Morro Bay Estuary Bacteria and Dissolved Oxygen Analysis
Water Year 2025

Date Range: Water Year 2025 (October 1, 2024 to September 30, 2025)
Analytes: Dissolved Oxygen, *Enterococcus spp.*

1. Background

The Morro Bay National Estuary Program's Monitoring 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.

Monitoring data is collected by Estuary Program staff and volunteers, under the guidance of a Quality Assurance Project Plan (QAPP) which is reviewed and approved annually by the EPA and the State Water Resources Control Board. This quality control 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 is available at www.mbnep.org/qapp.

2. Bay Bacteria

The Estuary Program's goal for bay bacteria monitoring is to assess the safety of the bay shoreline waters for recreational contact. Since 2005, program volunteers have sampled monthly at eight bay shoreline sites and analyzed the samples for the indicator bacteria enterococcus. The samples are collected using sterile technique. The Estuary Program formed a partnership with Cuesta College in which student volunteers collect and analyze samples with the IDEXX method in a biology lab on campus. This partnership provides real-world skills for students while helping the Estuary Program continue to collect this long-running data set.

3.1 Analysis Specifications

Specification	Value
Method	IDEXX Enterolert
Detection Range	10 to 24,190 MPN/100 mL
Hold Time	24 hours
Sample storage conditions	4°C in the dark

For results of < 10 MPN/100 mL, which is the detection limit for this method, a random value between 0.1 and 10 was assigned. For reports through WY2021, new random values were generated for all non-

detects in the time series during each year's analysis. Starting with WY2022, the randomized non-detect values for previous years have been kept static to reduce the differences between subsequent reports. This method of handling non-detect data is utilized by the Central Coast Regional Water Quality Control Board (CCRWQCB) in their own analysis.

2.1 Monitoring Locations

The eight bay shoreline monitoring sites were selected because they represent the areas with the most frequent recreational contact (Figure 1). The sites are (from north to south) Coleman Beach (site code COL), Tidelands Park (TID), Windy Cove (WIN), State Park Marina (SPM), Pasadena Point (PAS), Baywood Pier (BAY), Cuesta Inlet (CIN), and Sharks Inlet (SIN).

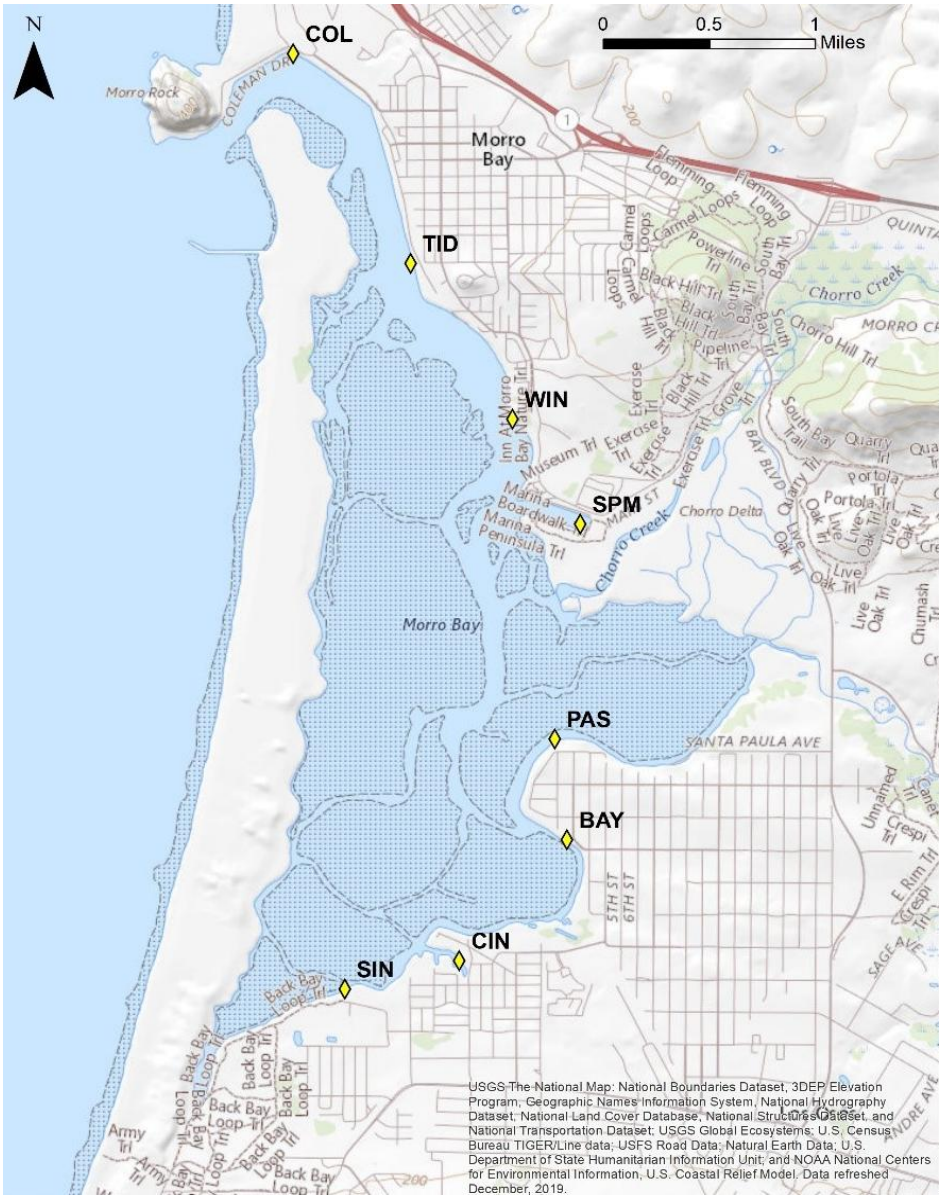

Figure 1. *Locations of shoreline bacteria monitoring sites in the Morro Bay estuary.*

2.2 Results

Indicator bacteria data show how frequently the waters in specific locations along the bay shoreline have levels greater than those safe for recreational contact.

The following graph (Figure 2) shows the percentage of samples from Water Year 2025 (WY2025) that exceeded the Statistical Threshold Value (STV) criteria. Ideally, no more than 10% of samples exceed this value of 110 MPN/100 mL for enterococcus in marine waters. This guiding value is from the State Water Resources Control Board's Bacterial Objectives. This state guidance was developed for a situation where multiple samples are collected in a month. As the Estuary Program collects only one sample each month, the comparison of program data to this criterion should be considered an adaptation of these water quality objectives and are not adequate for regulatory decision making.

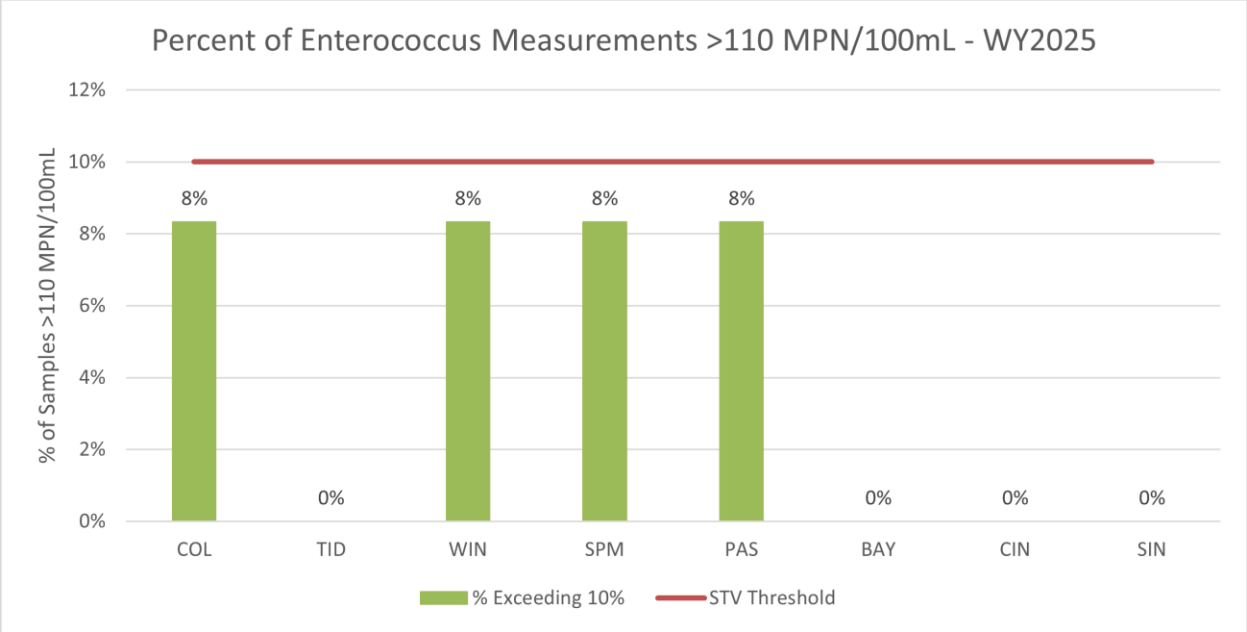

Figure 2. *Percent of Enterococcus results greater than 110 MPN/100 mL for WY2025. The red line indicates when 10% of samples exceed the STV threshold. Ideally no more than 10% of samples exceed this threshold, a condition that was met at all sites in WY2025.*

Figure 3 shows the geomean of all WY2025 data for each site. Ideally, the sample geomean remains below the regulatory threshold of 30 MPN/100 mL. This criterion is from the State Water Resources Control Board's Bacterial Objectives. Once again, this state guidance was developed for a situation where multiple samples are collected in a month. As the Estuary Program collects only one sample each month, the comparison of program data to this criterion should be considered an adaptation of these water quality objectives and are not adequate for regulatory decision making.

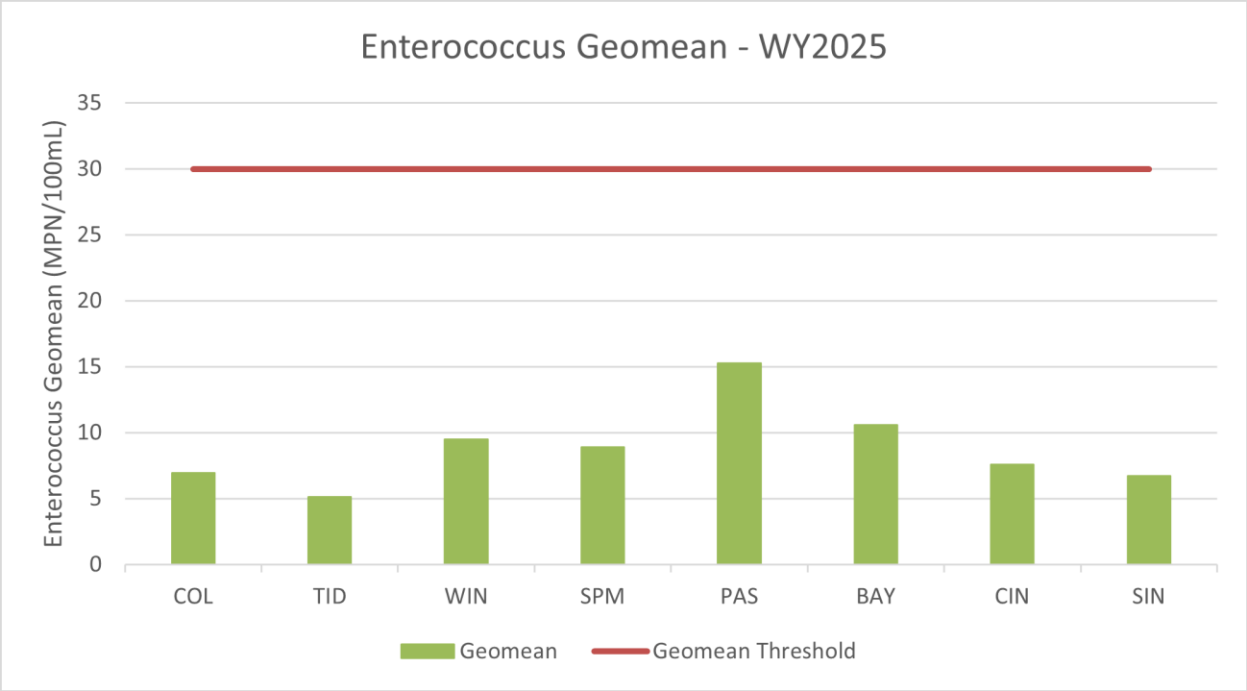

***Figure* 3.** *Geomean values from WY2025 collected from Morro Bay estuary shorelines sites. The red line indicates the geomean threshold of 30 MPN/100 mL. Ideally the geomean of data from a site remains below this threshold. All eight sets met the geomean criteria in WY2025.*

2.3 Discussion

Of the eight sites monitored, historical trends have shown six sites only rarely exceed recreational contact standards. The four sites toward the mouth of the bay (COL, TID, WIN, and SPM) have historically had very few elevated bacteria results. These sites are along the well-mixed main channel and are thought to be primarily influenced by ocean water entering the bay with the incoming tide. While the two sites furthest back in the bay, Cuesta Inlet (CIN) and Sharks Inlet (SIN), may experience some water circulation issues due to the shallow depth and minimal mixing with the incoming tides during certain times of year, they rarely exceed the recreational standards. This may be due at least in part to lower levels of bacterial input from sources such as urban storm runoff.

Two sites, Baywood Pier (BAY) and Pasadena Point (PAS), have had frequent exceedances of recreational standards over 20 years of monthly monitoring. During WY2025, PAS exceeded the STV threshold once and no samples from BAY exceeded the threshold. Figures 4 and 5 illustrate historic exceedances of regulatory thresholds from WY2010 to WY2025.

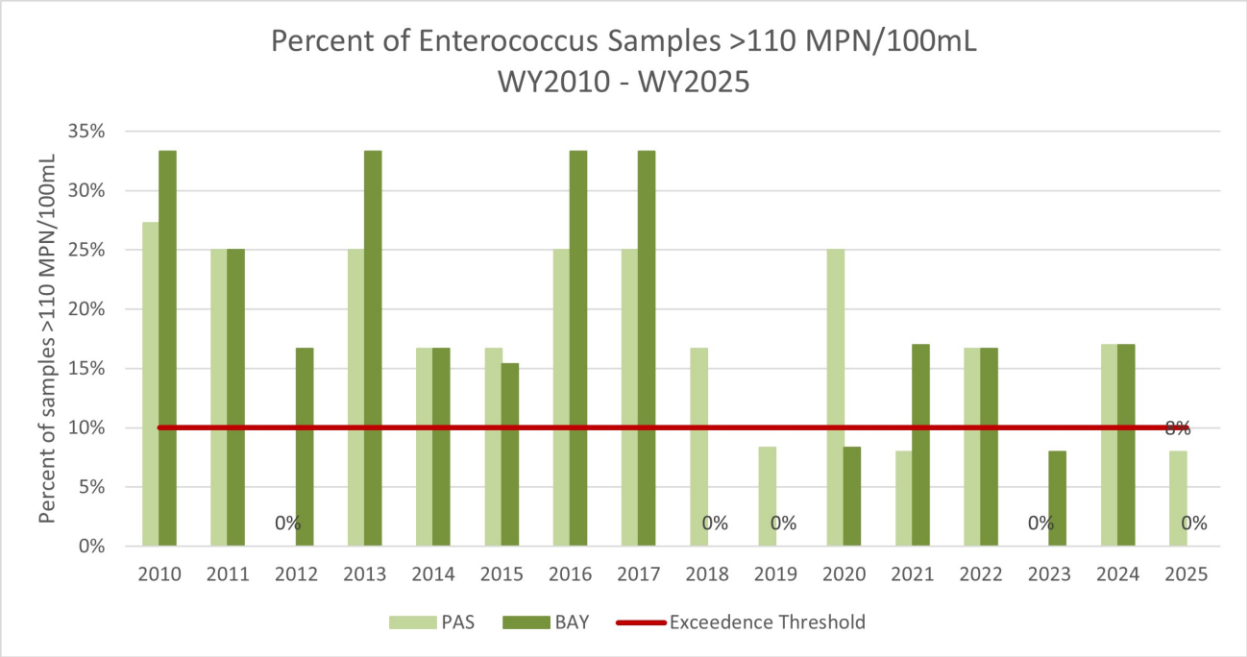

Figure 4. *Percent of Enterococcus samples greater than the Statistical Threshold Value (STV) of 110 MPN/100 mL over the last 16 years. Note that the absence of a bar indicates that 0% of samples exceeded the threshold for the year. The red line indicates when 10% of the samples exceed the STV, or Exceedance Threshold. Ideally no more than 10% of samples exceed the threshold.*

Figure 4 shows the exceedances of the recreational standard, identified as years where more than 10% of samples were at levels unsafe for swimming, for the last sixteen years. Both BAY and PAS have exceeded this threshold eleven out of sixteen years, although these did not always occur during the same year. When no exceedances were reported throughout the water year, it is represented in the graph with the absence of a line and a label of 0%.

The following graph (Figure 5) shows the geomean of bacteria results for each water year from WY2010 to WY2025. All monthly data for the year is used to calculate a single geomean value representing bacteria concentrations for that year. For PAS, four of sixteen years exceeded the geomean criteria of 30 MPN/100 mL. For BAY, six of sixteen years exceeded the geomean criteria of 30 MPN/100 mL. In the last eight years, neither site has exceeded the geomean criteria. The reasons for this are unclear, but it is likely due to a combination of factors including increased efforts to reduce agricultural runoff, sampling dates further from rain events, or septic system decommissioning in Los Osos.

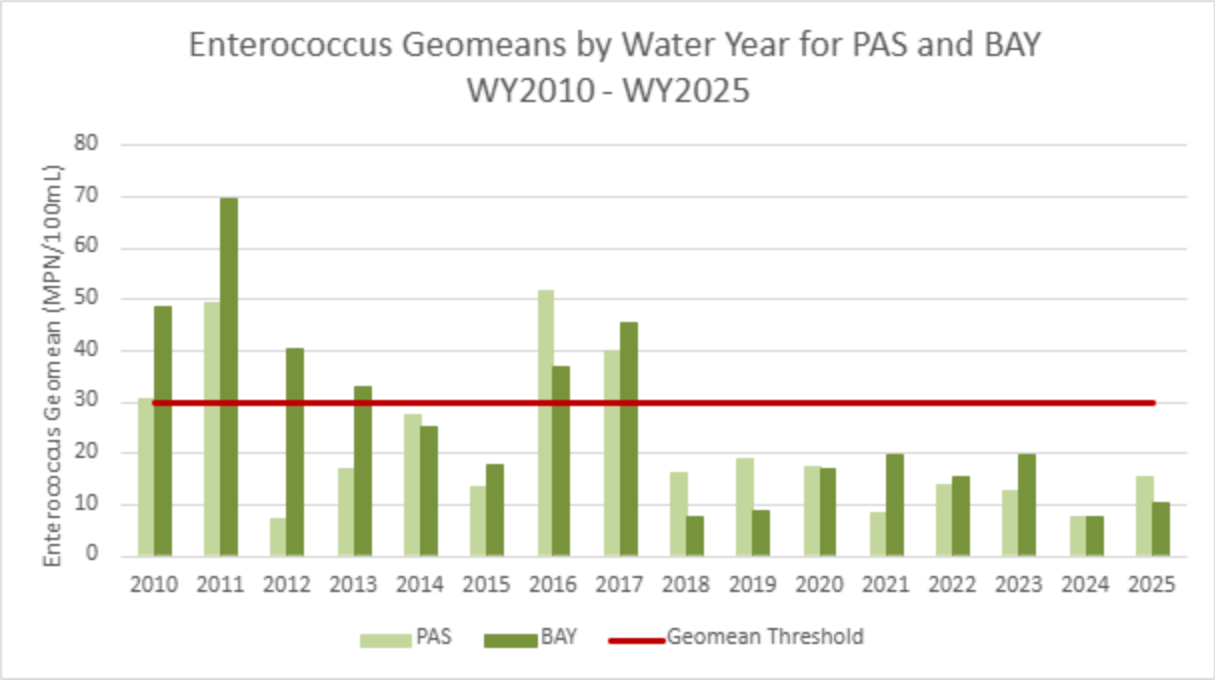

Figure 5. *Enterococcus geomean by year for PAS and BAY. The red line indicates the geomean threshold of 30 MPN/100 mL. Ideally, geomean values remain below this threshold.*

Pathogens are often flushed downstream into the bay by rainfall events, influencing the seasonality of enterococcus exceedances. Research into the flushing time of the Morro Bay estuary has quantified the amount of time it takes for estuarine water to exchange and mix with oceanic water, which can play a role in the amount of time bacteria introduced by runoff is retained within the bay. Flushing time along the Front Bay sites (COL, TID, WIN, SPM) is typically less than five days, while the Back Bay sites (BAY, PAS, CIN, SIN) experience flushing times of up to two weeks at certain times of year during neap tide cycles (Taherkhani et al. 2023). Potential sources of bay bacteria could include runoff from land, leaks from boat-waste holding tanks, contaminated groundwater, and wildlife.

3. Bay Dissolved Oxygen

Since 2002, Estuary Program volunteers have collected surface measurements for dissolved oxygen (DO) concentration, temperature, and salinity at seven sites in the bay on a monthly basis. The monitoring occurs within two hours of sunrise to capture the lowest DO levels of the diurnal cycle. Monitoring the lowest DO levels of the day allows the Estuary Program to assess the extent to which various regions of the bay support aquatic species that require adequate oxygen levels to thrive.

3.1 Equipment Specifications

The Estuary Program uses a YSI Pro 2030 meter, which measures DO concentration (mg/L), DO % saturation, temperature (°C), specific conductance (µS/cm), and salinity (ppt).

The equipment specifications for DO are as follows:

Specification	Value
Sensor Type	Polarographic
Measurement Range	0 to 50 mg/L
Calibrated Range	0 to 20 mg/L; 0 to 35°C
Accuracy	±2% of reading for 0 to 20 mg/L; ±6% of reading for 20 to 50 mg/L
Resolution	0.01 mg/L

To ensure data quality, the Estuary Program calibrates the meters weekly for DO using an internal calibration. For specific conductance and salinity, the meters are calibrated using known standards on a weekly basis.

3.2 Monitoring Locations

Seven bay monitoring sites were selected to represent different regions of the bay. The sites are (from north to south) Tidelands (site code ATP), State Park Marina (SPO), Los Osos Channel (LO2), Pasadena Point (PSP), Cuesta Channel (CHI), Cuesta Inlet (CSI), and Sharks Inlet (SHI).

The following map (Figure 6) shows the seven monitoring locations. Sites are grouped into two sets: Front Bay and Back Bay. Sites within each group are sampled on the same day, but the two groups are generally not sampled on the same day.

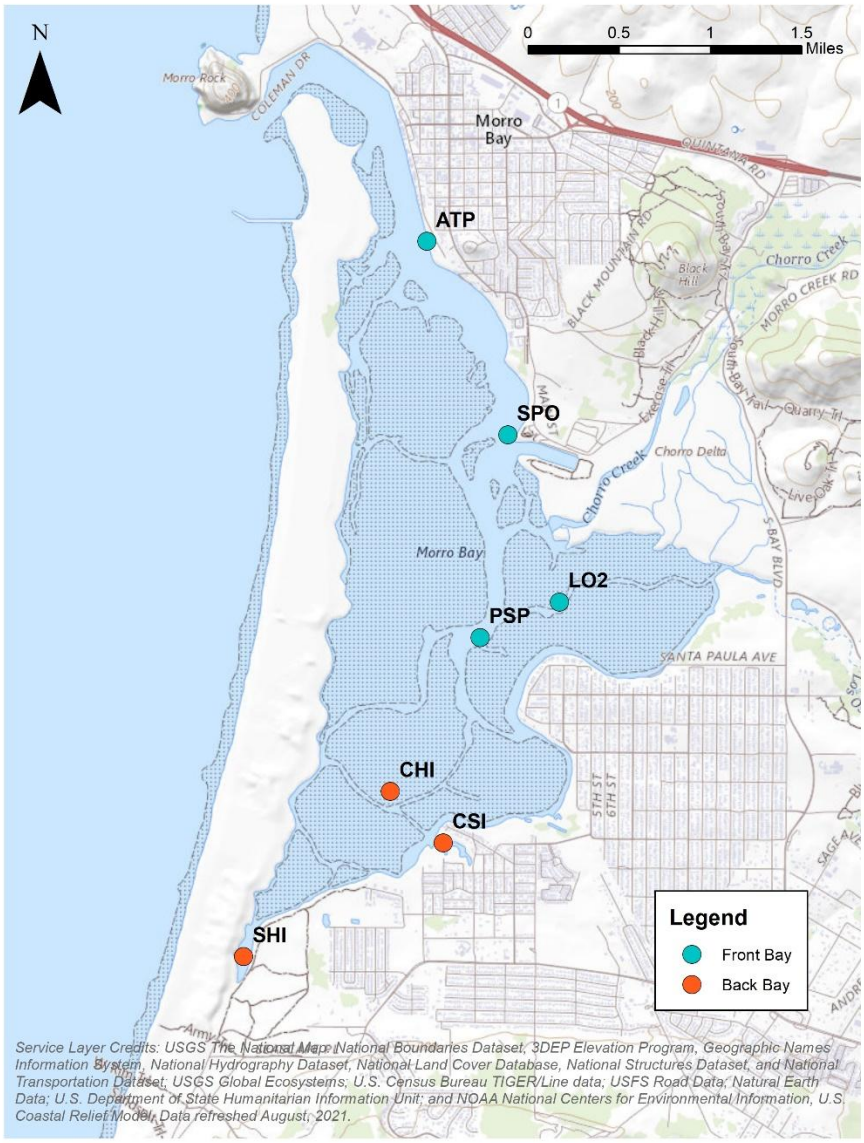

Figure 6. *Map of bay dissolved oxygen monitoring locations.*

3.3 Results

Analysis compares measured DO levels to standards protective of aquatic life. The CCRWQCB has designated the Morro Bay estuary as Marine Habitat and lists an objective that DO concentrations must remain at 7 mg/L or higher to be protective of aquatic life.

Data collected at the PSP and LO2 sites in the Front Bay during November 2024 were excluded due to equipment errors that resulted in inaccurate readings. Data collected in the Back Bay at the CSI site in October 2024 and in the Front Bay at the ATP site in April 2025 were also excluded due to equipment errors. Thus, a full year of readings are not available for these sites in WY2025.

The following graphs show the DO concentration data for WY2025 at each of the seven sites. Figure 7 shows the distribution of measurements for each site over WY2025 using a box-and-whisker plot.

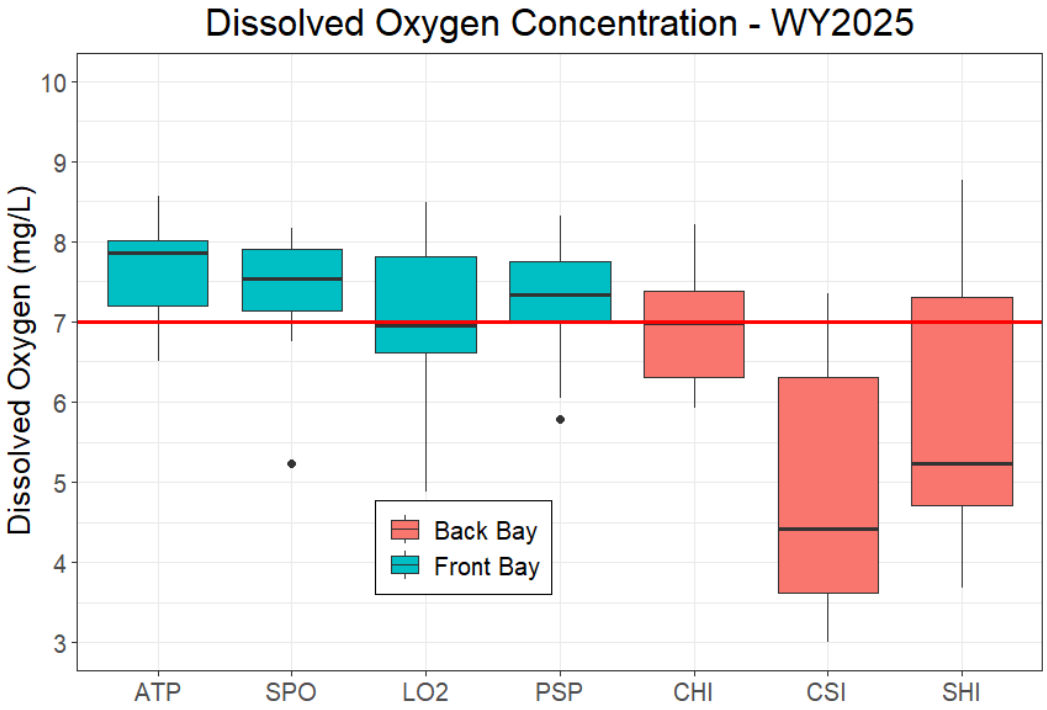

Figure 7. *Dissolved oxygen concentration distribution at seven representative sites during WY2025. The horizontal red line depicts the 7 mg/L protective limit. Ideally DO concentrations remain at or above 7 mg/L at all times. The April results from ATP, October results from CSI, and November results from both PSP and LO2 were excluded due to inaccurate sensor readings.*

Figure 8 shows the percentage of DO concentration readings in WY2025 that were less than 7 mg/L, meaning that the recorded DO measurements failed the numeric objective set by the CCRWQCB to be protective of marine waters. Ideally, no more than 10% of results would fall below the standard.

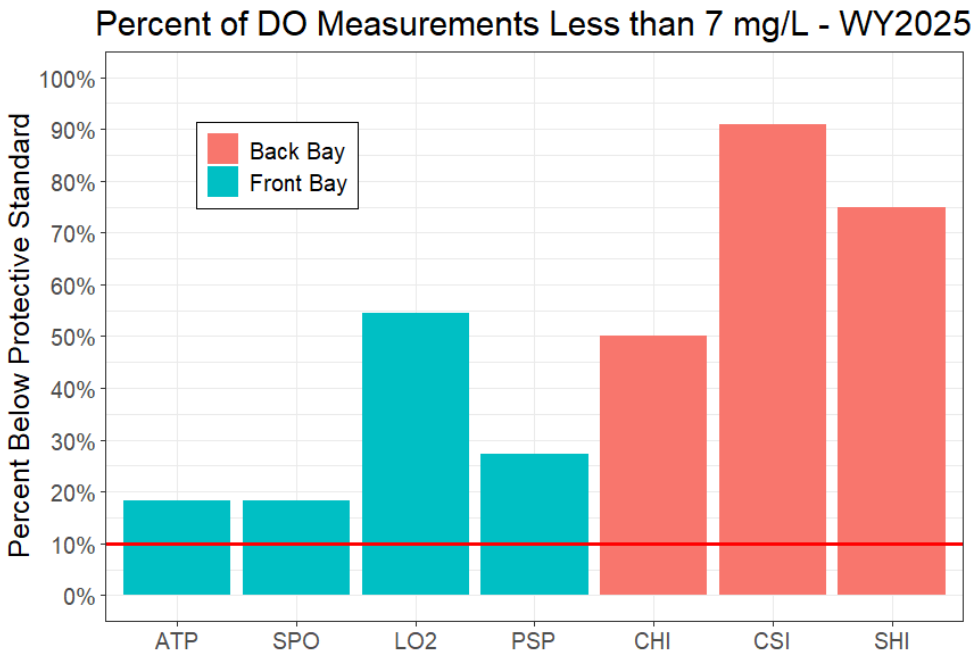

Figure 8. *Percent of DO measurements less than 7 mg/L during WY2025. All sites had more than 10% of samples fall below the protective standard. The horizontal red line depicts the 10% threshold. The April results from ATP, October results from CSI, and November results from both PSP and LO2 were excluded due to inaccurate sensor readings.*

Figure 9 shows the average DO values for WY2025 data. Ideally, all readings are greater than 7 mg/L to ensure adequate oxygen to be protective of aquatic life and to comply with CCRWQCB standards.

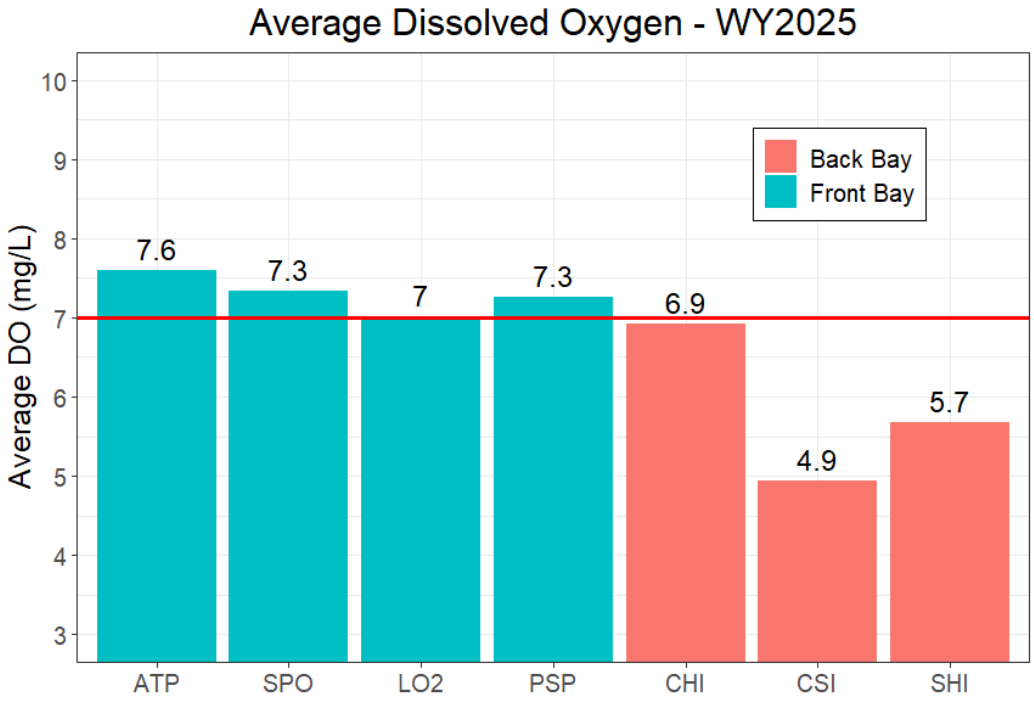

Figure 9. *Average of dissolved oxygen levels measured during WY2025. The horizontal red line depicts the 7 mg/L protective limit. Ideally, DO concentrations stay above that limit at all times. The April results from ATP, October results from CSI, and November results from both PSP and LO2 were excluded due to inaccurate sensor readings*

For the following figure (Figure 10), data from all Front Bay sites were combined (ATP, SPO, LO2, PSP) and data from all Back Bay sites were combined (CHI, CSI, SHI) to show how dissolved oxygen levels varied throughout WY2025. Sites in the Front Bay remained above the level of concern from October to December, then dipped below the threshold in January before returning to healthy levels from February to May. In June and July, it fell back below the threshold before reaching healthy levels again for the remainder of WY2025. The Back Bay was only above the threshold from December to February (Figure 10).

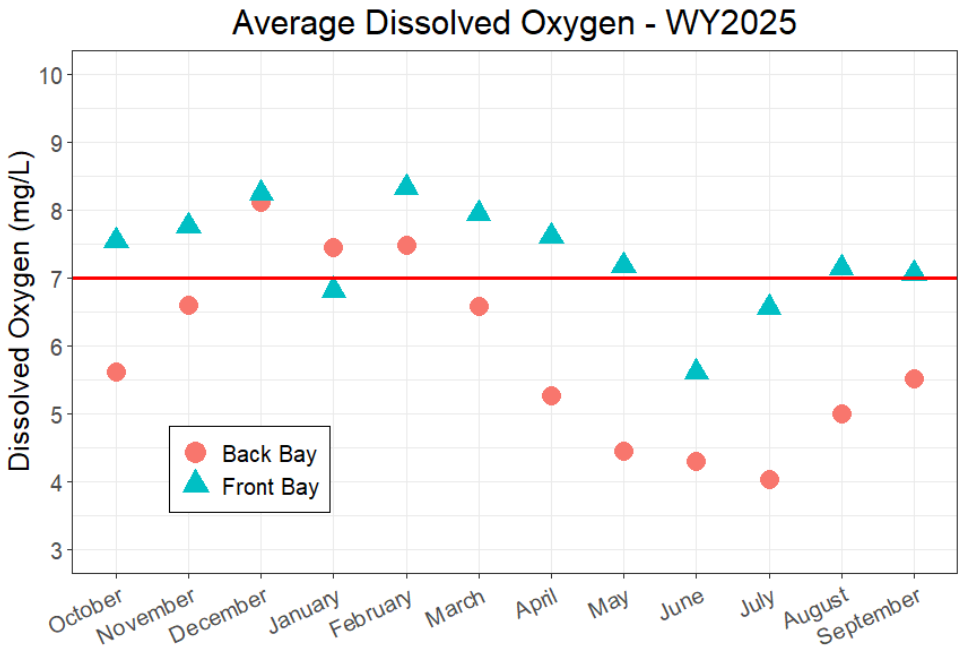

Figure 10. *For each month in WY2025, average dissolved oxygen levels for all Front Bay sites were combined and for all Back Bay sites were combined. The horizontal red line depicts the 7 mg/L protective limit, and ideally DO concentrations stay above that limit at all times. The April 2025 results from ATP, October results from CSI, and November results from both PSP and LO2 were excluded due to inaccurate sensor readings.*

In Figure 10, dissolved oxygen in the Front Bay and Back Bay appears to follow a general trend, which can also be seen in their respective five-year averages. Dissolved oxygen stays above the protective limit during cooler months and drops below the limit during warmer months, with the Back Bay sites

experiencing the largest decrease in concentration. Five-year averages for the Front and Back Bay sites can be seen in more detail in Figure 11.

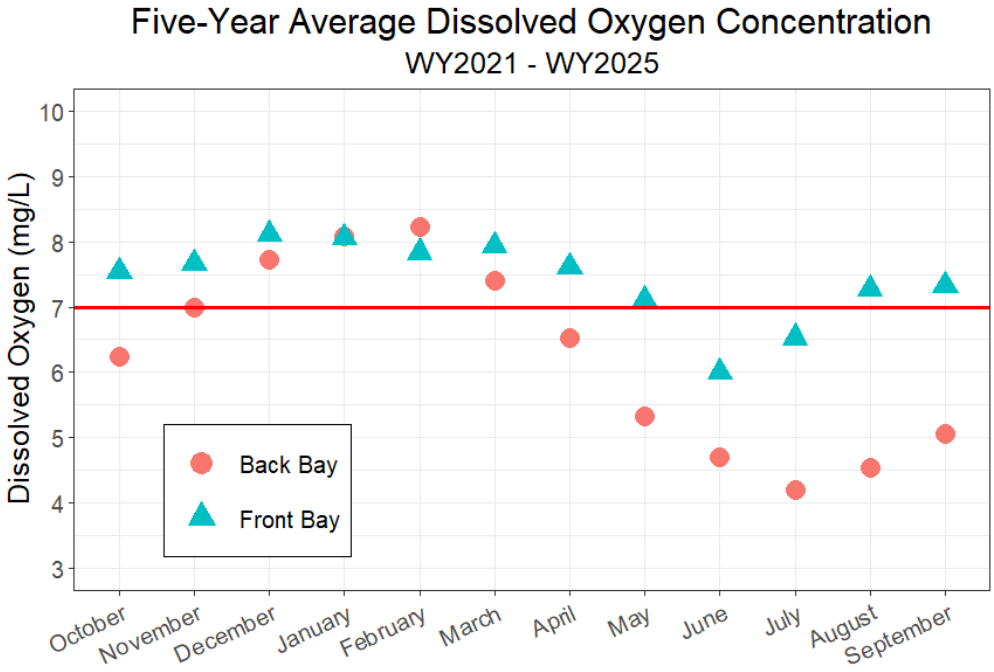

Figure 11. *Five-years of DO concentration data averaged by month for all Front Bay sites and for all back Back Bay sites, from WY2021 to WY2025. Monthly averages are presented to depict seasonal trends, with the 7 mg/L level of concern in red. Ideally DO concentrations stay above that limit at all times.*

3.2 Discussion

Instantaneous data collected by the Estuary Program shows DO levels frequently below the 7 mg/L water quality objective protective of the beneficial uses of the estuary, as outlined by the Water Quality Control Plan for the Central Coastal Basin. Sites located closer to well-mixed channels (ATP, SPO, LO2, and PSP) had fewer readings that fell below 7 mg/L. Sites toward the back of the bay often have lower DO concentrations on average than those located in the main channel and towards the front of the bay. Depressed DO levels in summer and fall may be due in part to shallower water throughout the bay. Shallower waters and warmer temperatures lead to saltier water, which cannot retain as much oxygen as fresh water. Poor water circulation may exacerbate these issues during the height of the summer.

Nutrient availability likely plays a fundamental role in the observed DO levels of aquatic environments. When excess nutrients enter the bay, the overall biomass of photosynthetic organisms like algae can increase. While this may lead to elevated peak DO levels, the microbial organisms that eventually break down this plant material absorb oxygen and cause very low minimum DO values. In addition to nutrients, many other factors such as temperature, light availability, and tidal currents also contribute to the distribution of algae in the bay and its effect on localized DO concentrations.

The anomalous Front Bay dissolved oxygen readings in January and June of WY2025 are likely due to the timing of Dawn Patrol surveys coinciding with periods of maximum or minimum tidal exchange. During the winter, low water temperature is consistent across the estuary, so salinity is a primary driver of

dissolved oxygen variability. In January, the DO readings were collected following a series of extreme tidal swings (>7 ft) which brought salty, oceanic water into the bay and contributed to reduced DO in the Front Bay. Since the Back Bay is flushed with freshwater from the incoming creeks (Chorro Creek and Los Osos Creek), it retained lower salinity than the Front Bay, which may have contributed to its slightly higher concentration of dissolved oxygen. Conversely, in June, the lower-than-average dissolved oxygen in the Front Bay was measured during low tidal swings and above average temperatures. Temperature is generally the primary driver of DO variability in the summer, so minimal tidal exchange reduced the amount of cold water flushing in the Front Bay, thus resulting in low DO concentration. These anomalous values are a reminder of how short-term physical and biological processes can drive enhanced DO variability, making it difficult to capture the magnitude of this variability with instantaneous grab samples (Walter et al. 2022).

4. Data Availability

The data is available from the California Environmental Data Exchange Network (CEDEN), a State Water Resources Control Board data portal. To retrieve data,

- Visit https://ceden.waterboards.ca.gov/.
- Click on Find Data, then select CEDEN Query Tool.
- For Program, choose Morro Bay National Estuary Program.
- Bay Bacteria: For Stations, choose Morro Bay sites Coleman Beach shoreline, Tidelands Park shoreline, Windy Cove, State Park Marina shoreline, Pasadena Point shoreline, Baywood Pier shoreline, Cuesta Inlet shoreline, and Sharks Inlet shoreline.
- Bay DO: For Stations, choose Tidelands Park, State Park Marina bay, Sharks Inlet bay, Pasadena Point Bay, Near Cuesta Inlet, North of Cuesta Inlet Mouth, and Los Osos Creek Channel.
- Click on Submit to retrieve data.

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

This project has been funded wholly or in part by the United States Environmental Protection Agency under assistance agreements CE-98T25101 and 4T98T47301 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.