



Morro Bay Watershed Creek Health For Water Year 2021

Date Range: October 1, 2020 to September 30, 2021

Analytes: Water temperature, nitrates as nitrogen, orthophosphates as phosphorus

Background

The Morro Bay National Estuary Program conducts monitoring in the Morro Bay estuary and 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 State Water Resources Control Board. 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/>.

Water Temperature

The Estuary Program wanted to be able to assess how often local creeks had water temperature conditions that were supportive of sensitive wildlife like the Southern California Coast steelhead (*Oncorhynchus mykiss*) during water year 2021 (WY2021), which runs from October 1, 2020 through September 30, 2021.

The Estuary Program deploys [HOBO TidbiT MX 2203](#) temperature data loggers at sites throughout the watershed. These loggers monitor daily fluctuations and seasonal trends of water temperature in Morro Bay watershed creeks. Loggers are deployed year-round, and data is collected at 30-minute intervals.

Equipment Specifications:

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 collected an independent temperature measurement from a second meter at time of deployment for comparison. These duplicate readings were repeated periodically throughout the deployment for quality assurance.

Water Temperature Monitoring Locations:

Data presented in this memo includes continuous temperature data collected in WY2021 from six sites throughout the Morro Bay watershed, all within the Chorro Creek subwatershed (Figure 1).

Three of the six monitoring sites are located along the mainstem of Chorro Creek since it is known to support *Oncorhynchus mykiss*, a sensitive species of concern. Historic data has also shown elevated temperatures along Chorro Creek. The remaining sites were chosen along tributaries to Chorro Creek: Pennington Creek, San Luisito Creek, and Dairy Creek. These tributaries have historically provided spawning ground for *O. mykiss*.

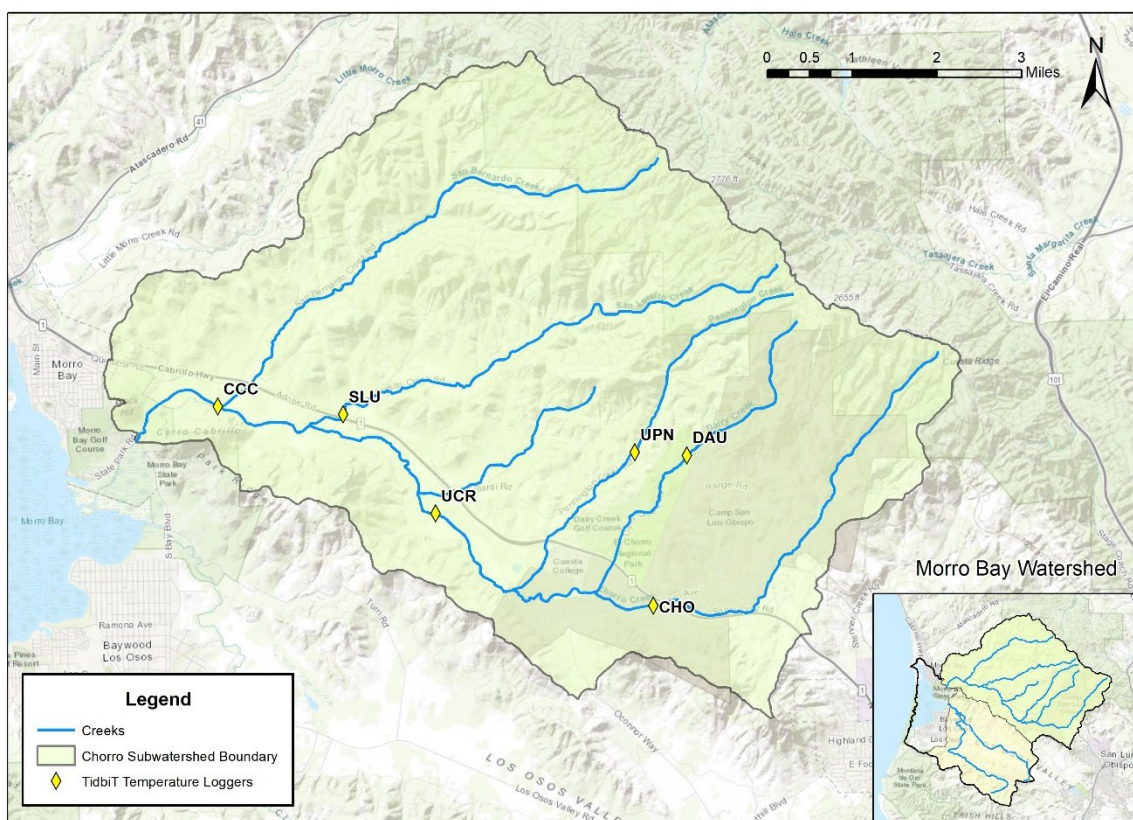


Figure 1: Continuous temperature monitoring sites in the Chorro Creek subwatershed during WY2021.

Results

Continuous temperature data is of value because it shows the time of day and duration of elevated temperatures. Temperature values were defined as elevated when compared to a threshold of 18°C, which was selected based on research that identified the optimal temperature range for *O. mykiss* as between 13 and 21°C (Moyle 2002). Prolonged exposure to temperatures above 18°C can negatively impact *O. mykiss* reproduction, growth, migration timing, stress levels, and survival.

The following datasets illustrate water temperature data collected at 30-minute intervals throughout WY2021, compared to the 18°C threshold. Temperatures were analyzed for the water year and on a seasonal basis. Dates used to define the WY2021 seasons can be found in Appendix B.

Chorro Creek

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

- The uppermost monitoring site is located at Camp San Luis Obispo (site code CHO) at the Highway 1 bridge.
- The middle Chorro Creek site is downstream of the California Men's Colony Wastewater Treatment Plant (CMC WWTP) and just upstream of the Chorro Creek Ecological Reserve. The site is referred to as Upper Chorro Reserve (site code UCR).
- The furthest downstream monitoring site is at Chorro Creek Road (site code CCC) near the bottom of Chorro Creek, just upstream of Chorro Flats. It is above the zone of tidal influence from the bay.

The following graphs show water temperatures at CHO, UCR, and CCC mainstem sites. The graphs illustrate water temperatures for the entire water year, color coded by season. 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 steelhead and other sensitive species.

Camp San Luis Obispo (CHO)

The following graph (Figure 2) shows water temperatures at Chorro Creek near Camp San Luis Obispo (CHO). The temperature logger at CHO was deployed from the start of WY2021 (October 1, 2020) until January 26, 2021. Due to a large storm that pushed the logger out of the water, late winter and early spring data is not available. The logger was placed back in the water on March 25, 2021 and was active until the end of WY2021 (September 30, 2021).

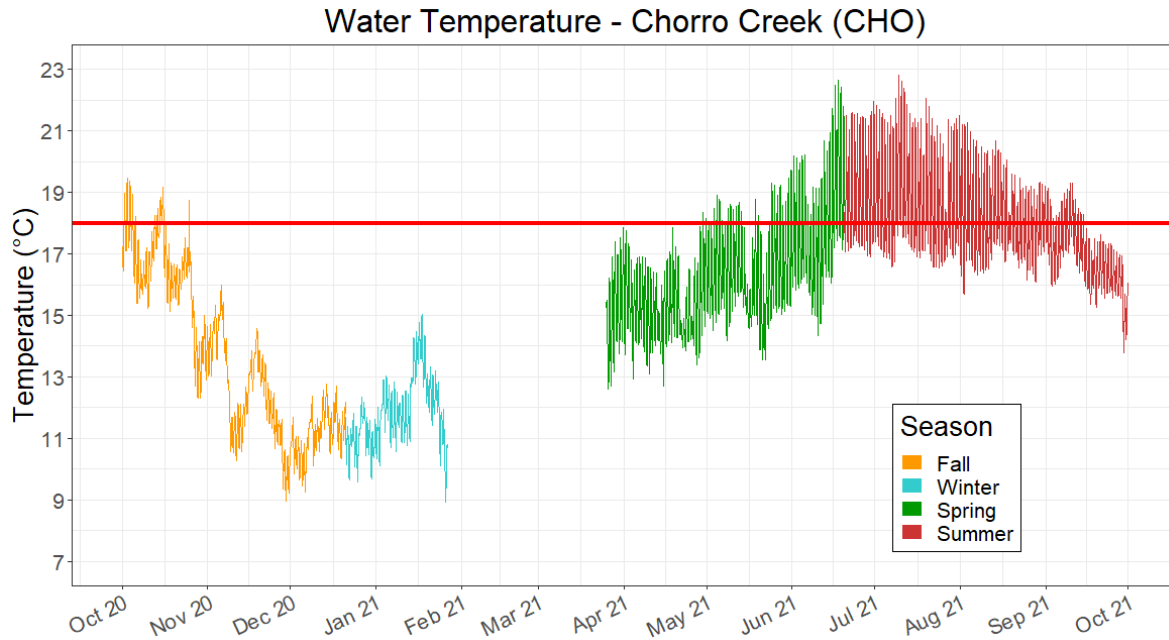


Figure 2: Water temperature at Chorro Creek (CHO) during WY2021, colored by season. Data was not available from January 27, 2021 to March 24, 2021.

Upper Chorro Reserve (UCR)

The following graph (Figure 3) shows water temperatures at Chorro Creek upstream of the Chorro Creek Ecological Reserve (UCR). The temperature logger at UCR was deployed for the entire water year: October 1, 2020 to September 30, 2021.

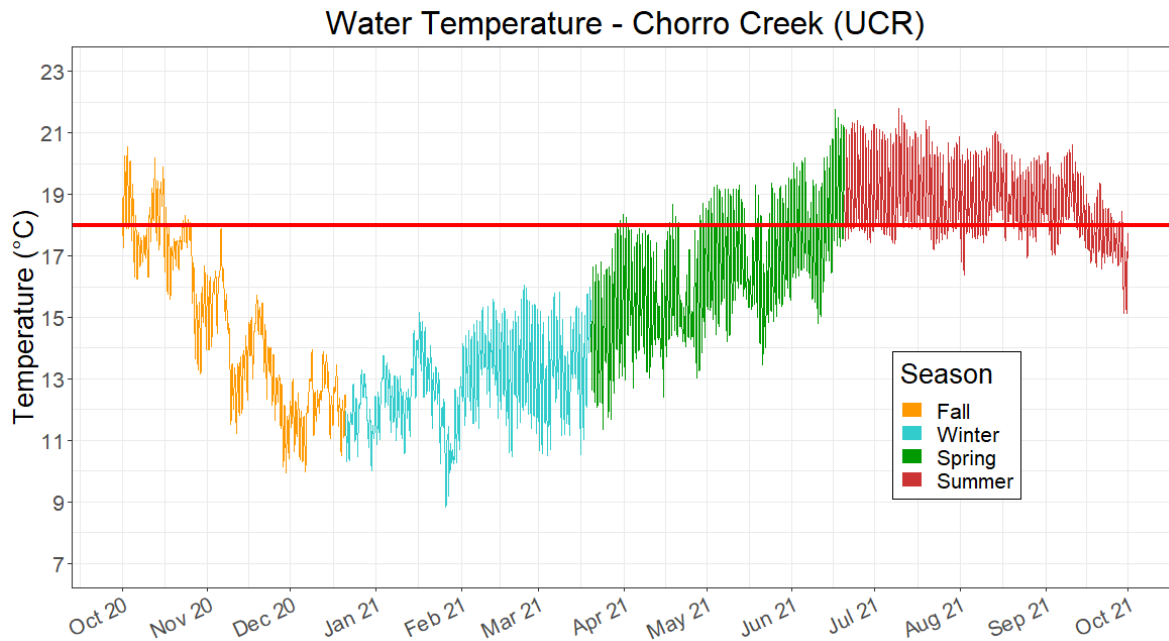


Figure 3: Water temperature at Chorro Creek (UCR) during WY2021, colored by season.

Chorro Creek Road (CCC)

The following graph (Figure 4) shows water temperatures at Chorro Creek near Chorro Creek Road (CCC). The temperature logger at CCC was deployed for the entire water year: October 1, 2020 to September 30, 2021.

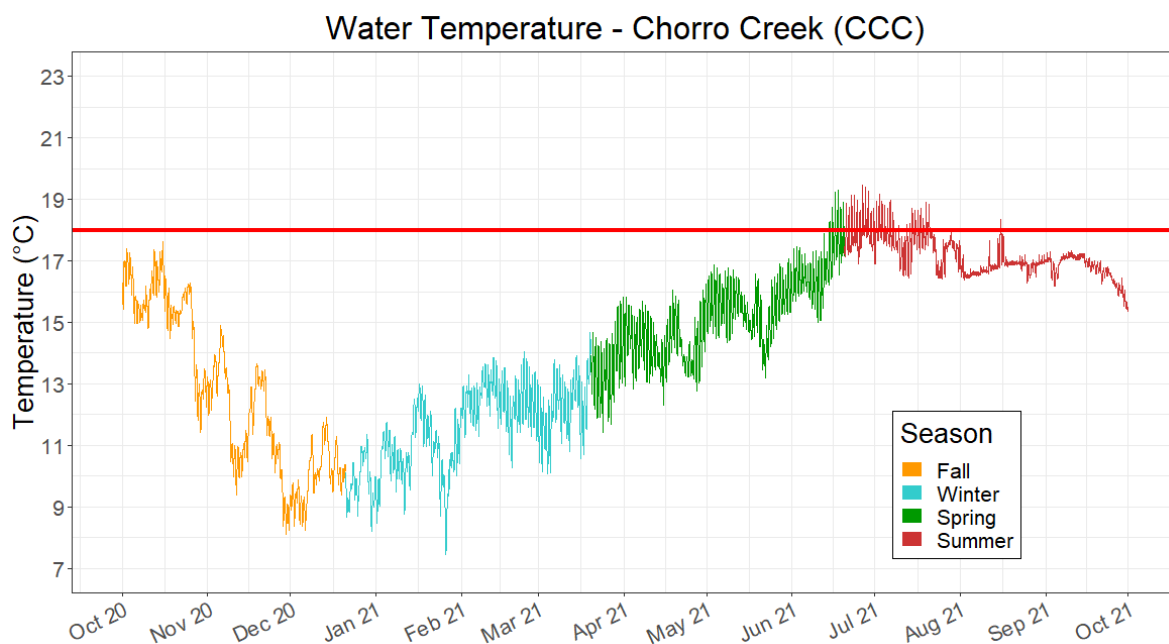


Figure 4: Water temperature at Chorro Creek (CCC) during WY2021, colored by season.

Chorro Creek Tributaries

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

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

The following graphs show water temperatures at San Luisito, Pennington, and Dairy Creek tributary sites. The graphs illustrate water temperatures for the entire water year, color coded by season. In each graph, the multi-colored line indicates water temperature in °C, recorded at 30-minute intervals, and the horizontal red line indicates the 18°C threshold protective of steelhead and other sensitive species.

San Luisito Creek (SLU)

The following graph (Figure 5) shows water temperatures at San Luisito Creek at Adobe Road (SLU) during WY2021. The temperature logger at SLU was deployed for the entire water year: October 1, 2020 to September 30, 2021.

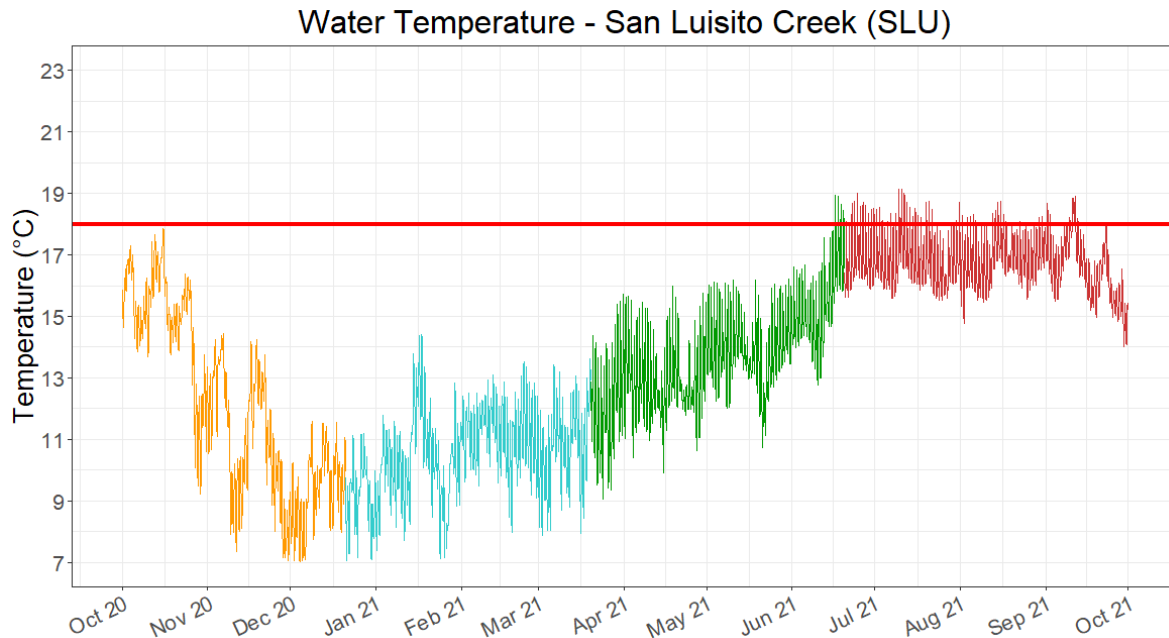


Figure 5: Water temperature at San Luisito Creek (SLU) during WY2021, colored by season.

Pennington Creek (UPN)

The following graph (Figure 6) shows water temperatures at Pennington Creek near the Cal Poly Beef Center (UPN) during WY2021. The temperature logger at UPN was deployed for the entire water year: October 1, 2020 to September 30, 2021.

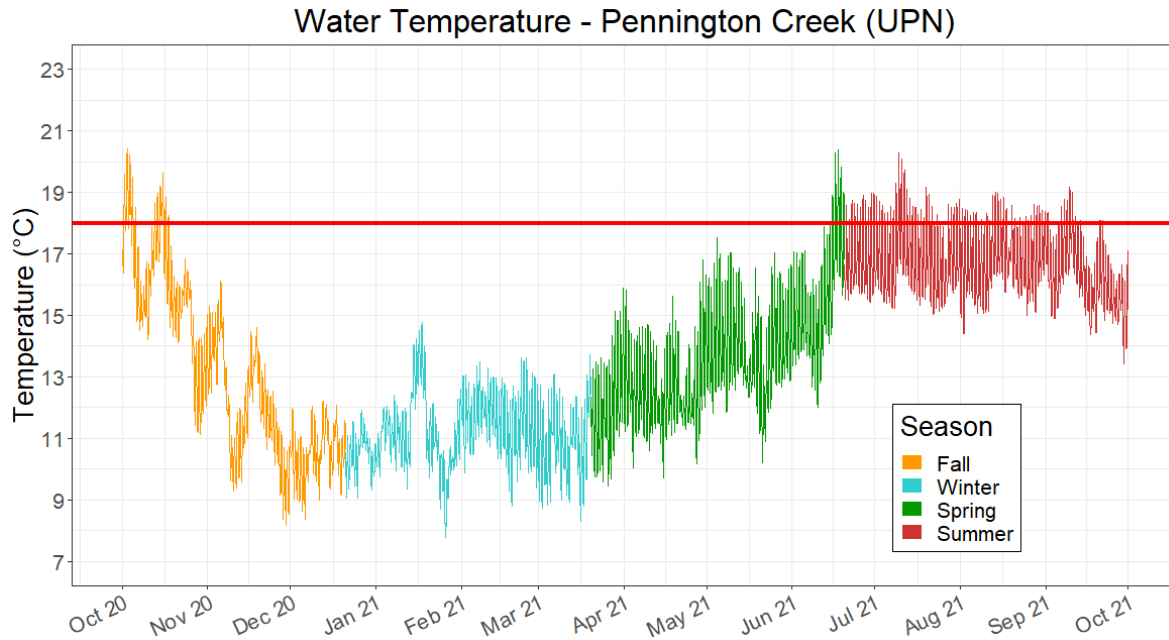


Figure 6: Water temperature at Pennington Creek (UPN) during WY2021, colored by season.

Dairy Creek (DAU)

The following graph (Figure 7) shows water temperatures at upper Dairy Creek above El Chorro Regional Park (DAU) during WY2021. The site was dry at the start of WY2021, so the temperature logger at DAU was deployed after flows had resumed on January 21, 2021. Data collected after June 17, 2021 was excluded because the site went dry again.

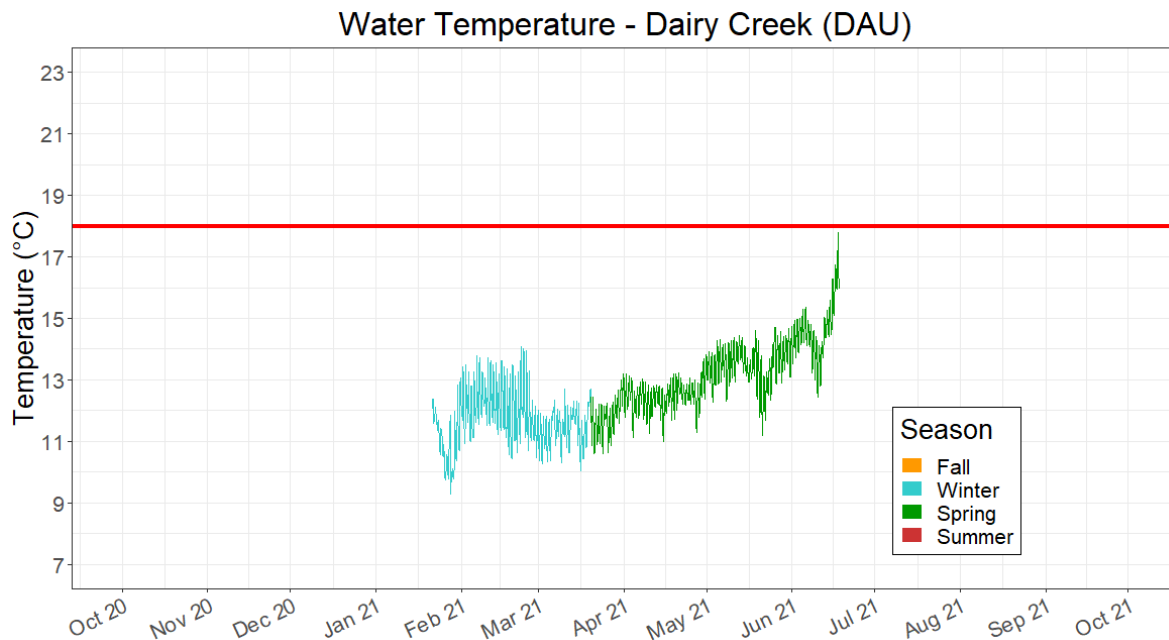


Figure 7: Water temperatures at Dairy Creek (DAU) during WY2021, colored by season. Data is not available before January 21, 2021 or after June 17, 2021 due to lack of surface flows.

Discussion

Water temperatures during WY2021 were analyzed using a variety of metrics. First, percent exceedance was calculated to see how frequently sites had water temperatures higher than 18°C. Exceedance was calculated for the entire deployment period of the logger, which varied on a site-by-site basis, 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 WY2021. The deployment periods vary based on site locations. See Appendix A for more details.

Timeframe	Percent of Readings above the 18°C Threshold					
	Site					
	CHO	UCR	CCC	UPN	DAU	SLU
Full Deployment Period	20.1%	27.8%	3.4%	6.1%	0.0%	2.3%
Fall Season	5.3%	12.3%	0.0%	6.7%	-	0.0%
Winter Season	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Spring Season	14.9%	18.0%	1.8%	1.9%	0.0%	0.8%
Summer Season	43.3%	72.7%	10.3%	14.8%	-	7.5%
Number of days deployed in WY2021	309	365	365	365	150	365

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 used in reference 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 on a monthly basis 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 WY2021. Salmon and trout life stage thresholds adapted from [EPA, 2003](#).

Maximum Weekly Average Temperature (MWAT) - WY 2021												
Site	Oct '20	Nov '20	Dec '20	Jan '21	Feb '21	Mar '21	Apr '21	May '21	Jun '21	Jul '21	Aug '21	Sep '21
CHO	17.5	14.4	11.7	-	-	-	15.5	16.9	19.2	19.3	18.4	17.9
UCR	18.4	15.8	12.7	13.7	13.7	14.9	15.6	17.1	19.2	19.4	19.3	19.0
CCC	16.4	13.5	10.7	12.0	12.9	13.8	14.5	15.8	18.0	18.0	17.1	17.1
UPN	17.5	14.0	11.0	12.7	12.0	12.3	12.8	14.3	17.2	17.4	17.2	17.2
DAU	-	-	-	-	12.4	12.0	12.6	13.9	-	-	-	-
SLU	16.4	12.9	10.1	11.9	11.6	12.3	13.0	14.3	17.0	17.2	17.2	17.6

Maximum Weekly Maximum Temperature (MWMT) - WY 2021												
Site	Oct '20	Nov '20	Dec '20	Jan '21	Feb '21	Mar '21	Apr '21	May '21	Jun '21	Jul '21	Aug '21	Sep '21
CHO	18.5	15.1	12.3	-	-	-	17.1	19.1	21.9	22.1	20.9	19.0
UCR	19.3	16.6	13.4	14.5	15.6	17.5	17.8	19.2	21.3	21.2	20.7	20.2
CCC	16.9	13.9	11.2	12.6	13.6	15.1	15.5	16.7	19.2	18.9	17.5	17.2
UPN	18.8	15.1	11.7	13.8	13.2	14.6	15.0	16.8	19.3	19.4	18.7	18.6
DAU	-	-	-	-	13.6	12.6	13.2	14.6	-	-	-	-
SLU	17.2	13.7	11.0	13.3	13.0	14.7	15.3	16.0	18.7	18.8	18.3	18.3

	> 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 the MWAT. All temperature monitoring sites show elevated summer temperatures that exceeded a MWMT of 18°C, including the tributaries to Chorro Creek. The MWAT table similarly shows elevated temperatures during this time but the only exceedances of 18°C MWAT were at sites located along the mainstem of Chorro Creek (UCR, CHO, and CCC). During the winter months, the MWAT table shows tributary temperatures that could support all salmonid life stages from December to April, while the MWMT table shows little sustained viability for salmonid egg incubation during the most crucial time of year.

The highest MWAT and MWMT values from WY2021 occurred on Chorro Creek at UCR (downstream of the CMC WWTP), followed by Chorro Creek at CHO, which is located approximately two miles upstream of UCR at the Highway 1 overcrossing. Both sites have had frequent and sustained issues with elevated temperature. Elevated temperatures at UCR could be affected from incoming treated effluent from the CMC WWTP. Warmer temperatures are less frequent downstream at CCC, likely due to increased canopy cover and cooler water coming in from tributaries. CHO is the furthest upstream of the three mainstem sites. This site is more exposed to sunlight when compared to downstream sites and does not receive cooler incoming water from tributaries.

Bimonthly Nutrient Monitoring

The Estuary Program wanted to be able to assess ambient nutrient levels throughout the Morro Bay watershed. This information provides long-term trend data and assists in targeting restoration and conservation efforts.

Estuary Program staff collect samples for laboratory analysis for nitrate as nitrogen ($\text{NO}_3\text{-N}$, mg/L), and for orthophosphate as phosphorus ($\text{PO}_4\text{-P}$, mg/L) at various locations throughout the watershed. Sites were initially visited on a quarterly basis, or four times each year. As of June 2019, sites are now visited on a bimonthly basis, or six times each year. As such, this effort was previously referred to as Quarterly Nutrient Monitoring (QNM) and is now referred to as Bimonthly Nutrient Monitoring (BNM).

Analytical Specifications

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

Nitrate as Nitrogen (mg/L):

Specification	Value
Method Number	EPA 300.0
Minimum Detection Limit (MDL)	0.024 mg/L
Project Quantitation Limit (PQL)	0.10 mg/L
Hold Time	48 hours
Sample storage conditions	4°C in the dark

Orthophosphate as Phosphorus (mg/L):

Specification	Value
Method Number	EPA 365.1
Minimum Detection Limit (MDL)	0.017 mg/L
Project Quantitation Limit (PQL)	0.050 mg/L
Hold Time	48 hours
Sample storage conditions	4°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 and project quantitation limit for the results. For each result that is less than the Project Quantitation Limit (PQL), a random number between zero and the PQL is generated in R and used for analysis. This is the same method utilized by the Central Coast Regional Water Quality Control Board (CCRWQCB) to manage non-detects in their own analysis.

Monitoring Locations

Nine sites were initially selected to represent Chorro and Los Osos Creeks, as well as their tributaries (Figure 8). During WY2021, only seven sites were sampled due to staffing and access limitations: Dairy Creek middle (site code DAM), Pennington Creek upper (UPN), Chorro Creek middle (UCR), Chorro Creek

lower (TWB), San Luisito Creek lower (SLU), Warden Creek middle (TUR), and Los Osos Creek upper (CLV).

Morro Bay Watershed Bimonthly Nutrient Monitoring Sites

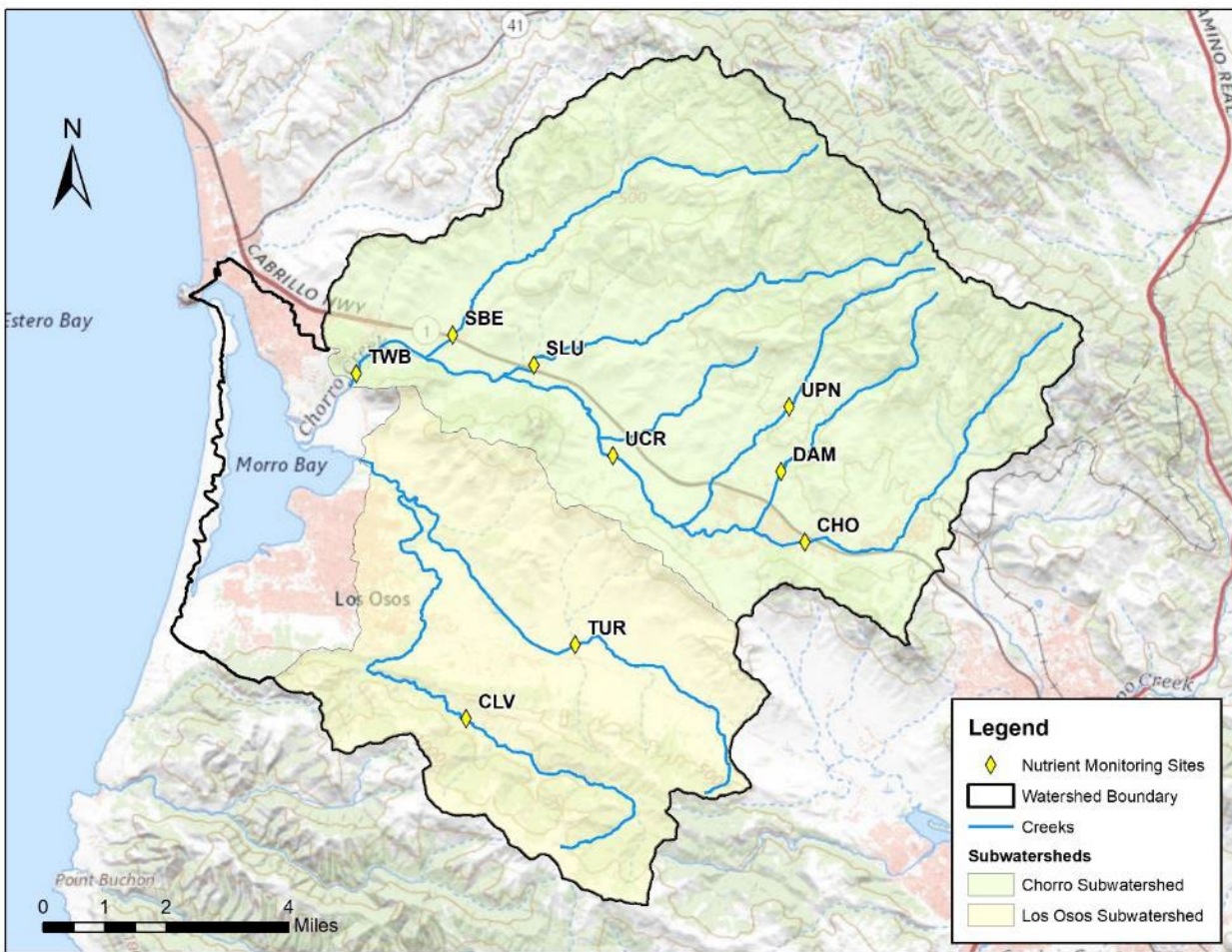


Figure 8: Bimonthly nutrient monitoring locations. Only seven were monitored during WY2021.

Results

Nitrate as Nitrogen

Nitrate results are compared to two standards. In freshwater systems, the CCRWQCB considers a water body to be impaired by nitrates if nitrate as nitrogen ($\text{NO}_3\text{-N}$) concentrations are greater than or equal to 1 mg/L as N and if the site shows other signs of impact such as widespread algal growth and low dissolved oxygen (DO) concentrations. The EPA has a maximum contaminant level (MCL) of 10 mg/L $\text{NO}_3\text{-N}$ 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 9 indicates the average NO₃-N concentration for sites monitored in WY2021. 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 WY2021

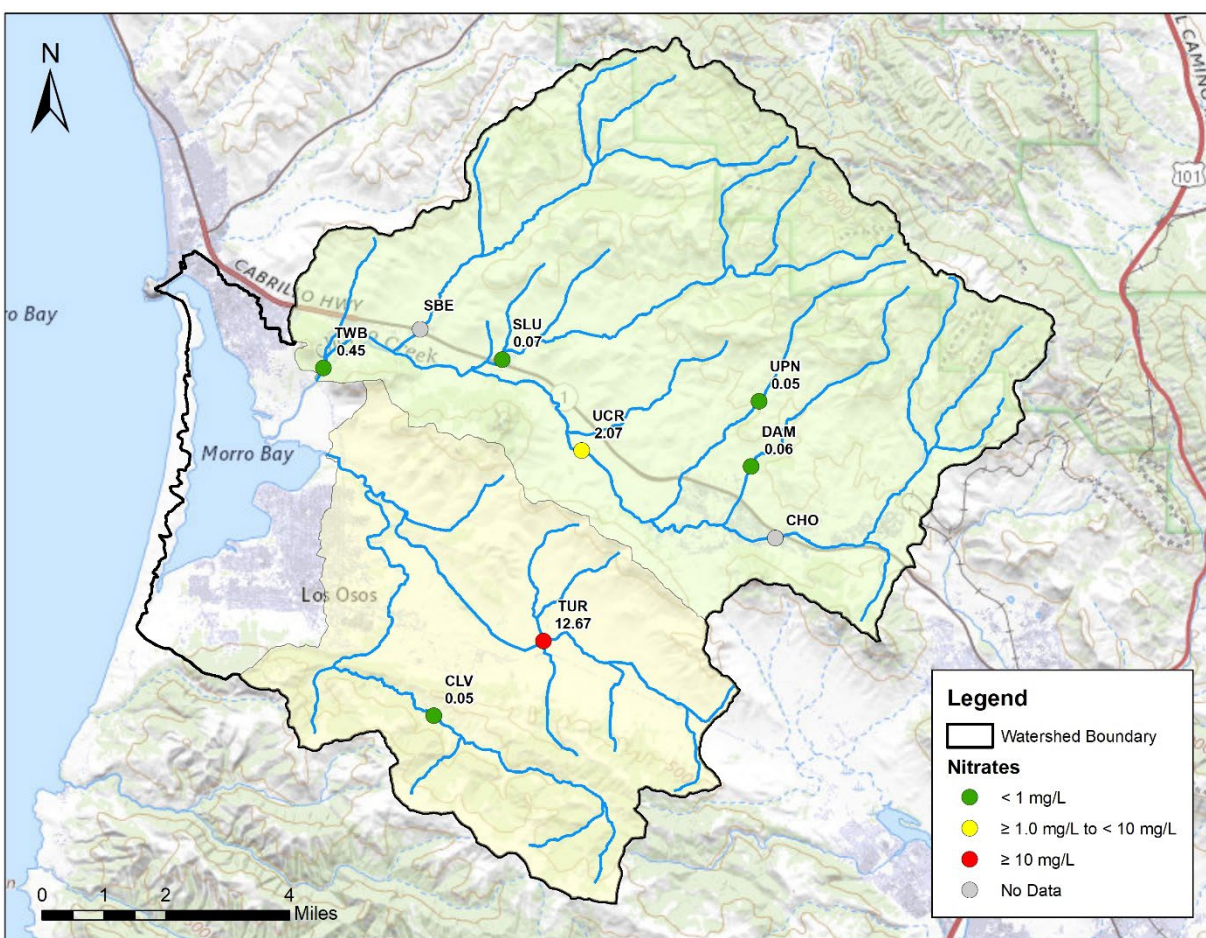


Figure 9: Average NO₃-N concentrations for WY2021 at seven representative monitoring locations.

Historical NO₃-N averages were compared to results from WY2021 (Table 3). Historic data includes nutrient monitoring data from WY2016 through WY2021. Values highlighted in green indicate concentrations which are protective of aquatic and human health (<1 mg/L NO₃-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 NO₃-N). Values highlighted in red exceed the level protective of human health (≥ 10 mg/L NO₃-N). The relative percent difference (RPD) was then calculated to compare WY2021 data to historical data. Sites with higher RPDs indicate greater differences between WY2021 and historical data. Sites with "-" indicate that there is no data available.

Table 3: Historical NO₃-N averages compared to WY2021 averages.

Site Code	CHO	UCR	TWB	DAM	UPN	SLU	SBE	TUR	CLV
Historical Average, NO ₃ -N mg/L	0.13	2.26	0.76	0.06	0.07	0.10	0.39	12.76	0.09
WY2021 Average, NO ₃ -N mg/L	-	2.07	0.45	0.06	0.05	0.07	-	12.67	0.05
Relative Percent Difference	-	8.9%	50.9%	3.6%	26.6%	42.9%	-	0.8%	54.6%

Orthophosphate as Phosphorus

Orthophosphate as phosphorus (PO₄-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 at low risk for eutrophication. 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 9 indicates the average PO₄-P concentrations for sites monitored in WY2021. 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 WY2021

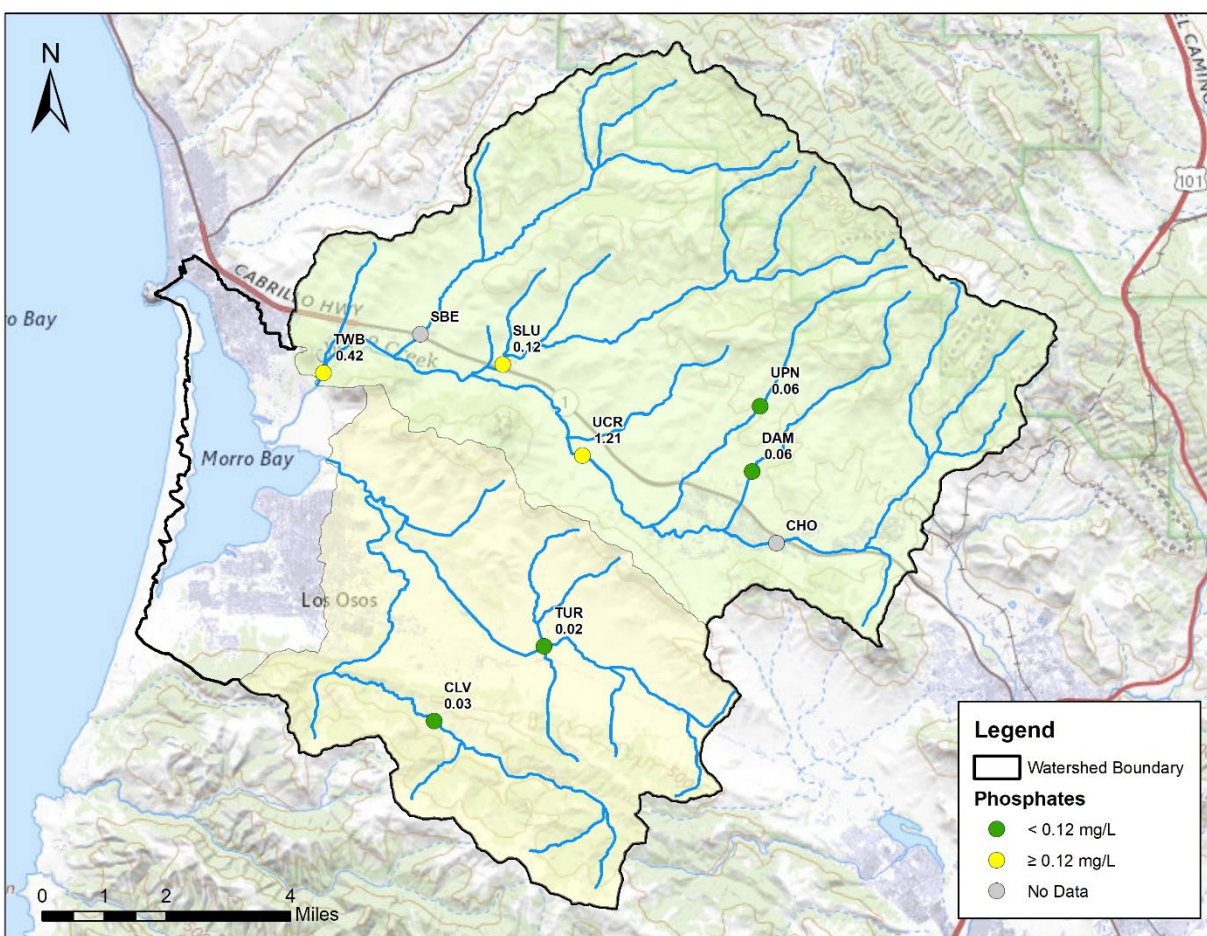


Figure 10: Average PO_4 -P concentrations for WY2021 at seven representative monitoring locations

Historical PO_4 -P averages were compared to results from WY2021 (Table 4). Historical data includes nutrient monitoring data from WY2016 through WY2020. 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 relative percent difference (RPD) was then calculated to compare WY2021 data to historical data. Sites with higher RPDs indicate greater differences between WY2021 and historical data. Sites with “-” indicate that there is no data available.

Table 4: Historical PO_4 -P averages compared to WY2021 averages.

Site Code	CHO	UCR	TWB	DAM	UPN	SLU	SBE	TUR	CLV
Historical Average, PO_4 -P mg/L	0.03	0.86	0.44	0.08	0.04	0.10	0.14	0.04	0.04
WY2021 Average, PO_4 -P mg/L	-	1.21	0.42	0.06	0.06	0.12	-	0.02	0.03
Relative Percent Difference (%)	-	33.4%	3.5%	24.7%	49.8%	23.1%	-	72.4%	12.7%

Discussion

The highest NO₃-N values in the Morro Bay watershed have consistently been detected on Warden Creek (TUR), which is heavily impacted by surrounding agricultural cropland. Elevated NO₃-N values from Warden Creek have consistently exceeded the level of protection for aquatic health and for human health. Data collected from Chorro Creek immediately downstream of the CMC WWTP outfall (UCR) has also resulted in elevated NO₃-N concentrations relative to upstream and downstream levels. These levels have historically exceeded the level of protection for aquatic health but not the level of protection for human health.

PO₄-P concentrations are typically higher in the Chorro Creek subwatershed than in the Los Osos Creek subwatershed. The sites located along the mainstem of Chorro Creek tend to track with higher PO₄-P concentrations than the surrounding tributaries. Chorro Creek at UCR represents the higher end of PO₄-P concentrations in the watershed, followed by lower Chorro Creek at TWB.

Nutrient impairment often tracks with large DO fluctuations and excess algae. Since continuous DO data is not available for WY2021¹, temperature can be used as a proxy to estimate when DO levels were likely low. For example, UCR had the second highest rate of elevated temperatures during the summer season. Thus, it is likely that less-than-ideal DO conditions occurred during the summer of WY2021 at this site, and nutrient enrichment may have further contributed to the decline.

The presence of algae is also an indicator of nutrient impairment. Although the Estuary Program collects observational algal data when conducting bimonthly nutrient monitoring, data collected to date is too limited to report. The Estuary Program hopes to share a more robust dataset in the future.

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.

To retrieve Nutrient data, visit www.CEDEN.org

- Click on “Find Data”
- Choose the “CEDEN Query Tool”
- Under “Select Program,” choose the Morro Bay National Estuary Program, then choose “Done”
- Under “Select Stations,” choose Dairy Creek within cattle enclosure (site code DAM), Pennington Creek upstream from horse corral (UPN), Chorro Creek at Camp SLO (CHO), Chorro Creek at upper Chorro Creek Ecological Reserve (UCR), Chorro Creek at South Bay Boulevard (TWB), San Luisito Creek @ Adobe Rd (SLU), San Bernardo Creek at Adobe Rd (SBE), Warden Creek at Turri Road (TUR), and Los Osos Creek Clark Valley Road (CLV)
- Click on “Retrieve Data”

For continuous monitoring temperature data, contact the Estuary Program.

For additional details, please contact the Estuary Program at 805-772-3834 or staff@mbnep.org.

¹ The Estuary Program was not able to deploy continuous dissolved oxygen loggers from WY2019 to WY2021 due to equipment malfunctions. However, equipment has been purchased to resume continuous dissolved oxygen deployments in WY2022.

Literature Cited

- Beschta R.L., Bilby R.E., Brown G.W., Holtby L.B., Hofstra, T.D. (1987). Stream temperature and aquatic habitat: fisheries and forestry interactions. *Streamside Management: Forestry and Fishery Interactions*, University of Washington Institute of Forest Resources. 191-232. Available online at: https://www.fs.fed.us/rm/boise/AWAE/labs/awae_flagstaff/Hot_Topics/riphreatbib/beschta_etal_streamtempaquahab.pdf
- McCullough, Dale. (2010). Are coldwater fish populations of the United States actually being protected by temperature standards? *Freshwater Reviews*, 3. 147-199. 10.1608/FRJ-3.2.4.
- Moyle, P.B. (2002) *Inland Fishes of California*. University of California Press.
- U.S. Environmental Protection Agency (USEPA). (1986). *Quality Criteria for Water* ("Gold Book"). U.S. Environmental Protection Agency, Office of Water, Washington, D.C. EPA 440/5-86-001. Available at: <http://www.epa.gov/waterscience/criteria/library/goldbook.pdf>.
- U.S. Environmental Protection Agency (USEPA). (2003). *EPA Region 10 Guidance for Pacific Northwest State and Tribal Water Quality Standards*. Region 10, Seattle, WA. EPA 910- B-03-002. 49pp. Available at: <https://www.epa.gov/nscep>.
- Welsh, H. H., Jr., Hodgson G. R., Harvey B. C., and Roche M. E. (2001). Distribution of juvenile Coho salmon in relation to water temperatures in tributaries of the Mattole River, California. *North American Journal of Fisheries Management*, 21 (1): 464-470.
- Williamson, R. (1994). The Establishment of Nutrient Objectives, Sources, Impacts, and Best Management Practices for the Pajaro River and Llagas Creek. San Jose State University.

This project has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreement CE-98T25101 to the Bay Foundation of Morro Bay. The contents of this document do not necessarily reflect the views and policies of the Environmental Protection Agency, nor does the EPA endorse trade names or recommend the use of commercial products mentioned in this document.

Appendix A: WY2021 Deployment Timelines

Site	Deployment
CHO	10/1/2020 - 1/26/2021 and 3/25/2021 - 9/30/2021
UCR	10/1/2020 - 9/30/2021
CCC	10/1/2020 - 9/30/2021
DAU	1/21/2021 - 6/17/2021 (site went dry after 6/17/2021)
UPN	10/1/2020 - 9/30/2021
SLU	10/1/2020 - 9/30/2021

Appendix B: WY2021 Dates for each Seasonal Period

Time Period	Start	End
Water Year 2021	10/1/2020	9/30/2021
Fall Season	10/1/2020	12/20/2020
Winter Season	12/21/2020	3/19/2021
Spring Season	3/20/2021	6/19/2021
Summer Season	6/20/2021	9/30/2021