MORRO BAY
NATIONAL ESTUARY PROGRAM

STATE OF THE BAY | 2020

A report on the health of the Morro Bay Estuary

Meet the Morro Bay Estuary

In Morro Bay, freshwater from two creeks runs down from the hills and mixes with saltwater that comes in with the tides from the ocean. This mix of salty and fresh waters makes Morro Bay an estuary—a unique place that supports an abundance of wildlife and a vibrant coastal community. People visit Morro Bay year-round to appreciate its beauty, to kayak and fish, and to watch the birds and sea otters that thrive here.

The Morro Bay National Estuary Program was established in 1995 to help protect and restore this special place. The Estuary Program is a local nonprofit that works collaboratively with citizens, agencies, and landowners. We restore degraded lands, track water quality and habitat conditions, and help locals and visitors alike understand how the estuary works and what we can all do to help preserve this nationally recognized resource.

The Estuary Program publishes a State of the Bay report like this one every three years. The report uses data gathered by our staff, volunteers, and partner organizations to examine the health of the Morro Bay estuary. It provides important information about environmental trends and guides local efforts to protect and restore this special place.

Questions Answered in this Report

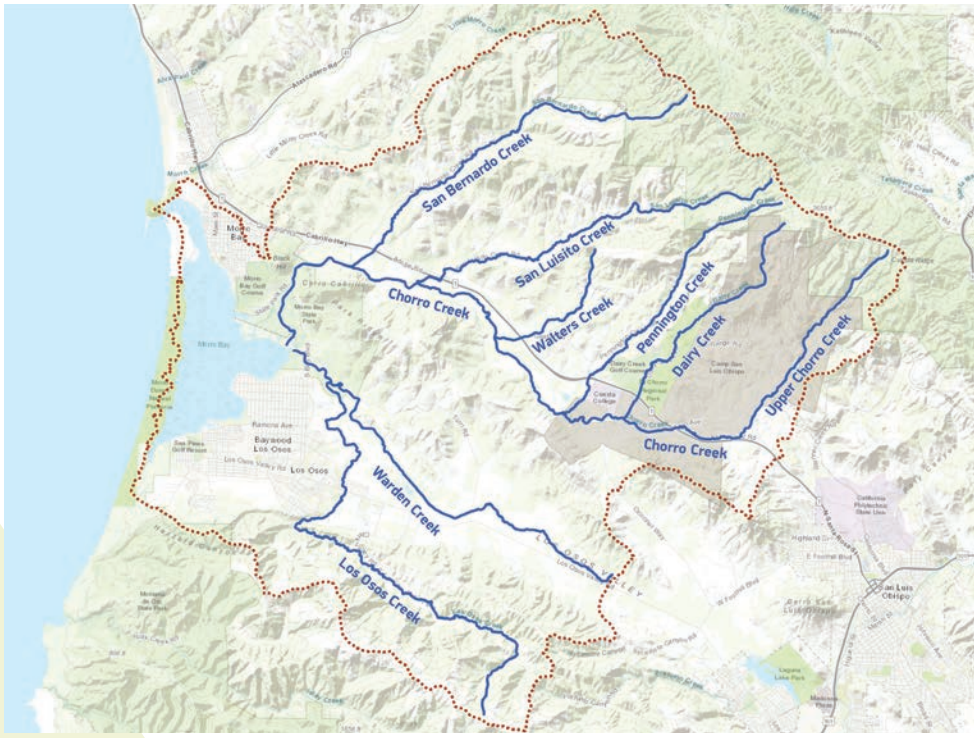
Authored by Estuary Program staff

Ann Kitajima with great support from Lexie Bell, Karissa Willits, Rachel Pass, Justin Klaparda, and Evelyn Barajas-Perez.

The Estuary Program sincerely thanks its many partners, volunteers, and committee members for their tireless 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 Sam Kowal

The Morro Bay Estuary and its Watershed



Watershed Boundary

The Morro Bay watershed is a network of creeks that drain rainfall and other freshwater from 48,000 acres of land into Morro Bay. The connection between the land and the estuary means that what happens on the land has a large impact on the health of the estuary.

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 arrow indicates an improving trend (up arrow) or a worsening trend (down arrow). The color of the base of the arrow indicates the status of historical data and the color of the triangular part 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 (grey).

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

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

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

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

Some areas are healthy and others are degraded.

Morro Bay's wildlife depends on clean water in order to thrive. Clean water means healthy habitats, which are places where wildlife can find food and shelter. The waters must have adequate oxygen levels to support marine life and be free of pollutants. The Estuary Program and its volunteers conduct monitoring throughout the bay and watershed to track the health of the waters and understand how they're changing over time.

Bay Dissolved Oxygen

Nitrates for Chorro Creek

Creek Health

Bay Oxygen Status

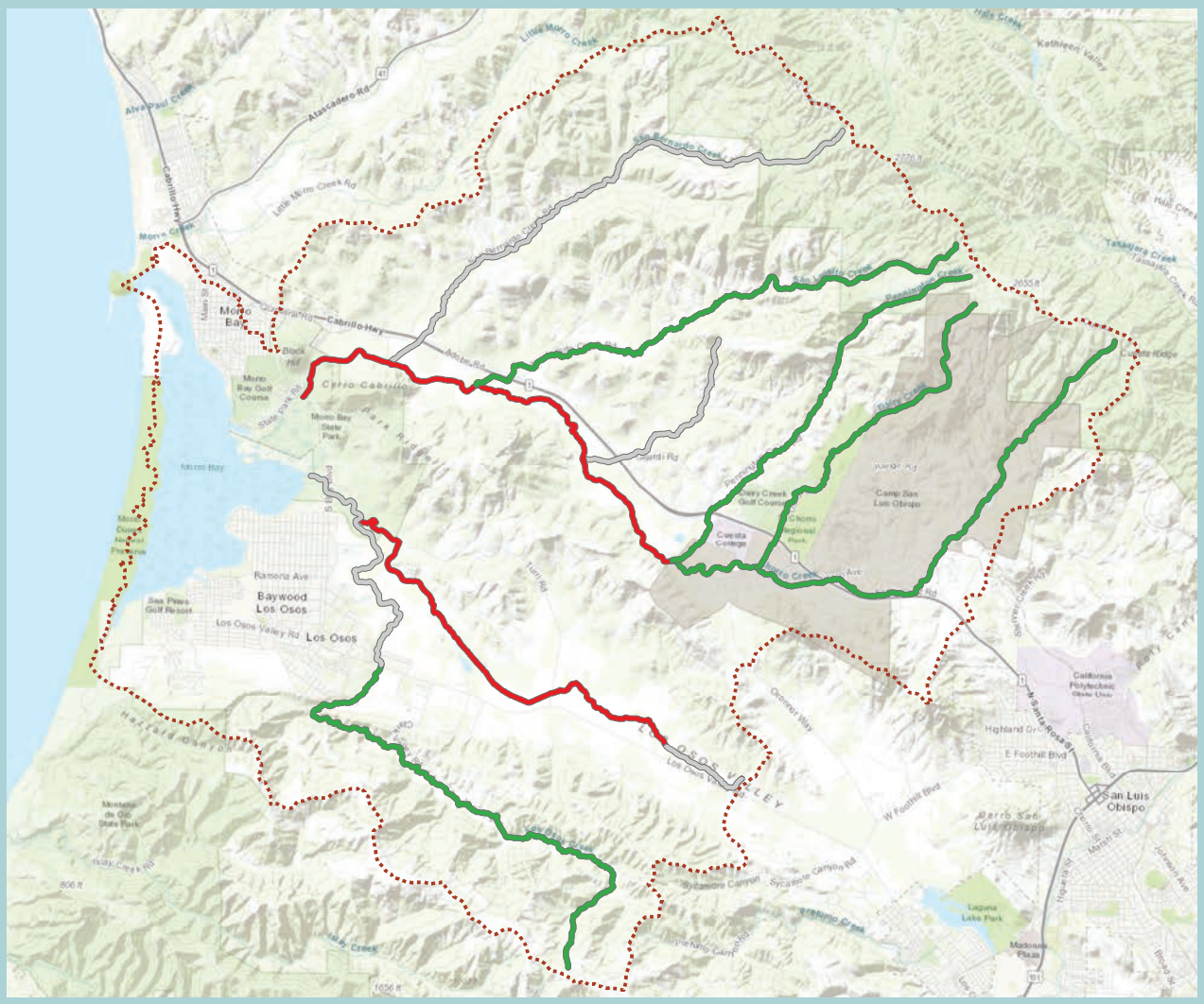
The map shows dissolved oxygen levels (the amount of oxygen available in the water for plants and animals) throughout the bay using monthly readings from 2002 through 2018. Estuary Program volunteers collect the data via kayak in the early morning hours to record the lowest oxygen levels of the day. The data consistently shows the trend of higher oxygen levels towards the front bay, where tidal flow in the deeper channels keeps the waters well-oxygenated. Towards the back bay, the shallow waters don't experience as much tidal mixing. The water can be stagnant there during certain times of year. Without the influx of cold, well-oxygenated ocean waters, temperatures can increase and cause oxygen levels to decrease. Bay scores have been relatively stable over time, although data showed a decrease in score at one of the back bay sites from Poor to Very Poor.

Bay Oxygen Status

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

Nitrate Status in the Watershed

Nitrates are a form of nutrient necessary for plants, from house plants to large-scale crops, to grow. Nitrates can become a problem if too much is applied to plants, as rain can wash these nutrients off yards and fields and into nearby creeks or the bay. Nitrates can also come from decomposing plants, animal waste, and treated wastewater. If the nitrate levels are elevated in a waterbody such as a creek or the bay, those waters can become choked with excess algae that can deplete the oxygen in the water.

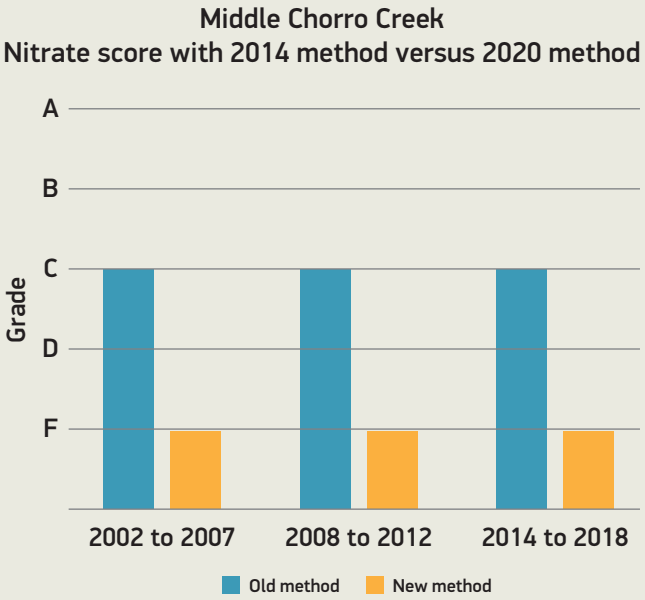


The map shows the nitrate scores for the creeks in the Morro Bay watershed. The green color indicates that the nitrate levels are Good (lower than levels that negatively impact aquatic life) in upper Los Osos Creek, upper Chorro Creek, and the tributaries to Chorro Creek. Middle and Lower Chorro and Warden Creeks have Very Poor nitrate levels (much higher than levels that can affect aquatic life). Some areas like Walters, San Bernardo, and lower Los Osos Creek lack adequate data to assign a score.

Nitrate Status

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

What's Behind the Scores?

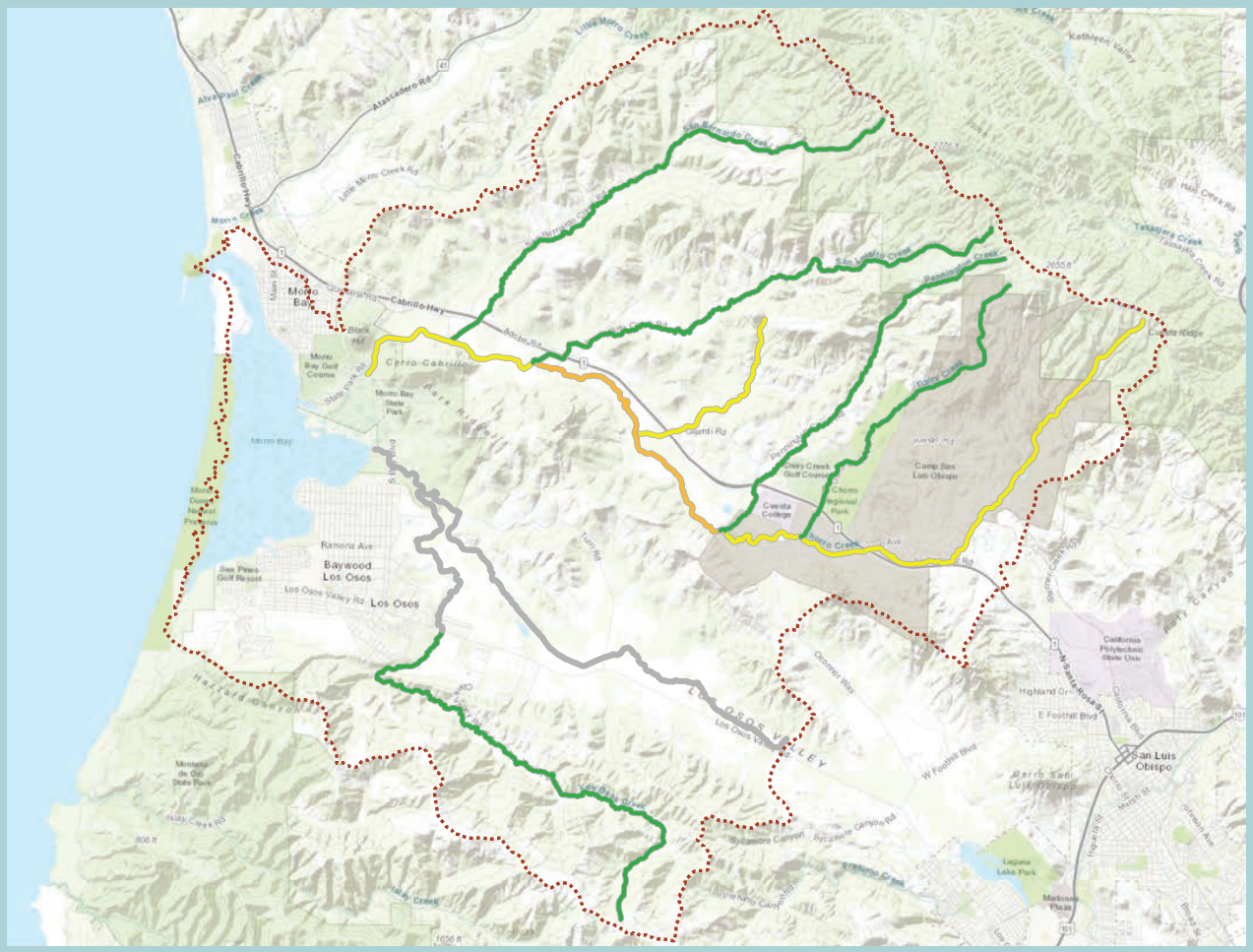


When comparing the nitrate scores from the 2020 State of the Bay Report (see previous map) to analyses from earlier reports, the nitrates appear to have degraded on middle and lower Chorro Creek. This is not due to worsening nitrate scores, but rather to Water Board (the state agency tasked with protecting California's waters) efforts to update analysis methods. To demonstrate this shift in scoring, the Estuary Program analyzed data from different time periods using the new method and the old method, and scores have remained relatively stable over time with each method. So, while the creek continues to be impacted by nitrates, the apparent decrease in scores in 2020 is due to updates to the analysis approach.

Creek Health in the Watershed

Trend status: Stable at all sites, with one site showing a slight improvement. No scores were available from areas that we expect are heavily impacted (Warden and lower Los Osos Creeks).

Creek health is important because these waters provide habitat for fish, plants, and other aquatic life. One of the ways we monitor creeks is to head out each spring to collect macroinvertebrates (including insects and snails) that spend at least a portion of their life cycle in the creek. Some of these species are extremely sensitive to pollution, so if we find them in a creek, the water quality is likely good. Other species are very tolerant of pollution, so if these are all that we find in a creek, the water quality is likely poor.



This map shows the average of index scores for each creek or stretch of creek in the watershed with data going back to the 1990s. Those colored green have Good scores and can support sensitive species of macroinvertebrates. Those colored yellow have Fair scores, meaning that the most sensitive species are unlikely to thrive. And those colored orange have Poor scores, where sensitive species are unlikely to be found. Upper Chorro, lower Chorro, and Walters Creek have Fair scores. This represents an improvement on Walters Creek. Scores are Good on the tributaries to Chorro Creek and in the Los Osos Valley above Los Osos Valley Road.

Creek Health

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

Is Morro Bay safe for swimming?

Yes, in most areas.

Residents and visitors alike are drawn to Morro Bay's scenic beauty. While many are satisfied with admiring it from the shore, more adventurous types will head out on the waters to boat, paddle, swim, and fish. To do these activities safely, the bay waters must be clean; otherwise, people who recreate on the bay could become ill from pathogens like bacteria, viruses, and protozoa.

Sources of pathogens are varied and can include pet waste, agricultural operations, marine wildlife, and sewage spills from treatment plants or waste-holding tanks on boats.

Estuary Program volunteers venture out monthly to monitor bay shoreline sites to determine if they are safe for recreational contact. This monitoring began in 2005 and, thanks to countless hours from dedicated volunteers, has resulted in a long-running dataset that tracks the safety of swimming conditions in the bay over time.

Estuary Program volunteers collect samples from eight sites along the bayshore using sterile technique. The samples are processed in a lab and incubated overnight. Results are available after eighteen hours of incubation and indicate the safety of waters at a site for swimming.

The map shows the safe swimming status of eight bay sites using data from 2005 through 2018. Green indicates that the bacteria concentrations are low, and waters are typically safe for swimming. Even clean waters can be contaminated by storm runoff, so it is best to stay out of the water for seventy-two hours after it rains.

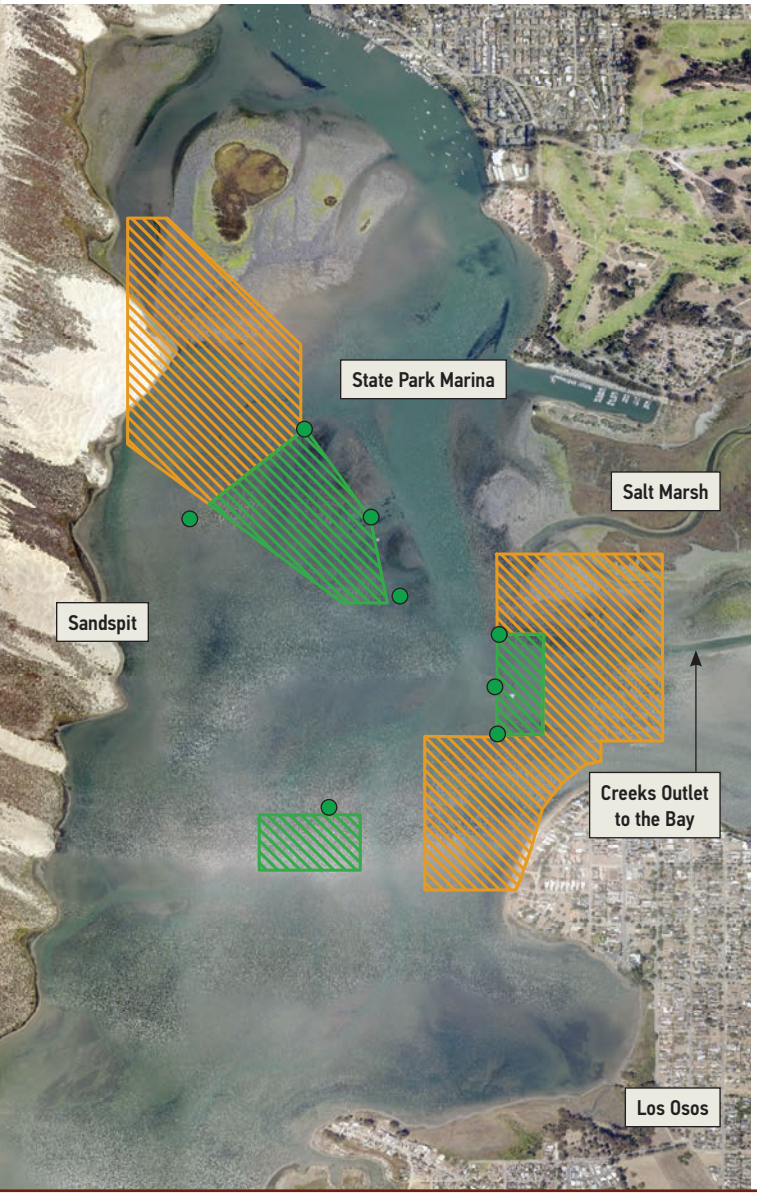
Bay Bacteria Status

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

Is the bay clean enough to support commercial shellfish farming?

Yes, in active harvesting areas.

The waters of the Morro Bay estuary provide not only recreational opportunities and majestic views, but also serve as a source of locally-grown food. The bay supports two commercial oyster farms, Morro Bay Oyster Company and Grassy Bar Oyster Company, whose products are sold in markets and restaurants locally and beyond. This industry depends on clean waters in the bay. Regular testing and oversight by the California Department of Public Health (CDPH) help ensure that shellfish are safe to eat.



The map below illustrates the lease areas where shellfish can potentially be grown. The green hashed areas show locations where water quality is clean enough for harvesting. These areas have shifted slightly due to changes in water quality conditions and changes in management, but the harvesting acreage has remained relatively stable. The orange hashed areas show sections that either have a history of poor water quality or a lack of data to assess conditions.

A thriving aquaculture industry puts Morro Bay's name on the culinary map, as oysters grown in the bay are known for their unique flavor. The future of the industry depends on a reliable supply, and this is only possible if the bay's waters are clean. A trend in water quality is difficult to determine due to changes in how the oyster growing waters are managed, but the end result of these management changes is that oyster farming can continue in Morro Bay.

Photo courtesy of Grassy Bar Oyster Company.

Bacteria (Fecal Coliform) Status

- Good
- Poor

Shellfish Lease Status

- Active Growing Area
- Inactive Growing Area

Changes in Growing Area Management

To help manage the oyster leases, CDPH added a seasonal closure for the farms, meaning that the farms automatically close during certain times of year when water quality has historically been poor. CDPH also changed the way it implements rainfall closures. Rather than closing when a certain amount of rain falls during a 24-hour period, a closure is triggered when the water levels in Chorro Creek exceed a certain height. High flows in this creek cause concern since bacteria are transported from the creeks into the bay during storm events.

To stay in operation during these closures, Morro Bay Oyster Company designed and built a depuration facility along the Embarcadero. By purifying bay water and using it in onshore oyster cultivation tanks, this facility ensures that oysters are safe to eat, no matter the weather; this allows oyster harvesting to continue on shore even when bay water quality is too low.

The Life of an Oyster

In Morro Bay, farmers grow the Pacific oyster, which originated in Japan. In order for Pacific oysters to spawn, the bay waters must be warm. Because these temperatures are rarely achieved in Morro Bay, oyster farmers must rely on seed from hatcheries for each crop of oysters. Seed for Morro Bay's farms typically comes from Washington or Hawaii. When the seed arrives in Morro Bay, each seed is about 3 mm in size and takes about eighteen months to grow into a small, three-inch oyster. At Grassy Bar Oyster Company, farm workers load up bags of seed oysters on a paddleboard to transport them out to the growing area (photo at right).

The Morro Bay Oyster Company's depuration facility consists of tanks, pumps, and filters that treat water from the bay to ensure that it is clean. Oysters can be pulled from the bay when waters are not clean enough for harvesting and after filtering in the facility's tanks, the oysters are then clean enough for market. Photo courtesy of Nash Moreno.

Photo courtesy of Grassy Bar Oyster Company.

Is the bay filling in at an unnatural rate?

Yes. While natural phenomena contribute sediment to the estuary, human activities within the watershed increase the rate and amount of sediment flow to the bay.

Morro Bay is an estuary, an area where freshwater from land mixes with the saltwater of the ocean. Estuaries are destined to fill in over time, converting eventually to mudflats and then marshes. Under natural conditions, this process would take thousands of years. Human activities can accelerate the sedimentation process, reducing the timescale of the process to hundreds of years.

This accelerated sedimentation has both human and ecological impacts. The bay mouth fills in and becomes dangerous for boats to navigate, necessitating annual dredging. The back bay becomes shallow and silty with reduced water circulation, leading to low oxygen conditions that impact aquatic life. These changes in the bay mean loss of habitat for birds, excess algae growth, and impacts to industries like tourism and shellfish farming.

Natural phenomena like winds and ocean currents can also affect sediment transport to the bay.

Understanding a Changing Bay: Sediment Sampling

The Estuary Program has partnered with California Polytechnic State University (Cal Poly) to study this issue. A portion of the project focused on sampling the sediment on the bottom of the bay to determine differences between different regions of the bay. At the mouth, there is more sand and gravel due to the stronger currents, tidal flushing, and wave action that sweep away the finer silts and clays. In the back bay, the currents are much weaker, and because of the poor circulation, the water remains there for longer periods of time. Two creeks, Chorro and Los Osos, empty into the bay, bringing with them fine silts and clays. These sediments eventually settle out in areas with weaker currents, causing the back bay to become shallower and siltier over time.

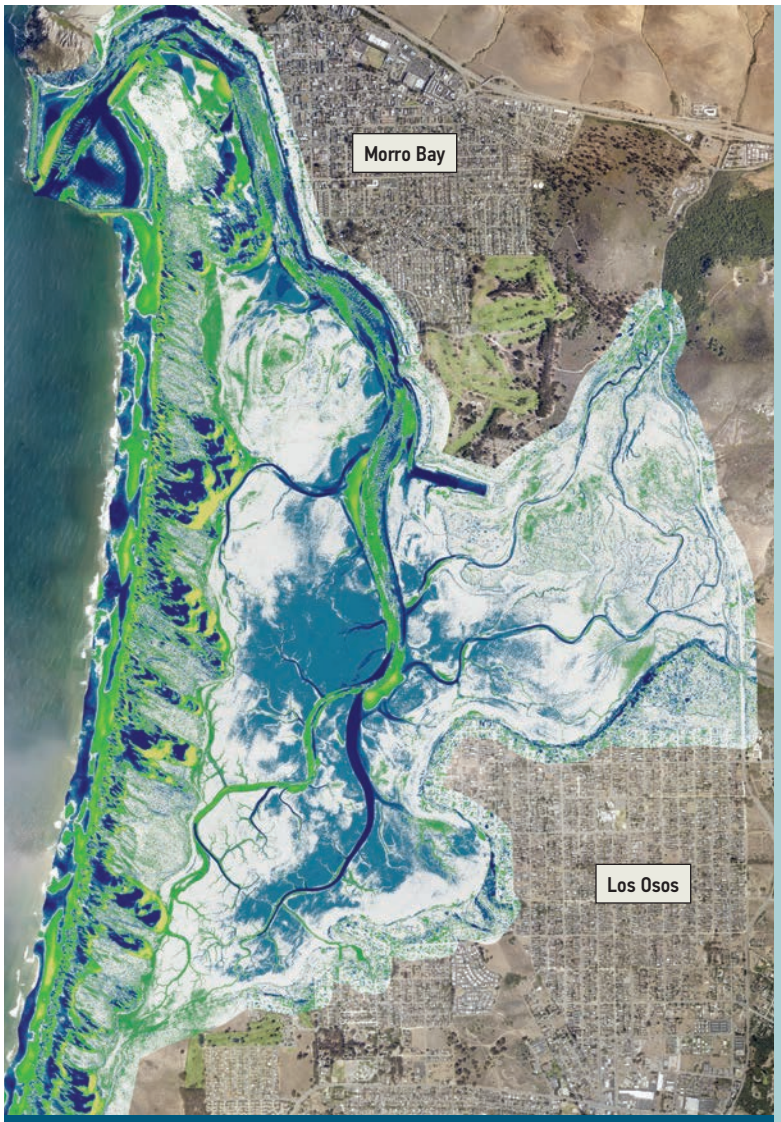
The map shows the results of sediment sampling from subtidal locations during the winter of 2019. The percent of sand and gravel is nearly 100% near the bay mouth (i.e., sediment is composed of all sand and gravel). In the mid to back bay, the bottom sediment is made up of only 30–60% sand and gravel, with the remaining sediment made up of finer silts and clays. These changes in the composition of the bay bottom can have impacts for aquatic life. The fine silty material is more easily stirred up and takes longer to settle back to the bottom. This can lead to cloudy (turbid) waters that block the sunlight from reaching eelgrass, a photosynthesizing plant.

Subtidal Channel Percent Sand and Gravel

- 100 to 80%
- 79 to 60%
- 59 to 40%
- 39 to 20%
- 19 to 0%

Mapping the Bay Floor

One way to study the changing bay is to conduct a topobathy lidar survey, which is an underwater map of the bay floor. The bathymetry data is collected using sonar from a boat in the deeper channels, and data from topographic lidar (laser pulses used to measure the distance to the earth) is captured from a plane to map the shallower areas. The data sets are seamed together to create a comprehensive map of bay floor elevation. The Estuary Program conducted a topobathy lidar survey of the bay in spring 2019. By comparing this 2019 data set to historic bathymetry maps, we can track changes in the bay over time.



This data is meant to be informational and should not be used for navigational, regulatory, or decision-making purposes.

The numbers in the legend for the topobathy lidar map refer to the elevation of the bay bottom relative to the average height of the lowest tide of the day (referred to, here, as MLLW). The map shows approximate differences in bay depths between a 2009–2010 survey and the 2019 survey, in feet. The white areas are those with very little change (between – 0.25 feet to + 0.25 feet in elevation change). Areas that are green represent locations that have a higher elevation in 2019 than in 2009–2010, which means sediment was deposited in those areas. Areas on the map in shades of blue are locations with lower elevations in 2019 than in 2009–2010.

Elevation above MLLW line (feet)

- < -3.0
- -3.0 to -2.0
- -2.0 to -1.0
- -1.0 to -0.25
- No Change (-0.25 to 0.25)
- 0.25 to 1.0
- 1.0 to 2.0
- 2.0 to 3.0
- 3.0 to 4.0
- 4.0 to 5.0
- > 5.0

Thank You to Research Partners

The Estuary Program has partnered with Cal Poly physics professor Ryan Walter, United States Geological Survey scientist Sean Vitousek, and former Cal Poly faculty Jennifer O'Leary to study circulation and sedimentation in the Morro Bay estuary. This research will help us better understand changes in the bay, as well as what might happen in the future with climate change and the resultant sea level rise.

Does Morro Bay support healthy eelgrass beds?

No, the amount of the eelgrass in the bay has declined sharply over the past decade; however, the amount of eelgrass in the bay appears to have stabilized.

Eelgrass is a flowering plant that puts down roots in Morro Bay, where it serves many functions. Its overlapping roots help stabilize the bay floor and keep the waters clear. It puts oxygen into the water to support other wildlife. And its floating blades form an underwater meadow that provide shelter and a place to find food for the bay's aquatic life.

The Estuary Program has mapped eelgrass and monitored bed health around the bay since the early 2000s. A baywide map created in 2007 indicated 344 acres of eelgrass. Over the next five years, eelgrass acreage dwindled, with large stable beds all but disappearing from the mid and back bay areas. Our 2017 mapping effort indicated 13 acres of intertidal eelgrass. In the past two years, monitoring efforts showed patches of eelgrass in areas where it has not been present for several years. Although these new plants are not enough to increase the overall acreage significantly, they could indicate positive trends for eelgrass in the future.

Eelgrass Acreage: 2007 and 2017

2007

2017

Eelgrass acreage (represented in yellow) has declined since 2007 when 344 acres were mapped. While beds toward the front bay and along the main channel have remained relatively stable, nearly all eelgrass was lost in the mid and back bay. Eelgrass loss has since stabilized, and the 2017 map shows small patches of eelgrass recurring in areas that suffered almost total loss.

Restoration Success

The Estuary Program has worked with partners including Cal Poly San Luis Obispo (Cal Poly), California Sea Grant, and countless volunteers to conduct experimental eelgrass restoration in the bay. Plants are harvested from the healthy beds toward the front of the bay, and then transplanted in the mid and back bay where eelgrass loss has been the most severe. This small-scale experimental restoration allows us to test out the timing, method, and locations for transplanting. We are learning a great deal from this work, and the success we've seen as a result supports expanding our restoration efforts in the future.

Left: Staff and volunteers braved mud, wind, and chilly waters to help harvest and transplant eelgrass. Harvested plants are anchored using u-shaped garden stakes to hold them in place while they take root.

Below: The harvested eelgrass is planted in one-by-one meter quadrats just like the white square in this photo. Two years after planting, each of the plots has expanded greatly beyond the original planted area.

Research Efforts

To help understand the reasons for the eelgrass decline, Cal Poly and the Estuary Program, with support from California Sea Grant, are conducting a multi-year study of water circulation in the bay and how it may have changed over time. Changing conditions such as shallower, more turbid waters, for example, could be having negative impacts on eelgrass. The results of this research, expected in 2020, will help guide our future restoration efforts and other projects that could potentially tip the balance in favor of eelgrass. The photos on this page show members of the Cal Poly project team at work, including undergraduate students Sydney Wewerka and Edwin Rainville, Senior Research Scientist Ian Robbins, and Physics Professor Ryan Walter.

In this picture, Sydney Wewerka (left) and Professor Walter (right), lower a sampler into the bay to gather sediment from the bay bottom. Samples are sent to a lab to conduct grain size analysis.

Sydney Wewerka, Professor Walter, and Ian Robbins (pictured left to right) collect sediment samples to determine how much silt, clay, and sand are present in different regions of the bay. *See page 9 for results.*

Cal Poly researchers lower an array of water quality sensors into the bay where they will continuously gather data for one month. The measurements include temperature, water velocity, and salinity.

Photos courtesy of Ryan Walter

Edwin Rainville helps install sensors in the middle of the bay near Windy Point. Along with sensors near the Coast Guard station and the oyster farms, the data helps track water quality conditions throughout the bay.

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.

Birds are a useful proxy for the health of an estuary. If there are many different types of birds and their populations are stable, that is a sign that the bay is faring well.

More than 200 types of birds are seen around Morro Bay in the wintertime. This number has been stable for the past two decades, indicating good local conditions for a wide variety of birds to thrive. However, some types of birds are facing conditions that make it hard to survive in our area.

Protecting Plovers

The western snowy plover, considered threatened under federal law, prefers to nest on the same sandy beaches frequented by human visitors. These small, black, brown, and white birds resemble animated cotton balls with legs, darting between dunes to seek food. They lay their eggs directly in the sand, making them vulnerable to being stepped on or eaten by predators. Plovers can also abandon their nests if they are disturbed too often.

The Morro Bay sandspit is an important nesting site in coastal California. California State Parks manages this area to support the recovery of these threatened birds. In 2018, only 169 nests were laid compared to an average of 234 nests over the previous four years. Though the overall number was low, 53% of the nests hatched, which was a five-year high. Of the 47% that failed, most suffered from abandonment or animals such as red fox and coyote eating the eggs. Despite the dip in the number of nests laid in 2018, the general trend has been increasing since 2008.

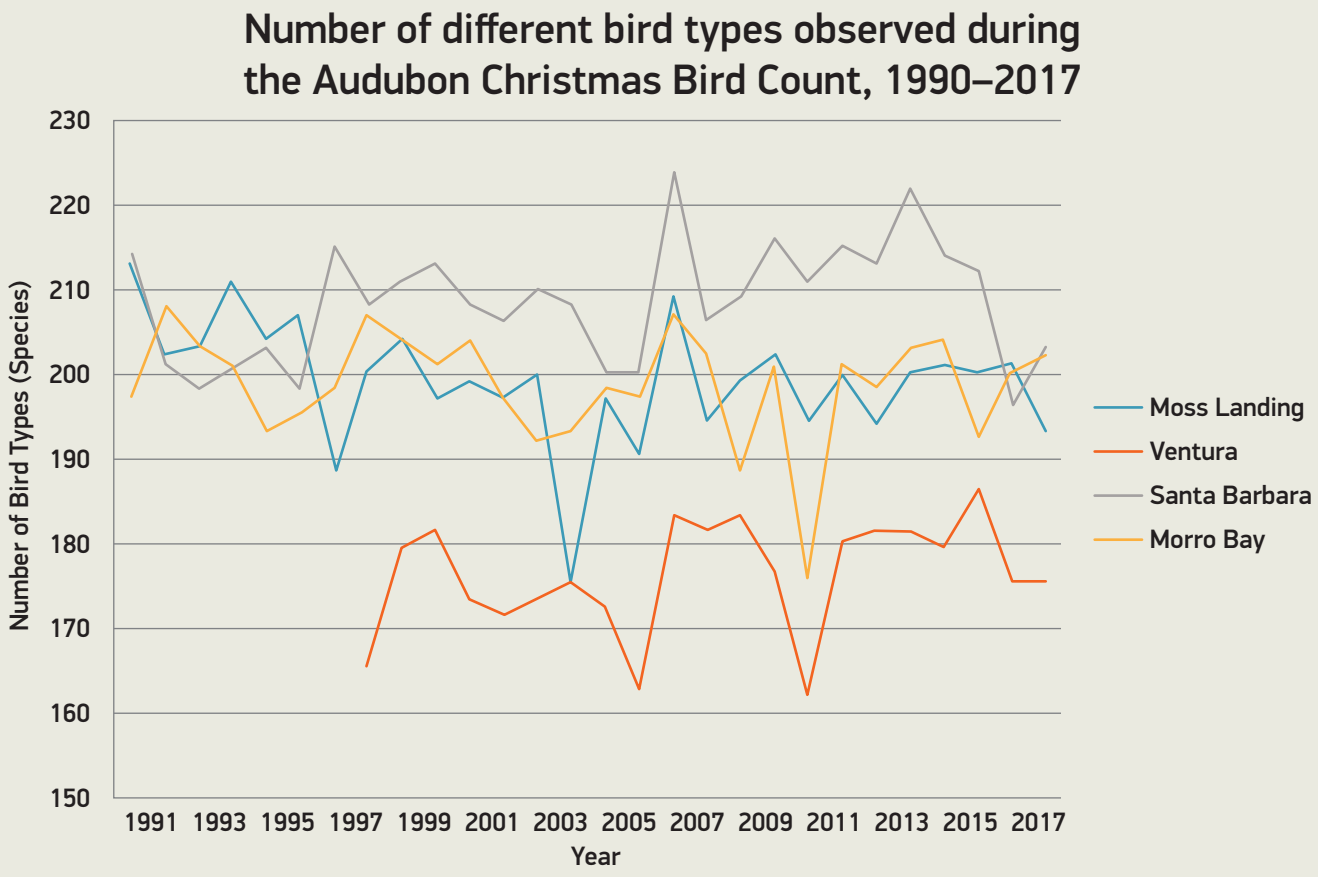
Over the past eighteen years, western snowy plovers have laid an average of 176 nests each season on the Morro Bay sandspit. Photos courtesy of Michael "Mike" Baird, bairdphotos.com.

Less Eelgrass Means Fewer Brant

Huge flocks of black brant were once common on the bay in wintertime, when they stopped here to rest and snack on eelgrass during their long migration from Alaska to Baja California. With the decline of eelgrass in Morro Bay and warmer winters in Alaska, fewer brant of the next generation are learning to stop here. Healthy eelgrass beds in Morro Bay can offset changes elsewhere along the coast only if each new generation learns to locate Morro Bay as a place of refuge.

The number of brant observed in Morro Bay over the past seven years has been relatively stable but more than 90% lower than the most recent peak in 2002. Photo courtesy of Michael "Mike" Baird, bairdphotos.com.

Regional Bird Populations



The number of types of birds observed on and around the bay in wintertime has been stable over the past twenty-five years. A nationwide annual bird count, conducted by the National Audubon Society, collects data about the number of different bird types observed by experienced volunteers. Morro Bay's bird populations are comparable to Moss Landing's and Santa Barbara's, two similar coastal areas within the region.

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.

Morro Bay and its watershed are fortunate to be a home to a unique species, *Oncorhynchus mykiss*. Some of these fish spend their entire lives in freshwater creeks and are called rainbow trout. Others—though they are genetically identical—hatch in freshwater creeks, migrate to the ocean to grow to adulthood, and then return to our creeks to reproduce. These fish are called steelhead trout, and they are the anadromous (or salt-water-going) form of the same species. Both varieties of the fish can be referred to generally as trout.

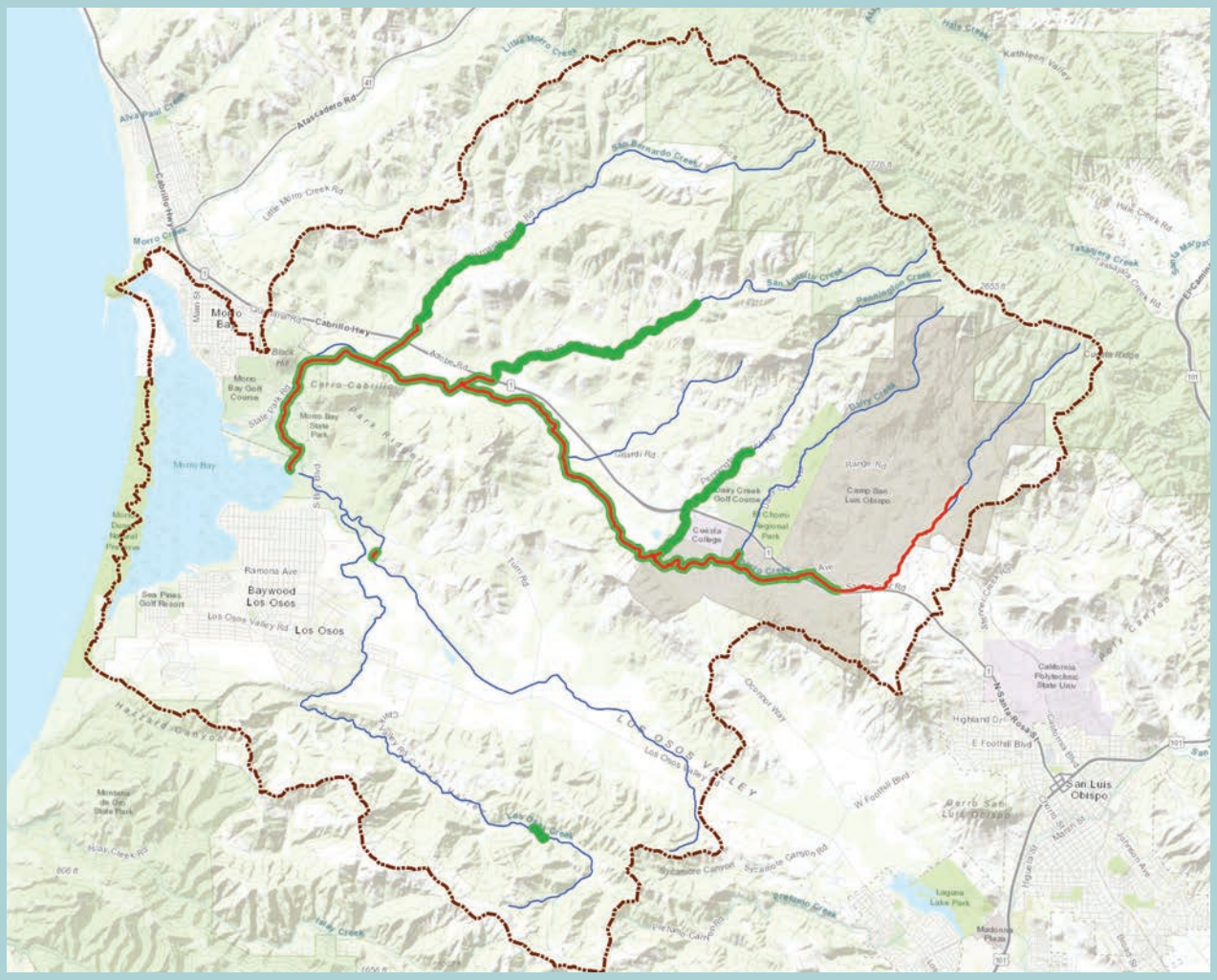
While steelhead were once abundant in our area, they are now federally-listed as a threatened species. These fish require good habitat, clean waters, and creeks free of structures that block their path upstream to spawn and downstream to reach the ocean. Another threat comes in the form of invasive species. Sacramento pikeminnow are known predators of trout and compete with them for food and habitat. The Estuary Program works to maintain water quality and quantity, remove migration barriers, and manage threats to trout, such as this invasive fish.

Using the Latest Science

To better understand the distribution of trout and pikeminnow within Morro Bay's creeks, we employed a tool called environmental DNA (eDNA). In 2018, researchers took water samples from local creeks and analyzed them for the unique DNA left behind by trout and pikeminnow. Sampling and analysis were conducted on all of the watershed creeks by Stillwater Sciences and the UC Santa Barbara Marine Sciences Institute.

Stillwater Sciences and Estuary Program staff use sterile technique to collect a water sample for eDNA analysis. Photo courtesy of Stillwater Sciences.

Trout and Pikeminnow Distribution in the Morro Bay Watershed



The results of the eDNA sampling and observations from snorkel surveys conducted in 2019 by the California Conservation Corps confirmed the presence of trout and pikeminnow throughout Chorro Creek, with limited distribution in tributaries to Chorro Creek. In San Bernardo, San Luisito, and Pennington Creeks, trout were detected or observed both downstream and upstream of partial barriers at Highway 1, while pikeminnow were limited to the lowermost portions of tributaries. An exception was San Bernardo Creek where pikeminnow DNA was detected upstream of the partial barrier at Highway 1. Trout and pikeminnow DNA were also detected in the lower section of Warden Creek. Although no DNA from either species was detected in lower Los Osos Creek, trout were observed in upper Los Osos Creek near Clark Valley Road during snorkel surveys in 2019.

Legend

- Watershed Boundary
- Creeks

Fish Distribution

- Trout
- Pikeminnow

Impact of Invasive Pikeminnow on Trout

After eDNA analysis alerted us to the presence of both species in local creeks, the next step was to assess the level of pikeminnow predation on trout in Chorro Creek. To do this, scientists analyzed the stomach content of pikeminnow for eDNA to determine if they were consuming trout. Out of nearly 40 pikeminnow sampled, about 20 percent had trout DNA in their stomachs. If each of the large, predatory adult pikeminnow consumes around 40 juvenile trout per year and if the entire population of around 200 large pikeminnow in Chorro Creek has a similar predation rate, the estimated annual loss would be more than 7,000 juvenile trout per year.

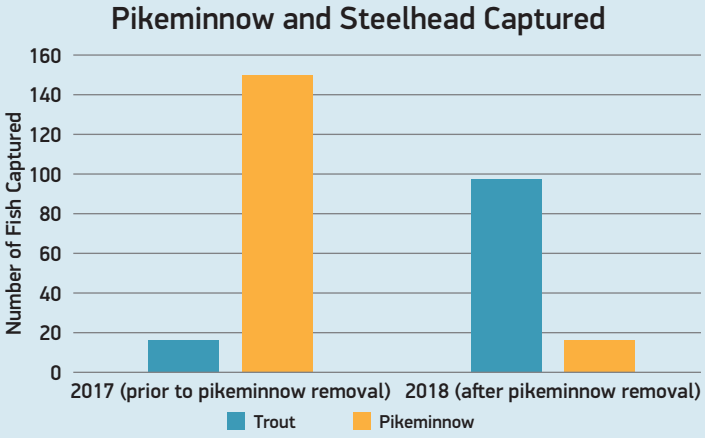
Invasive Species Management

Since pikeminnow predation on trout is so high, the Estuary Program worked with biologists from Stillwater Sciences to reduce the pikeminnow population. For a fish that is a voracious predator for around three to four years of its life, removing one pikeminnow can protect around 150 to 200 trout juveniles.

A trout from Chorro Creek. Scientists measured and then returned the fish to the creek. Photo courtesy of Stillwater Sciences.

Stillwater Sciences and Estuary Program staff utilize electrofishing backpacks. This temporarily stuns the fish so that they can be scooped up in nets. Photo courtesy of Stillwater Sciences.

Clearing the Way for Fish Migration



Prior to pikeminnow removal efforts in 2017, a section of Chorro Creek had very high numbers of pikeminnow (the orange bars on the graph) with very few trout (the blue bars on the graph). In 2018, the same locations had high numbers of trout and only a few pikeminnow. Although the data is limited, pikeminnow removal appears to greatly benefit trout.

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

Models and analyses continue to predict hotter, drier weather with more severe storm events, drought, and accelerating sea level rise.

A changing climate has far-reaching implications for our lives. Drought, more intense storms, and wildfires are a few examples of potential impacts. In an effort to understand how global climate change might affect Morro Bay and the lands that surround it, the Estuary Program has examined new climate models. Results from these tools indicate that the local climate will likely shift toward greater volatility in all types of weather conditions, including warmer surface temperatures, drier conditions, more intense storms, and continued sea level rise.

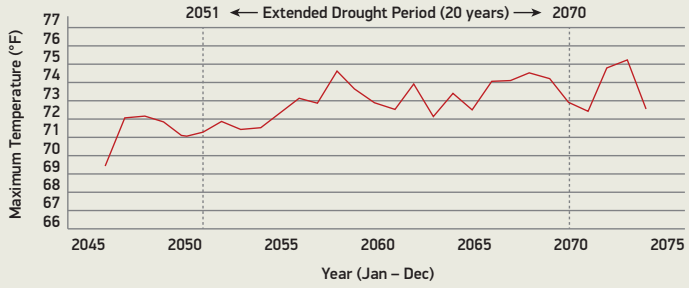
The Estuary Program works to stay abreast of evolving climate science, to understand the impacts of projected changes, and to implement on-the-ground projects to increase the resiliency of natural areas around the estuary.

Impacts of Extended Drought

Those living in the west are already familiar with the concept of drought. Recent research indicates that extended droughts ("mega-droughts") could become more common in the future.

Maximum Temperature

Maximum daily temperature which typically occurs in the early afternoon

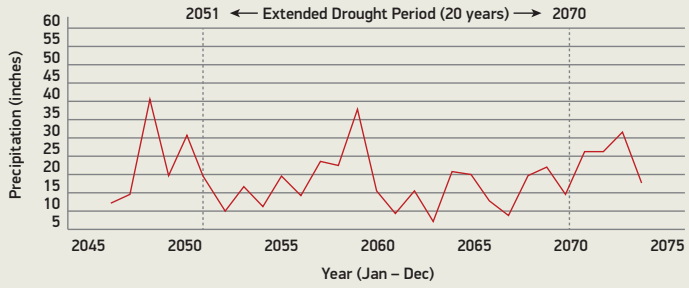


OBSERVED HISTORICAL
1961–1990 Average
66.4 °F

DROUGHT SCENARIO
2051–2070 Average
73.0 °F

Precipitation

Accumulated rainfall and snowfall



OBSERVED HISTORICAL
1961–1990 Average
19.3 inches

DROUGHT SCENARIO
2051–2070 Average
16.8 inches

These graphs depict the impacts of drought on temperature and precipitation. The data for the future (2051 to 2070) has been projected based on a warmer/drier climate model and "business as usual" greenhouse gas emissions, which assumes that emissions will continue to rise strongly through 2050 and plateau around 2100. This model predicts an increase of 6.6°F (3.68°C) in maximum temperature and a 2.5 inch (6.35 cm) decrease in precipitation in the Morro Bay watershed.

Impacts of Sea Level Rise and Storm Surge in Morro Bay

Sea level rise gets a lot of attention in coastal communities, where it threatens low-lying habitats and could damage roadways, seaside buildings, and other infrastructure. To better understand these future changes on the Central Coast, the United States Geological Survey (USGS) developed a localized model called the Coastal Storm Modeling System (CoSMoS), which predicts storm-induced coastal flooding, erosion, and cliff failures.

The map shows the model results given two meters (6.6 feet) of sea level rise, pictured in blue, resulting in significant impacts to both infrastructure and habitats, such as the salt marsh. The orange on the map indicates areas that might be impacted by two meters of sea level rise coupled with a 100-year storm, which is a storm so large that it has a one-percent chance of occurring in any given year. The warming climate is expected to bring more volatile storms, meaning that 100-year storm events could become more frequent.

Legend

- 2 m sea level rise
- 2 m sea level rise with 100-year storm event

Increasing Coastal Resiliency: Project Spotlights

In the face of a changing climate, communities must focus on building resiliency, which is the capacity to survive, adapt, and grow. The Estuary Program implements on-the-ground projects to increase resiliency in the estuary and the Morro Bay watershed.

Floodplain Restoration: Historically, creeks were often restricted to narrow channels to prevent flooding of nearby fields and buildings. Unfortunately, this resulted in erosion, reduced water quality, and less habitat for aquatic wildlife. Floodplain restoration reconnects creeks to these low-lying adjacent areas, allowing them to flood during storm events. This creates habitat for fish, improves water quality, and allows water to percolate into the ground to recharge groundwater storage to increase resiliency in water supply and flood control.

These photos were taken before and after a successful floodplain restoration along Chorro Creek, called the Chorro Flats Enhancement Project. This project contributes to climate resiliency by allowing stormwater to spill over into the floodplain where it can slow, spread, sink, and nourish plants rather than rushing downstream and bringing excess sediment into the bay.

Chorro Flats: Before Restoration

Chorro Flats: After Restoration

Land Protection: Strategies such as land preservation, acquisition, and easements create a land buffer to give habitats room to migrate as climates change and to protect migration corridors. For humans, these local planning efforts encourage development and climate-smart growth that allows coastal communities to be more responsive to the impacts of a changing climate. An easement in the Los Osos Valley (pictured here) protects a 540-acre ranch, which keeps the land in agriculture and prevents subdivision of the property for development.

Photo courtesy of The Land Conservancy of San Luis Obispo County.

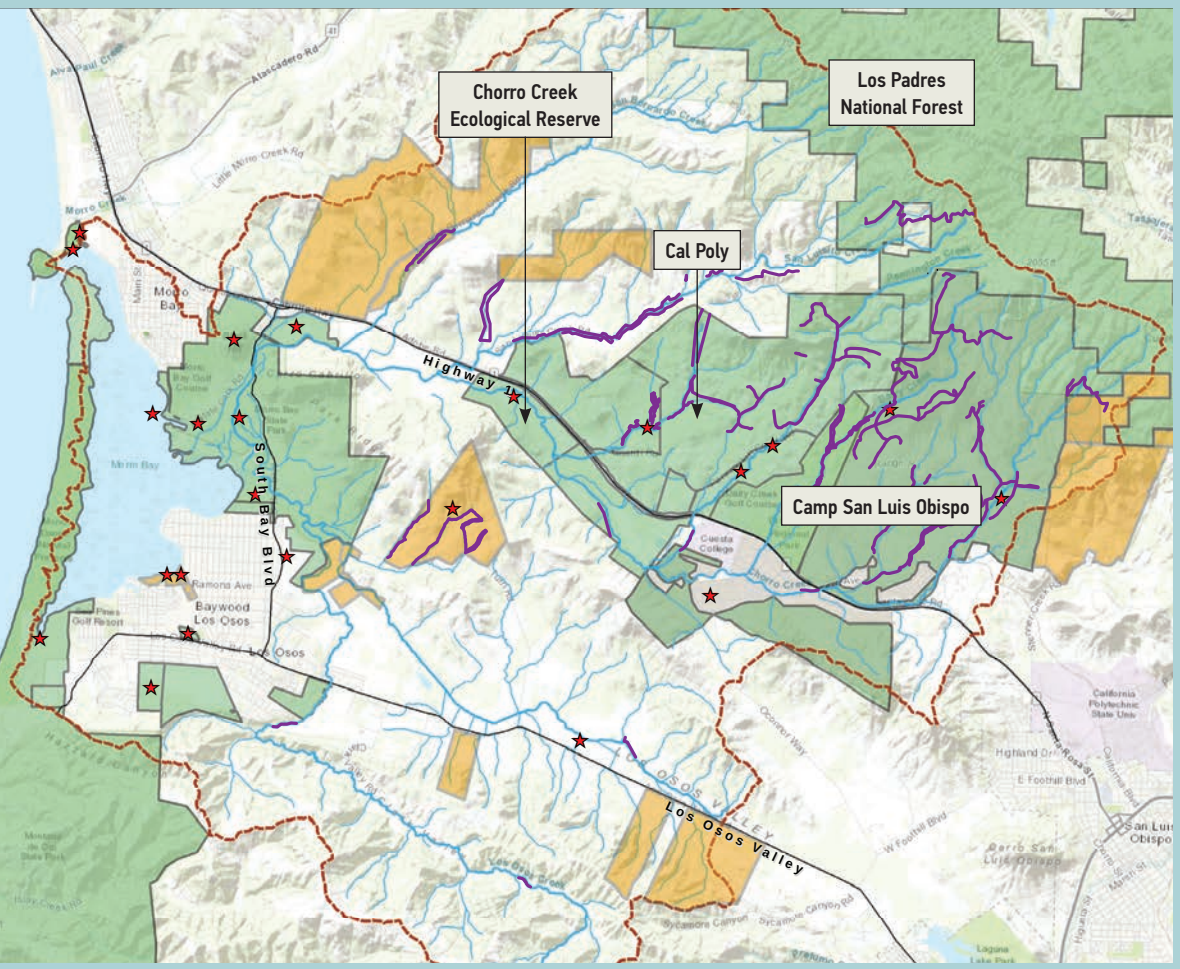
Invasive Species Management: Shifting climates sometimes favor invasive species to the detriment of native species. In our local creeks, climate change conditions such as warmer waters benefit invasive Sacramento pikeminnow (pictured here) over the native trout. The Estuary Program will continue to work with partners to manage invasive species and protect native species.

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

Yes, more than 5,000 acres have been protected and 23 projects have been completed to improve natural areas and water quality.

Wild natural lands support wildlife, clean water, healthy soils, and a rich array of life in our diverse watershed. The Estuary Program and our partners work to **protect**, **enhance**, and **restore** wild lands that support native plants and animals, are resilient to changes in climate, and support natural processes.

Natural Areas Conserved, Enhanced, and Restored in the Morro Bay Watershed



This map summarizes the areas in the Morro Bay watershed that are conserved, as well as locations of various types of improvement projects.

- Watershed improvement projects along streams
- Watershed improvement projects
- Easements and private preserves
- Public-owned and Managed Open Space
- Watershed Boundary
- Creeks

Conservation easements preserve land and protect historic uses

Protecting lands from future development and high-intensity uses ensures natural areas will persist for many decades to come. Land can be protected using two common approaches—buying property outright for a public agency or environmental organization to own or manage, or entering into an agreement with a willing landowner to limit future land uses without purchasing the property. This second option is called a **conservation easement**.

The Estuary Program partners closely with The Land Conservancy of San Luis Obispo County to promote land conservation in our watershed. Since our 2017 State of the Bay report, three new conservation easements on private land have been completed. These easements total nearly 1,000 acres. The Estuary Program contributed funding to help complete an important agreement on the Kandarian Organic Farms.

Enhancing and restoring protected lands

After natural areas have been protected, active management helps maintain the integrity of wild lands and reduce risks to people and wildlife. One management approach is **enhancement**, which means improving habitat conditions to reduce future impairment. Over the past few years, our local State Parks team has worked in Morro Bay State Parks to reduce future fire risk and improve natural conditions. Fire management sometimes means setting prescribed, or planned, fires to reduce the fuel available for future wildfires and to support natural vegetative growth while maintaining recreational areas. Morro Bay State Park efforts have reduced fuel loads, resulting in healthier natural areas in one of the region's most visited parks.

Restoration is a more intensive approach to land management that aims to return degraded lands to conditions that support wildlife and natural functions. The Estuary Program is working on a seven-acre restoration project on former agricultural land along a half mile of Chorro Creek. The completed project will restore open areas where the creek can flood during storms, keeping sediment from muddying the waters. Before the project is complete, more than 1,500 native plants will be planted to support nesting birds, and to add vegetative cover that keeps the creek area cool and provides refuges to many wild animals.

Protection: Kandarian Organic Farms, Los Osos Valley

Kandarian Organic Farms covers 133-acres in the Los Osos Valley and is now protected under a conservation easement held by The Land Conservancy of San Luis Obispo County and funded in part by the Estuary Program. Photo courtesy of Larry Kandarian.

Restoration: Chorro Creek Ecological Reserve Floodplain Restoration

The dedication of multiple partner organizations is resulting in critical restoration work to improve water quality, protect threatened wildlife, and strengthen the resilience of natural areas. This aerial image shows the site after the completion of construction work to restore the natural floodplain, and before seeding and planting have begun.

Enhancement: Morro Bay State Park

Local State Parks management has enhanced natural areas in Morro Bay State Park (seen here from Black Hill) using many methods, including prescribed burns to reduce fuel loads, protect local communities, and support native vegetation and wildlife.

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.

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

The Central Coast Regional Water Quality Control Board (Water Board) updated the scoring method for assessing the status and trends of waterbodies using all available data, some of it going back to the 1990s. The creek nitrate scores for the 2020 report differed greatly from the 2014 report, which is the last time the analysis was done. The difference is due to changes in the Water Board's method of analysis, rather than a change in nitrate conditions on local creeks. The trend for the bay oxygen and creek nitrates was determined by assessing data before and after January 1, 2014.

Is Morro Bay safe for swimming?

The map includes enterococcus data collected and analyzed by Estuary Program volunteers from 2005 through 2018 using the IDEXX method. The scoring, status, and trends are based on the Water Board's criteria. The trend was determined by assessing data before and after January 1, 2014.

Is the bay clean enough to support commercial shellfish farming?

Data and updates to the lease areas in the map were provided by the California Department of Public Health. The map shows the geometric mean of the fecal coliform data from 2014 through 2018.

Is the bay filling in at an unnatural rate?

Bay sediment samples from subtidal depths during winter 2019 were collected by Cal Poly and sent to a laboratory for grain-size analysis. The sediment map graphic is courtesy of Ryan Walter (Cal Poly physics professor) and student Matthew Kehrli. The 2019 bay-wide topobathy lidar survey was conducted in spring 2019. The historic data for comparison is from the California Coastal Conservancy lidar data set from 2009 to 2010 provided by the California Seafloor Mapping Program of the Ocean Protection Council and NOAA's National Center for Environmental Information. The two images were aligned and the resulting map shows the change in elevation throughout the bay when the 2010 data is subtracted from the 2019 data.

Does Morro Bay support healthy eelgrass beds?

The eelgrass maps from 2007 and 2017 were created using multispectral imagery collected in the fall and an automated classification scheme, with ground-truthing by Estuary Program staff. Small patches of eelgrass that were detected in 2017 are not highly visible on the map. Refer to the higher resolution version available online.

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

The Regional Bird Population data is from the Audubon Christmas Bird Count. Western snowy plover data is from the San Luis Obispo Coast District of California State Parks. Local brant data is from John Roser, a local biologist, using standardized methods. Brant migration information is from U.S. Fish and Wildlife Service.

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

Stillwater Sciences developed the map indicating pikeminnow and trout presence based on the eDNA results and snorkel surveys from 2019. Stillwater Sciences developed rates of pikeminnow predation on trout based on eDNA results and their extensive experience working in Chorro Creek.

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

The extended drought projections come from Cal Adapt. Results were projected for the future using the HadGEM2-ES model (warmer/drier scenario) and the RCP 8.5 emission scenario (assumes emissions rise strongly until 2050 and plateau around 2100). The sea level rise and storm surge map was created using Coastal Storm Modeling System (CoSMoS), a USGS tool to assess impacts to coastal areas.

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

The map includes publicly and privately-protected lands and areas 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, California State Parks, Morro Coast Audubon Society, Trout Unlimited, and many others.

For more details on these data sources, please visit our website at MBNEP.org/state-of-the-bay

We need you to protect and preserve Morro Bay!

Learn. Donate. Act.

Learn

To learn more about the Morro Bay estuary and how you can help, subscribe to our weekly blog at MBNEP.org/blog

Donate

Donations support our monitoring, restoration, and education efforts. Every donation, regardless of size, helps protect this special place that we all treasure. MBNEP.org/donate

Act

We can all pitch in to create a better future for the Morro Bay estuary and other wild places.

Volunteer

The Estuary Program and our partners rely on dedicated volunteers to help with restoration, education, research, and monitoring efforts. To find out more about volunteer opportunities around the estuary, visit our website at MBNEP.org/volunteer

Help change our climate future

Participate in the conversation in your community and region about actions we can all take to ensure a climate-resilient future.

How much climate change affects us depends on how much carbon dioxide we put into the air. You can do three simple things to reduce the amount of carbon dioxide you create and release.

1. **Drive less.** Combine your errands into one trip, so you travel fewer miles overall. You'll burn less gas, make less carbon dioxide, and save time and money.
2. **Turn off the lights when you leave a room.** This conserves energy, which keeps power plants from producing more electricity and carbon dioxide unnecessarily.
3. **Take shorter showers.** Shave 5 minutes off your shower to save 2.25 pounds of carbon dioxide and 12.5 gallons of water. Over one year, you will produce 820 fewer pounds of carbon dioxide and save more than 4,560 gallons of water.

Whether it's Coastal Cleanup Day or any day at the beach, you can make a difference by picking up trash and recycling before it blows or washes into the bay.

MORRO BAY
NATIONAL ESTUARY PROGRAM

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