

A Changing Casco Bay

The Bay Where You Work and Play Is at Risk



Friends of Casco Bay
Casco BAYKEEPER



Learn How You Can Help Protect the Health of Casco Bay

Go Beneath the Surface

The dots indicate work that Friends of Casco Bay volunteers and staff have done around the Bay over the past 25 years.

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Casco Bay by the Numbers

236,483 = Number of residents living in the Casco Bay watershed, from Bethel to the Bay (2010)

1 in 5 = Number of Mainers living in the Casco Bay watershed

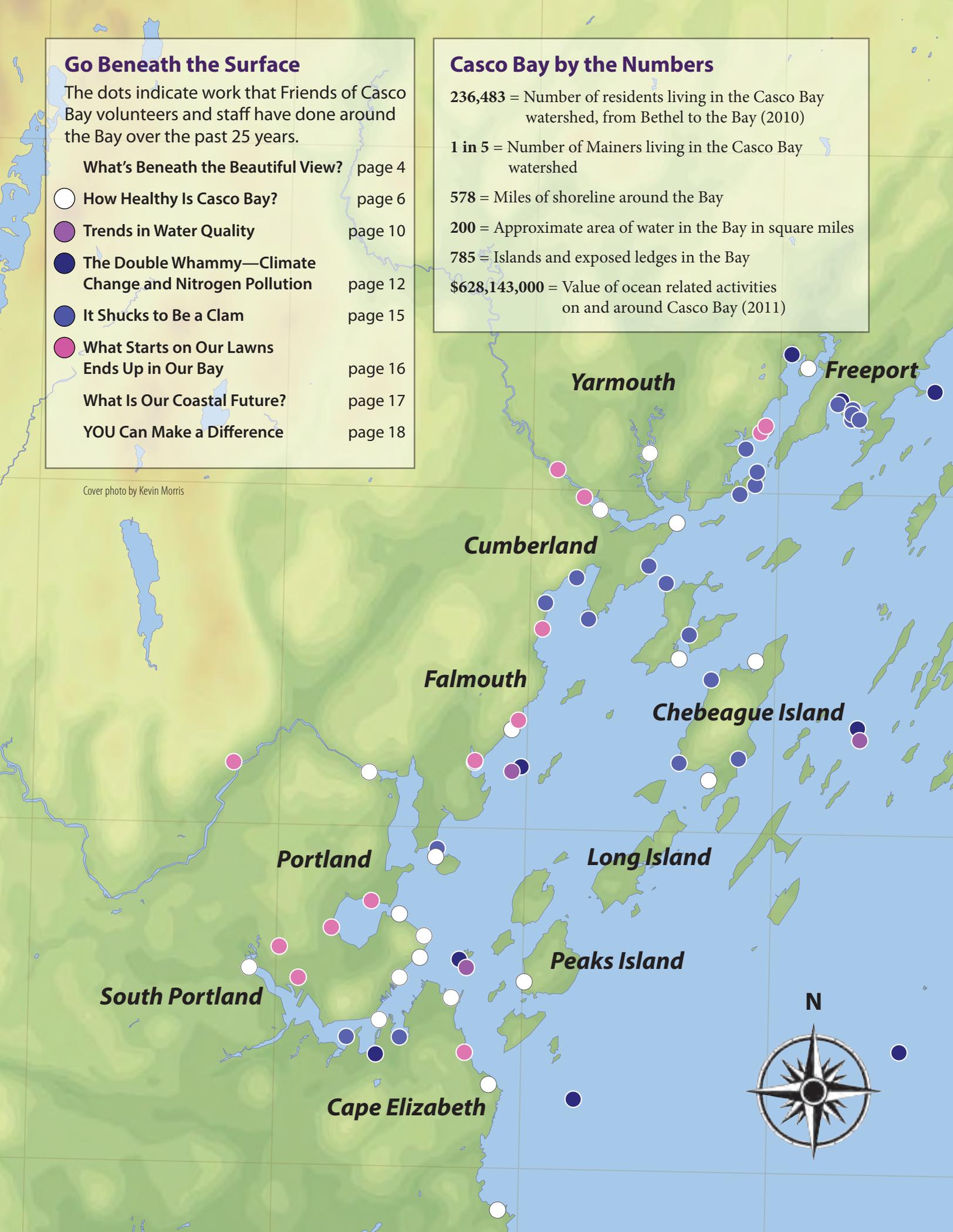
578 = Miles of shoreline around the Bay

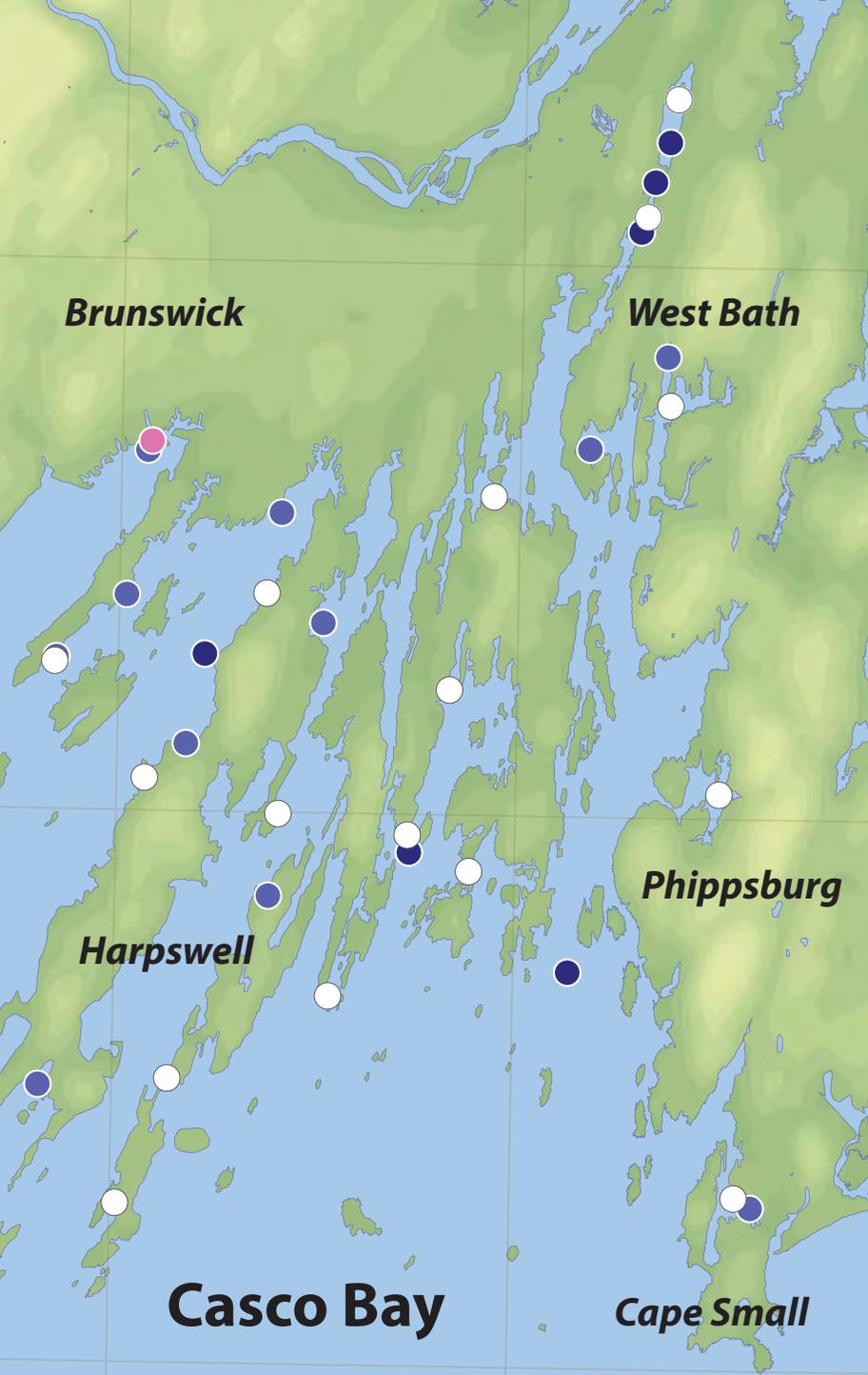
200 = Approximate area of water in the Bay in square miles

785 = Islands and exposed ledges in the Bay

\$628,143,000 = Value of ocean related activities on and around Casco Bay (2011)

Cover photo by Kevin Morris





Working Waterfront and Scenic Postcard

Casco Bay extends from Two Lights in Cape Elizabeth to Cape Small in Phippsburg, encompassing 13 coastal communities, including two of Maine's largest cities, Portland and South Portland, and two of Maine's newest towns, Long Island and Chebeague Island. The Casco Bay watershed collects water across a landscape of nearly 1,000 square miles, from 42 communities between Bethel and the coast.

Casco Bay is an estuary, where rivers and tides converge. Rivers add nutrients, tides deliver cold, oxygen-rich seawater, and relatively shallow depths provide protected habitat. These factors make our estuary the feeding, breeding, and nursery grounds for 850 species of marine life in Casco Bay, from microscopic plants to migrating pilot whales, and for 150 kinds of waterbirds that nest here.

The circulation of water around Casco Bay is affected by runoff from rivers and streams, tidal action, currents, winds, and geography. Many small rivers, including the Fore, Presumpscot, Harraseeket, Royal, and Cousins, empty directly into Casco Bay, but their collective volume cannot match the influence of the Kennebec River. Even though it is not in the Casco Bay watershed, we have detected runoff from the Kennebec at Halfway Rock, nearly nine nautical miles from where the river enters the ocean.

Casco Bay is both a working waterfront—a port of call for cruise ships, oil tankers, and bulk cargo transports—and a scenic postcard of historic forts, stalwart lighthouses, and secluded anchorages.

In the mid-1800s, tanneries, foundries, slaughterhouses, and shipyards crowded the Casco Bay waterfront. Later, power plants, filling stations, tank farms, and discharge pipes from industry and sewage treatment plants were added to the shoreline. Though many of these pollution sources have been removed, polluted runoff, overflows from sewage pipes en route to sewage treatment plants, boater sewage, the threat of oil spills, and the effects of climate change jeopardize the health of the Bay.

For over 23 years, staff and volunteers have been collecting data for Friends of Casco Bay, to give us a better understanding of the health of our coastal waters. This report focuses on nitrogen, oxygen, water clarity, pH, and pesticides, to create a comprehensive overview of the water quality of the Bay.

Valued for its rich diversity of marine life, Casco Bay was designated an Estuary of National Significance by the federal government in 1990. A technical report from the National Oceanic and Atmospheric Administration on environmental benchmarks found that Casco Bay had twice as many marine organisms as other temperate bays. Since 1989, **Friends of Casco Bay** has been working to improve and protect the environmental health of Casco Bay.





What's Beneath the Beautiful View?

It may be hard to believe today, but in the late 1980s, a report entitled “Troubled Waters” labeled Casco Bay as one of the most polluted estuaries in the nation. That report inspired a group of concerned citizens to form Friends of Casco Bay in 1989 to improve and protect the environmental health of Casco Bay.

When we were founded, pollution was widespread, but the truth was that no one had a handle on the environmental health of the Bay. So Casco **BAYKEEPER**® Joe Payne, our first employee, launched our Water Quality Monitoring Program, enlisting volunteer Citizen Stewards to “take the pulse” of Casco Bay using proven scientific methods. Monitoring the water allows us to look at what’s beneath the beautiful view. Joe compares it to “getting a check-up from your doctor. If the usual diagnostic tests, like blood pressure and pulse, show an anomaly, then you do more testing to determine the cause.” We have collected data on many different aspects of water quality over the years; this report focuses on nitrogen, oxygen, water clarity, and pH, as well as other factors, to determine the relative health of our waters.

We are celebrating our 25th anniversary. Over the years, thanks in part to our work, industrial pollution in our coastal waters has decreased, municipalities have worked to reduce sewage pollution, and the Bay has been designated a No Discharge Area, making it one of the most protected water bodies from ship pollution in the country. Today, Casco Bay is ever present on Top Ten vacation and sailing lists. And Friends of Casco Bay is ever present on our waters, working to keep the view beautiful both above and below the surface.

What Do Friends of Casco Bay Volunteers Do?



Volunteers help us host community events such as the Wild & Scenic Film Festival.



Volunteers stencil clean water messages on storm drains.



Volunteers pick up trash from beaches and salt marshes.



What Is a Waterkeeper?

Joe Payne was one of the first Waterkeepers in the nation and helped cofound **WATERKEEPER® ALLIANCE**. Today, 220 Waterkeepers around the world work to resolve pollution problems that threaten their water bodies.

Because of our work-with approach, the Casco Baykeeper has become a model for other Waterkeepers. Friends of Casco Bay attempts to balance both economic and environmental values among those who live, work, and play around the Bay.

It Takes a Community to Protect the Bay

Friends of Casco Bay’s most valuable asset is a committed corps of volunteers. Together, they have donated more than 150,000 hours of service over the past 25 years. Our neighbors around the Bay help us tackle issues and projects in ways that significantly enhance the work of our staff of ten.

We piloted our Water Quality Monitoring Program in 1992 to prove that volunteers could collect reliable data. The U.S. Environmental Protection Agency has repeatedly given our monitoring methods its scientific “seal of approval.” Our communities and governments could not afford to pay professional scientists and contractors for the work our volunteer citizen scientists do for free. Our volunteers sample on 10 selected Saturdays, at 7 a.m. and 3 p.m., from April through October.

Our volunteers and staff collect data sets that:

- Ground our advocacy with credible, scientifically accurate facts
- Are legally defensible and are incorporated into Maine’s biennial report to Congress under the Clean Water Act
- Create a portrait of Casco Bay that documents baseline conditions and environmental changes
- Inspire stewardship by encouraging community service and volunteerism
- Stimulate and support research by government agencies, universities, and scientific institutions



Volunteers urge legislators to protect the Bay.



Volunteers collect invaluable information that tells us how healthy Casco Bay is.



—And, YOU can, too!
Go to www.cascobay.org/volunteer



Thank you to nearly 500 volunteer citizen scientists around the Bay who made our Health Index possible.

If you would like to join our monitoring team, sign up at cascobay.org/water-quality-monitoring.

— Casco Baykeeper Joe Payne

Photo by Dennis Welsh

How Healthy Is Casco Bay?

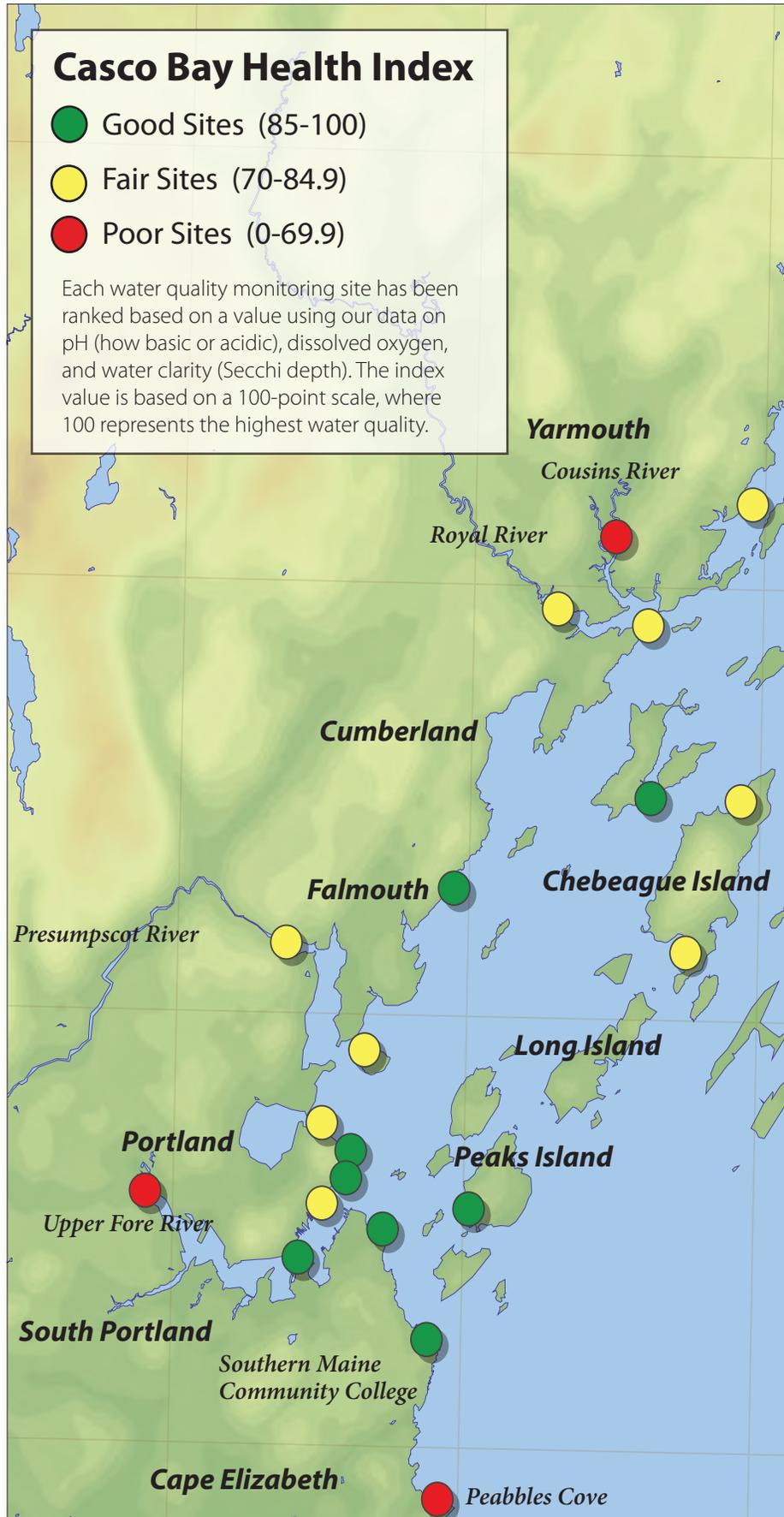
Friends of Casco Bay has developed the **Casco Bay Health Index**, an easy-to-interpret, visual guide to the health of the Bay. The Index allows us to integrate data from selected water quality parameters into a single value to compare and rank each site as Good, Fair, or Poor.

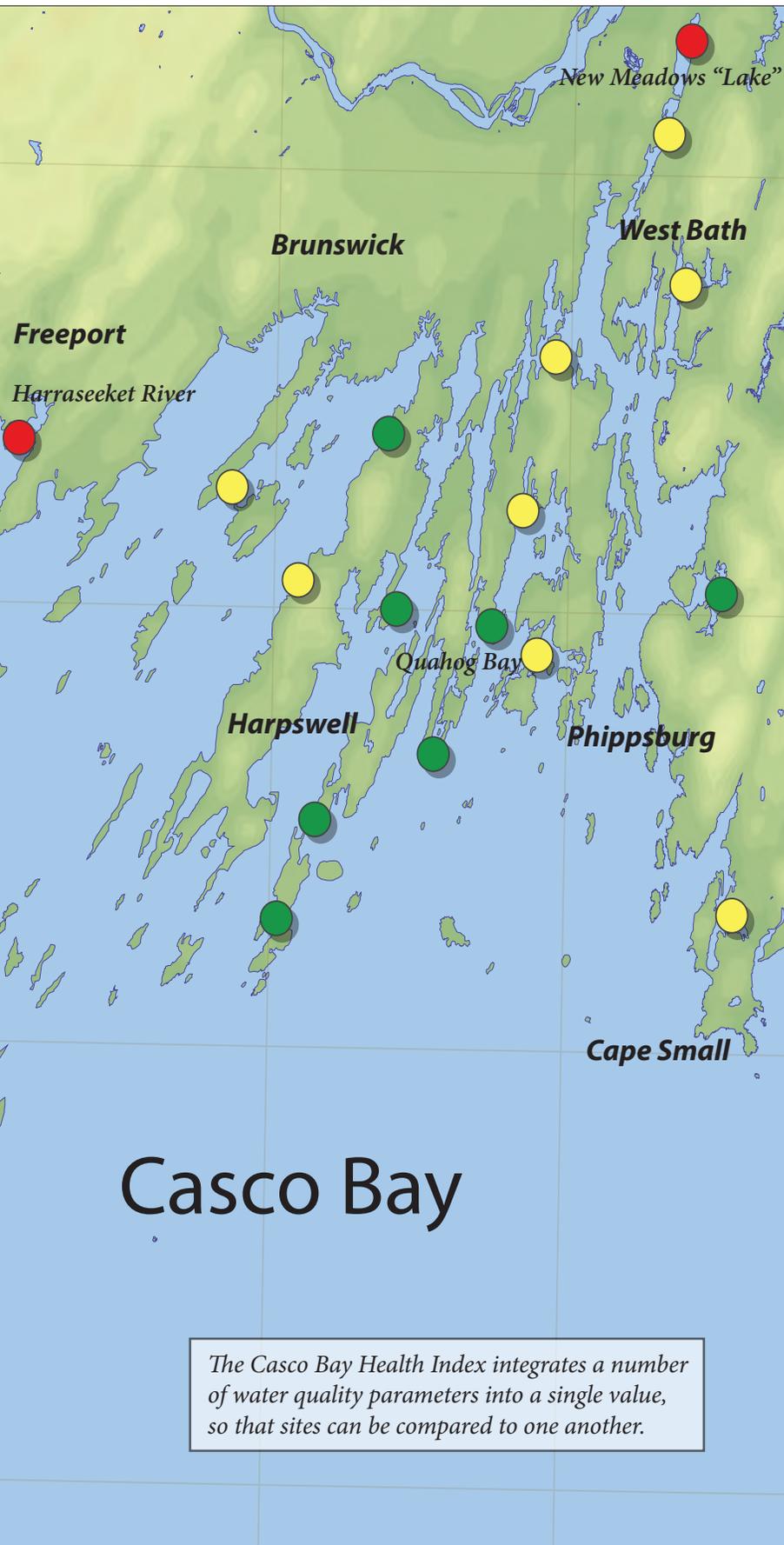
Overall, the water quality in Casco Bay is good, but there are instances when low oxygen, low pH, and murky waters are cause for concern. The 2014 Health Index reveals that over 20% of the sites are considered Poor, but more than 40% of the sites meet the Good standard.

The relative rankings were calculated by analyzing **dissolved oxygen**, **water clarity**, and **pH** data from shoreside sites that our volunteer Citizen Stewards monitored from 2005 to 2012. The values we chose to use were the 90th percentile of the dissolved oxygen percent saturation, the mean of the Secchi depth, and the mean of the diurnal differences in pH. For detailed information, visit www.cascobay.org/health-index.

Green Dots Mean Healthier Sites

Having plenty of oxygen, clean water, and safe pH levels are essential to healthy marine waters. We need oxygen, and so do critters living in the ocean! Dissolved oxygen is the most important parameter our volunteers measure. Dissolved oxygen levels indicate the amount of oxygen available for marine life. pH refers to how acidic or basic our waters are. Water clarity refers to how clear our water is and is a measurement of how far below the surface sunlight can penetrate. Green dots show conditions conducive to thriving ecosystems.





● Quahog Bay, Harpswell

Our water quality testing over the past decade has shown that oxygen levels in the deep water of Quahog Bay have been improving steadily. In nearby Harpswell, the whole town appears to have adopted the motto *A clean Casco Bay starts with you, one step at a time*. The Conservation Commission published *A Resident's Conservation Guide to Casco Bay*, which gives advice on yard care, household waste management, and boating practices, which help “reduce polluted runoff and keep our bay healthy.” Neighbors “take the pledge” not to use lawn chemicals. Realtors tout the environmental ethic of the community. Cause and effect? We don't know, but something is making life different—and better—for Harpswell's underwater neighbors.



Photo by Jeff Ryan

● Southern Maine Community College, South Portland

A drowned island of shelter and security for many animals is how Rachel Carson described eelgrass, the sinuous sea meadows that grow just beneath the surface of the Bay. Eelgrass beds provide critical estuarine habitat for marine life, trap sediments, and dampen wave action. But eelgrass needs clean, clear water. Here, clear, cold water and strong currents provide ideal habitat where eelgrass thrives, even as it is disappearing along other parts of the Maine coast.

During 2013, the Maine Department of Environmental Protection and the Casco Bay Estuary Partnership planned an aerial survey of eelgrass beds of Casco Bay to map these critical and sensitive habitats. But the flights would be useless if the water was too turbid to get good photographs. The 2013 eelgrass survey team used our Secchi depth readings to help decide when the water was clear enough to conduct overflights for the survey of Casco Bay.

Red Dots Signify Troubled Waters . . .

Low oxygen levels, murkiness that prevents sunlight from penetrating the water, and dangerous acidity levels are recipes for troubled waters in our Bay. We may not be able to prove what could be harming these areas, but our monitoring efforts do show where problems can lurk.

● New Meadows “Lake”

In 1937, a causeway was built across the New Meadows River to connect Brunswick and West Bath. It effectively dammed the upper portion of the small embayment, significantly reducing its tidal range. In the 1960s, a second causeway was added, creating two “salt lakes.” Friends of Casco Bay identified a seasonal dead zone devoid of oxygen at the bottom of the lower “lake” that spills over into the New Meadows estuary itself. In the lower dammed “lake,” we’ve measured concentrations of nitrogen higher than at the outfall of a sewage treatment plant. Damming the embayment concentrates polluted runoff in the upper estuary. So far, some surrounding neighbors have not embraced the idea of increasing the flow through the causeway, afraid that opening it up will replace their water views with smelly mud.



We have measured high levels of nitrogen in the New Meadows. As water from the dammed New Meadows squeezes through the narrow causeway, organic matter is whipped into a foam.



● Bartol Island Causeway, Harraseeket River

The outlets of rivers, such as the Harraseeket and Cousins rivers, have some of the lowest dissolved oxygen levels in Casco Bay during the warm summer months. Our monitoring site at the Bartol Island Causeway is in the estuary of the Harraseeket River, where small streams deposit silt and organic matter from farther upstream. This nitrogen-rich organic matter acts like a fertilizer, promoting plankton blooms, which grow, reproduce, die, and decay in rapid succession. Decomposing plant matter and warm water temperatures lower water quality within the estuary. But the filtering action of the estuary’s wetlands contributes to good water quality by trapping nitrogen, thereby helping to protect the outer waters of Casco Bay. Estuaries are essential incubators for life in the ocean, where juvenile sea creatures find many places to hide, and abundant food nurtures residents and visitors alike. It is important to regulate land development around estuaries and to limit nitrogen pollution from wastewater treatment plant discharges, farms, lawns, and boat anchorages so that we don’t overwhelm our vital estuaries.

● Cousins River

Our sampling site on the Cousins River estuary is located next to Route One on the line between Yarmouth and Freeport. The Maine Department of Environmental Protection has designated this area as an impaired water body. Above the site, the river snakes through a salt marsh, draining water and runoff from the surrounding suburban communities. Silt and other debris reduce water clarity, blocking light from penetrating to the shallow bottom. Instead of a carpet of green plants, rotting seaweeds coat the shoreline. Leaking septic systems and development upstream increase nitrogen pollution. Despite the challenges this area faces, visitors can spy birds and wildlife, including river otters and even seals.

● Upper Fore River, Portland

This site on the Fore River is downstream from a variety of Portland neighborhoods, including parts of outer Congress Street, Libbytown, and Rosemont sections of the city. The salt marshes of this area are frequented by birds, juvenile fish, crabs, and other marine life looking for food and shelter. As outdoor enthusiasts know, the popular Fore River Sanctuary and Capisic Pond Park are found just upstream. Despite these urban green spaces, the poor water quality at this site may be a symptom of road runoff, fertilizers from lawns, sewer pipe overflows, and nitrogen and sediments flushed from the salt marsh.

● Pebbles Cove, Cape Elizabeth

Citizen Steward Darren McLellan overlooks his monitoring site at the southern end of Casco Bay. Darren's site is not far from where he summered as a child. He recalls, "I



Darren McLellan surveys his monitoring site in Cape Elizabeth, which exhibits poor water quality due to accumulations of rotting seaweed.

remember most of the cottages along the shore dumping raw sewage into the water." Though today it looks pristine, the area exhibits some of the poorest water quality in the Bay. Large rafts of seaweed cling to the rocks, and stormcast seaweeds decay along the shore.

This site is no longer polluted by these human activities; rather, the poor water quality is because there is just too much biological activity. Darren finds huge swings in dissolved oxygen and pH levels between his early morning and late afternoon samples. "In general terms, the water quality is lower in the morning and higher in the afternoon," says Darren. During daylight hours, the growing seaweeds photosynthesize, releasing oxygen into the water. At night, the process is reversed; the plants absorb oxygen from the water. Decomposing seaweeds and other plants use up even more oxygen and release carbon dioxide into the water, increasing its acidity.

The Clean Water Act

A true watershed event

In 1971, Senator Edmund Muskie of Maine introduced legislation that would eventually become the Clean Water Act. He said, "Today, the rivers of this country serve as little more than sewers to the seas. Wastes from cities and towns, from farms and forests, from mining and manufacturing, foul the streams, poison the estuaries, and threaten the life of the ocean depths."

Casco Baykeeper Joe Payne attests, "In our line of work, the Clean Water Act is the most important piece of legislation ever passed. Its implementation has prevented millions and millions of gallons of raw sewage and untreated industrial waste from being discharged into Casco Bay."

Our work to reduce pollution is, at its heart, about keeping the Clean Water Act's promise of making our waters safe for fishing and swimming.

Marine Water Quality Data Exhibits High Variability

Water quality refers to the physical, chemical, and biological characteristics of water. Coastal water quality by its very nature is highly changeable, as it is impacted by many variables—from natural dynamics (sunlight, weather patterns, winds and currents, biological and ecological processes), as well as from human activities.

The parameters of water quality we measure show significant variability—annually, seasonally, and even daily. Because of this variability, long-term trends can be very difficult to isolate and identify. The background "noise" from the various influences is too great in much of our data to identify statistically significant trends while looking at specific parameters; but, using a simple linear regression applied to annual means can provide a look at how some key parameters change over time.



Trends in Water Quality

Data collected over the past decade by Friends of Casco Bay has revealed a significant downward trend in pH in bottom water samples at our sentinel sites, as well as a marked difference in nitrogen concentrations between nearshore and offshore sites.

pH Is an Important Factor

pH is a measure of the acidity or alkalinity of water. The pH scale is logarithmic, ranging from 0 to 14. Each whole pH value below 7 (neutral) is ten times more acidic than the next higher value. Though seawater at 8.2 is basic, the ocean's chemistry is shifting toward the acidic side of the pH scale.

In coastal systems, many factors contribute to variations in pH. The major driver of pH change in seawater is the addition or removal of carbon dioxide. Carbon dioxide and water react to form carbonic acid. The more

carbon dioxide, the more acidic the water (and the lower the pH), while the removal of carbon dioxide reduces acidity (and pH is higher). Carbon dioxide is added and removed from seawater in a number of ways, some of which are naturally occurring and some of which are exacerbated by human activity.

The pH of Water in Casco Bay Varies Between Night and Day

Algae can have a huge influence on pH levels in the water. On a daily basis, seaweed and phytoplankton photosynthesize, taking up carbon dioxide and releasing oxygen; this process causes pH to rise throughout the day. But at night, during respiration, algae take up oxygen and release carbon dioxide into the seawater, which lowers pH. These two processes generally result in lower pH in the morning, after a night of respiration, and steadily higher pH by late afternoon. Much of the variability of pH in Casco Bay can be explained by changes caused by photosynthesis during the day and respiration at night. Since oxygen is produced through photosynthesis and removed by respiration, we can see the dynamic in our data when we compare levels of dissolved oxygen in the water to pH: the higher the oxygen levels, the higher the pH; the lower the oxygen levels, the lower the pH. This data is available because of the efforts of our intrepid water quality volunteers, who sample both at 7 a.m. and then again at 3 p.m. on scheduled monitoring days.

The swing in pH from morning to afternoon—the diurnal difference—can be an indication of productivity. The more algae in the water, the greater the diurnal change. A healthy and productive water body will have a relatively modest change in pH from morning to afternoon, but a large swing in pH may indicate that a site is overly productive, or eutrophic. This happens when excess nitrogen over-stimulates algal growth.

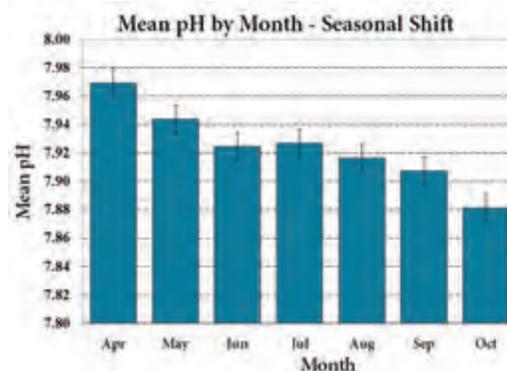
The pH of Water in Casco Bay Varies Seasonally

Seasonally, mean pH on a monthly basis drops over the course of the summer. Two dynamics are in play. As waters warm during the summer, mean pH values decline. In addition, algae blooms peak in the spring, then die and decompose through the summer into early fall. Bacteria responsible for decomposition respire and add carbon dioxide to the water and sediments. The overall effect is gradually declining pH values as we head into fall.

What's a Sentinel Site?

Friends of Casco Bay's staff scientists collect water quality data from the surface to the bottom year round at ten profile sites across Casco Bay. In some months, especially during the winter, bad weather prevents us from getting to all ten sites. Even so, as stalwart mariners, we have managed to visit three of the ten sites every month of the year for over 23 years. We call these sites our sentinel sites. We chose to analyze data from the bottom depths of these three sites, where conditions are less affected by wind, waves, and weather:

- Broad Sound, our deepwater site
- Clapboard Island, Falmouth, our "suburban" site
- Fort Gorges, our "urban" site in Portland Harbor



The mean pH values in Casco Bay decline monthly between April and October. This reflects the shifting balance between algal productivity and respiration.

Dissolved Oxygen

Oxygen is essential to marine life. Friends of Casco Bay staff and volunteers test for dissolved oxygen, a measure of how much oxygen is available to marine life. Generally, dissolved oxygen values in Casco Bay are good. But not all areas of the Bay have healthy oxygen levels all the time. The lowest oxygen levels can be found during the early morning in the late summer at river mouths and narrow embayments. In these locations, Friends of Casco Bay has detected oxygen levels that would cause fish, lobsters, and other marine life to be stressed or killed. Low levels of dissolved oxygen in the water contributed to massive die-offs of pogies in the upper New Meadows River and Quahog Bay in the early 1990s. Long-time residents of eastern Casco Bay still remember the awful smell of rotting fish from those die-offs.

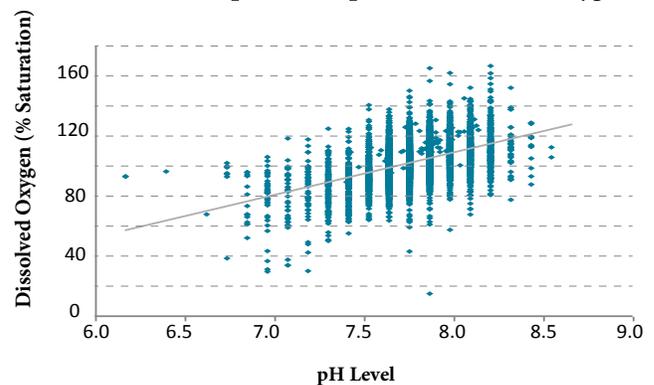


Photo from the Times Record

Big Daily Swings in pH Can Spell Trouble

While we expect pH to be variable, large changes in pH over the course of a day can be cause for concern. The average diurnal difference of pH in Casco Bay is about 0.1 pH units. However, some of our monitoring sites experience an average diurnal difference of as much as 0.3 units—this is a huge swing. This indicates that parts of the Bay could be eutrophic, meaning those regions will suffer from lower oxygen levels, increased carbon dioxide levels, increased acidity levels, nuisance algae outbreaks, and potential fish and shellfish die-offs.

Relationship Between pH and Dissolved Oxygen



In coastal environments—like Casco Bay—there is a close link between pH and dissolved oxygen as algae add and remove oxygen from our marine waters through photosynthesis, respiration, and decay.

$$y = 32.1x - 151.1, R^2 = 0.23^*$$

*The trend lines of the graphs throughout this report illustrate the pattern of the data. The equation (y=) describes the trend line that best fits the data. The R² value tells us how well the data fit around the trend line, indicating the reliability of the line.

Our Staff Is on the Bay Year Round

Friends of Casco Bay staff scientists use our Baykeeper boat to sample our research sites monthly, all year long. By January, our vessel is usually the only boat left in the slips at Breakwater Marina, South Portland. Bundled up in work suits lined with flotation gear, Citizen Stewards Coordinator Peter Milholland and Research Associate Mike Doan shovel snow off the deck and leave early to complete the 75 nautical-mile circuit of the Bay by nightfall.

Many winter mornings the air is colder than the ocean, creating a bank of sea smoke that wraps around the islands. The only other vessels encountered are commuter ferries, Coast Guard boats, and oil tankers, their bows caked with frozen sea spray.

Our boat stops at each sampling station for about 20 minutes, long enough for hands to become numb. “It’s important to sample all year round in order to understand the overall health of Casco Bay,” explains Peter.

By the time the crew returns to Breakwater Marina, the last rays of the setting sun momentarily blind them, a final reminder that nothing is easy on the water in winter. Yet, these stewards agree that being on Casco Bay at this time of year is magical.





Photo by Kevin Morris

The Double Whammy—Climate Change and Nitrogen Pollution

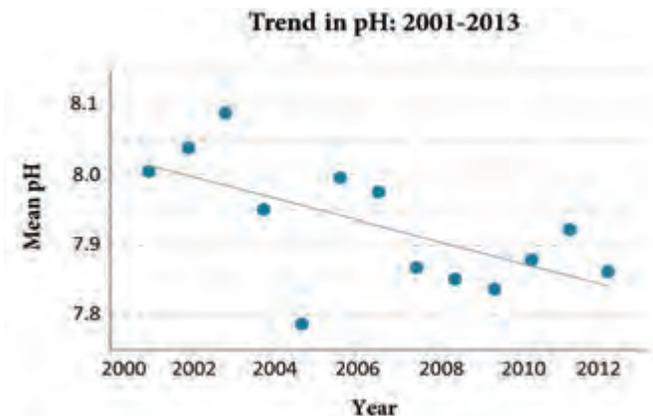
Nearly everyone has heard of the threat of global warming—as more carbon dioxide is released into the atmosphere through the burning of fossil fuels, the planet’s climate is changing. Not all carbon dioxide released into the atmosphere stays there; scientists estimate that nearly a third is absorbed by the oceans. As marine water absorbs this carbon dioxide, it forms carbonic acid, making the oceans more acidic. Scientists have discovered that over the past two hundred years, the average pH of the ocean has dropped 0.1 pH units. This means that the world’s oceans have become 30% more acidic than they were before the start of the Industrial Revolution. As more and more carbon dioxide is released into the atmosphere, the pH of the oceans continues to decline. This is known as Ocean Acidification.

Casco Bay suffers from a double whammy of carbon dioxide resulting from human activities. First, there are the effects on our local waters from Ocean Acidification. But we are finding excess nitrogen coming from onshore sources, namely polluted rainwater running off fertilized lawns and city streets, emissions from smokestacks and tailpipes, and sewage discharges, all of which send an overdose of nitrogen into our coastal waters. This nitrogen bonanza can stimulate the growth of large blooms of algae, beyond what animals in the ecosystem can consume. Much of these blooms end up dying and settling on the mud. This organic material decomposes; the bacteria responsible for decomposition respire during this process, removing oxygen and adding carbon dioxide. The carbon dioxide and seawater combine to form carbonic acid, lowering the pH of our water and our clam flats. This is called Coastal Acidification.

As more nitrogen pollution enters the Bay, more algae are produced, resulting in more decomposition, which adds more carbon dioxide to the water and sediments, lowering pH. This increased acidity can mean dissolution and death for young clams and other shellfish.

We See a Disturbing Trend in the pH of Bottom Water

Measurements at our sentinel sites show a decline in the pH of the bottom water. The points on the graph to the right show annual mean pH for each of thirteen years and illustrate high variability; the dots bounce all over the graph. While this is not surprising, given that coastal systems everywhere exhibit high variability, we did not expect to see this statistically significant downward trend in pH, with the overall slope of the line dropping 0.014 pH units per year over the thirteen-year period. This is a serious and disturbing trend.



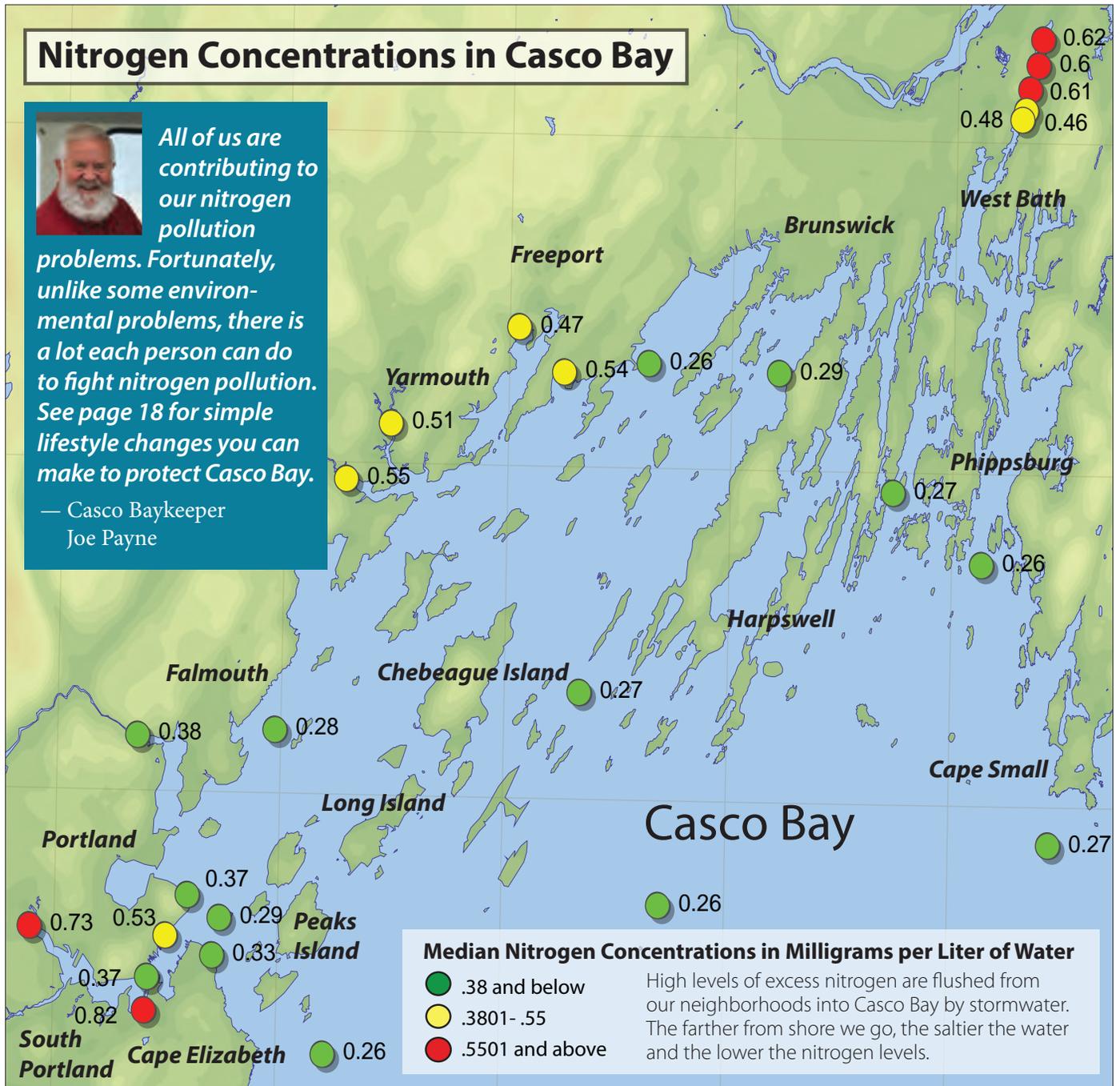
At our sentinel sites over the past decade, pH has been trending in the wrong direction.

$$y = -0.01x + 36.6, R^2 = 0.39^*$$

Nitrogen—Can't Live Without It, Can't Live With Too Much of It

All living things need nitrogen to grow. Nitrogen stimulates the growth of plants—both on land and in the ocean. In the marine environment, nitrogen jumpstarts blooms of algae—seaweed and phytoplankton, the tiny plants that form the base of the ocean food chain and provide half the oxygen we breathe. But an overdose of nitrogen triggers excessive growth of nuisance, and even harmful, algae. As these plants decay, bacteria take oxygen out of the water and release carbon dioxide into our coastal waters.

The map below shows concentrations of nitrogen around the Bay. There is a very clear trend of decreasing nitrogen away from shore. This indicates that land-based sources are contributing excess nitrogen to our waters. The farther offshore, the better the water quality!



Where Does All This Nitrogen Pollution Come From?

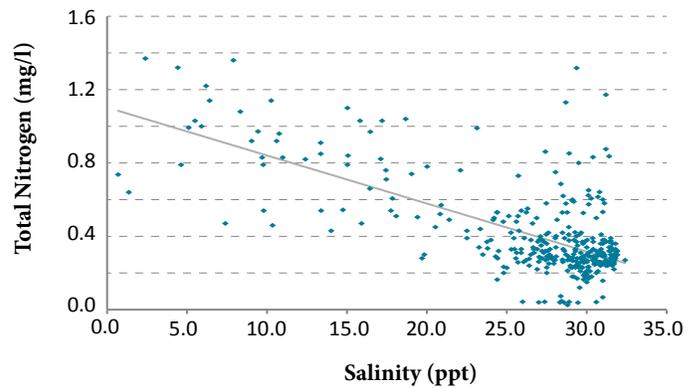
Excess nitrogen comes into Casco Bay from three different sources, almost in equal proportion—from sewage, from stormwater runoff, and from the sky (see pie chart below).

When we look at the relationship between nitrogen and salinity, we see high levels of nitrogen closer to shore where salinity is lower. This is evidence that much of the excess nitrogen found in Casco Bay is coming from land-based activities, such as polluted stormwater runoff and sewage treatment plant discharges.

Salinity is the measure of how salty water is. Salinity of the open ocean is 35 parts per thousand or 3.5% saltiness. Casco Bay is less salty and averages around 31 parts per thousand, mainly because of stormwater and fresh water from rivers and streams flowing into coastal waters. The water in Casco Bay, in general, is saltier farther from land, though fluctuations do occur.

The time of year also has a big impact on the salinity of Casco Bay. Salinity plummets every spring as snow melts, flooding rivers and streams that run into the Bay. Heavy rains also reduce salinity in the Bay.

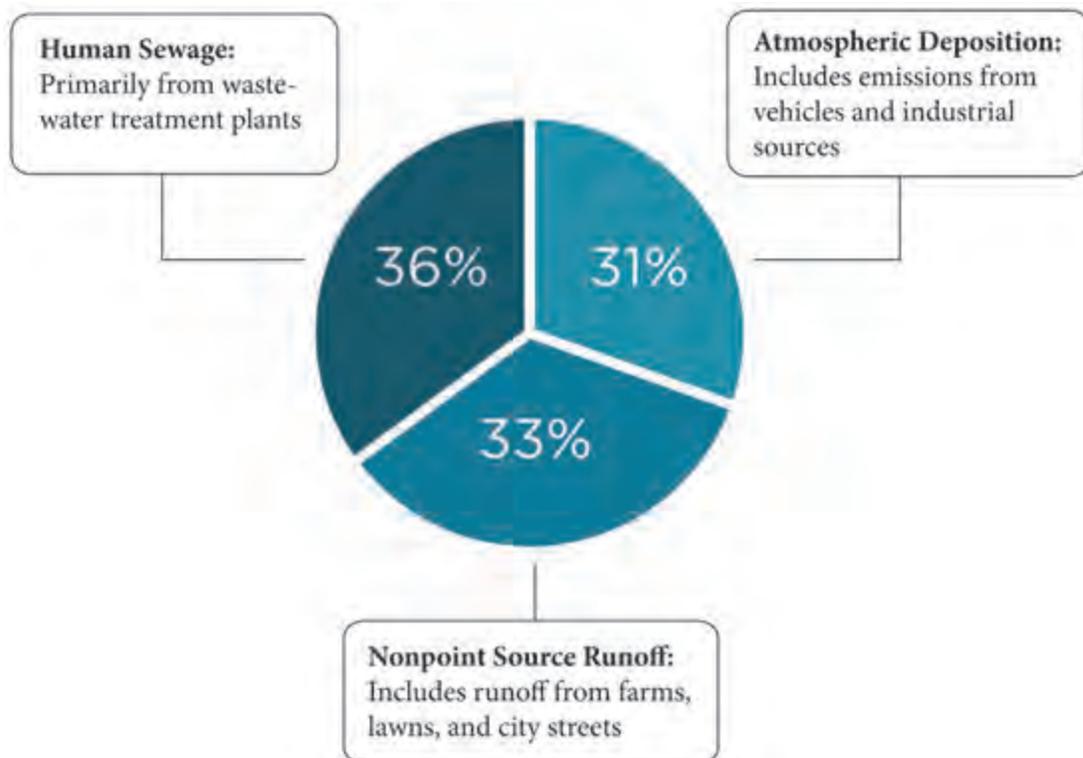
Relationship Between Total Nitrogen and Salinity



Higher levels of nitrogen are found closer to shore where salinity is lower. This indicates that much of the excess nitrogen found in Casco Bay is coming from land-based sources such as polluted stormwater runoff and sewage treatment plants.

$$y = -0.03x + 1.1, R^2 = 0.46^*$$

Sources of Excess Nitrogen to Casco Bay



Source: Castro, M. S., Driscoll, C. T., Jordan, T. E., Reay, W. G., and Boynton, W. R., 2003, Sources of Nitrogen to Estuaries in the United States. *Estuaries* 26, No. 3: 803-814.

The Impact of Coastal Acidification—It Shucks to Be a Clam

As our coastal waters become more acidic (as the pH decreases), clams, mussels, and other shellfish are having a harder time building and maintaining their shells. Juvenile clams may dissolve outright. Our research has found a disturbing link between acidic mud and clam flats where it is no longer profitable for clambers to harvest shellfish.

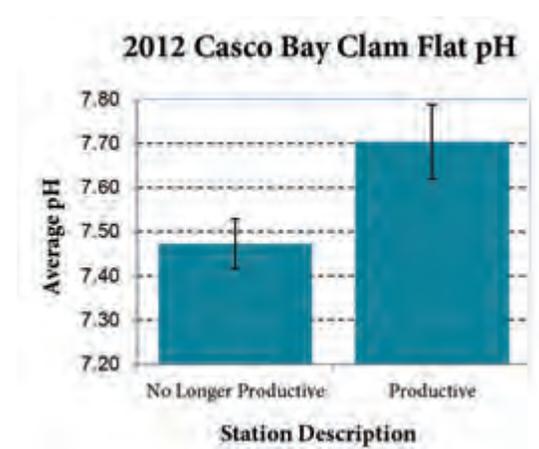
In 2011, Friends of Casco Bay began to publicize and investigate coastal acidification. We developed a scientific procedure for sampling the acidity of mud on clam flats. We wanted to compare the pH of clam flats that are actively being harvested by clambers to those that are no longer productive.

This groundbreaking work assesses how acidified sediments threaten the survival of baby clams in Casco Bay. Three years of data show that areas with the highest acidity (lowest pH) are the same flats where clams are now scarce.

We found a strong correlation between high levels of nitrogen and carbon in the mud—indicating organic matter—and lower pH. In other words, a lot of dead, decaying stuff makes matters worse.

Many people are interested in the results of our cutting-edge coastal acidification research, including the 1,700 registered Maine diggers who support a \$16.8 million-a-year industry harvesting soft-shell clams. Those of us who define summer as a delicious plate of steamers have a gastronomic interest, too!

In the summer of 2014, Friends of Casco Bay placed hatchery-reared baby clams in the mud at Recompence clam flat in Freeport, Maine, where we measured very low pH levels. Image A shows a clam prior to deployment in the mud. Image B shows a clam after just one week in the mud, where it became heavily pitted due to the high acidity of the mud. Image C is a close-up of the same clam. All of the deployed clams exhibited obvious signs of pitting.



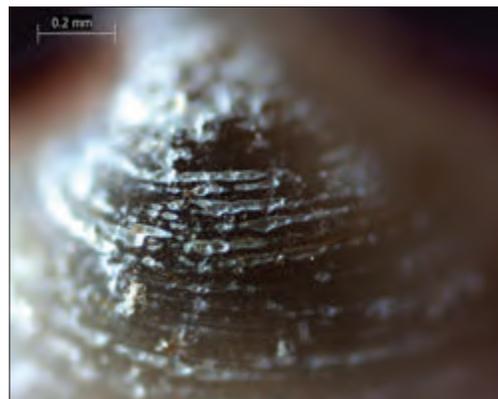
Our research on mud pH on 30 clam flats around Casco Bay suggests that the more acidic the clam flat, the less hospitable it is for clams.



Clam B



Clam A



Clam C

Lawns Are to Blame for Much of the Nitrogen and Toxic Chemicals in the Bay

Casco Baykeeper Joe Payne received a panicked call from a member of Friends of Casco Bay who lived on a cove in Falmouth. He asked Joe to discover the polluter whose actions had turned his scenic inlet bright green. When Joe walked out onto the flat to investigate, his boots sank four inches into green slime. He observed that the member had recently installed a culvert under the driveway that channelled rainwater runoff directly into the cove. He turned to his worried friend and said, “You did this.” The culvert was collecting runoff from fertilized yards in the neighborhood, stimulating a lush growth of green algae across the entire cove.

Friends of Casco Bay’s stormwater monitoring reveals that this neighborhood is not the only one over-fertilizing the Bay. We have found nitrogen and lawn care pesticides in waters around Casco Bay.

When Friends of Casco Bay tested stormwater for pesticides in a South Portland waterfront neighborhood, we found Diazinon and 2,4D, a component of weed and feed products. This prompted further testing at every coastal community around Casco Bay. We detected more pesticides flowing into the Bay in stormwater. Our findings inspired our BayScaping program, which teaches residents how to reduce their use of lawn chemicals.

Pesticides and fertilizers can harm marine life, as well as children and pets. But the good news is there are simple ways you can grow a green lawn that keeps Casco Bay blue.

BayScaping will save you time, save you money, save your lawn, and save the Bay! Join your neighbors, and learn more at casco bay.org/bayscaping.



Joe’s footprints in green slime at a cove in Falmouth

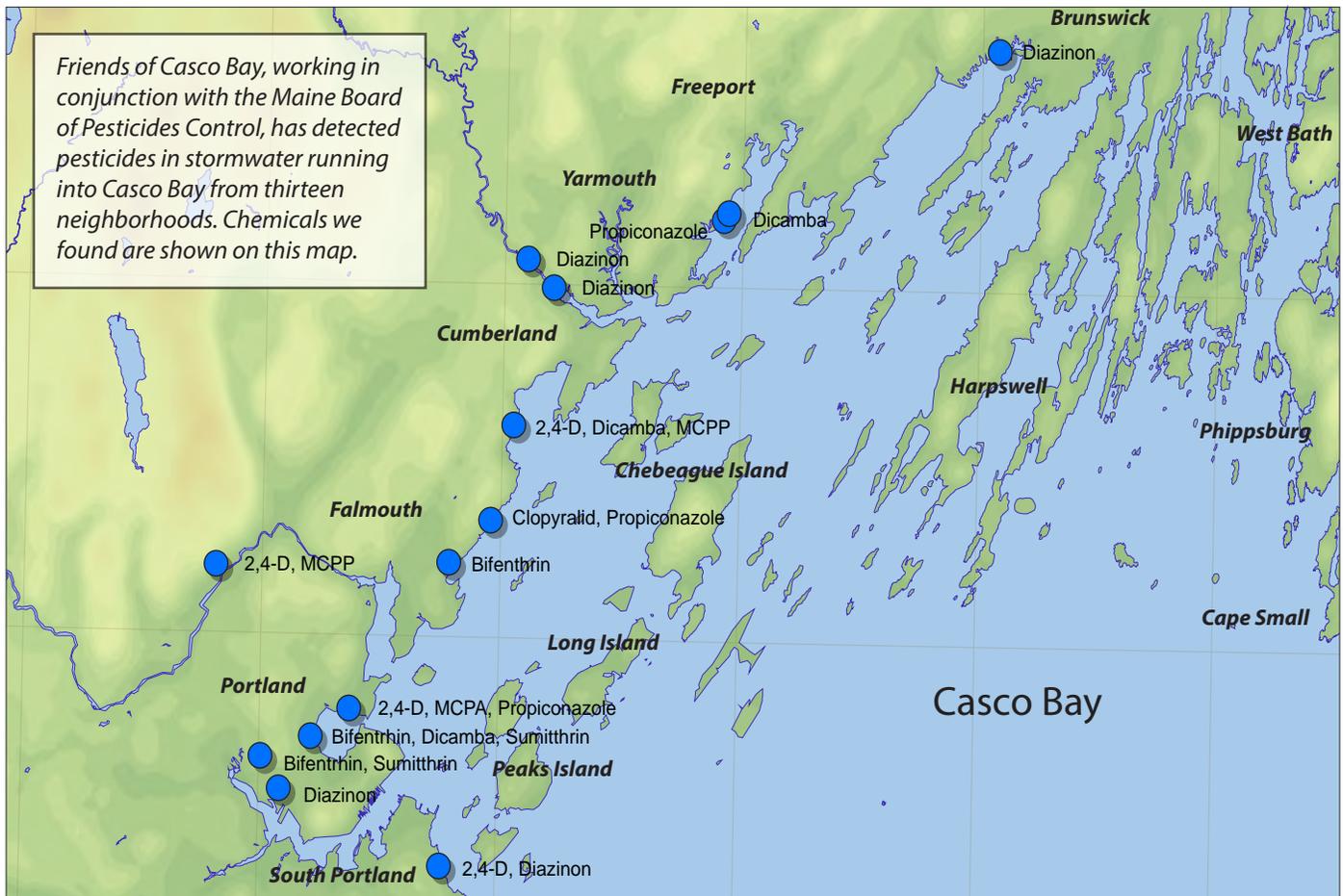




Photo by Jeff Ryan

What Is Our Coastal Future?

While Casco Bay is still a thriving ecosystem, it is changing, and more rapidly than we might expect. In some years, lobster populations appear to be moving inshore and molting earlier.

Soft-shell clams, Maine's third largest fishery (after lobsters and elvers), face an uncertain future. As both the waters and the mudflats of Maine become more acidic, our valuable marine resources find themselves in an increasingly inhospitable environment. Friends of Casco Bay has confirmed that coastal acidification is altering the very mud in which juvenile clams, mussels, and oysters are attempting to establish a foothold.

Clammers say that green crabs are overrunning our clam flats, devouring juvenile clams, and devastating many formerly productive clam flats in Casco Bay and beyond. Green crabs from Europe invaded our coastal waters in the early 1900s. Now, a species of green crab from Scandinavia is beginning to show up in Maine waters, probably well equipped to adapt to our cold winters.

In the mid-1990s, Casco Bay had approximately 8,700 acres of eelgrass beds, the largest and densest concentration of eelgrass along the entire coast of Maine. A 2013 aerial survey of Casco Bay, initiated by Casco Bay Estuary Partnership and Maine Department of Environmental Protection, found only about 3,700 acres, a nearly 60% decline in eelgrass beds since 2001, primarily in the embayments of Maquoit and Middle bays.

What does this mean for those of us who live, work, and play around the Bay? We have a lot of work to do. Fortunately, unlike some environmental problems, there are many things each of us can do to tackle threats to the health of Casco Bay.



Photos by Stephen Karpak



You Can Make a Difference in the Health of Casco Bay

Confronting the consequences of climate change and the changing chemistry of our oceans—specifically, the carbon dioxide that threatens our coastal waters—may seem daunting, but Maine has many advantages to help it meet the challenge. Mainers are known to be resolute, resourceful, and committed to community. Our residents value the environment, understanding that our future prosperity is dependent on maintaining the state's beauty and natural resources. If any place can identify and implement solutions, it is Maine.

Even if you adopt only one or two of the suggestions below, you will be helping to improve the health of Casco Bay. Acting locally, ultimately, can have a global impact.



Photo by Mark Sundermann

BayScaping promotes green yards that keep Casco Bay blue.

Think About Casco Bay as You Care for Your Lawn

Why? Nitrogen is public enemy #1. Fertilizers intended for lawns and fields can end up feeding phytoplankton instead. In addition to killing bugs, pesticides kill sea life.

- Do not use fertilizers and pesticides, which our testing has demonstrated can end up in the ocean.
- Adjust lawn mower to highest setting, preferably 3½-4 inches. This promotes vigorous root growth and healthier grass.
- Leave grass clippings as you mow. (That's right—no raking!) These natural fertilizers return about 50% of the nitrogen back to the soil, where it belongs.
- Do a soil test to determine what, if any, amendments are needed.
- Find out more at cascobay.org/bayscaping.

Responsible Boaters Are Important Stewards of the Bay

Why? Because boaters are on the water, in the water, or next to the water working on their boats, they are the first line of defense in protecting Casco Bay. Those who enjoy the Bay have a special responsibility to keep pollutants out of the water, including sewage, urine, fuel, oily bilge water, cleaning supplies, paint, and varnish.

- Use a pumpout facility for your marine toilet. (And don't pee over the side!) Find a list of pumpout stations in Casco Bay at cascobay.org/boat-pumpout-program.
- When refilling your tank, avoid spilling fuel and don't overfill.
- If you do spill fuel, don't squirt dishwashing liquid on it; sop it up with the fuel spill pads at the fuel dock.
- Reduce fuel consumption: keep the engine tuned, clean your hull, and drain the bilge and holding tanks properly before departure. Store unneeded supplies and equipment ashore.
- Recycle oil from your boat at recycling centers, often located at marinas, town transfer stations, auto parts stores, and service stations. You can also recycle your oil filters and engine batteries.



Friends of Casco Bay's pumpout service has kept nearly 150,000 gallons of raw sewage out of Casco Bay.



In over 20 years as Casco Baykeeper, everyone I've met wants to do the right thing to improve and protect Casco Bay. They just need to know what that is.

— Casco Baykeeper Joe Payne

Green up Your Ride

Why? Cars and trucks are big sources of nitrogen pollution (nitrous oxides), carbon dioxide, and other greenhouse gases.



Be kind to cyclists. They are keeping nitrogen pollution and carbon dioxide out of the Bay.

- Bike, walk, use public transportation, or carpool.
- Maintain your car so oil, antifreeze, and other toxic substances don't leak. By keeping your car tuned up, it will run cleaner, burn less fuel, and get better gas mileage.
- When you do have to drive, plan ahead to combine trips to reduce the distance you travel. For example, shop and do errands on the way home from work.
- Don't idle—get out of the car instead of using the drive-thru.
- Check tire inflation every week to increase miles-per-gallon by 3%.
- When it is time to replace your car, buy a fuel-efficient model.

Reduce the Energy You Use in Your Home

Why? By conserving energy, you will be limiting the release of greenhouse gases, lowering both your carbon and your nitrogen footprints. Burning less oil, wood, and coal to heat your home reduces the release of nitrogen, as well as your fuel bill.

- Get an energy audit.
- Adjust your thermostat by 2 degrees cooler in winter.
- Replace incandescent light bulbs with LEDs.
- Make it a habit to turn off lights when you leave a room.
- Wrap insulation around your water heater.
- Unplug “vampire” electronics and appliances when not in use, such as cell phone chargers and cable or satellite TV boxes.
- Install weather stripping and caulking around doors and windows of your home.
- Dry clothes on a clothesline. A clothes dryer accounts for 12% of home energy use.
- Wash your clothes in cold water.

Use Less Water

Why? Up to a third of our electricity is used to move, clean, and dispose of water and wastewater, so every drop saved also saves electricity and reduces power plant emissions. Sending less water to the sewage treatment plant means the facility has to process less water.

- Turn off the water while shaving, doing dishes, and brushing your teeth.
- Install water-saving faucets, toilets, and showerheads.
- Fix your toilet if it tends to run after flushing.
- Fix that dripping faucet!
- Only run your dishwasher and washing machine when they are full.



Everyone in your home can contribute to saving energy.

Calculate Your Impact

There are personal actions each of us can do so that the next generation inherits a cleaner and healthier Casco Bay. Calculate your nitrogen footprint at either of these sites:

<http://www.cbf.org/news-media/multimedia/nitrogen-calculator>

http://n-print.org/sites/n-print.org/files/footprint_java/index.html#/home

Many carbon footprint calculators also can be found online.



Pick up after your dog! Pet waste is a significant source of nitrogen pollution.

Manage Your Waste

Why? We're talking about sewage here. Sewage, including urine, is loaded with nitrogen, which can be flushed into coastal waters, leading to algae blooms.

- Pick up pet poop. Carry a “pooper scooper” or plastic bag whenever you take your dog out for a stroll.
- Have your septic system inspected yearly and pumped every 2-3 years to remove sludge.
- Don't dump anything down a storm drain, as polluted rainwater, along with anything else that goes down the street drain, can end up in Casco Bay, usually without first being treated at the sewage treatment plant.

Keep Water From Running off Your Property

Why? Prevent pollutants, such as nitrogen and other chemicals, from being washed into the Bay. Plantings act as sponges, giving rainwater time to soak into the ground.

- Redirect your downspouts from hard surfaces to your lawn or garden.
- Position rain barrels to catch water that runs off roofs and sheds. Use it to water the yard and garden.
- Plant a buffer strip of bushes and trees between lawn and water's edge.
- Cover bare soil with grass seed and compost to keep it from washing away—and to keep down weeds.
- Replace asphalt or concrete on driveways, sidewalks, patios, and pool decks with gravel or pervious pavers interspersed with gravel or grass.
- Create a rain garden of water-loving plants or a grassy swale to hold rainwater runoff.
- Wash your car on a grass or gravel surface instead of the street or your driveway. This will allow soapy, dirty wash water to soak into the ground rather than running down storm drains.



Water your garden with the rainwater your rain barrel collects.

Buy and Eat Local

Why? An average plate of food travels over 1,300 miles, consuming large amounts of energy to transport it. Frozen and processed foods, especially, require a lot of energy to produce and transport.

- Grow your own vegetables and buy fresh food from local farmers.
- Buy only what you'll eat.
- Opt for meatless Mondays—or more. Eating meat generates 2½ times more greenhouse gases than eating vegan, but any reduction lowers greenhouse emissions.
- Compost food wastes.
- Bring reusable shopping bags. US consumers use 100 billion plastic bags a year.
- Make kitchen cleanup green, too. Clean counters and fridge with baking soda or a spray bottle of vinegar and water.



Maine is well known for delicious local food.





Casco Bay belongs to all of us! With this privilege comes great responsibility.

— Casco Baykeeper Joe Payne

Get Involved—What You Can Get Others to Do

Why? Volunteers and voters are vital in catalyzing changes in communities, businesses, and governments. Friends of Casco Bay, and other nonprofits, could not accomplish our work (often, activities that government can't or won't do) without the help of citizen scientists and community activists.



You can join fellow community members and become a champion for Casco Bay!

- If legislation is introduced to limit the application of pesticides and fertilizers on a state level, please support it.
- Support municipal actions and fees to reduce sewage pollution.
- Ask businesses about their energy and conservation policies.
- Encourage “green development.” Attend town hall presentations by developers and planners, to encourage projects that incorporate vegetated median strips, parking lots with permeable pavement, more green space, and green roofs.
- Join a town committee, such as the conservation commission or planning board, to help create a vision for the future.

Help Us Help the Bay!

Why? Friends of Casco Bay started as a grassroots community organization 25 years ago. Our success today continues because of the commitment of our volunteers and members! Find out more at cascobay.org.

- Become a member and donor of Friends of Casco Bay. Go to donate.cascobay.org.
- Become a Champion for the health of Casco Bay. Learn more about issues that pose a threat to the Bay and use our Bay Papers to educate friends and family. www.cascobay.org/bay-papers
- Invite a dynamic speaker from Friends of Casco Bay to talk about issues impacting Casco Bay. www.cascobay.org/hostaspeaker
- Volunteer with us to pick up trash from beaches and marshes, test water quality, and lobby your legislators. www.cascobay.org/volunteer
- Borrow Friends of Casco Bay's storm drain stenciling kits to spray paint reminders to others: *Do not dump. Drains to Casco Bay.* www.cascobay.org/storm-drain-stenciling
- Host a neighborhood BayScaping social on ecological lawn care practices that will save you time, save you money, save your lawn, and save Casco Bay. www.cascobay.org/bayscaping

- Limits on nitrogen discharges are needed. In 2007, Friends of Casco Bay helped persuade the Maine Legislature to pass a law requiring the Maine Department of Environmental Protection (DEP) to establish a limit on how much nitrogen sewage treatment plants and other facilities may discharge into coastal waters. The DEP has yet to fulfill that directive. Tell your state legislator to make the DEP take action.
- Encourage your community to adopt ordinances to ban pesticides, at least in parks, school yards, and playing fields, where children and pets can come in direct contact with toxic chemicals. When Friends of Casco Bay tested rainwater running into Casco Bay, we found pesticides at 13 coastal neighborhoods, some in amounts the Environmental Protection Agency has determined can harm fish and other sea life.



Photo from Friends School of Portland

Stenciling storm drains is a great community service project.

Thank You to Our Volunteer Citizen Scientists

Over the past 23 years, Friends of Casco Bay's volunteer citizen scientists have monitored the health of our waters, collecting data on water quality around Casco Bay. This data on the Bay's health informs our advocacy decisions, enables researchers to recognize changes in our waters, and allows us to track water quality trends over time. Today, this award-winning program is one of the longest-running volunteer monitoring efforts in the country and is a solid beginning of a long term data set. Our data collection methods are certified by the Environmental Protection Agency, making the data scientifically usable and credible. Many researchers, municipalities, and government agencies use our data, including the National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service, Portland Water District, Maine Department of Environmental Protection, Maine Department of Marine Resources, Wells National Estuarine Research Reserve, and others. The data we collect is even sent to Congress every two years when the State of Maine submits its required Clean Water Act reports. All of this would be impossible without our dedicated volunteer citizen scientists.

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Casco Bay Estuary Partnership	Lee & Lulu Grodzins	Eileen Monahan & Penny Pollard	Jan & Steve Specker	Meg & Tom Wolff
Central Maine Power	H M Payson & Co	Charles G. Moore III	The Seth Sprague Educational &	Anne & Robert Wood
Chad Little Outdoor Power Equipment	Thomas Haas	Daniel Morgenstern &	Charitable Foundation	Judith & Douglas Woodbury
Elisabeth & Clint Chase	Nate & Tobin Hagelin	Moriah Moser	Martha & Mitchell Stein	Amy Woodhouse & Tobey Scott
Drs. Barbara Chilmonczyk &	Fred & Mary Eileen Haley	Megan Mousse	Steven Leuthold Family Foundation	Edward Woodin
Richard Engel	Meredith & Myron Hamer	Mary & Randall R. Mraz	Richard & Kathleen Stevens	Carol DeTine & Roger Woodman Jr
Clark Charitable Trust	Lin Peyton & Morris Hancock	Mary & Kenneth Nelson		Bill & Patty Zimmerman
Marie Harris Clarke	Montagu & Marcia Hankin	Mary & Randy Nichols		
Nancy Heselton & Jeffrey	Margie & Turner Hansel	Anne & Ben Niles		
Clements	Charles Harriman	The Nine Wicket Foundation		
Judith & Andrew Coburn	Sally Heald	Mr. P. Andrews Nixon		
Sarah Coburn & Brendan O'Neil	Robert & Marge Healing	Walter & Helen Norton		
Bill & Martha Cooper	Cheryl & George Higgins III	Deirdre O'Brien		
Madeleine Corson	Daniel Hildreth	Mr. & Mrs. Joseph Oldfield		
Aileen Crawford	Hope Hilton & Terry Flanagan	James & Amy Nolan Osborn		
Peter Culley	Al & Dawn Hoffman	The Overlook Fund of the		
AJ Curran	Seth Holbrook	Maine Community Foundation		
Eliot & Melanie Cutler	Horizon Foundation	Stephanie Paine & John Pier		
Davis Conservation Foundation	William & Julie Howison	Patagonia Outlet		
Joan Dayton	Al & Lois Howlett	Joe & Kim Payne		
Drs. Charles de Sieyes &	Nate Huber	Michael Perry & Chris Wolfe		
Carol Ward	Sherry Huber	Perry/Wood Family Trust		
Deering Fund of the Maine	Albert & Marcia Hunker	Winslow Pillsbury		
Community Foundation	Chris & Betsy Hunt	Kirk & Nancy Pond		
Lynda DeHaan	Roy A. Hunt Foundation	Malcolm Poole		
DeLorme	Patricia Ianni & Mark	Mrs. Victoria Poole		
Jesse Deupree	Sundermann	Denley Poor-Reynolds & Matt		
DiMillo's On the Water	Alice Wheatland Ingraham	Reynolds		



Friends of Casco Bay
Casco BAYKEEPER

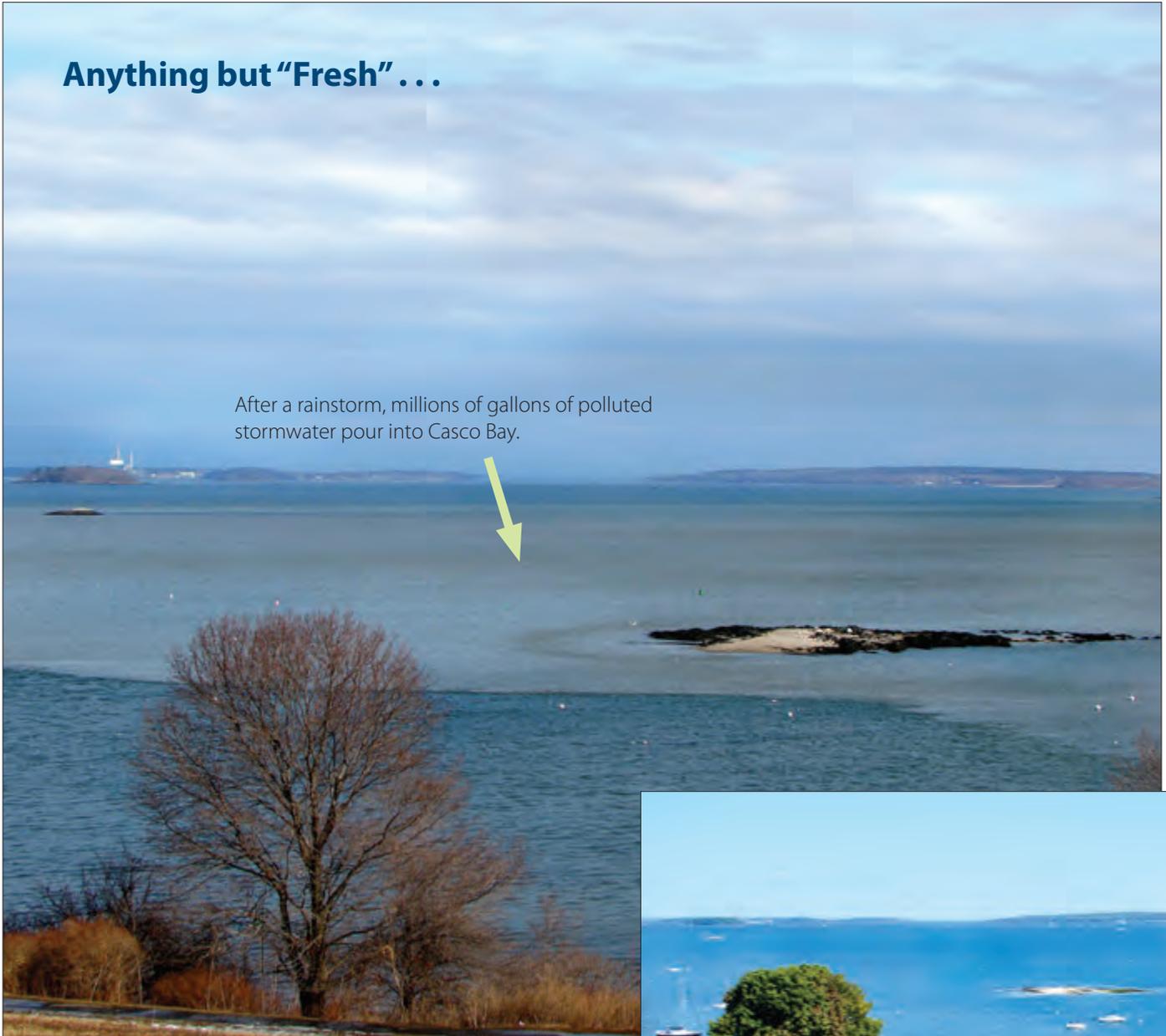
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Friends of Casco Bay's mission is to improve and protect the environmental health of Casco Bay. Founded in 1989, we are celebrating our 25th anniversary of protecting the waters we all love. Home to the Casco BAYKEEPER®, we are a founding member of the international WATERKEEPER® ALLIANCE.

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Anything but “Fresh” . . .

After a rainstorm, millions of gallons of polluted stormwater pour into Casco Bay.



Stormwater Is Anything but Fresh . . .

In recent years, long dry periods have been followed by heavy rains that dump inches of water in a few hours or days, sending plumes of polluted stormwater into Casco Bay. Millions of gallons of raw sewage, industrial wastes, fertilizers and pet wastes from yards, oil slicks from city streets, and toxins from tailpipes and smokestacks are flushed into Casco Bay.

As he gazes out over a brown bay after yet another torrential rain, Casco Baykeeper Joe Payne knows the coffee-colored stain spreading across the water’s surface is anything **but** fresh water. “This toxic soup can sicken swimmers, make seafood unsafe to eat, and harm marine life,” Joe says. Rainstorms in and of themselves are not bad, but the polluted runoff they flush into Casco Bay reminds us that we all need to do more to protect the waters that define our community. It takes a community to address the problems and ensure a cleaner, healthier Casco Bay for future generations.

You can help. Support Friends of Casco Bay. To donate or volunteer, go to www.cascobay.org.



The same scene from the Eastern Prom on a dry, sunny day paints a healthier picture.

