at SLU and UPN returned to levels closer to historical averages, suggesting that the elevated concentrations seen in WY2023 were likely driven by higher-than-average rainfall and peak flows.

4. Continuous Water Quality Monitoring

The Estuary Program collects continuous water quality data throughout the watershed using multiparameter sondes. The data collected provides insight into water quality trends and diurnal variations that may otherwise be missed with instantaneous measurements.

Routine deployments were conducted at two sites on Chorro Creek and two sites on Warden Creek for approximately one week each month throughout WY2024 (Figure 12). The following data detail continuous water quality conditions during these eight deployment periods. The data presented is not meant to represent a continuous time series but rather the results of these individual short-term deployments.

4.1 Equipment Specifications

The Estuary Program deploys YSI EXO3 multiparameter sondes that collect dissolved oxygen (DO), specific conductivity, water temperature, and pH at pre-programmed intervals. A central wiper brush installed on the sonde cleans off the sensors between each interval, preventing sediment buildup and biofouling during deployments. For the deployments conducted October 2023 - June 2024, all sondes were programmed to collect data at 15-minute intervals, however this was extended to one-hour

intervals in August and September 2024 to conserve battery power. July 2024 represented a transition between these methods, with 30-minute intervals utilized at CHO and UCR.

Specifications for the YSI EXO3 multiparameter sondes are as follows:

Specification	Value
Measurement/Operating Range	Dissolved Oxygen: 0 to 50 mg/L Specific Conductance: 0 to 100,000 µS/cm Temperature: -5 to 50 °C pH: 0 to 14 units
Accuracy	Dissolved Oxygen 0 to 20 mg/L: ±0.1 mg/L Dissolved Oxygen 20-50 mg/L: ± 5% of reading Specific Conductance: ± 2 µS/cm Temperature: ± 0.2 °C pH: ± 0.2 pH units
Resolution	Dissolved Oxygen: 0.01 mg/L Specific Conductance: 0.1 µS/cm Temperature: 0.001 °C pH: 0.01 units

4.2 Monitoring Locations

The Estuary Program deployed EXO3 sondes at four sites during WY2024. Two sites were located along Chorro Creek, co-located with the CHO and UCR TidbiT deployment sites. These sites are approximately 2.75 miles apart. The other two sondes were deployed along Warden Creek. The upstream sonde at Warden Creek (TUR) is located along a stretch of creek that is impacted by agricultural runoff and the downstream sonde is located within the Coastal San Luis Resource Conservation District property above the confluence of Warden Creek with Los Osos Creek (LWR) (Figure 12). These sites are approximately 2.5 miles apart.

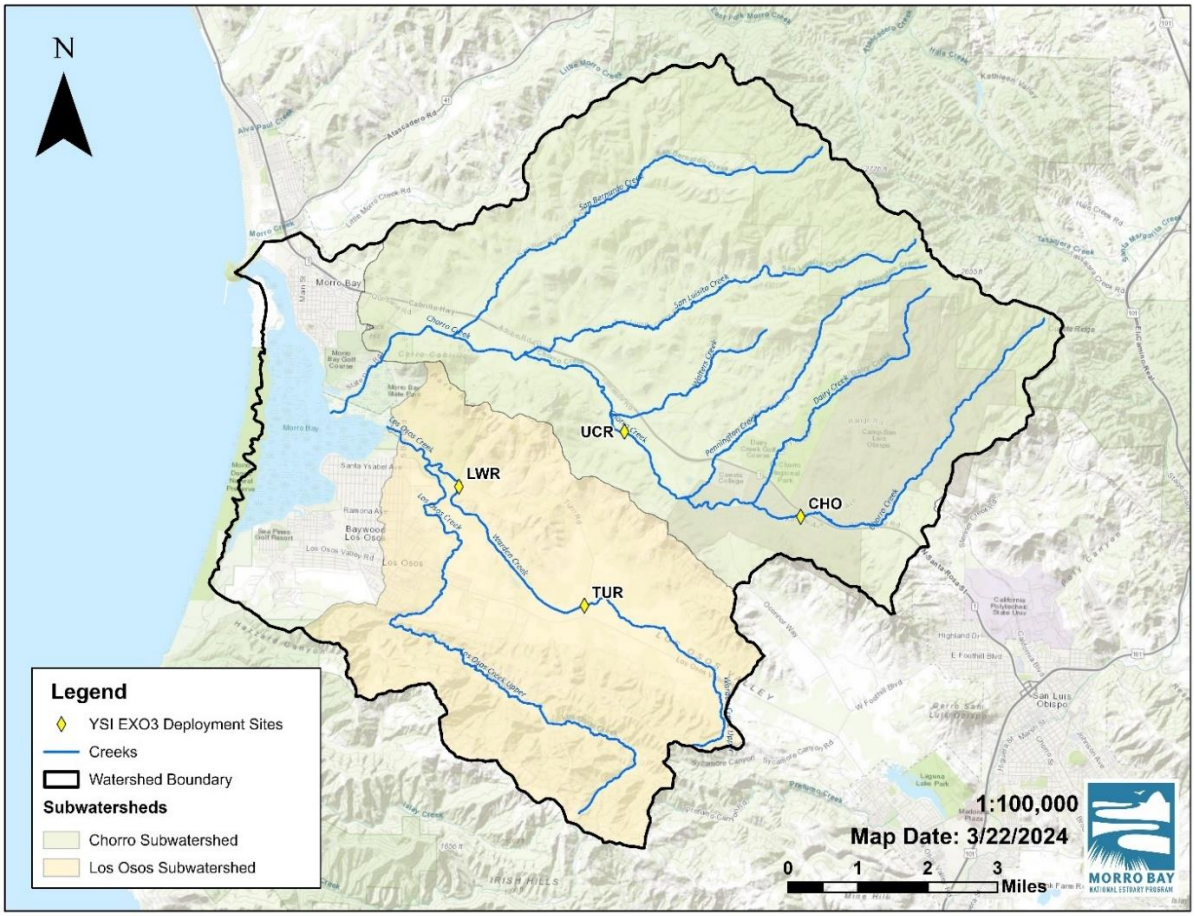

Figure 12. *YSI EXO3 multiparameter sonde deployment locations on Chorro Creek and Warden Creek during WY2024.*

4.3 Results

The CCRWQCB Basin Plan outlines water quality objective numeric targets to protect designated beneficial uses. Chorro Creek and Los Osos Creeks support several beneficial uses including cold freshwater habitat (COLD) and fish spawning (SPWN). To be protective of these uses, dissolved oxygen concentrations should not drop below the 7.0 mg/L numeric target at any time, and surface waters must not have pH values below 7.0 or above 8.5, with changes in ambient pH levels less than 0.5. Temperature results ideally remain below 18°C, as described in Section 2.4.

Analyte	Criteria	Source
Dissolved oxygen	< 7 mg/L (COLD, SPWN)	CCRWQCB Basin Plan Water Quality Objectives for Specific Beneficial Uses (Section 3.3.2.2)
Temperature	> 18 °C	Moyle, 2002
pH	< 7.0 and > 8.5 (COLD, SPWN)	CCRWQCB Basin Plan Water Quality Objectives for Specific Beneficial Uses (Section 3.3.2.2)

Dissolved Oxygen

The following figures describe the mean and standard deviation of DO concentrations during each of the monthly deployments in WY2024. Most deployments lasted approximately seven days, with the exception of November 2023, when the sondes along Chorro Creek were deployed for three days, and September 2024, when the sonde at UCR was deployed for nineteen days and no sonde was deployed at LWR. The red line on each graph indicates the CCRWQCB water quality objective for dissolved oxygen.

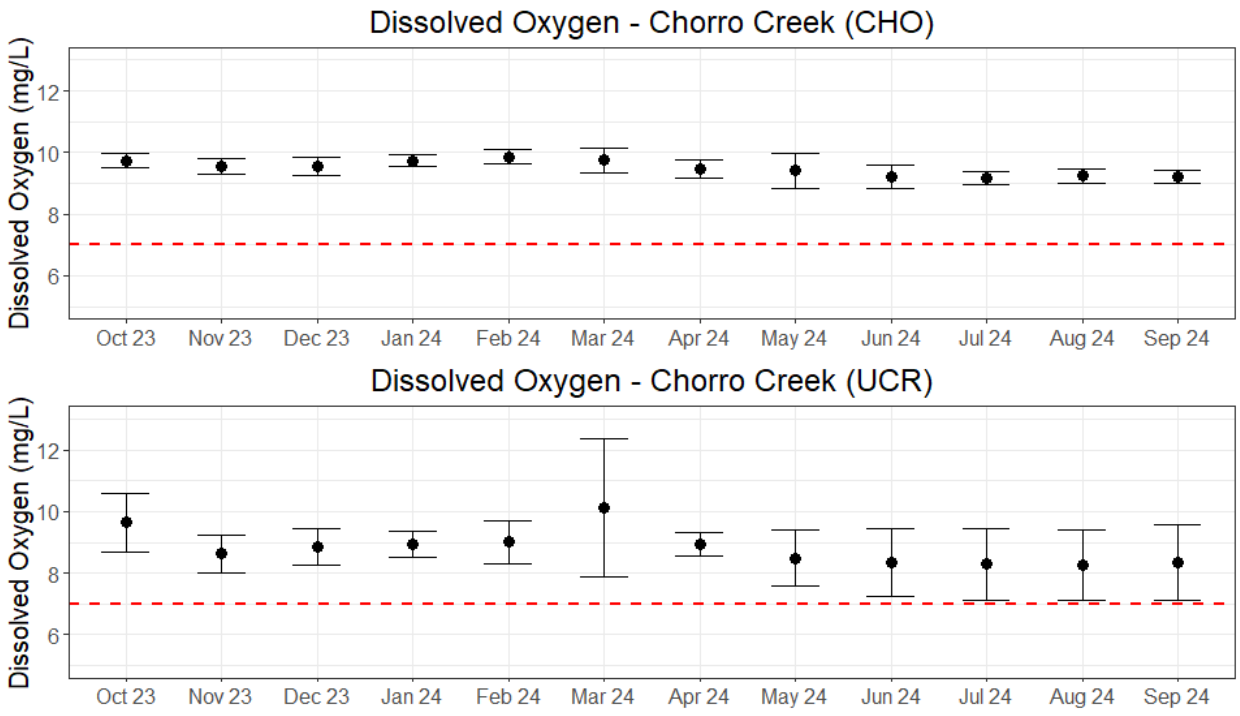

Figure 13. *Dissolved oxygen concentration (mg/L) from each deployment at two Chorro Creek sites (CHO, UCR) during WY2024. The horizontal red line represents the CCRWQCB Basin Plan objective (7 mg/L). Error bars represent one standard deviation of the mean. Typical deployments consisted of seven-day periods, however the November deployment was cut short at three days and the September deployment at UCR was extended to 19 days.*

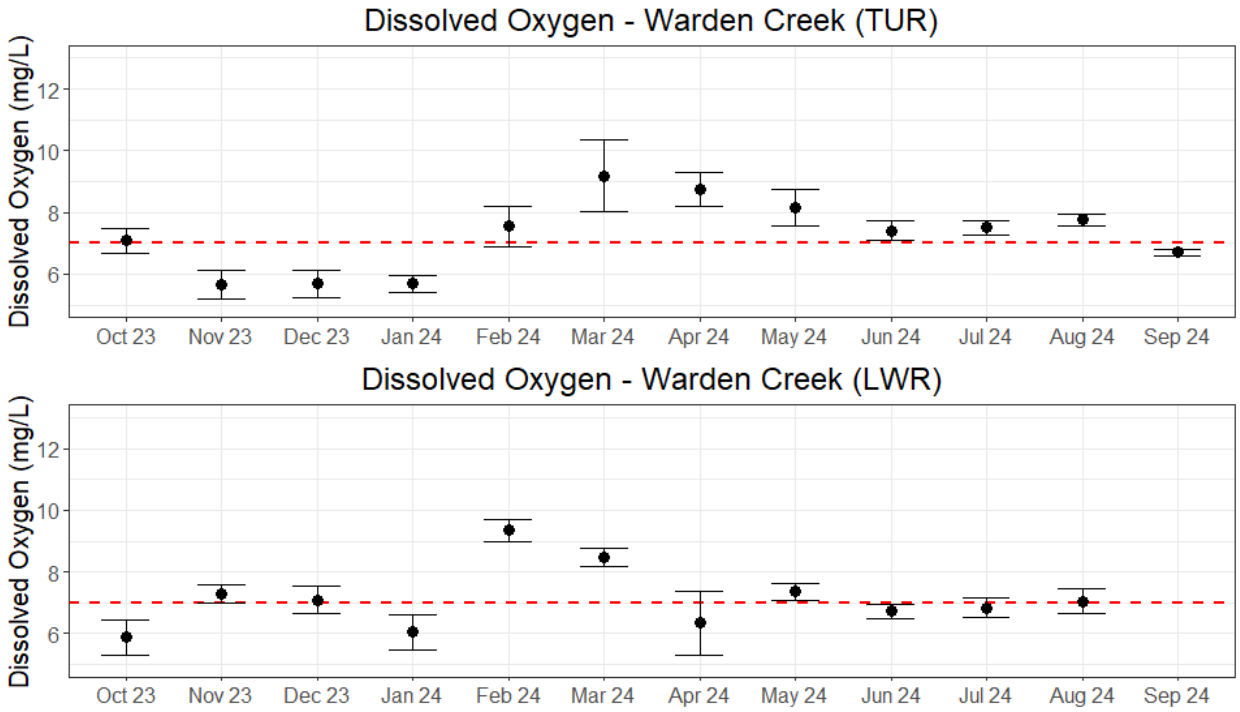

Figure 14. *Dissolved oxygen concentration (mg/L) from each deployment at two Warden Creek sites (TUR, LWR) during WY2024. The horizontal red line represents the CCRWQCB Basin Plan objective (7 mg/L). Error bars represent one standard deviation of the mean. Typical deployments consisted of seven-day periods. No sonde was deployed at the LWR site in September 2024 due to stagnant, disconnected conditions.*

Temperature and pH

The following figures describe the monthly mean temperature and pH levels during each of the monthly deployments in WY2024. The red line on the temperature graph indicates an 18 °C threshold, as described in Section 2.4. The red lines on the pH graph indicate the CCRWQCB water quality objective thresholds of 7.0 and 8.5.

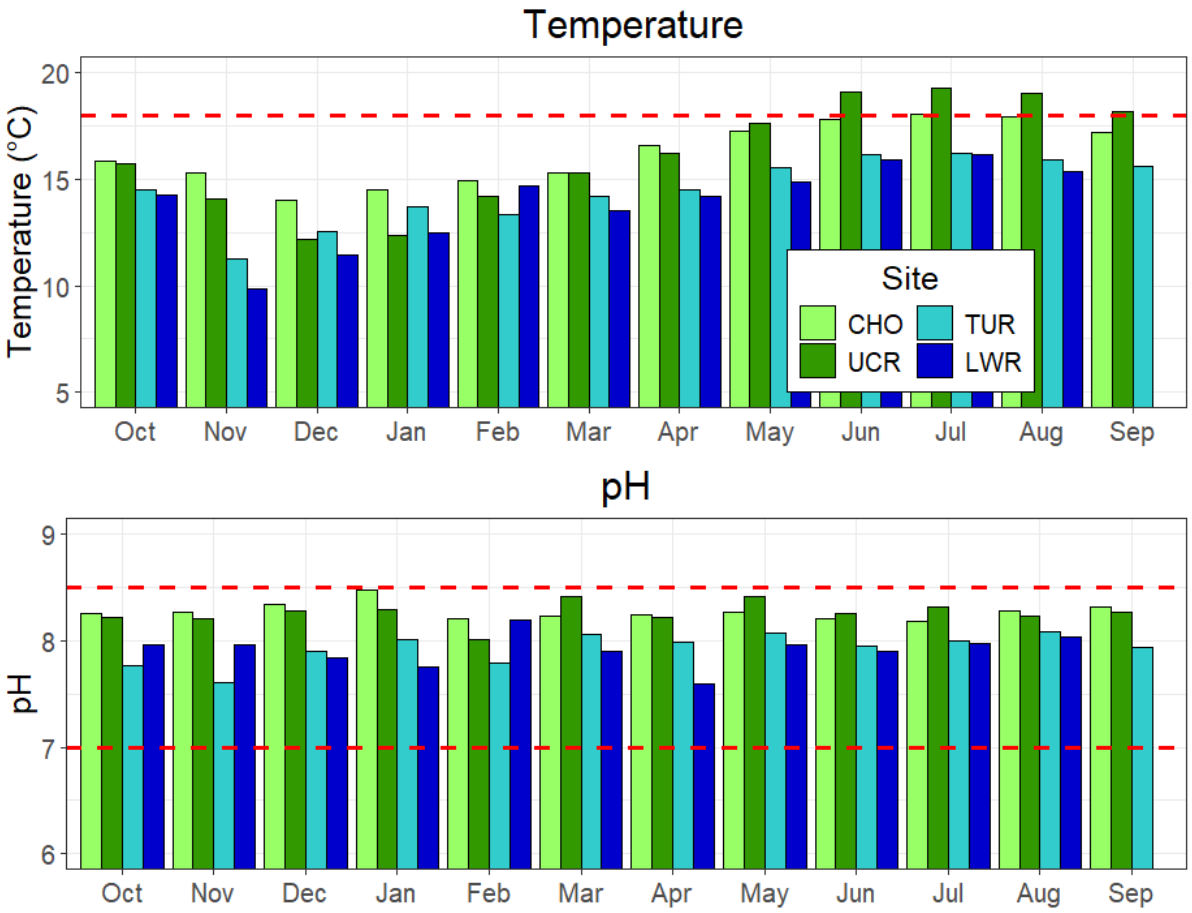

Figure 15. *Monthly mean water temperature (°C) and pH from two deployment locations in Chorro Creek (CHO, UCR), and two in Warden Creek (TUR, LWR) during WY2024. The horizontal red lines represent water quality objectives. For temperature, this represents an 18 °C threshold (Moyle, 2002). For pH, this represents pH values of < 7.0 and > 8.5 (CCRWQCB, 2019).*

Water temperature trends on Chorro Creek at CHO and UCR followed the same trend observed in Sections 2.3 and 2.4. Chorro Creek at UCR experiences more frequent exceedances of the 18 °C threshold than CHO. Average water temperature for UCR was over 18 °C for four consecutive deployments (June – September 2024) while this was only observed once at CHO, during the July deployment. Throughout WY24, the Warden Creek sites were generally colder than the Chorro Creek sites. During their respective deployments, neither TUR nor LWR had an average deployment temperature over 18 °C. Warmer temperatures along Chorro Creek may be due to thinner riparian cover and the consistent influx of effluent from the CA Men's Colony wastewater treatment plant at sites located downstream (UCR), which consist of an especially high proportion of treated effluent relative to creek water in the summer months.

Average pH levels were within the CCRWQCB range for cold freshwater habitat (COLD) and fish spawning habitat (SPWN) in all deployments, however the Chorro Creek sites experienced brief exceedances of the upper threshold. Chorro Creek at CHO exceeded pH values of 8.5 for short periods in January, and Chorro Creek at UCR exceeded this threshold in March and May. Brief periods of elevated pH are likely due to runoff from nearby gravel roads that raise the concentration of carbonate ions in the water, or high photosynthetic activity from freshwater algae that reduce carbon dioxide concentrations (EPA 2005).

4.4 Discussion

DO concentrations in freshwater systems have immediate implications for the health of aquatic organisms. DO concentrations fluctuate throughout the day, making instantaneous measurements less effective at fully capturing oxygen dynamics in the creeks. Continuous deployments allow for a more complete characterization of oxygen availability and impacts to the biota.

Table 5. *Percentage of readings collected during each deployment that were outside of CCRWQCB Basin Plan objectives for dissolved oxygen concentration in WY2024.*

Percentage of Deployment Below 7 mg/L DO Concentration												
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
CHO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UCR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8
TUR	100.0	100.0	100.0	51.2	21.9	0.0	0.0	0.0	10.4	0.0	0.0	99.4
LWR	6.1	35.3	99.1	100.0	0.0	0.0	53.5	0.0	86.4	68.2	57.7	NA

	76 - 100%
	51 - 75%
	26 - 50%
	1 - 25%
	0%

The results from the WY2024 sonde deployments indicate that DO concentrations along the Warden Creek sites are regularly much lower than the Chorro Creek sites. DO dipped below 7 mg/L for a small fraction of the September deployment at UCR, while both Warden Creek sites experienced significant portions of the late fall and early winter deployments below this threshold. For three straight months (October to December 2023), DO at TUR was below 7 mg/L for the entire deployment, even falling below 5 mg/L for brief periods. Despite being consistently colder than the Chorro Creek sites, Warden Creek's sites are subject to more frequent disconnection, when flow between the sites either goes subsurface or is entirely absent. The subsequent stagnant conditions stemming from a lack of circulation can result in suppressed DO concentrations.

5. Data Availability

Bimonthly nutrient monitoring data is publicly available from the California Environmental Data Exchange Network (CEDEN), a State Water Resources Control Board managed data portal[4]. For continuous monitoring data, please contact the Estuary Program.

To retrieve nutrient data, visit https://ceden.waterboards.ca.gov/.

- Select "Start" to retrieve data
- Under "Category," select "Water Quality (Chemistry)"
- Under "Program," select "Morro Bay National Estuary Program"
- Under "Analyte," select "Orthophosphate as P, Dissolved" and/or "Nitrate as N, Dissolved"
- Under "FromDate" and "ToDate," select the date range desired.
- Click on "Submit" to retrieve results.

[4] Please note that the Estuary Program's surface water chemistry data between 2020 to 2024 may not yet appear in the public CEDEN interface due to processing delays. This data can be accessed in the CEDEN Augmentation File available from the California Open Data Portal: https://data.ca.gov/dataset/surface-water-chemistry-results-ceden-augmentation.

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Appendix A. WY2024 TidbiT Deployment Timelines

Site	Deployments
CHO	10/30/2023 - 4/24/2024 *Pressure Transducer data used 10/1/2023-10/29/2023 and 4/25/2024- 9/30/2024*
UCR	10/1/2023 - 9/30/2024
CCC	10/1/2023 - 10/2/2023 and 10/26/2023 - 2/19/2024 and 2/29/2024 - 3/29/2024 and 4/14/2024 - 9/30/2024 *Pressure Transducer data used to fill all data gaps*
DAU	10/1/2023 - 9/30/2024
UPN	10/1/2023 - 9/30/2024
SLU	10/1/2023 - 2/21/2024 and 2/27/2024 - 3/8/2024 and 3/27/2024 - 9/30/2024

Appendix B. WY2024 Dates for Each Seasonal Period

Time Period	Start	End
Water Year 2024	10/1/2023	9/30/2024
Fall Season	10/1/2023	12/20/2023
Winter Season	12/21/2023	3/18/2024
Spring Season	3/19/2024	6/19/2024
Summer Season	6/20/2024	9/30/2024

Appendix C. WY2024 EXO3 Deployment Timelines

Month	Chorro Creek	Warden Creek
October	10/23 - 10/30	10/12 - 10/18
November	11/13 - 11/16	11/22 - 11/28
December	12/8 - 12/14	12/21 - 12/27
January	1/10 - 1/19	1/23 - 1/31
February	2/23 - 2/29	2/23 - 2/29
March	3/22 - 3/29	3/13 - 3/21
April	4/17 - 4/24	TUR: 4/9 - 4/17 LWR: 4/9 - 4/15
May	5/23 - 5/30	5/8 - 5/15
June	6/20 - 6/27	6/20 - 6/27
July	7/24 - 7/31	7/9 - 7/15
August	8/7 - 8/14	8/7 - 8/14
September	CHO: 9/11 - 9/18 UCR: 9/11 - 9/30	TUR: 9/12 - 9/19 LWR: No deployment

List of Acronyms

Acronym	Definition
CCRWQCB	Central Coast Regional Water Quality Control Board
CEDEN	California Environmental Data Exchange Network
DO	Dissolved oxygen
EPA	Environmental Protection Agency
EXO3	YSI Multiparameter Sonde Model EXO3
MDL	Method Detection Limit
MWAT	Maximum Weekly Average Temperature
MWMT	Maximum Weekly Maximum Temperature
NO3-N	Nitrate as Nitrogen (dissolved)
O. mykiss	*Oncorhynchus mykiss*, rainbow trout (resident) or steelhead trout (anadromous)
PO4-P	Orthophosphate as Phosphorus (dissolved)
RL	Reporting Limit
RPD	Relative Percent Difference
SD	Standard deviation
WY	Water Year (Oct 1 to September 30; named for the year in which it ends)

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