MORRO BAY
NATIONAL ESTUARY PROGRAM

STATE OF THE BAY | 2023

A report on the health of the Morro Bay Estuary

How healthy are the estuary and the lands that surround it?

Morro Bay is a unique spot on California's Central Coast that supports both a diversity of wildlife and a thriving community. Its scenic beauty and ample opportunities for outdoor recreation inspire residents and visitors alike.

The Morro Bay National Estuary Program is a non-profit that works to protect and restore Morro Bay and the lands that surround it for people and wildlife.

The program brings together members of the public, government, nonprofits, and landowners to preserve the area's habitats while maintaining balanced uses of the bay such as commercial fishing, shellfish farming, bird watching, and on-water recreation.

Every three years, the Estuary Program gathers scientific data to answer some of the common questions we are asked about the health of the estuary and watershed.

Questions Answered in this Report

Photo courtesy of Michael "Mike" Baird, bairdphotos.com.

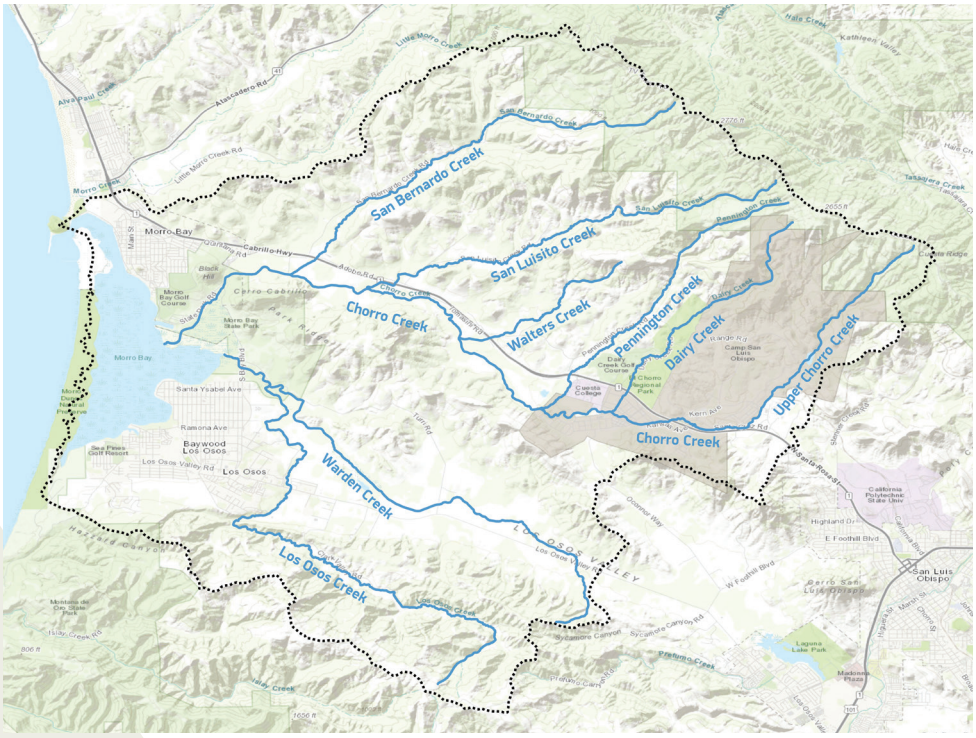
Authored by Estuary Program Staff

Ann Kitajima with great support from Nick Soares, Makenzie O'Connor, Carolyn Geraghty, Melodie Grubbs, and Riley Hine.

The Estuary Program sincerely thanks its many partners, volunteers, and committee members for their dedication to the Morro Bay Estuary and their continued support. The report was funded in part by a grant from the U.S. EPA.

Cover photo by Melodie Grubbs

The Morro Bay Estuary and its Watershed



Watershed Boundary

The Morro Bay watershed contains a network of creeks that drain rainfall and other fresh water from 48,000 acres of land into Morro Bay. The fresh water from land meets with the salty water from the ocean to create a unique environment called an estuary. This connection between the land and the estuary means that what happens on the land has a large impact on the health of Morro Bay.

How to Read Estuary Health Symbols

The Estuary Health Symbols represent how the status of each question is changing over time. A round symbol indicates that the trend is stable. An up arrow (↑) indicates an improving trend while a down arrow indicates a worsening trend (↓). The color of the rectangular base of the arrow indicates the status of historical data and the color of the point of the arrow indicates the status of the newer data. The color of the symbol indicates the status as follows: Good/Very Good (green), Fair (yellow), Poor (orange), Very Poor (red), and Unknown (gray).

This symbol indicates that the water quality was Very Poor and has improved to Fair.

This symbol indicates that the trend is stable but we lack adequate data to assign a quality indicator.

- Very Good/Good
- Fair
- Poor
- Very Poor
- Unknown

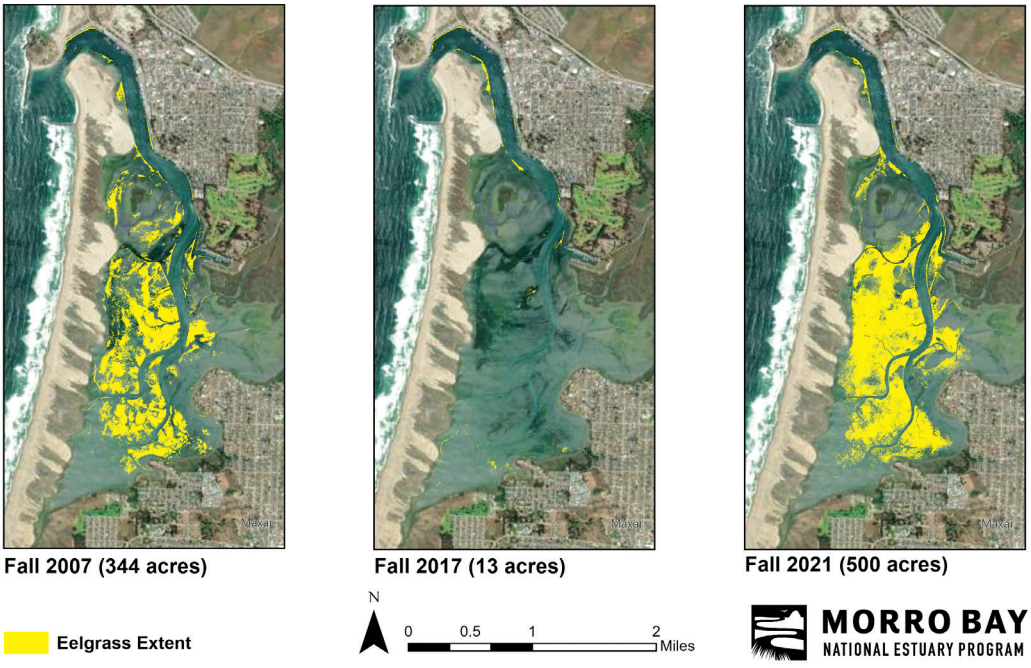
Does Morro Bay support healthy eelgrass beds?

Yes, the amount of eelgrass in the bay has increased rapidly over the last few years, with acreage surpassing pre-decline levels.

Eelgrass is a flowering plant that serves many important functions in an estuary. Its roots help hold bay sediments in place, which reduces erosion and keeps the waters clear. Eelgrass sequesters carbon, which keeps it out of the atmosphere and helps mitigate the effects of climate change. As a photosynthesizing plant, eelgrass also puts oxygen into the water to support other aquatic life. The plant's floating blades form a sort of underwater forest that provides shelter and a place to find food for a wide variety of wildlife.

The Estuary Program has led efforts to map eelgrass for the past twenty years. The 2007 map indicated 344 acres of eelgrass. Over the next decade, eelgrass experienced a precipitous decline to only 13 acres. Since 2017, mapping has indicated an eelgrass recovery, with 500 acres mapped in 2021. Although the reasons for the decline and rapid recovery are not fully understood, a combination of factors such as water quality and elevation change likely played a role. Restoration efforts have also bolstered the recent recovery.

Eelgrass Acreage: 2007, 2017, and 2021



Eelgrass acreage (represented in yellow) declined from 2007 when 344 acres were mapped. In 2017, small patches of eelgrass appeared in the mid and back bay, which were the areas with the most eelgrass loss. Acreage has been increasing since 2017, with the 2021 map indicating 500 acres. Although some changes in the mapping methods occurred over time, the strong eelgrass recovery is welcome news to the Estuary Program and the community.

Eelgrass Restoration

Faced with a large-scale eelgrass decline, the Estuary Program led restoration efforts from 2017 to 2021 with partners including Cal Poly, Tenera Environmental, Inc., and many volunteers. Over the last five years, nearly 15,000 plants were harvested from healthy eelgrass beds and transplanted at 39 sites in both intertidal and subtidal areas. Initial efforts focused on small-scale plantings to determine factors that improved restoration success, including donor bed locations, time of year, and anchoring methods. This photo shows a Tenera diver preparing to install eelgrass plants tied to a bamboo stake, a successful method of transplanting eelgrass. Each year, we applied the lessons learned and expanded the scale of restoration. The majority of the restoration sites in Morro Bay have thrived. Locations with poor transplant success were likely affected by factors such as shallow depths and an overabundance of macroalgae.

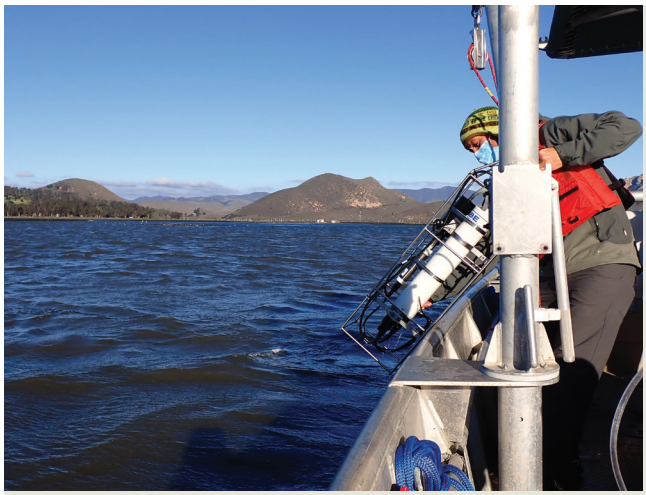
With 500 acres of eelgrass mapped in 2021, the Estuary Program has ended restoration efforts and will continue to monitor the health of existing eelgrass beds and track large-scale changes in acreage over time.

Macroalgae Impacts on Eelgrass

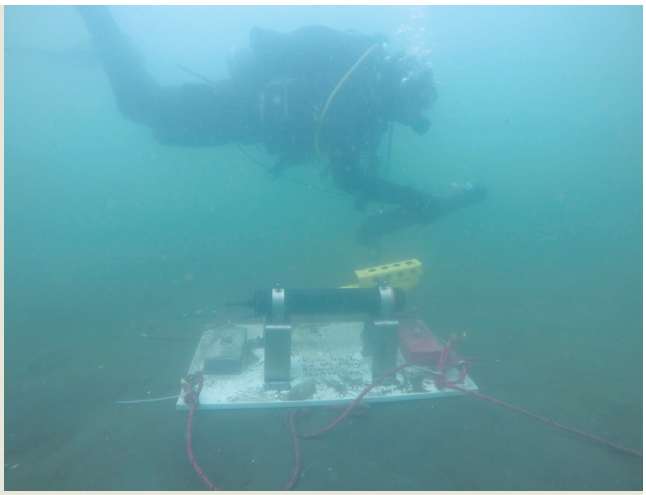
Macroalgae can play a beneficial role in an estuary, providing food, habitat, and nutrient cycling in the bay. However, excess macroalgae can have negative impacts. It can shade eelgrass plants, blocking the sunlight they need to grow, and when macroalgae decomposes, it can deplete oxygen in the water and in the sediment, harming fish and invertebrates. The amount of macroalgae in Morro Bay can fluctuate greatly from year to year. We have observed a recent increase in macroalgae, and eelgrass monitoring efforts indicate areas where macroalgae outcompeted eelgrass, as pictured on the right. We will continue to monitor macroalgae, its impacts on eelgrass, and how issues such as elevated nutrients affect both species.

Eelgrass Research

To better understand the conditions that influence eelgrass health, the Estuary Program partnered with Cal Poly on a Restore America's Estuaries Coastal Watershed Grant. The multi-year project focused on eelgrass mapping and monitoring, restoration, bay elevation-change tracking, and water quality. These photos show the work of Dr. Ryan Walter of the Physics Department and Dr. Emily Bockmon of the Chemistry Department along with their students.



Dr. Walter deployed sensors to measure water quality parameters such as temperature and salinity. Measurements were collected at high tide and low tide in July and December 2021. Photo courtesy of Dr. Emily Bockmon.



Cal Poly deployed water quality sensors within an eelgrass bed and in a nearby area without eelgrass to study how the plant alters water currents and pH levels in the surrounding water. Photo courtesy of Dr. Ryan Walter.

Dr. Bockmon and her students collected water samples each month from six sites along the bay shoreline as part of the research effort. Samples were analyzed for nutrients and carbonate chemistry. Photo courtesy of Dr. Emily Bockmon.

Senior Research Scientist Ian Robbins conducted maintenance on a monitoring sensor station at the north T-pier that measures water quality parameters such as temperature, pH, oxygen, and salinity. Photo courtesy of Dr. Ryan Walter.

Is Morro Bay safe for swimming?

Yes, most of the time in the locations we test.

The Morro Bay estuary is a popular recreation destination for tourists and residents. Clean water is essential for people to safely paddle, sail, kayak, and swim in the bay. Polluted water can contain things like bacteria, viruses, and protozoa that can make people ill. These pathogens can come from sources such as stormwater runoff, pet waste, agricultural operations, wildlife, treatment plant spills, and improperly operating septic tanks or boat-waste holding tanks.

To track bay bacteria concentrations each month, Estuary Program staff and volunteers collect and analyze water samples at bay shoreline sites where people often recreate.

New Monitoring Partnership

The Estuary Program is partnering with Drs. Laurie McConnico and Silvio Favoreto of Cuesta College on a joint bacteria monitoring effort. Cuesta students, pictured here collecting field samples, will process them in Cuesta's lab to contribute to our long-running data set. For the past twenty years, we have conducted this work in the City of Morro Bay wastewater treatment plant lab, and the Estuary Program thanks the city for this collaboration.

This map shows the safe swimming status of eight bay sites using data from 2005 through 2021. The green circles indicate that the bacteria levels are low at these locations and that the waters are typically safe for swimming. However, storm runoff can bring contaminants into the bay, so Surfrider and Heal the Bay recommend staying out of the water for 72 hours following a storm.

Bay Bacteria Status

- Very Good/Good
- Fair
- Poor
- Very Poor

Is the bay clean enough to support commercial shellfish farming?

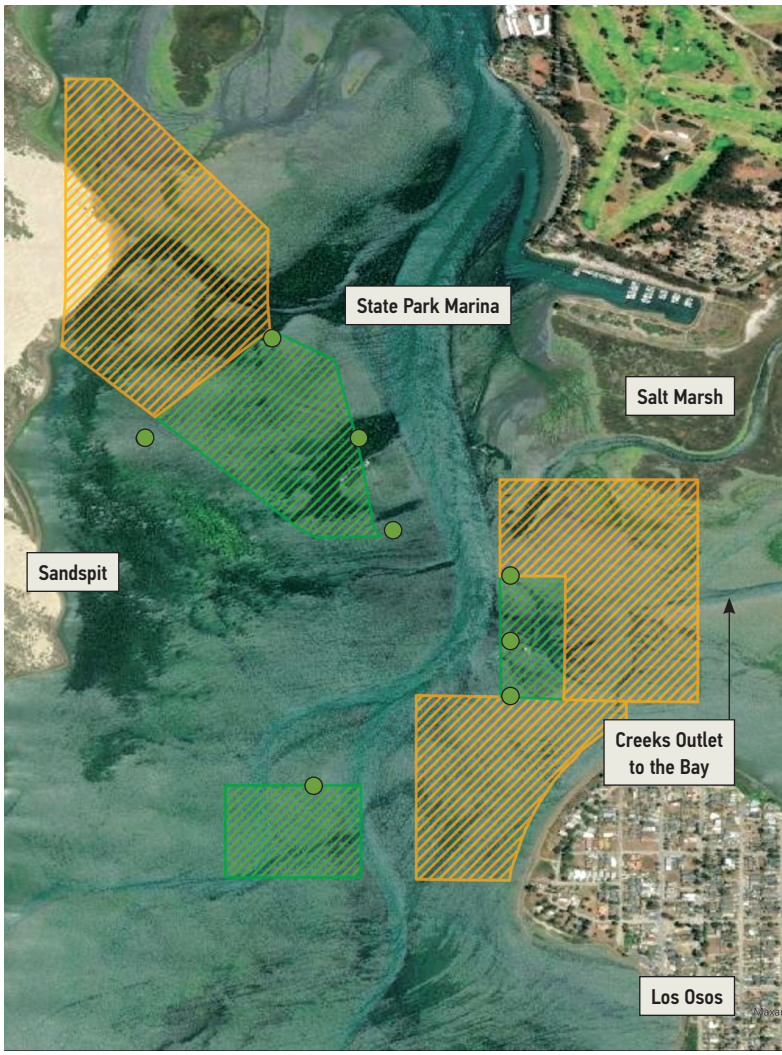
Yes, in active harvesting areas.

Morro Bay is fortunate to be one of the few areas on the California coast with our own source of local oysters. The Morro Bay Oyster Company and Grassy Bar Oyster Company grow Pacific oysters in the bay's waters for sale in markets and restaurants. There are approximately 73 acres available for oyster farming, which is only 3% of the bay's total acreage. The aquaculture industry depends on clean water, and the California Department of Public Health is responsible for determining if the water quality in the bay is suitable for growing oysters. One of the measures they consider are the levels of bacteria in the water at the oyster farming sites.

Above: *Photo courtesy of Grassy Bar Oyster Company.*

Right: *The shaded areas on the map represent potential shellfish farming lease areas. The green sections of each lease area have clean water where shellfish harvesting is permitted. Shellfish harvesting is not permitted in the orange areas either because of poor water quality or a lack of data.*

Morro Bay Shellfish Growing Areas



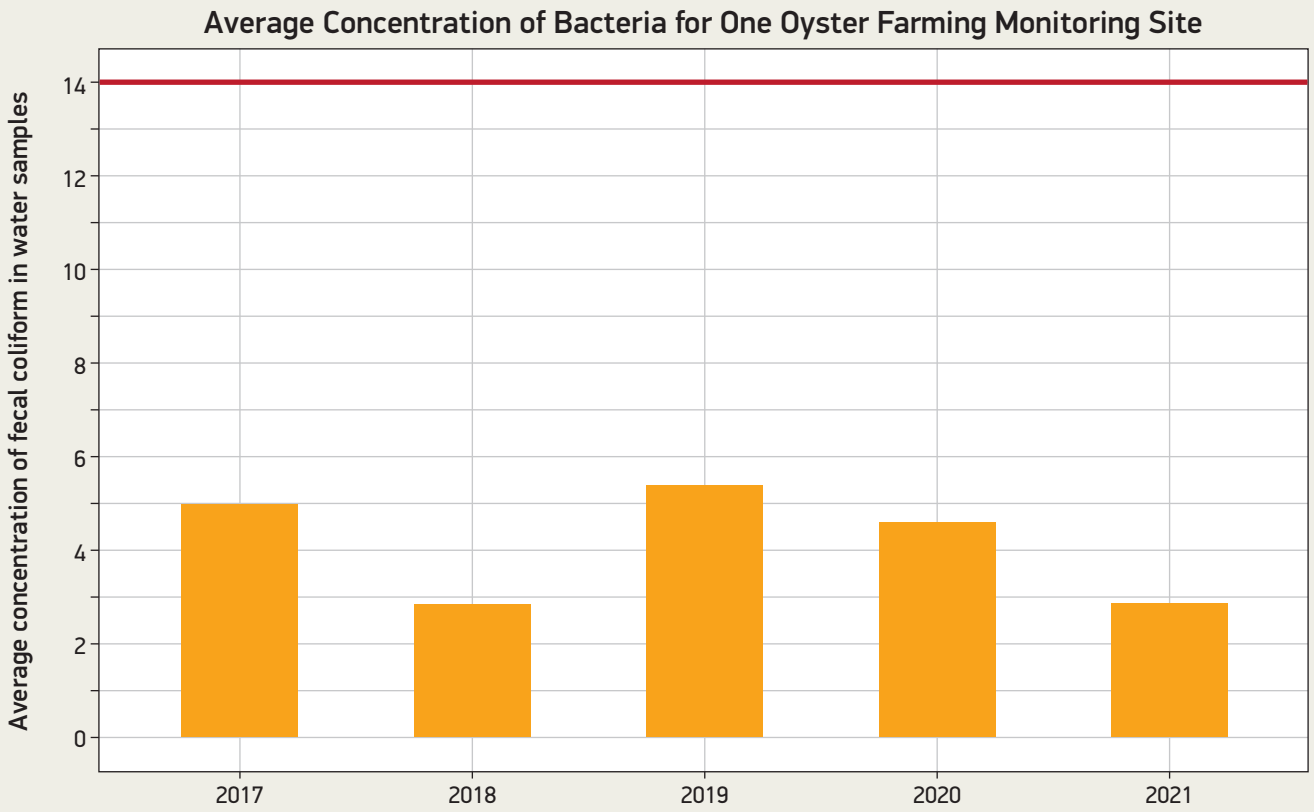
Bacteria (Fecal Coliform) Status

- Good
- Poor

Shellfish Lease Status

- Active Growing Area
- Inactive Growing Area

A Closer Look at Water Quality



The graph shows the annual average bacteria levels in the water at one of the monitoring sites in the oyster growing areas. The bacteria levels must remain below the red line for the shellfish to be safe for consumption.

Views of the Farms

Morro Bay is home to two oyster growing operations. This drone image of Grassy Bar Oyster Company at a low tide shows the barge where oysters are prepared for market (at the top of the image). The long lines are cables anchored to the bay floor, with mesh bags attached that contain the growing oysters. Drone image courtesy of Cal Poly.

This close-up view of Morro Bay Oyster Company at low tide shows the mesh growing bags with floats on one end. As the tide comes in, the floats rise up and the oysters are tipped to the bottom of the bag. Without this periodic mixing of the oysters, they would grow in a clump that would not produce marketable shellfish. Photo courtesy of Morro Bay Oyster Company and Christa Renee.

Is water in the creeks and bay clean enough for fish and aquatic life?

Some areas are healthy and others are degraded.

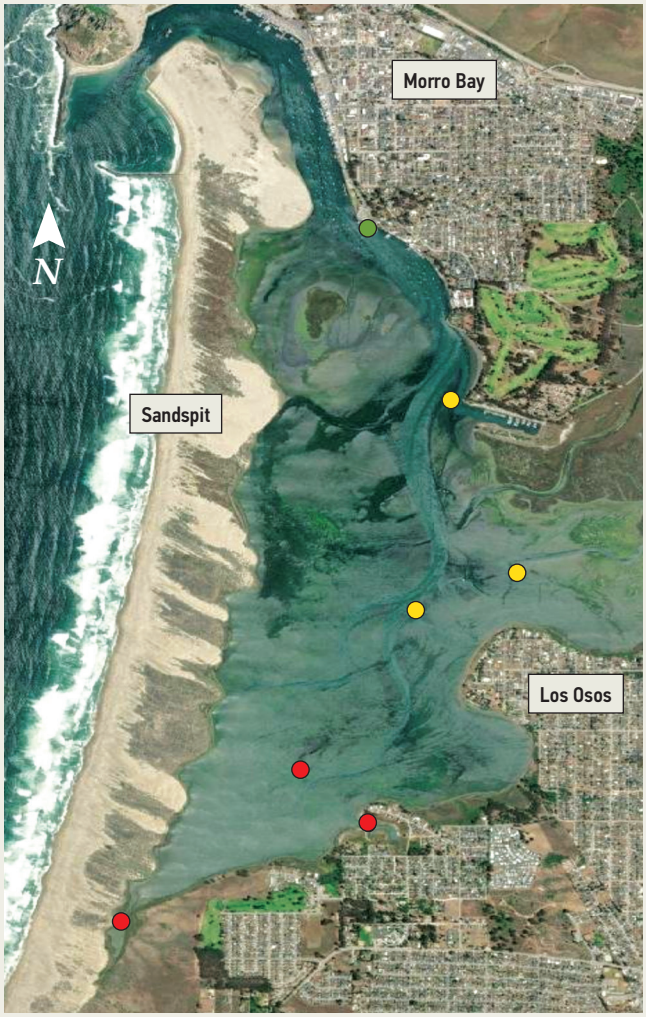
Clean water is important not only for humans but also for the wildlife that call those waters home. To provide healthy habitat, the water must be well-oxygenated and free of pollutants. Estuary Program staff and volunteers have been monitoring the creeks and bay for over twenty years to track long-term conditions.

Bay Dissolved Oxygen

Nitrates for Chorro Creek

Creek Health

Bay Oxygen Status



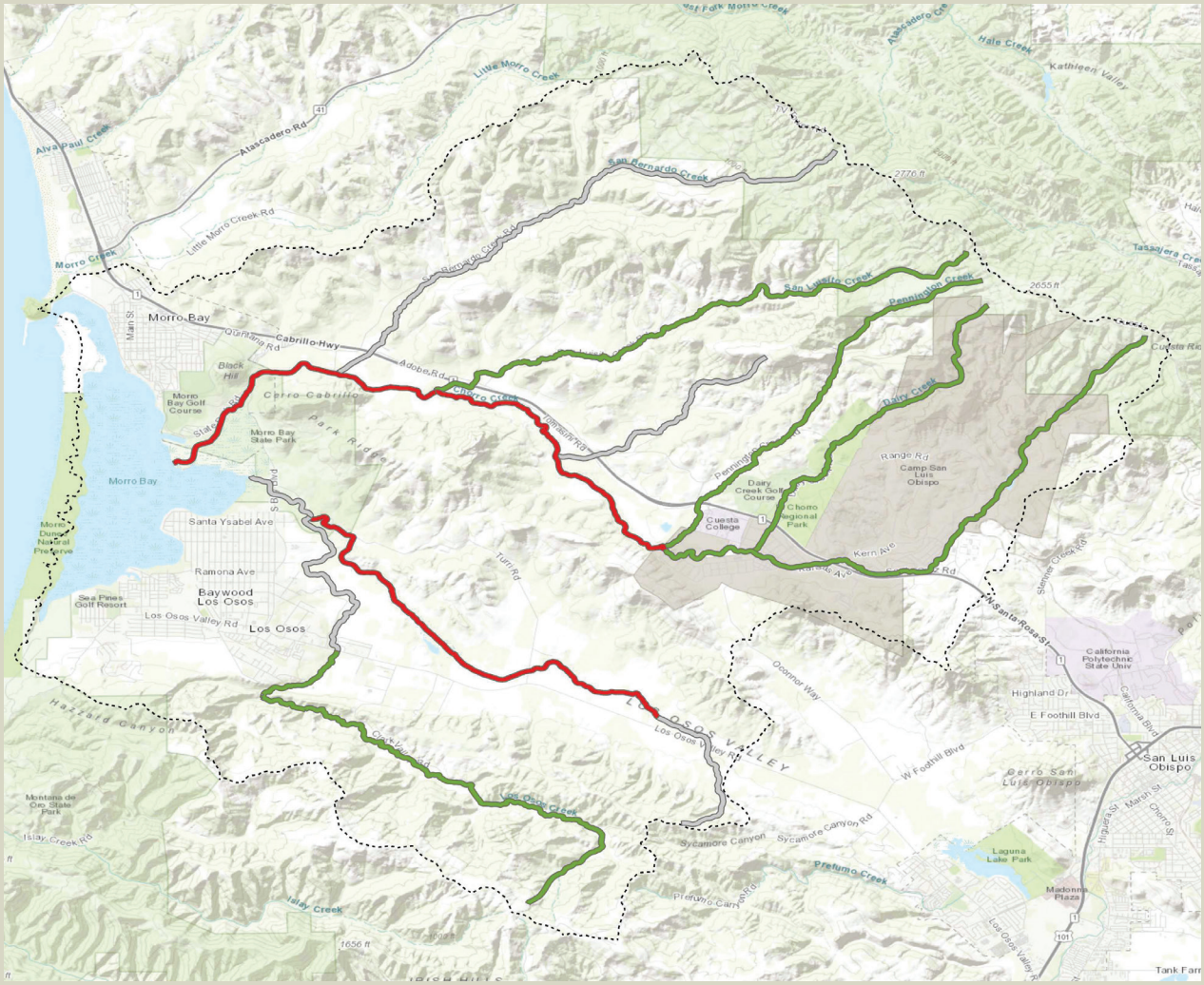
Fish and other aquatic life need adequate levels of oxygen to thrive. Typically, the lowest oxygen values of the day occur around sunrise. So, to track the minimum oxygen levels around the bay each month, Estuary Program volunteers paddle to seven sites in the early morning hours to measure the levels of oxygen in the water. The data, which goes back to 2002, shows a consistent trend of higher oxygen levels toward the front of the bay and lower levels toward the back of the bay. This is thought to be due at least in part to the shallowness of the back bay waters. The incoming tide easily pushes colder well-oxygenated water from Estero Bay through the deeper channels in the front bay, but these waters don't always make it to the southern-most part of the bay. The shallower waters also warm more quickly in the sun, which can reduce their oxygen levels. Oxygen trends have been relatively stable, with some improvement at Tidelands Park.

Bay Oxygen Status

- Very Good/Good
- Fair
- Poor
- Very Poor

Nitrates in the Watershed

While nitrates are essential for plant growth, excess nitrates can cause an imbalance in an aquatic system. Sources of nitrates include agricultural and residential fertilizing, faulty septic systems, and wastewater treatment plants. When nitrates contaminate groundwater and surface waters, the health of humans and aquatic life can suffer. High nitrates in creeks or the bay can stimulate algae growth that can crowd out other aquatic life and deplete the water of oxygen.



The map shows each creek segment in the watershed. Upper Los Osos Creek, Upper Chorro Creek, and the creeks that drain into Chorro Creek (Dairy, Pennington, and San Luisito Creeks) have Good (low) levels of nitrates. Middle and Lower Chorro Creek and Warden Creek have Very Poor nitrate levels, which means the high concentrations of nitrates make it difficult for the most sensitive wildlife to thrive. The creek segments that are greyed out show areas where we lack adequate data to make an assessment.

Nitrate Status

- Very Good/Good
- Fair
- Poor
- Very Poor
- Unknown
- Watershed Boundary

Tracking Algae in Our Creeks

In the summer, water temperatures rise and water levels fall, creating isolated pools of warm water with the perfect conditions for algae. If the creek has elevated nitrate levels, algae can bloom, crowding out more beneficial plants and depleting the oxygen that fish need to survive. The Estuary Program has observed algal cover in the creeks during monthly site visits for years, but the recent addition of chlorophyll pigment sensors allows for continuous measurement of changes in algal concentrations. This new data will help further our understanding of how algae in the watershed impacts the health of habitats for fish and other aquatic life.

What's Behind the Scores?

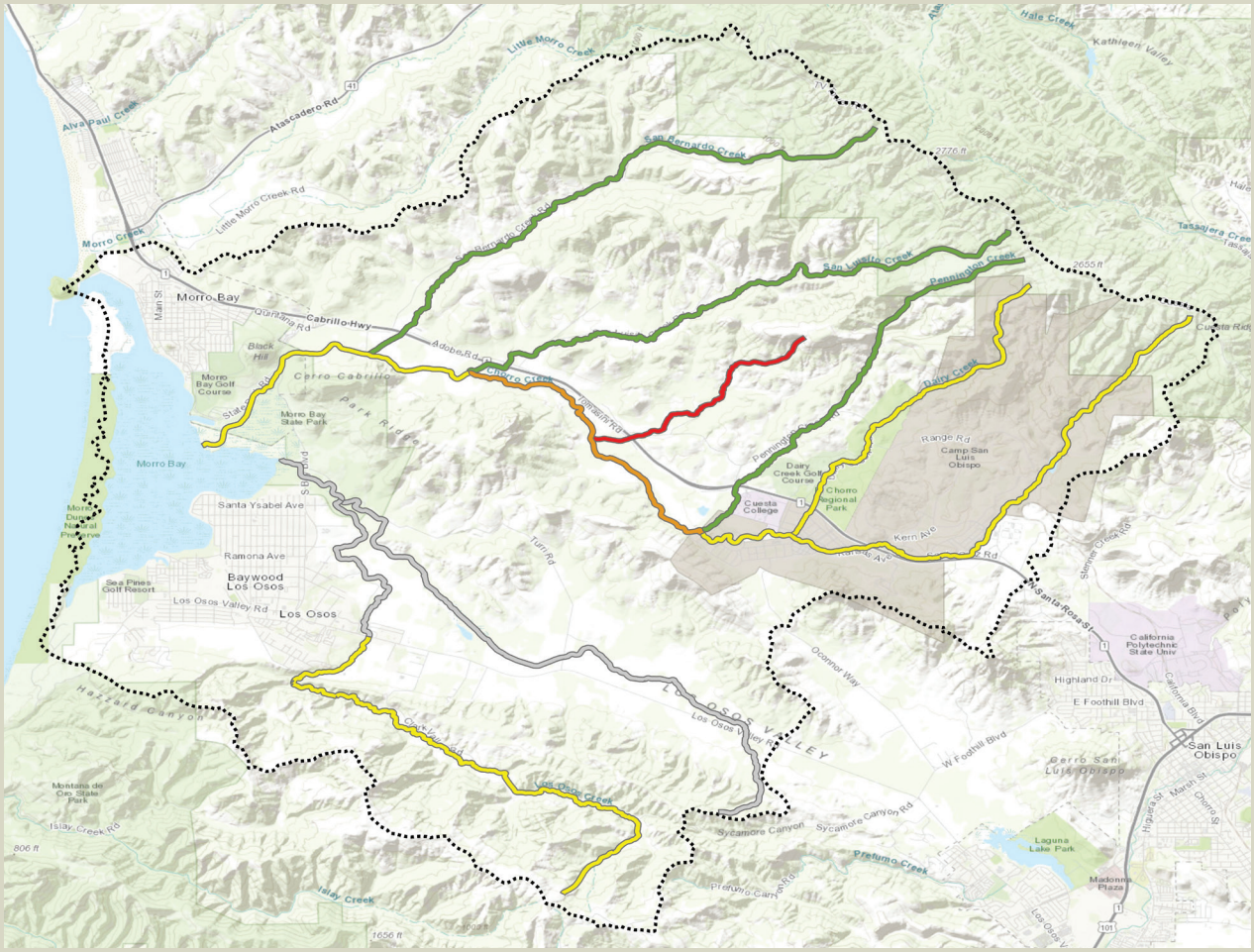
When comparing data for this report to previous reports, the creek health scores have degraded on Dairy, Walters, and Los Osos Creeks. This is not due to worsening conditions, but rather a change in the method of analysis utilized by the Water Board (the agency tasked with protecting waterways in the state). The new metric uses site-specific information like climate, geology, and watershed size to determine creek health. The new analysis method resulted in a slight decrease in scores at Walters, Dairy, and Upper Los Osos Creeks, which dropped their health grades down a category.

This stonefly from Upper Pennington Creek is sensitive to pollution, so its presence typically indicates healthy creek habitat fit for sensitive species like steelhead trout.

Creek Health in the Watershed

Trend status: Scores remain stable, with slight decreases at Upper Los Osos, Walters, and Dairy Creeks (note: there was a change in analysis method). No scores were available from areas that we suspect are heavily impacted.

Fish and other aquatic life rely on a healthy creek ecosystem. One of the ways that we monitor the health of our creeks is by collecting and analyzing the insects that live in creek beds. Certain species are sensitive and can survive only in very clean waters, while other species can tolerate high levels of pollution. Creeks where we find more pollution-sensitive species are more likely to have better quality habitat than creeks with more pollution-tolerant species.



The map above shows the average health scores for each creek or stretch of creek within the watershed, using data going back to the early 1990s. The segments of creek shown in green have scored as Good, meaning that they can support sensitive species of macroinvertebrates, while sections in red have scored as Very Poor, meaning that the creek may not be able to support any sensitive macroinvertebrates. Walters Creek stands out in the watershed as having Very Poor scores, which is due in part to low water levels.

Creek Health

- Very Good/Good
- Fair
- Poor
- Very Poor
- Unknown
- Watershed Boundary

Are the bay and creeks impacted by accelerated sedimentation?

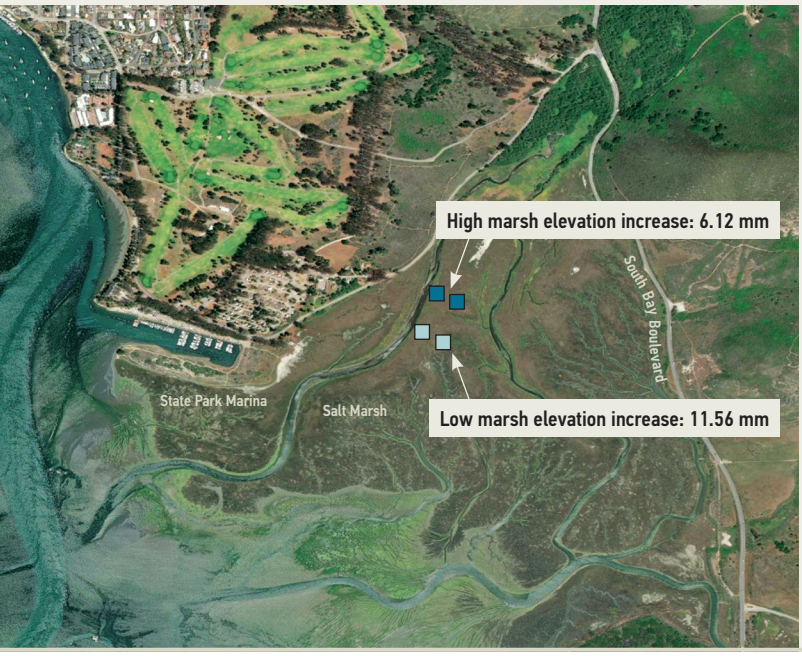
Yes. Reducing accelerated sedimentation in the creeks is crucial for sensitive species like steelhead. Sedimentation impacts are more complex in the estuary, where sea level rise could outpace marsh elevation increases, resulting in large shifts in habitat.

The interaction between an estuary and the lands that surround it can be complex. In Morro Bay, sediment naturally washes from the uplands, down the creeks, and into the bay. However, human activities can greatly increase erosion, sending an excess of sediment into the bay. Historical maps of Morro Bay show that the introduction of ranching and other land uses in the watershed corresponded with a rapid expansion of the salt marsh.

Excess erosion can negatively impact habitat. For example, a creek that is clogged with fine sediment won't have the gravel that steelhead need for their eggs. The Estuary Program works with landowners in the watershed on projects that prevent excess erosion and trap sediment before it can degrade downstream habitats.

With climate change and sea level rise, though, we are facing a paradigm shift for tidal marsh habitats. While large sediment inputs can directly smother eelgrass and degrade habitats, climate models indicate that tidal marsh elevation gains will not keep pace with sea level rise. This could mean that higher water levels will swamp the high marsh habitat, turning it to mudflats by the end of the century.

Monitoring Elevation Change in the Morro Bay Salt Marsh: 2013 to 2021



To better understand how marsh elevation is changing over time, the U.S. Geological Survey (USGS) established four monitoring sites where they collected highly accurate measurements of elevation change. The map shows the millimeters of elevation increase since 2013. Annual gains have averaged 0.77 mm in the high marsh and 1.16 mm in the low marsh, just about keeping pace with sea level rise. However, with the rate of sea level rise projected to accelerate, this marsh habitat will be more frequently inundated by the tides and could eventually convert to mudflats.

Trapping Sediment in the Watershed

Nearly twenty years ago, the Estuary Program helped purchase and protect 580 acres at the foot of Hollister Peak, which later became known as the Chorro Creek Ecological Reserve and is now managed by the California Department of Fish and Wildlife. We completed a nearly five-acre floodplain restoration project there in 2019 to reduce the amount of sediment flowing to the estuary, improve creek water quality, support groundwater recharge, and create habitat for sensitive species like steelhead and red-legged frogs. Floodplains are low-lying areas along creeks that allow water to spread out and slow down during storms. This gives time for sediment, nutrients, and other pollutants to filter out of the water, rather than continuing downstream to the estuary.

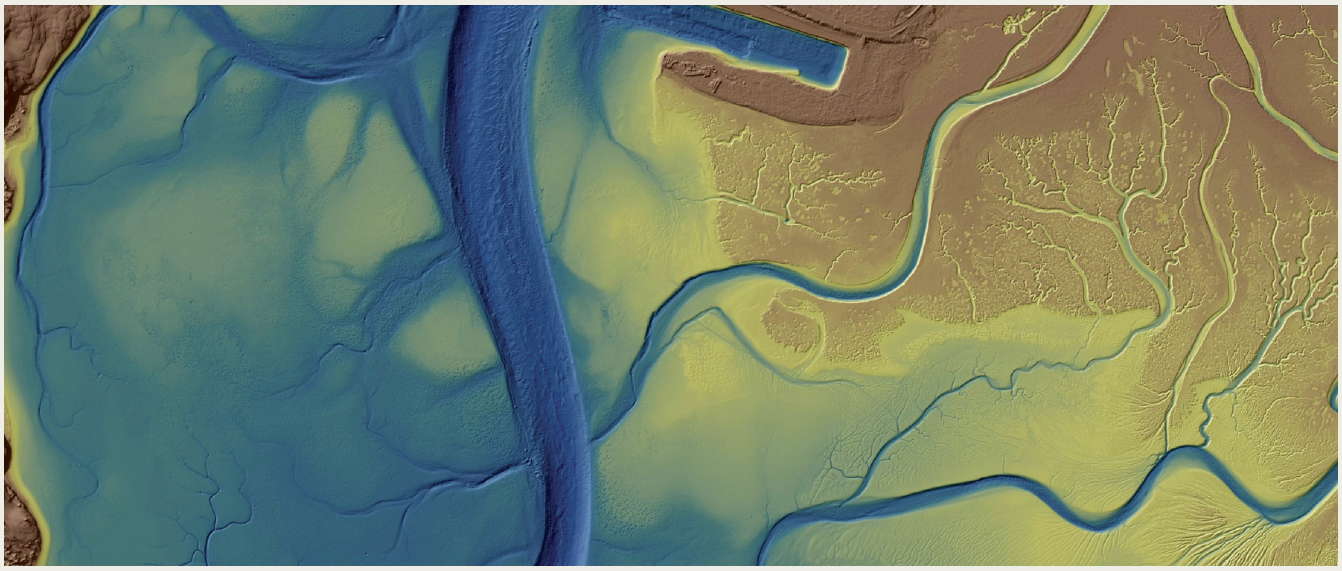
The project involved creating a new side creek channel and additional floodplain space, installing large pieces of wood in the creek to create fish habitat and slow water flows, and planting close to 1,500 native trees and shrubs. The project was put to the test in January 2021 during a ten-year storm (a storm that happens on average once every ten years). As planned, the rushing waters were able to overflow into the new floodplain and created deep pools and gravel bars.

The Estuary Program and partners will continue to track the evolution of the project and the resulting ecological benefits.

Above: *This photo shows the Ecological Reserve in action during a ten-year storm in January 2021 where eight inches of rain fell in a three-day period. The stormwater in the creek was able to spread out and slow down, allowing sediment to filter out before the water continued on its way to the estuary.*

Right: *Reconnecting the creek to the floodplain allows creeks to deposit excess sediment at the project site during storms, reducing the amount of sediment that flows to the estuary.*

Tracking Bay Elevation Change



This is an underwater map of the bay floor. The blue colors represent the deeper depth of the channels near State Park Marina, and the brown shades represent higher elevations like the mud flats and salt marsh. The map came from a 2019 topobathymetric lidar (light detection and ranging) and sonar survey, which supported research into how eelgrass loss changed the bay floor. Using this survey and an older survey completed prior to the large eelgrass decline, Dr. Ryan Walter of Cal Poly's Physics Department found that erosion occurred in over 90% of locations that had lost eelgrass, leading to the bay getting deeper in those locations. However, at the bay mouth where eelgrass beds were more stable, significantly less erosion occurred and the bay actually got slightly shallower.

Analysis is underway on another lidar data set collected in summer 2022, and with the rebound in eelgrass since 2019, this information should provide insights into the relationship between eelgrass and erosion.

During a lidar survey, a plane flies over the bay at a low tide, transmitting a water-penetrating laser toward the water and exposed mudflats. A receiver on the plane detects the reflected light, which is then used to create a map of the bay-floor elevation. Part of the mapping effort involves field crews using survey-grade GPS (global positioning system) equipment (pictured here) to collect survey control points nearby. This information helps position the lidar data to create an accurate map.

The Estuary Program and USGS are partnering to use data such as the lidar surveys and tidal marsh sediment monitoring to model various future sea level rise scenarios and consider adaptation strategies to address habitat loss and coastal flooding.

Do the estuary and watershed support a healthy population of steelhead?

No, the local steelhead population continues to be threatened even with some habitat improvement.

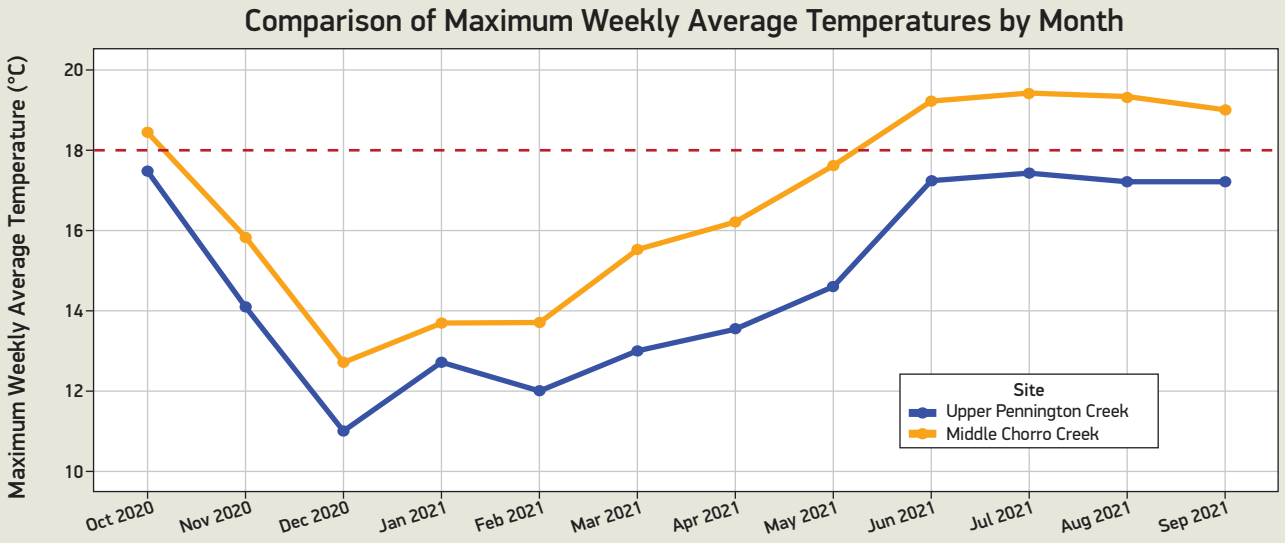
Steelhead are a migratory fish species native to the Morro Bay watershed. Steelhead are anadromous, meaning that they spend part of their lives in freshwater creeks and part of their lives in the ocean. Rainbow trout are the resident form of the fish that, unlike steelhead, spend their lives entirely in fresh water. While these two forms of the fish have divergent life histories, they are genetically identical and collectively called *Oncorhynchus mykiss*.

While once abundant along the Central Coast, steelhead are now federally-listed as a threatened species. Without further protection, they may become endangered. Steelhead survival largely depends on the quality and availability of their habitat. They need good water quality as well as deep pools to rest and find food. Steelhead also need creeks to be free of barriers like dams or road crossings that could disrupt or block their migration.

Finding Refuge in Cool Water

Deep shaded pools provide the cool, well-oxygenated water that steelhead require for survival during the dry summer and fall seasons. The Estuary Program collected water temperature data from local creeks to get a better sense of locations with ideal conditions for steelhead and to identify where to restore habitat.

While steelhead may tolerate warm temperatures for short periods of time, they are sensitive to prolonged elevated temperatures. The Estuary Program uses the maximum weekly average temperature to identify times of year when temperatures are too high for too long to support a healthy population of steelhead.

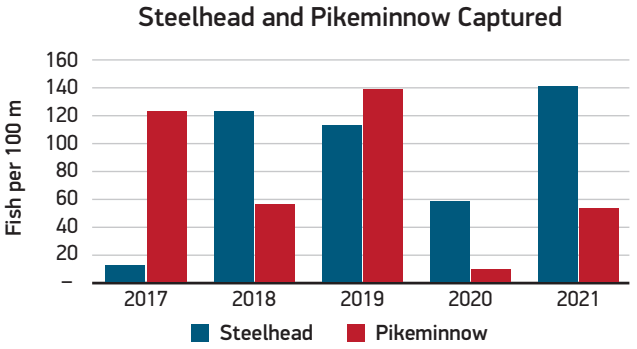


The graph shows the maximum weekly average temperatures in two creek locations during 2021. The red-dashed line represents 18 °C (64 °F); temperatures that fall below this threshold are more favorable for steelhead than temperatures that rise above it. The orange line shows temperature data at a site along Chorro Creek, which tends to be warmer than ideal for steelhead. The blue line shows temperatures on Pennington Creek, a tributary to Chorro Creek that tends to have cooler waters and better steelhead habitat.

Managing Invasive Predators that Threaten Steelhead

One of the many threats to steelhead in the watershed is an invasive species called the Sacramento pikeminnow (*Ptychocheilus grandis*). Adult pikeminnow are voracious predators that consume juvenile steelhead and compete with them for food and habitat.

The Estuary Program partnered with Stillwater Sciences to manage invasive pikeminnow in the watershed beginning in 2017. Since then, over 800 pikeminnow have been removed from Chorro Creek. Removing one pikeminnow can protect around 150 to 200 juvenile steelhead. Sites with repeated pikeminnow management work have shown a significant increase in steelhead abundance.



The graph above shows the number of fish captured during pikeminnow management efforts at two locations on Chorro Creek from 2017 to 2021. The steelhead population has responded well in areas with regular pikeminnow management efforts.

Managing Pikeminnow in Our Streams

Controlling the pikeminnow population is vital for successful steelhead recovery. One method of management involves electrofishing, where fish in the vicinity are temporarily stunned by an electric current put into the water using an electrofishing backpack. The fish are scooped up to be identified and measured, and all but the pikeminnow are returned to the creek.

Mapping Steelhead in the Morro Bay Watershed

Sometimes the best way to see what's in a creek is to take the plunge. Snorkel surveys give us a sense of the proportion of steelhead to pikeminnow and help us target pikeminnow management efforts. The photo shows a California Conservation Corps NOAA Veterans Fisheries Corps member training for surveys on Chorro Creek. Photo courtesy of Meredith Hardy.

Are bird populations that depend on the bay and surrounding lands stable?

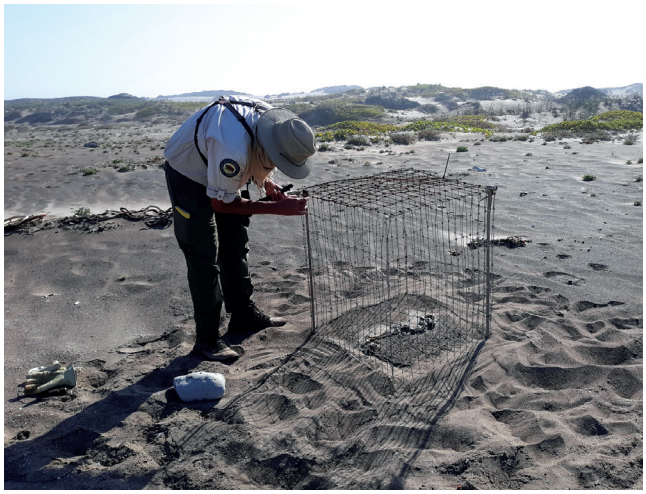
Yes, the diversity of birds in the Morro Bay area appears stable, but some types of birds face difficult conditions or are changing their behavior due to forces such as climate change and habitat loss.

Morro Bay is well-known as a birder's paradise, with more than 200 types of birds present in the wintertime. Birds serve as an indicator of environmental health, as a diversity of bird species can indicate that multiple habitats are doing well. While Morro Bay's bird numbers have been relatively stable over the past twenty-five years, some species are facing challenges from factors such as habitat loss and climate change.

Challenges for the Western Snowy Plover

The western snowy plover is a small shorebird that nests directly on the sand. The federal government has determined that this species requires additional protection and management to improve its chances of survival. Plover nests are vulnerable to trampling, habitat loss, and being eaten by predators. Also, if plovers are disturbed too often, they can abandon their nests. California State Parks is responsible for managing plover habitat in our area. Surveys of plover nests in 2020 and 2021 saw further declines from the steep drop experienced in 2019.

To minimize human-plover interaction, State Parks ropes off common nesting areas each year to encourage people to recreate outside of these areas. During the COVID-19 pandemic, State Parks noticed an increase in recreation close to plover habitat areas. They also documented 757 more incidences of visitors entering these fenced off areas on the Sandspit in 2020 than in 2019.



Predation is the leading factor in plover mortality and nest failure. Predators destroyed 70 out of 106 nests in 2020 and 36 out of 61 nests in 2021. Crows and ravens are the most common culprits. To protect plovers, State Parks now builds enclosures around some plover nests, and in 2021, all nests inside enclosures hatched successfully. Photos courtesy of California State Parks.

Climate Change Impacts on Black Brant

These small stocky geese are a familiar site in Morro Bay in late fall to early spring. Black brant are a migratory species, stopping by Morro Bay on their way to Mexico to escape the bitter cold of the Alaskan winter. They migrate along the Pacific Flyway, which is the north-south corridor for bird migration in the Americas.

In the past, the number of black brant in the Morro Bay estuary has fluctuated with the changes in eelgrass acreage, since it serves as an important food source for these birds. Even though the bay's eelgrass has made a significant comeback over the past few years, the Morro Bay brant population has not rebounded to the same degree.

This decline in the Morro Bay brant population is potentially due at least in part to the impact of climate change. As the Alaskan Peninsula continues to experience warmer winters, more brant are opting to skip the arduous 3,000-mile journey to warmer climes and instead remain in Alaska. This means fewer brant are stopping by Morro Bay to forage on eelgrass.

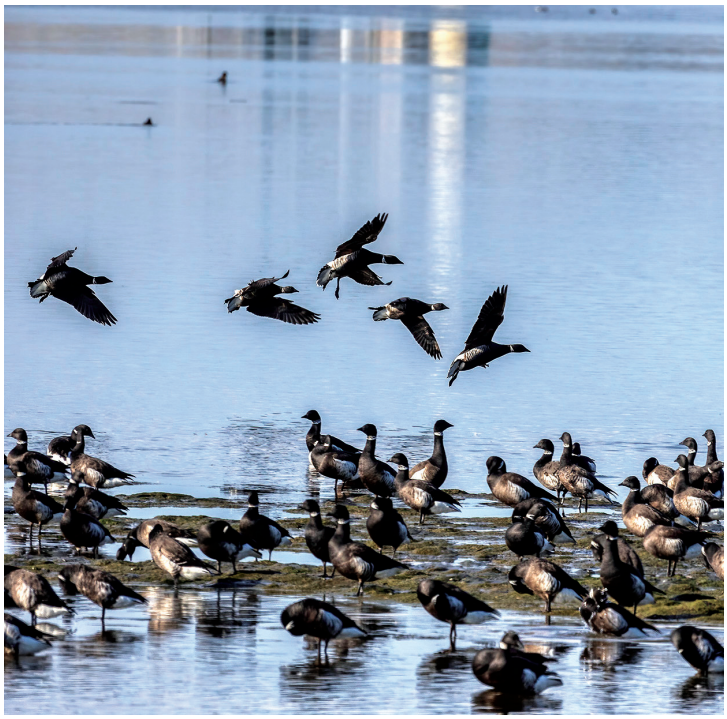
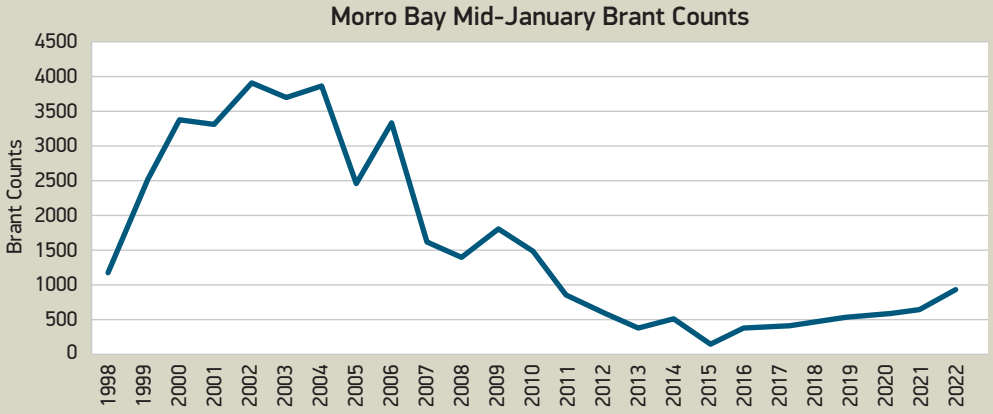
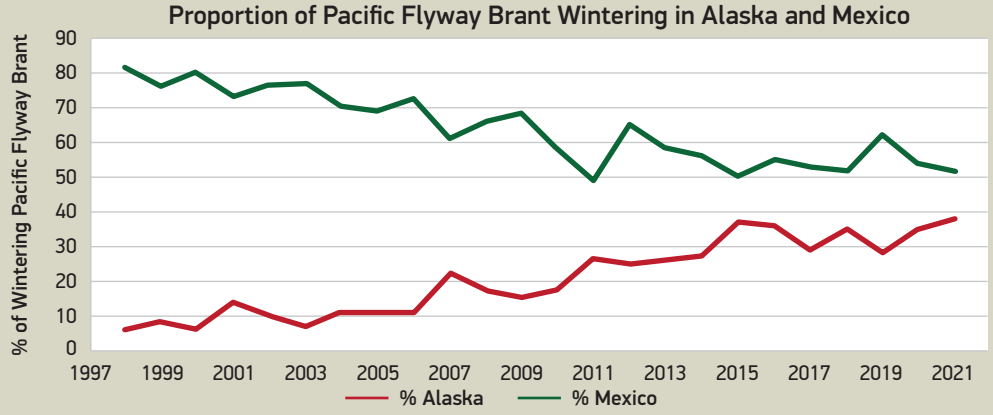


Photo courtesy of Marlin Harms.



The blue line represents the Morro Bay brant population. The decline in brant numbers tracks with the eelgrass decline from 2007 to 2017. With the eelgrass recovery, Morro Bay has experienced a modest increase in brant numbers.



The falling green line represents the decreasing number of brant opting to winter in Mexico, while the rising red line shows the increasing number of brant remaining in Alaska for the winter.

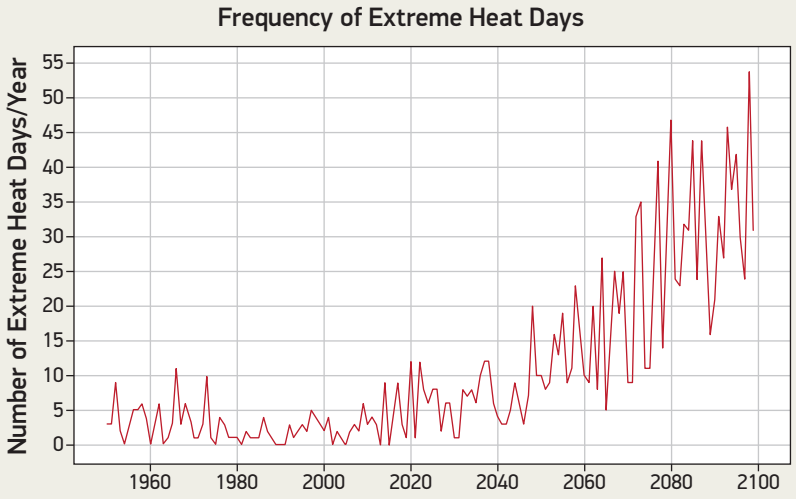
How will climate change likely affect the Morro Bay watershed and estuary?

Models continue to predict hotter, drier weather with more severe storms and drought as well as accelerating sea level rise.

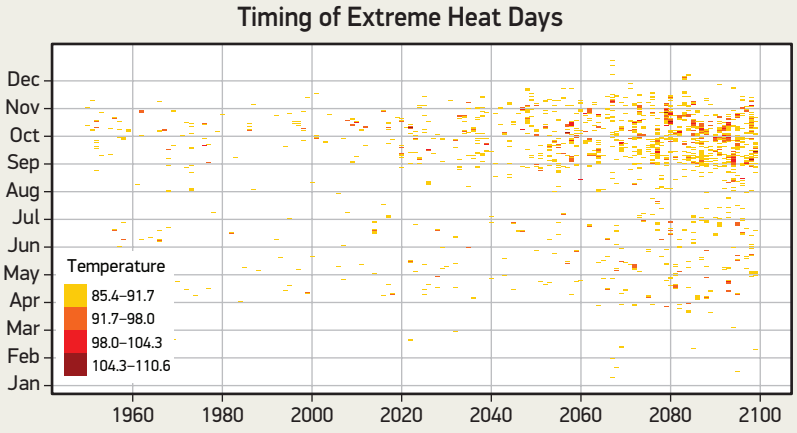
Science-based models and real time observations show that our climate is changing, which can impact the severity and frequency of droughts, fires, and floods. Furthering our understanding of local climate change impacts and working with partners to develop adaptation strategies are important steps towards building resiliency.

Temperatures are expected to increase on a global and local scale. In Morro Bay, our maximum average temperature of 66.9 °F could increase to 75 °F by the end of the century. Though this increase may not seem large, when combined with climate stressors like sea level rise, it could have significant impacts to ecosystems in the bay and watershed.

Climate Change Causes Changes in Temperatures



In the Morro Bay area, extreme heat days are defined as days when the maximum temperature exceeds 85.4 °F. Historic data indicates an average of three extreme heat days per year, but the graph illustrates a potential sharp increase in the number of extreme heat days by the end of the century.

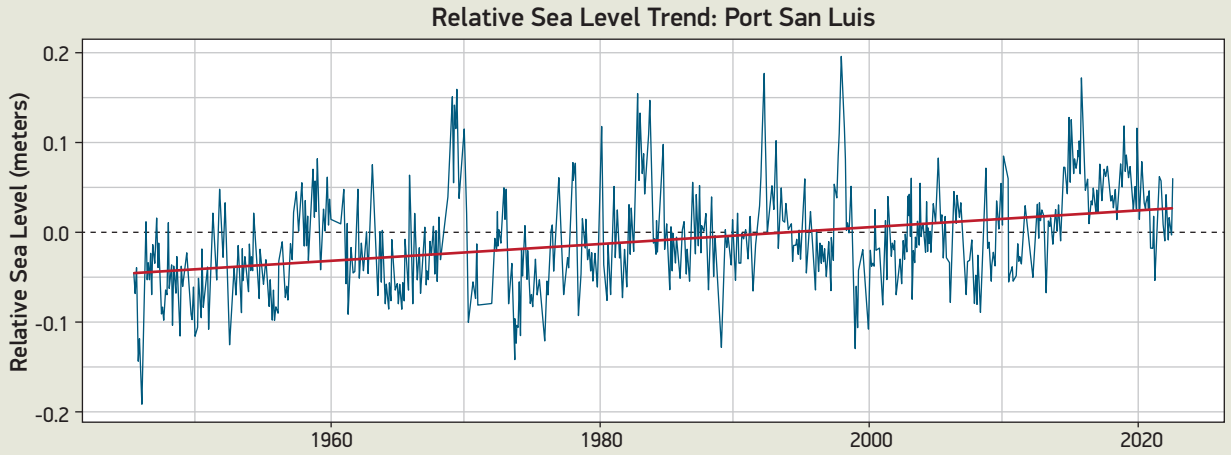


The graph shows in which months extreme heat days occurred each year over the past seventy years. These days tended to occur in the summer and early fall. The graph also shows when climate models forecast extreme heat days to fall from now until the end of the century. We are likely to experience more of these extreme heat days throughout the year, and they are likely to be hotter than they were historically.

Impacts of Rising Seas: Historic and Projected

Even seemingly small increments of sea level rise can cause major impacts on marshes, beaches, and coastal infrastructure, especially when combined with high tides and flooding from storm events.

Understanding these local impacts and developing adaptation strategies is critical to building climate resiliency for the estuary, watershed, and surrounding communities.



Historic Sea Level Rise

Observations from local NOAA sensors and monitoring equipment help track sea-level change in the region, including at Port San Luis. While the level increases in some years and dips down in others, the data indicates a relative increasing sea level trend (represented by the red line) of 0.97 mm/year, which is equivalent to 0.32 feet of rise over the last 100 years. The rate of sea level rise is also likely to accelerate, with estimates indicating sea levels up to an additional meter higher by the end of the century.

Projected Future Sea Level Rise

To better understand and plan for rising seas, the U.S. Geological Survey (USGS) developed a model called the Coastal Storm Modeling System (CoSMoS) that projects coastal flooding for different amounts of sea level rise coupled with waves and storm surge. Guidance from California state indicates that sea level rise in our region is likely to be between 0.3 meters and one meter by the end of the century. This zoomed in view of water inundating some well-known areas around Morro Bay illustrate the potential effects of a one-meter rise.

One meter of sea level rise results in complete inundation of the State Park Marina as well as the nearby salt marsh area. Storm surge coupled with this sea level rise could flood the lower portions of the golf course and push salt water up Chorro Creek. One meter of sea level rise would flood nearly 90 acres in this area.

This map of the salt marsh shows which areas the CoSMoS model predicts will be inundated given one meter of sea level rise (pictured in blue). The orange areas represent further flooding when sea level rise is coupled with a 20-year storm event, which is a storm so large that it has only a one-in-twenty chance of occurring in a given year.

Climate Impacts on Water Quality: Ocean Acidification

Ocean acidification (OA) due to climate change is a global issue that can impact water quality and habitat conditions for shelled creatures. Research is essential to understanding the local impacts of OA on estuary habitats, plants, and wildlife.

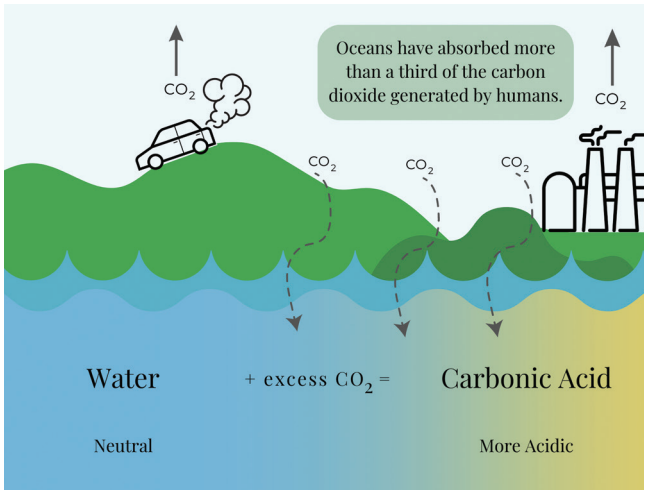
OA Research in Our Bay

Dr. Emily Bockmon of Cal Poly's Chemistry Department collects water samples to analyze their nutrient and carbonate chemistry, indicators of ocean acidification. This research project involved analyzing samples from the bay mouth to the back bay to see how the influx of ocean water and the presence of eelgrass impact water quality. Photo courtesy of Cal Poly.

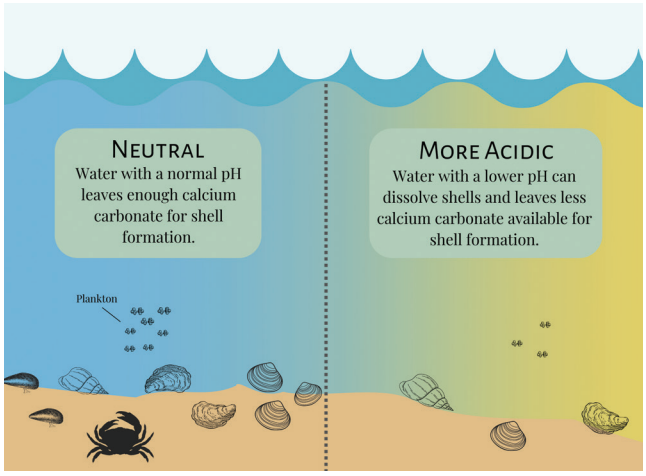
OA Impacts in Our Bay

Increasingly acidic conditions in our bay could greatly impact our two commercial oyster farms, as well as bay wildlife. Photo courtesy of Morro Bay Oyster Company and Christa Renee.

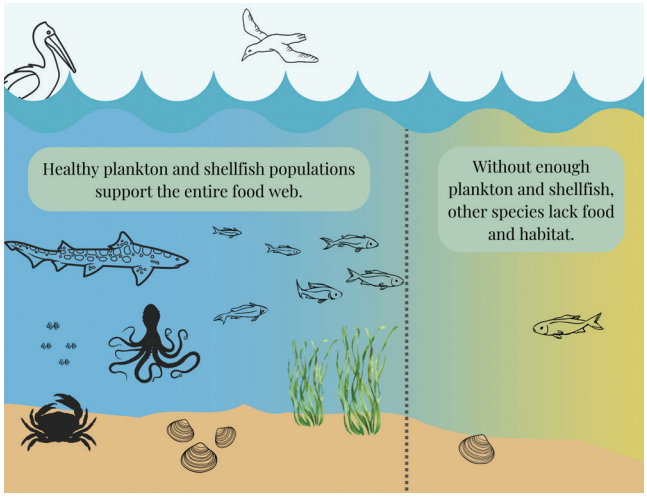
What is ocean acidification?



How does ocean acidification impact shelled creatures?



How does ocean acidification affect the food web?

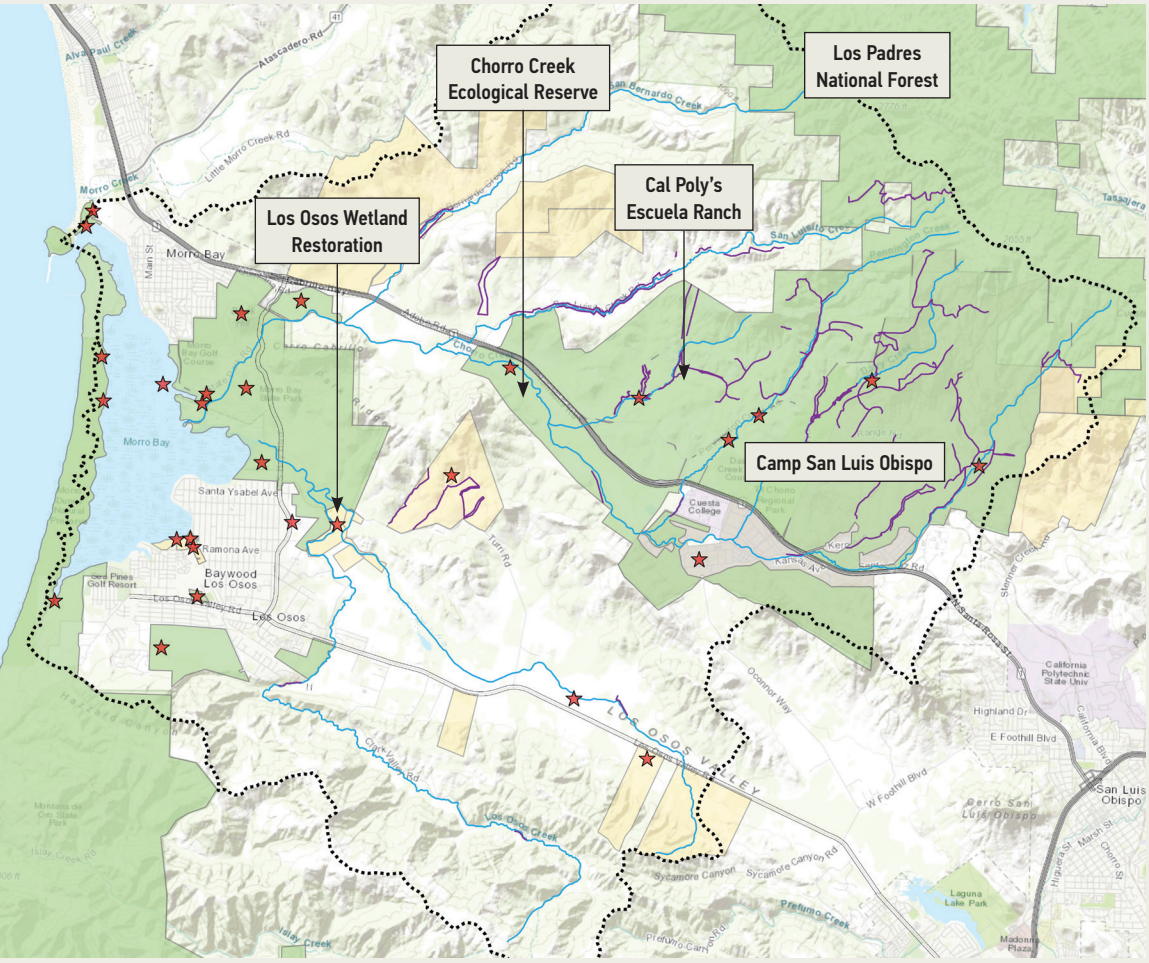


Are important natural areas being protected, enhanced, and restored?

Yes, more than 5,400 acres have been protected and thirty projects have been completed to improve natural areas and water quality.

The Estuary Program and our partners work to protect, restore, and enhance habitat in the estuary and the lands that surround it. These efforts help to maintain open space, conserve water, prevent pollution, and maintain healthy habitats for wildlife and for people.

Morro Bay Watershed Habitat Protected, Enhanced, and Restored



This map shows the areas in the Morro Bay watershed that are conserved and protected, as well as locations of habitat improvement projects including native planting and invasive plant removal.

- Watershed improvement projects along streams
- Watershed improvement projects
- Easements and private preserves
- Public-owned and managed open space
- Watershed Boundary
- Creeks

Healthy Wetlands Support Water Quality and Wildlife

Wetlands help control flooding, reduce erosion, improve water quality, and provide habitat for wildlife. Despite these positive impacts, many landowners in the past saw them as wasted space, and would often levee creeks and drain wetlands to maximize land available for farming. Unfortunately, these practices disconnect the creeks and wetlands from the surrounding floodplain, removing their ability to function naturally and provide these important ecosystem services. Restoring wetlands helps create a healthier watershed and bay.

Protecting the Land

The Coastal San Luis Resource Conservation District (CSLRCD) is an Estuary Program partner organization that works to protect and restore habitat. In 1998, they purchased a conservation easement to protect land that included a degraded wetland off Turri Road to ensure that it would not be developed. In 2015, they purchased the 80-acre property to permanently protect it.

Restoring the Land

In fall 2021, the CSLRCD completed a restoration project along a floodplain of Warden Creek, near the confluence with Los Osos Creek. The effort included breaching 400 feet of an earthen levee that separated Warden Creek from its floodplain, removing culverts that acted as a barrier to fish passage, and replanting native vegetation. The project returns the property, including its wetland, to conditions that support wildlife and natural functions.

The CSLRCD's efforts permanently protected land and restored wetland function to improve water quality and habitat. These actions improve long-term watershed resiliency in the face of climate change.

Controlling Invasive Plants to Protect Native Species

In Morro Bay's salt marsh, Chorro Creek and Los Osos Creek deliver fresh water to the bay while incoming tides push salt water through the marsh channels. This habitat hosts unique plant and animal diversity, but the delicate balance can be disrupted by nonnative species.

European sea lavender (*Limonium duriuscilum*) is an invasive plant that's been making an appearance on our coast. It can outcompete native plants such as California sea lavender (*Limonium californicum*) and endangered salt marsh bird's beak (*Chloropyron maritima*). Native species typically provide greater benefits because they are well-suited to the climate and because other plants and animals have come to rely on them.

The Estuary Program partnered with The Land Conservancy of San Luis Obispo County and California State Parks to monitor for and remove invasive sea lavender. Staff and volunteers venture out throughout the year to search for the invasive plant. Once located, the plants are removed by hand, taking care to pull up all of the roots and to prevent seed dispersal. The combined effort of multiple partners allows for a rapid response to nonnatives in order to protect native species that provide greater habitat benefits.

Staff from The Land Conservancy of San Luis Obispo County point out the features of European lavender that differ from the native variety. The native sea lavender has longer, thinner leaves with tiny flowers that are a less vibrant purple than those of the nonnative variety.

Data Notes

The data used in this report is the cumulative work of many organizations. The data is informational and not intended to be used for regulatory or decision-making activities. While every effort has been made to ensure accuracy, the Estuary Program and its partners assume no responsibility for errors and omissions, even if advised of the possibility of such damage.

Does Morro Bay support healthy eelgrass beds?

The eelgrass maps from 2007 and 2017 were created using multi-spectral imagery collected in the fall, using an automated classification scheme. They were ground-truthed by Estuary Program staff. The map for 2021 was created using drone imagery collected in the fall by Cal Poly and hand-digitizing of eelgrass. The map was ground-truthed by Estuary Program staff.

Is Morro Bay safe for swimming?

The map includes enterococcus data collected and analyzed by Estuary Program volunteers from 2005 through 2021 using the IDEXX method. The scoring, status, and trends were based on the California Central Coast Regional Water Quality Control Board (Water Board) method (see water quality section below for reference). The trend was determined by assessing data prior to January 1, 2014 and data after that date for comparison.

Is the bay clean enough to support commercial shellfish farming?

Data and updates to the lease areas in the map were provided by the CA Department of Public Health. The bacteria data from 2017 through 2021 was analyzed for the geometric mean of the fecal coliform concentration.

Is water in the creeks and bay clean enough for fish and aquatic life?

The analysis for nitrates and bay oxygen utilized the Water Board scoring method called California Central Coast Healthy Watersheds Project – Part 1, Report Cards for Scoring Water Quality Data to Characterize Health and Change. The analysis looked at all available data. The trend was determined by assessing data prior to January 1, 2014 and data after that date for comparison. For the creek health scores, the California Stream Condition Index was utilized, and scores for individual sites were averaged to represent conditions on each creek segment.

Is the bay filling in at an unnatural rate?

The sediment elevation table data was collected and analyzed by the U.S. Geological Survey from 2013 to 2021. The 2019 baywide topobathy lidar survey was conducted in partnership with NOAA's Office of Coastal Management. Images, maps, and details on the survey methods were provided by NV5. Analysis of the elevation changes in conjunction with eelgrass loss was conducted by Dr. Ryan Walter of Cal Poly.

Does the estuary and watershed support a healthy population of steelhead?

Fisheries data collection and pikeminnow suppression efforts were conducted by Stillwater Sciences from 2017 to 2021 along Chorro Creek. The bar chart included in this report represents segments of Chorro Creek where suppression efforts have been conducted annually since 2017 and does not reflect all data collected by Stillwater Sciences. Maximum weekly average temperature values for Upper Pennington Creek and Middle Chorro Creek were calculated from data obtained by temperature loggers deployed and maintained by the Estuary Program that record water temperature every 30 minutes.

Are bird populations that depend on the bay habitat stable?

The plover data is from the San Luis Obispo Coast District of California State Parks. The brant migratory pattern data is from the U.S. Fish and Wildlife Service's Pacific Flyway Data Book 2021. The Morro Bay brant data was generated by local biologist John Roser using standardized methods.

How will climate change likely affect the Morro Bay watershed and estuary?

The climate metrics come from Cal-Adapt. Results were projected for the future using the HadGEM2-ES model (warmer/drier) and the RCP 8.5 emission scenario (assumes emissions rise strongly until 2050 and plateau around 2100). Information on the probability of sea level rise outcomes is from the State of California. The sea level rise and storm surge data are from the Coastal Storm Modeling System (CoSMoS), a USGS tool used to assess impacts to coastal areas. Sea level trends for Port San Luis are from NOAA station 9412110. The ocean acidification graphics were adapted from diagrams created by The Nature Conservancy in Washington.

Are important natural areas being protected, enhanced, and restored?

The map includes publicly and privately protected lands and land where restoration and conservation projects have occurred. The map includes projects by partners such as Coastal San Luis Resource Conservation District, The Land Conservancy of San Luis Obispo County, San Luis Obispo County, Morro Coast Audubon Society, and many others.

Maps throughout this report were developed using ArcGIS Pro® mapping software. ArcGIS Pro® is the intellectual property of Esri and is used by the Estuary Program under a maintained license. Service layer credits for maps used throughout this report are as follows: *San Luis Obispo County, Bureau of Land Management, Esri, HERE, Garmin, GeoTechnologies Inc., USGS, METI/NASA, NGA, EPA, USDA,* and *Maxar*.

For more details on these data sources, please visit our website at library.MBNEP.org

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.

What can you do to help Morro Bay?

Make a Difference

Collectively, we each have an impact on our environment. Here are simple things you can do to help protect this special place that we all treasure.

Conserve Water. Switching to a low-flow showerhead reduces water consumption and the energy needed to heat the water. They can pay for themselves in just four months.

Choose Natives. When gardening, choose native plants for your yard as they are adapted to survive in our area without excess water or fertilizer.

Respect Wildlife. Birds, otters, seals, and sea lions need space to thrive. Watch them from at least fifty yards away and get a closer look through binoculars or a camera.

Join the Effort

We need your help to protect and preserve Morro Bay. There are many ways you can support the Estuary Program's work.

Donate to support our monitoring, restoration, and education efforts. Every donation, no matter the size, helps. MBNEP.org/donate

Volunteer with us and our partners to support monitoring, restoration, education, and research efforts. MBNEP.org/volunteer

Learn more about how to help protect this special place by following us on social media (@morrobaynep) and subscribing to our blog. MBNEP.org/blog

MORRO BAY
NATIONAL ESTUARY PROGRAM

Morro Bay National Estuary Program
601 Embarcadero, Suite 11
Morro Bay, CA 93442
MBNEP.org