STATE OF THE DELAWARE INLAND BAYS 2021

Presented by the Delaware Center for the Inland Bays

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INLAND BAYS
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Delaware Inland Bays Watershed
Lewes
Cape Henlopen State Park
Rehoboth Beach
Dewey Beach
Rehoboth Bay Watershed
Georgetown
Rehoboth Bay
Delaware Seashore State Park
ATLANTIC OCEAN
Indian River Bay Watershed
Long Neck
Indian River Bay
Millsboro
Assawoman Wildlife Area
Holts Landing State Park
Midlands Wildlife Area
Dagsboro
Bethany Beach
Frankford
Little Assawoman Bay Watershed
Assawoman Wildlife Area
South Bethany
Little Assawoman Bay
Fenwick Island
Selbyville
Delaware
Maryland
New Jersey
Delaware Bay
DELAWARE CENTER FOR THE INLAND BAYS
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Miles
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EXECUTIVE SUMMARY

The Delaware Inland Bays provide a myriad of environmental, economic, and human health benefits. Bay ecosystems support abundant fish and wildlife, filter pollutants, and protect upland areas from storm damage. Overall, the Inland Bays contribute $4.5 billion in economic activity every year. Healthy Bay habitats and clean water are critical to ensure the long-term vitality of these shared resources and our overall quality of life.

Overall, the waters of the Inland Bays currently receive a "Poor" or "D" rating, exactly the same as five years ago.

D

Since the release of the 2016 State of the Delaware Inland Bays report, progress has been achieved in some areas. The conversion of discharge from the City of Rehoboth Beach's wastewater treatment system to an ocean outfall in 2018 means that all major point sources of nutrient pollution—that is nitrogen and phosphorus—have now been removed from the Inland Bays. Additionally, Sussex County facilitated the conversion of an estimated 52,884 septic systems to central sewer, far surpassing the 45,000 goal set in the Pollution Control Strategy.

Water quality in Little Assawoman Bay has continued to show modest improvements. Scattered beds of widgeon grass have been observed in the Bay, likely due to lower nutrient concentrations and clearer water there.

The first leases for shellfish aquaculture were issued in December 2017. While the COVID-19 pandemic led to some setbacks, ten growers harvested and sold over 400,000 oysters in 2021 alone. A growing shellfish farming industry is a win for both water quality and the local economy.

However, despite decades of work to improve the health of the Bays, the estuary continues to face serious challenges.

Overall, the waters of the Inland Bays currently receive a "Poor" or "D" rating, exactly the same as five years ago.

Inputs of nitrogen from nonpoint sources continue to far exceed healthy limits in all three Bays, with no improving trend. While well-flushed, open areas of the Bays have relatively good water quality, the water quality in most tributaries and canal systems remains poor. These areas consistently have unhealthy amounts of nutrient pollution and frequent summer algal blooms that deplete the water of oxygen. Nitrogen concentrations in the Indian River and Guinea Creek are particularly high. Baygrasses are extremely rare in the Bays—eelgrass is altogether nonexistent.

Land use in the watershed is changing in response to rapid population growth. Residential and commercial development has replaced large areas of forest and agricultural land. This development brings with it more roadways and other impervious surfaces, as well as increased demands on wastewater treatment systems. Conservation and restoration of natural habitats and shorelines has not kept pace with these changes.

While many areas of the Bays are generally safe for recreational water activities such as boating or wading, fecal bacteria levels in upper tributaries and canals may pose a risk for swimming. Moreover, slightly fewer monitoring stations met the swimming standard during the past five-year period than in 2016.

Climate change poses an existential threat to the Inland Bays and their surrounding communities—and its impacts already are apparent. Increasing concentrations of greenhouse gasses in the atmosphere are causing big changes to the local weather and climate. The past decade was the hottest on record in southern Delaware, and heavy rainfall associated with severe storms is becoming more frequent. Sea levels are rising at an accelerated rate. Flooding is more frequent, and higher waters are degrading the health of salt marshes. The Inland Bays are changing in direct response to a changing climate and so too will the habitats, wildlife, and communities that depend on this delicate system.

The health of the Bays, their living resources, and people are inextricably linked. The Center and its partners are committed to working together to clean Bay waters and preserve and restore natural habitats across the watershed.

Proactive planning and new environmental policies that implement the Inland Bays Comprehensive Conservation and Management Plan are key. A recent Sussex County ordinance intended to better protect wetlands and waterways by enhancing buffers was a step in the right direction. However, stronger protections are needed. At a pivotal moment for the Bays' health, the Center and its partners also are engaged in actions to mitigate and adapt to the impacts of a warming climate and rising seas on the Inland Bays and their watershed.

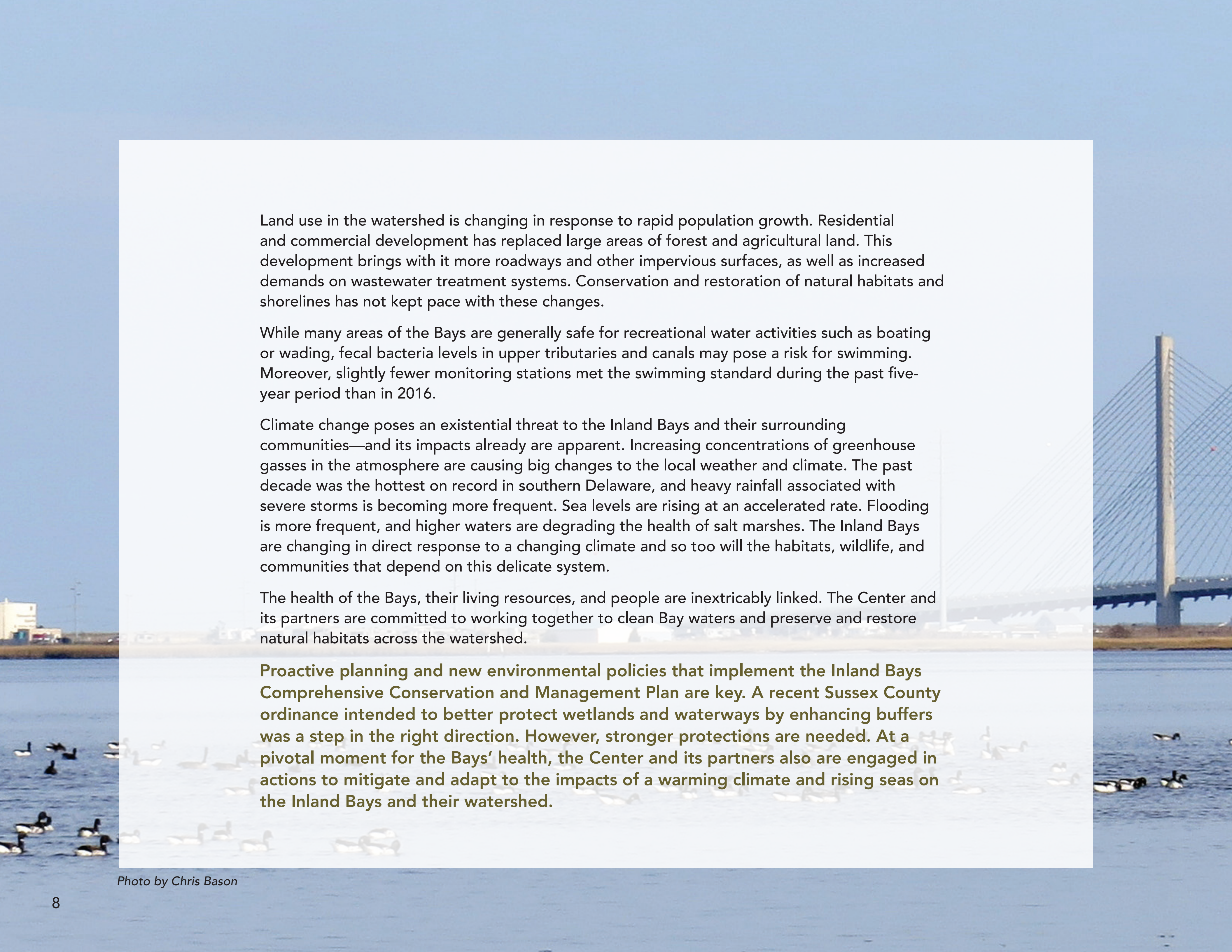


Photo by Chris Bason

BAY HEALTH AT A GLANCE

CHAPTER	STATUS & TREND	OVERVIEW
WATERSHED CONDITION	Fair; Degrading	Rapid population growth is driving many changes, including significant habitat loss. Conversion of farms and forest to development adds to urban pollution sources and stresses natural habitats. Sea-level rise and shoreline erosion threaten tidal wetlands.
MANAGING NUTRIENT POLLUTION	Fair; No Trend	All major point sources of nutrient pollution have been removed from the Inland Bays. However, nonpoint source inputs of nitrogen pollution remain far above healthy limits in all Bays. Conversion of septic systems to central sewer has surpassed previously set goals, while much work remains to reach goals for agricultural nutrient management practices and stormwater retrofits.
WATER QUALITY	Fair to Poor; No Trend	Nitrogen concentrations in most tributaries are extremely high. Water quality in Little Assawoman Bay continues to improve; however, conditions in the Indian River are degrading. Large summer algal blooms, driven by nutrient pollution, often lead to extended periods of very low dissolved oxygen in bay tributaries and canals.
LIVING RESOURCES	Fair; No Trend	Nesting activity of bald eagles and osprey is increasing, and the overall abundance of blue crabs has been relatively high in recent years. The number of horseshoe crabs spawning in the Bays is stable but far below historic levels. Baygrasses remain extremely rare. Poor water quality resulted in a record number of fish kills reported in 2021.
HUMAN HEALTH RISKS	Fair; No Trend	Pollution from fecal bacteria in upper tributaries and poorly flushed canals poses a risk for swimming. Shellfish harvest is prohibited in 32% of the Bays. Consumption of bluefish and striped bass caught in the Inland Bays remains under advisory.
CLIMATE	Poor; Degrading	Increasing concentrations of carbon dioxide in the atmosphere are bringing higher annual temperatures and more precipitation in southern Delaware. The frequency of intense coastal storms is also increasing, along with an accelerated rate of sea-level rise.

DELAWARE'S INLAND BAYS

The Delaware Inland Bays are three shallow, interconnected coastal lagoons, separated from the Atlantic Ocean by a narrow barrier island. They are unique places where freshwater flowing from the land, groundwater, and tributaries mixes with saltwater from the ocean. The Bays are dynamic, continually changing in response to human activities and the climate.

Located within Sussex County, Delaware, the watershed of the Inland Bays comprises 292 square miles of land that drains to 35 square miles of Bays and tidal tributaries. Rehoboth Bay and Indian River Bay are tidally connected to the Atlantic Ocean by the Indian River Inlet. Little Assawoman Bay is connected by the Ocean City Inlet ten miles to the south in Maryland. The Bays are shallow, generally less than seven feet, and have an average tidal range of three feet.

The Bays and their watershed contain a diversity of natural habitats, including salt marshes, tidal flats, freshwater wetlands, shellfish reefs, maritime forests, and winding creeks. These support an abundance of aquatic and terrestrial life, as well as a thriving human culture and economy.

Decades ago, the Bays were thought to be generally healthy–clear waters with plentiful baygrass meadows, productive oyster reefs, and oxygen levels that supported diverse and plentiful fish populations. But years of accumulated nutrient pollution and habitat loss have changed the Bays to generally murky waters that are dominated by algae, have very few baygrasses or oysters, and do not support healthy oxygen levels in many areas.

The services provided by the Bays are dependent upon good water quality and a healthy coastal ecosystem. Wise resource management decisions, habitat restoration, and major pollution reductions are needed to achieve a healthy estuary once again.

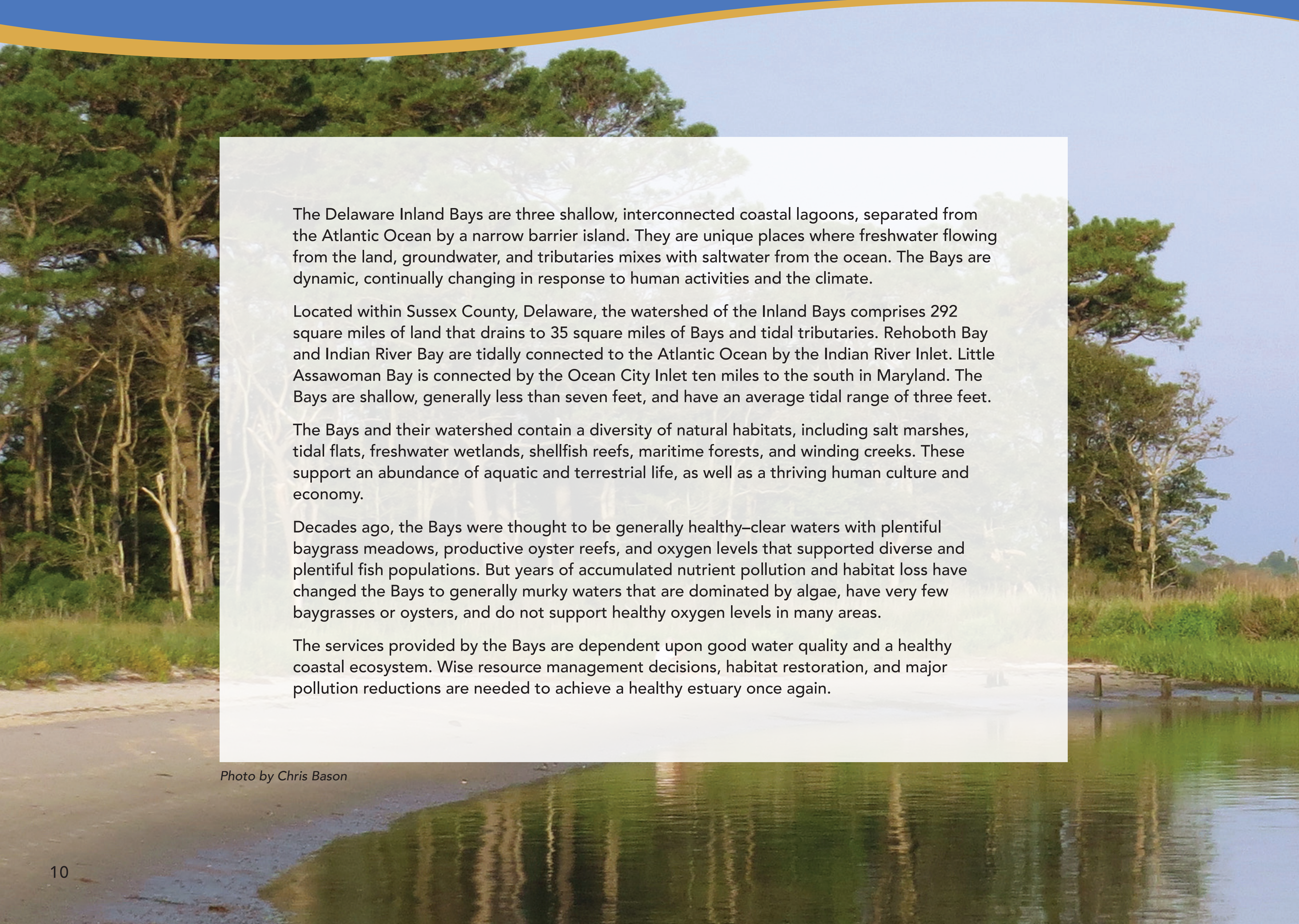


Photo by Chris Bason

The 2021 State of the Delaware Inland Bays report is a compilation of environmental data about the Bays and their watershed. It provides communities, decision makers, and concerned citizens with robust scientific information that they can use to help restore and protect the Bays and their resources. The report is updated and published every five years.

To assess the health of the Inland Bays, a suite of environmental indicators was selected. These are specific species and conditions that are measured over time to determine how the Bays are changing and how much progress has been made toward restoration goals.

A total of 39 individual indicators are grouped by subject matter and presented as the six chapters of this report. Each indicator is assigned a status and trend, assigned using best professional judgment and reviewed by scientists knowledgeable in these areas. Each chapter also is given an overall status and trend by assessing its indicators together.

Long-term trends are discussed, as well as short-term changes that have occurred since the previous State of the Delaware Inland Bays report was published in 2016.

HOW WE ASSESS THE HEALTH OF THE BAYS

FAIR

DEGRADING

INDICATOR: Icon

STATUS: Very good, good, fair, poor, or very poor

TREND: Improving, degrading, or no trend

The Peninsula community overlooking Indian River Bay in Millsboro. Photo by Driscoll Drones

WATERSHED CONDITION

FAIR | DEGRADING

Rapid growth in both permanent and seasonal population is driving many changes across the Inland Bays watershed. Watershed population has grown even faster than projected in 2016, and a new housing boom began in 2020. How the land is managed to accommodate this growth directly impacts water quality in the Inland Bays and the state of both natural and human habitats.

Farms and forests continue to be replaced by residential and commercial development—which has increased by nearly four square miles since the last report. Much of this development is occurring near waterways where the potential impact on the Bays is greatest. More people building and moving near the Bays also creates more pressure on wastewater systems, roadways, and other infrastructure. In addition, many more people are using the Bays themselves for fishing, boating, and other recreational activities.

Since the Indian River Inlet was stabilized in the late 1930s, the inlet has deepened over time due to scour, resulting in greater volumes of water moving in and out of the Bays with the tides. This increased flushing action has likely contributed to observed improvements in water quality in open Bay waters. However, many of the estuary's tidal wetlands are drowning. While the trend in tidal volume appears to have stabilized with construction of the new inlet bridge, sea-level rise will continue to impact the Bays and threaten wetlands.

In light of degrading trends in watershed condition, the Center and its partners are prioritizing conservation and restoration efforts, such as open space protections and the preservation or enhancement of forested buffers, wetlands, and natural shorelines along waterways. These natural habitats also help mitigate the increased risk of flooding on developed lands due to climate change. The Center's updated Comprehensive Conservation and Management Plan, released in 2021, outlines plans and strategies needed moving forward. Dedicated funding and incentives for wetlands protections and the conservation and enhancement of forested buffers are needed if these negative trends are to be slowed or reversed.

FAIR DEGRADING

HUMAN POPULATION GROWTH

Rapid population growth is changing our watershed in many ways. Growth in both residents and visitors brings more development, traffic, wastewater, and needs for recreation. This means more pressure on natural resources and increased potential for pollution. Population growth drives changes in many other indicators included in this report.

The 2020 census revealed that 237,378 year-round residents live in Sussex County, with 100,696 (or 42.4%) residing in the Inland Bays watershed. The highest population densities are found close to coastal waterways. In summer, the watershed's population more than doubles with visitors and tourists, putting even more pressure on infrastructure and natural resources.

Protecting and restoring the Inland Bays, their tributaries, and the surrounding landscape largely depends on how we plan for population growth and its impacts.

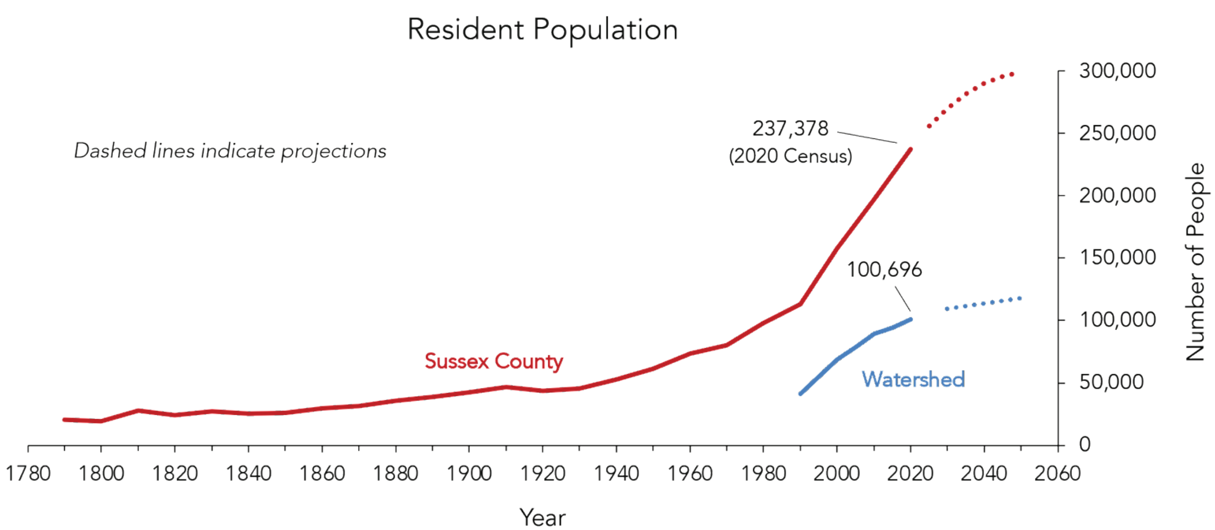
LONG-TERM TREND

Prior to 1970, population growth in Sussex County was gradual and most of the land surrounding the Bays was used for farming. Beach communities were mostly seasonal. Growth began to accelerate rapidly in the 1990s.

The county population more than doubled (210% growth) between 1990 and 2020. The number of residents in the Inland Bays watershed grew nearly 250% during that same time period.

CHANGE SINCE PREVIOUS REPORT

Since 2010, there has been a 13% increase in full-time residents, which is higher than projected five years ago.



Boaters gather at a sandbar in Rehoboth Bay. Photo by Driscoll Drones

LAND USE CHANGE

FAIR DEGRADING

How land is used directly affects water quality in the Bays. Different land uses deliver different types and amounts of pollutants to waterways. On average, agricultural lands contribute the highest amount of nutrient pollution per acre due to unintentional loss of fertilizers to ground and surface waters. Densely developed areas without adequate stormwater management can contribute four times as much nitrogen pollution to the Bays as a forest of the same size. Land use changes also impact the amount and quality of natural habitat in the watershed.

In 2017, the most recent year for which land use information is available, agriculture remained the largest land use in the watershed (29%), followed by developed/developing lands (22.3%), wetlands (19.5%), and forested lands (13.9%).

However, with a growing population, agricultural and forested lands are rapidly being replaced by development.

LONG-TERM TREND

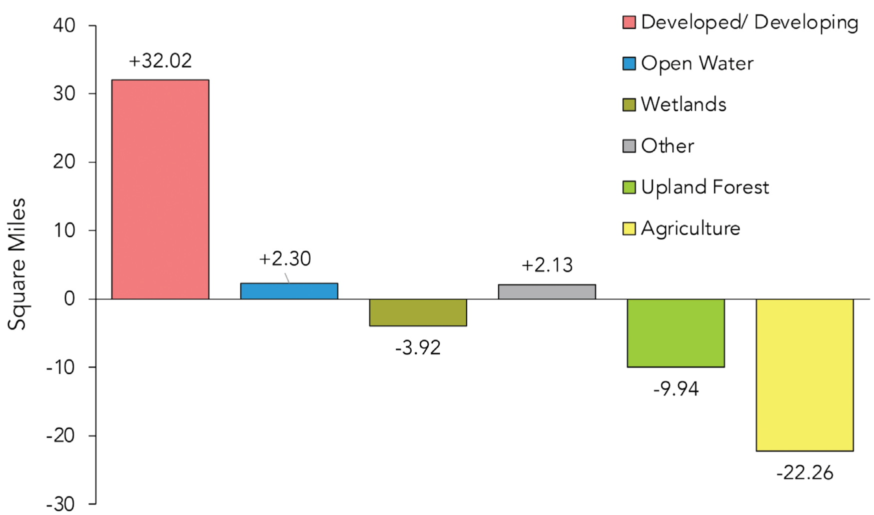
From 1992 to 2017, 18% of the watershed's forests and 19% of its farmlands were lost. In that same 25-year period, development increased by 32 square miles, or 78%.

CHANGE SINCE PREVIOUS REPORT

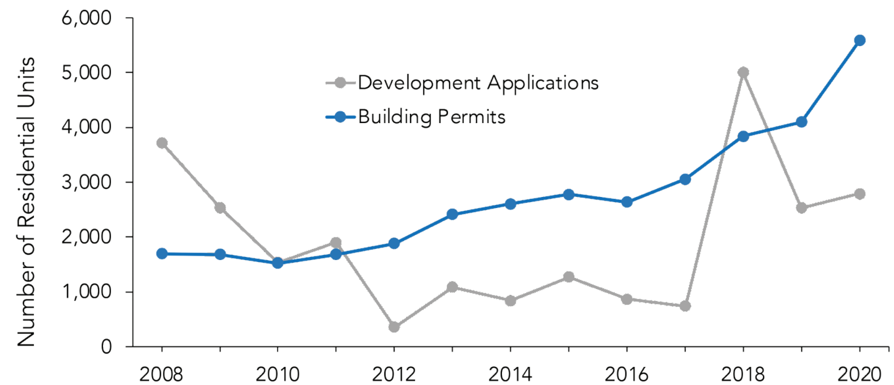
Between 2012 and 2017, agricultural and forested lands decreased by 4.0 square miles and 1.8 square miles, respectively, and developed lands increased by 3.8 square miles.

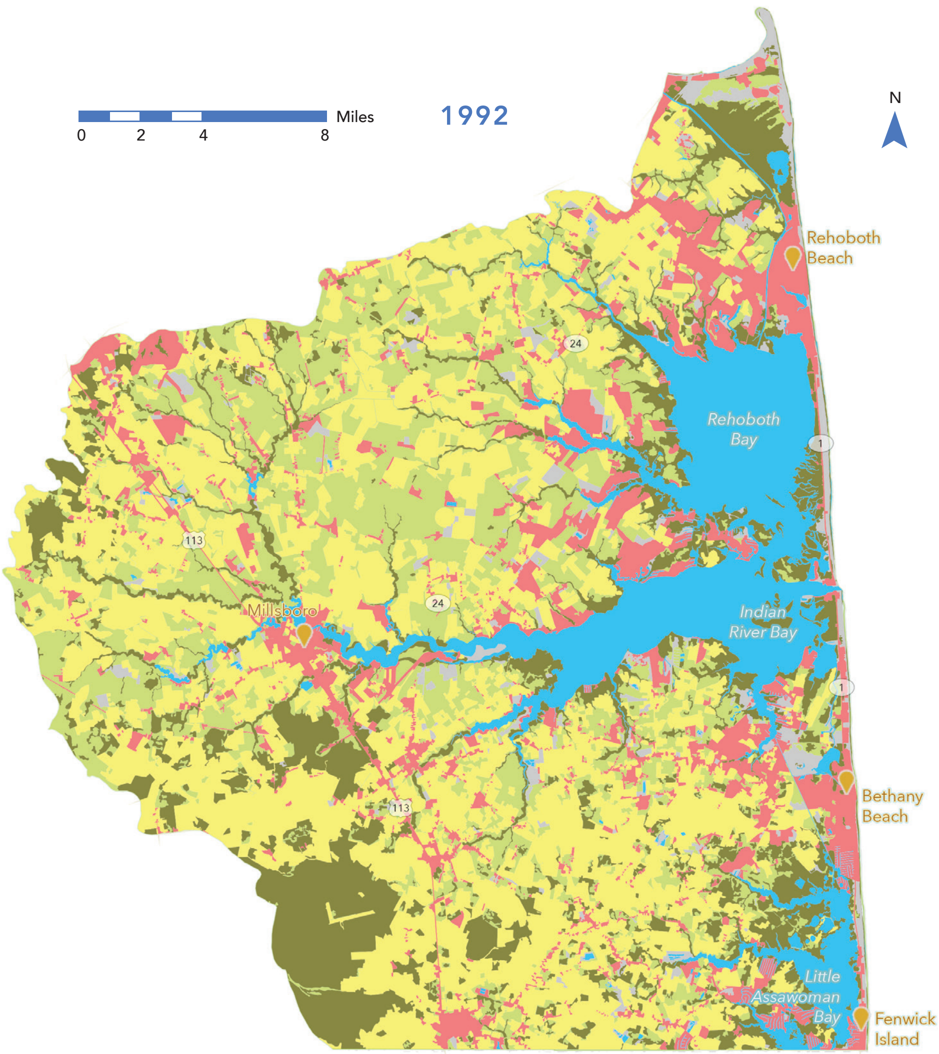
Extensive development continues near the Bays. Development applications in Sussex County declined after the 2008-2011 recession but began increasing significantly in 2017. A development boom occurred statewide in 2020, with the most residential building permits on record over the past 13 years.

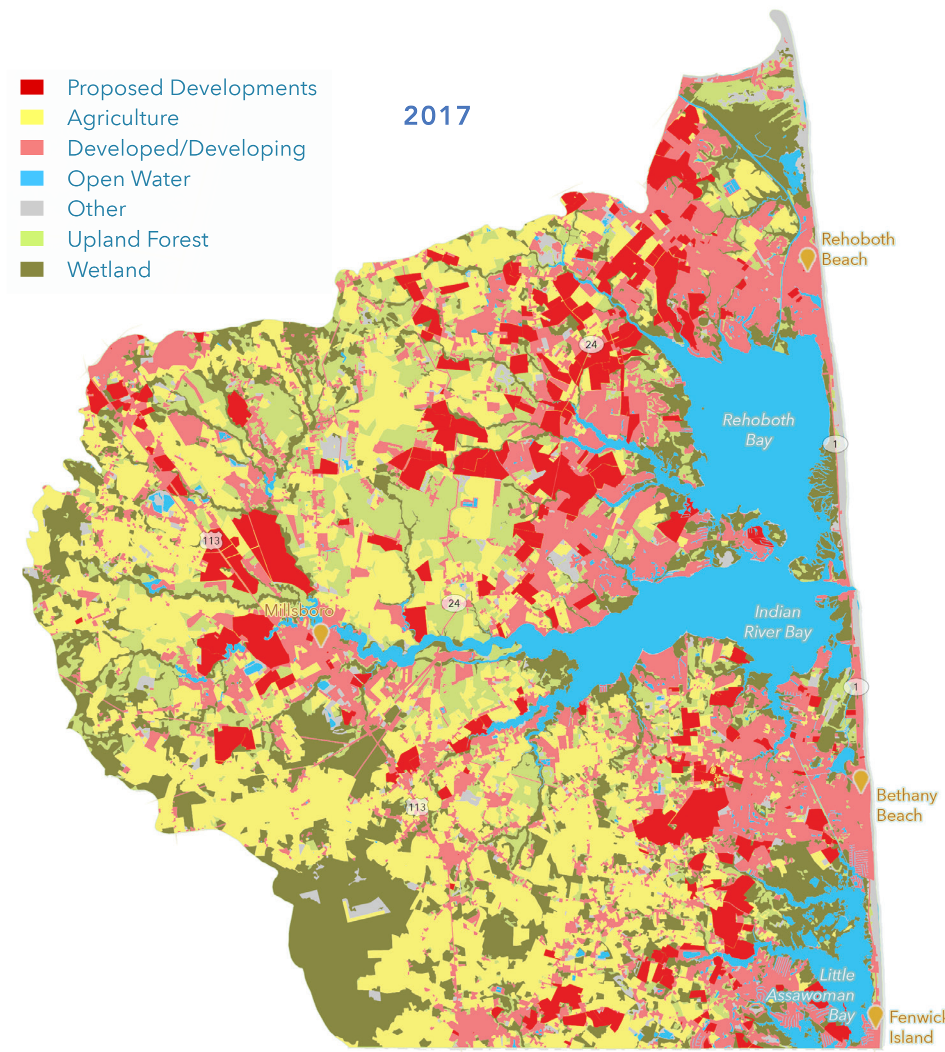
Changes in Land Use from 1992 to 2017



Sussex County Development Applications and Building Permits, by Year







Tree removal for development near Love Creek.

Changing land use on Camp Arrowhead Road. Photos by Driscoll Drones

FAIR DEGRADING

IMPERVIOUS SURFACE COVERAGE

Development brings more roads, parking lots, driveways, and rooftops to the watershed, increasing the amount of polluted runoff that enters the Bays and their tributaries. By reducing the ability of rainwater to soak into the ground, these hard, impervious surfaces also increase flooding risk. Stormwater control practices such as rain gardens, infiltration areas retention ponds, and permeable pavements can reduce these impacts of impervious surfaces.

As of 2016, the most recent year for which data are available, the Inland Bays as a whole reached 10.4% impervious cover. Some densely developed communities, however, may exceed 50% imperviousness, and impacts on water quality are high in these areas.

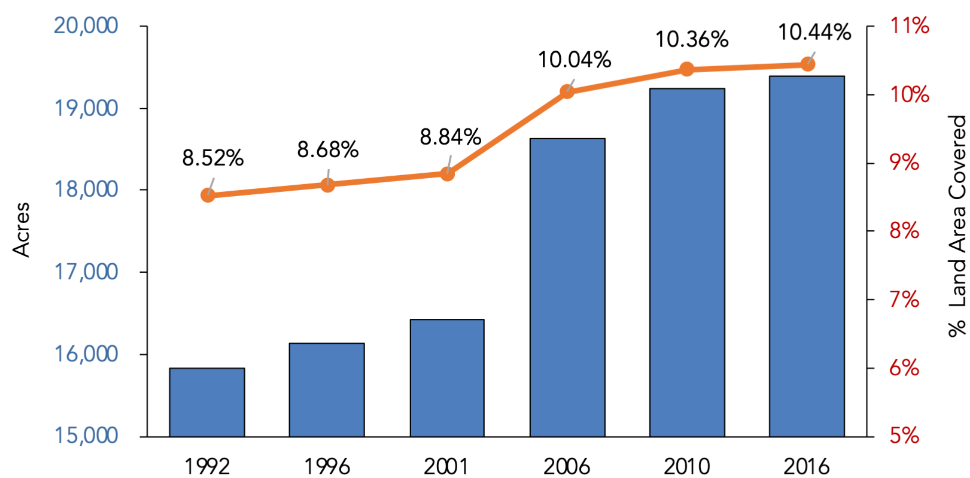
LONG-TERM TREND

Since 1992, the percentage of land in the watershed covered with impervious surfaces increased by 22.5%. The largest increase occurred between 2001 and 2006.

CHANGE SINCE PREVIOUS REPORT

There was only a slight increase in impervious surface coverage between 2010 and 2016, but a surge in residential and commercial development after 2016 is expected to drive a sharp increase that will be reflected in the next State of the Bays Report.

Land Area Covered By Impervious Surfaces



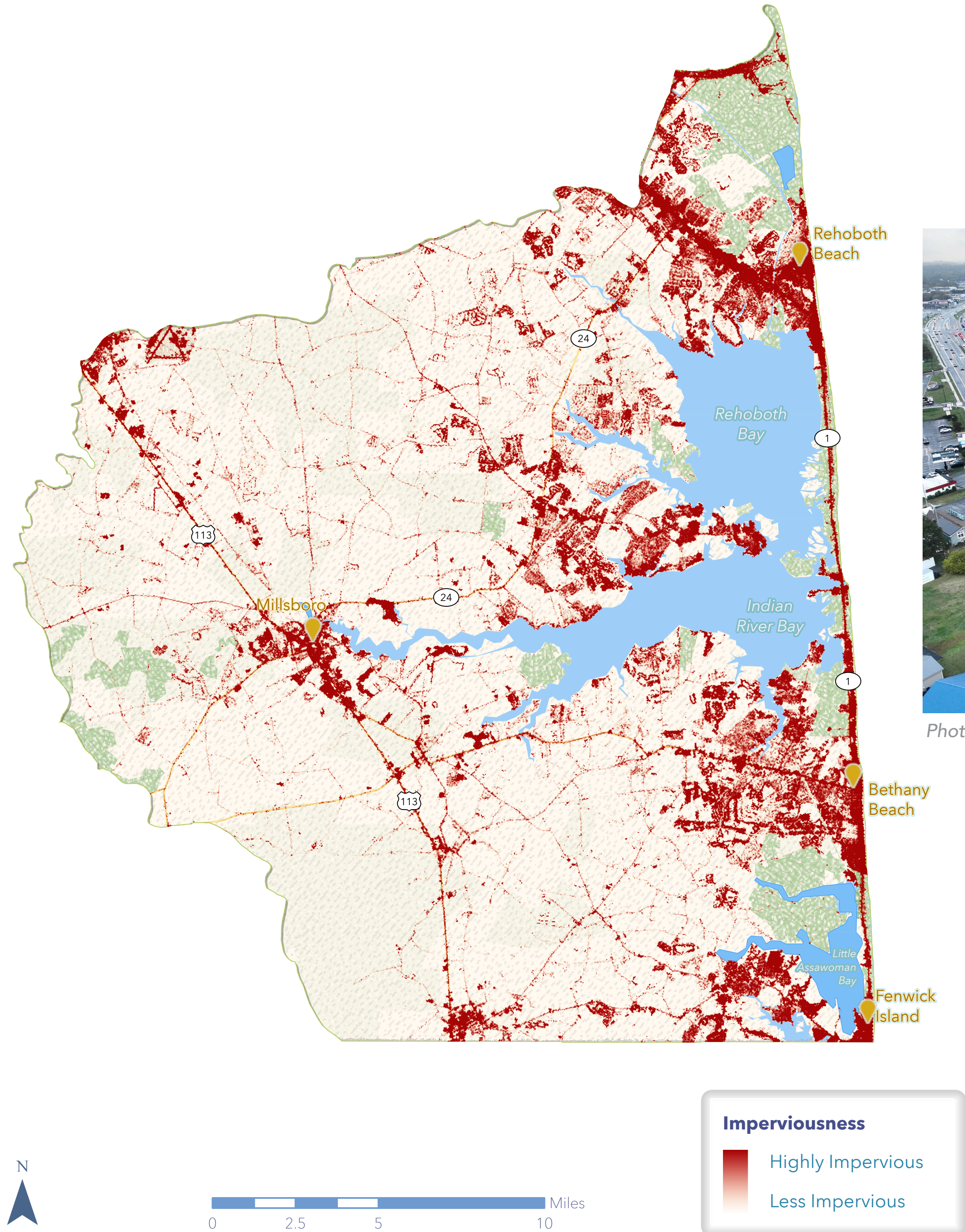


Photo by Driscoll Drones

WATER QUALITY BUFFERS

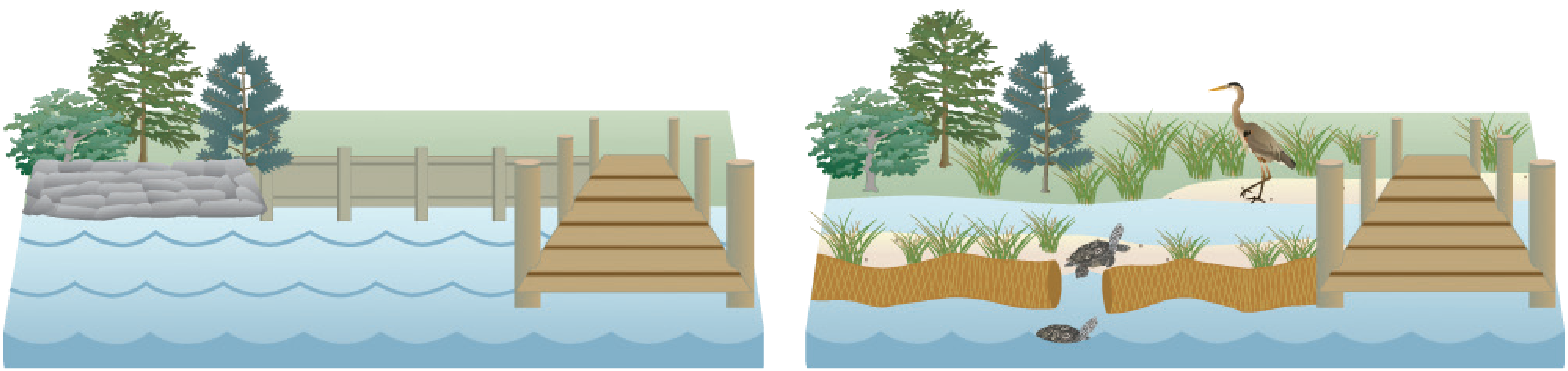
Nowhere are forests more beneficial to the health of an estuary than when they are near the water. Forested buffers between waterways and human land uses excel at pollution removal, carbon storage, and the protection of estuary habitats. Wider buffers are more effective at providing these services.

In the last report, the indicator for buffers on cropland showed a 25% reduction in buffer width from 1992 to 2012. New data were not available for this indicator, so it is not included here.

In 2022, Sussex County increased the width of buffers required between new subdivisions and wetlands and waterways. However, the new policies do not require forested buffers, which are the most protective. And the county policies continue to be the least protective among those of nearby counties and states.

In the agricultural landscape, little progress has been made on establishing buffers on croplands, with only 3% of the Inland Bays Pollution Control Strategy's goal being met.

Development trends strongly suggest continued clearing of forests and reduction in the overall width and function of forested buffers. Buffers remain an important driver of watershed condition, and a new buffer indicator will be developed for the next report.



Development often replaces natural shorelines with hard structures such as bulkheads, riprap, and rock revetments (left). Hardened shorelines, however, eliminate critical intertidal areas that provide nurseries, protection, and food for fish and other bay life. "Living shorelines" (right)—engineered designs that use natural materials such as logs, oyster shells, and wetland plants to stop erosion—are better for the environment and just as protective. Like buffers, living shorelines provide multiple benefits including shoreline stabilization, water filtration, and wildlife habitat. Illustration by Jane Hawkey, Integration and Application Network (https://ian.umces.edu/media-library/shoreline-erosion-control/)

The wide forested buffer around the community at right provides much more protection to the waterway than the narrower one on the left.

FAIR TO POOR DEGRADING

SALT MARSH ACREAGE AND CONDITION

Salt marshes provide many valuable services, including storm and flood protection, critical habitat for fish and wildlife, and water quality improvement. They also trap and store atmospheric carbon that contributes to climate change.

However, the tidal wetlands of the Inland Bays are under threat from sea-level rise and erosion, as well as from development that fails to preserve the vegetated buffers needed to provide room for marshes to migrate landward as water levels rise.

An important indicator of salt marsh health is the appearance of open water pools in the interior of the marsh. These areas are drowning, due to a combination of sea-level rise and poor drainage caused by networks of mosquito ditches dug in the 1930's. Large areas of interior pooling indicate that both the integrity of the wetlands and their ecological function are deteriorating.

The total acreage of salt marshes fringing the Inland Bays was estimated at just over 7,600 acres when last inventoried using data from 2017—a net loss of about 3,200 acres (29.4%) since 1938. In that same time, the area of open water on the interior of the marshes increased 770%, from 86 acres to 661 acres, indicating major deterioration in salt marsh health and likely future wetland losses due to drowning. These changes are particularly harmful to the water quality and living resources of the Bays.

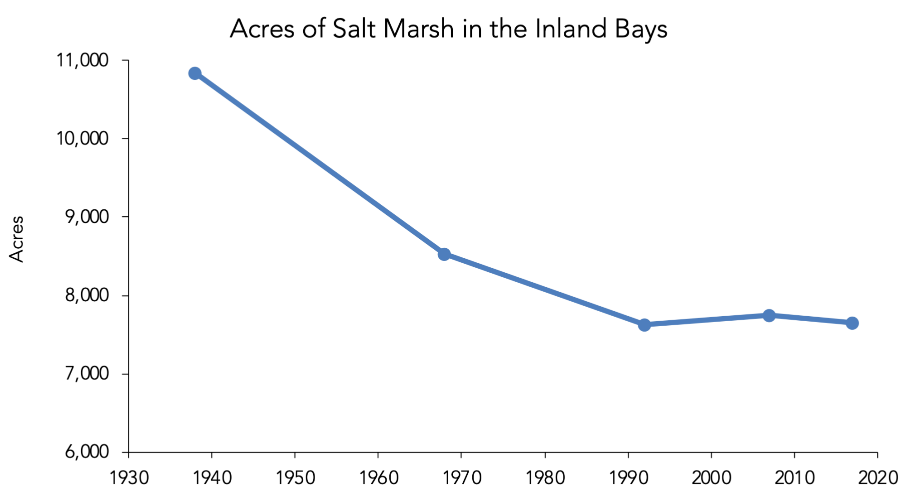
LONG-TERM TREND

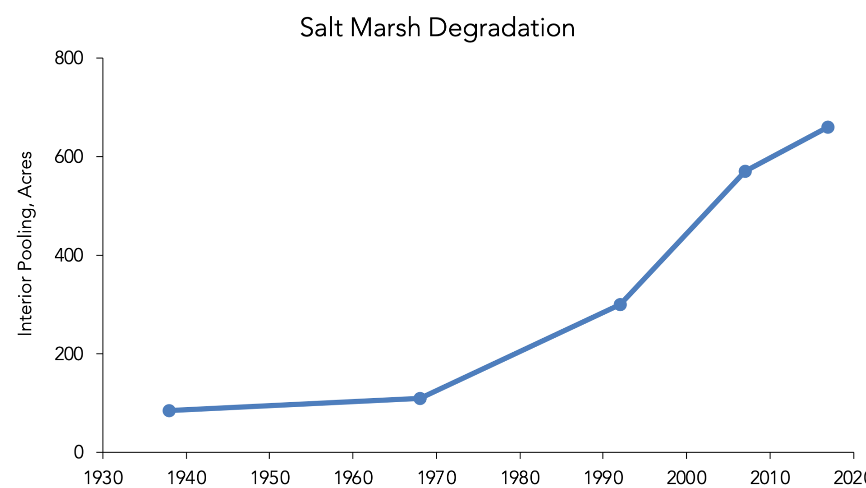
Between 1938 and 1968, 22% of the Bays' salt marshes were lost, largely to make way for development. That decline continues, but at a slower pace thanks to protections outlined by Delaware's 1973 Wetlands Act. However, salt marsh degradation has increased and accelerated since the 1970s.

Most of the wetland loss seen in the Inland Bays is no longer *directly* due to human impacts. The major cause of tidal marsh loss is erosion and the "drowning" of wetlands primarily due to land subsidence and sea-level rise.

CHANGE SINCE PREVIOUS REPORT

While the overall acreage of salt marshes has remained fairly stable, there has been a marked increase in the amount of open water in the interior of salt marshes, indicating a loss in marsh quality and function. Changes in the last decade have been most pronounced in Little Assawoman Bay and western Rehoboth Bay.

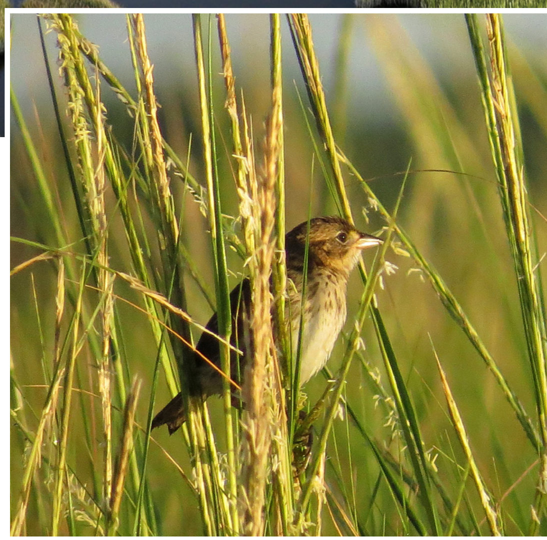




Herring Creek salt marsh, Lewes. Photo by Driscoll Drones

Did you know?

One acre of marsh can hold up to **1 MILLION GALLONS** of water during a storm event.



Seaside sparrows spend their entire lives in salt marshes. Photo by Chris Bason

Marsh periwinkles at Piney Point Tract of the Assawoman Wildlife Area.

FAIR NO TREND

NATURAL HABITAT PROTECTION AND RESTORATION

The natural habitats of the Inland Bays watershed support a wide diversity of animals and plants. The wetlands, forests, meadows, and beaches also provide beauty and recreational opportunities that are valued by both residents and visitors and drive much of the area's economic activity.

Changes in land use, however, have led to significant habitat loss. Many of the remaining natural areas have become fragmented, stressing or eliminating some sensitive species that require large tracts of wetlands or forests.

Protecting remaining high-quality natural areas and restoring degraded habitats is a priority for the Center and its conservation partners, including the Sussex Conservation Partnership and the Delaware Land Protection Coalition. Protection is accomplished through purchase of land or conservation easements that restrict development. Restoration seeks to reestablish or enhance natural ecosystems through projects such as reforestation, living shorelines, shellfish reefs, wetland creation, and control of invasive species.

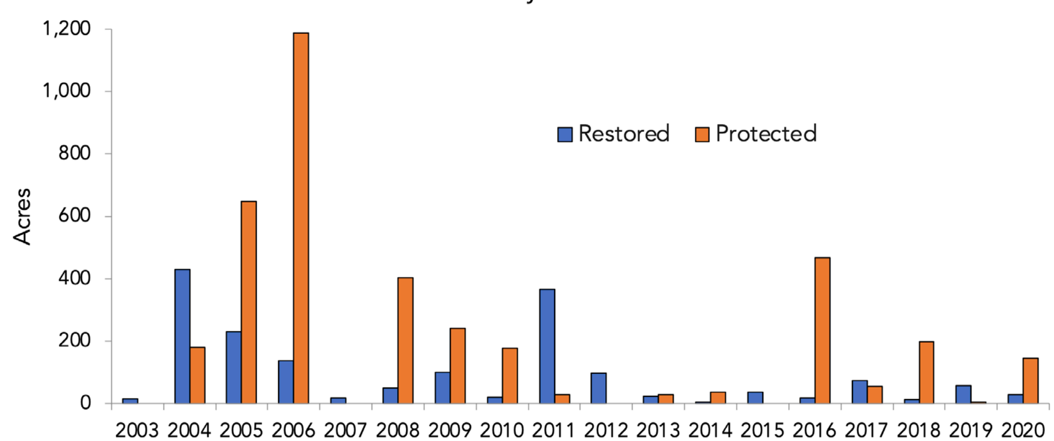
LONG-TERM TREND

As of 2020, 5,529 acres had been protected or restored in the Inland Bays watershed since 2003. Annual acreage numbers vary due to many factors, but progress is closely tied to availability of funding and incentives. The pace of habitat protection and restoration stalled between 2011 and 2015.

CHANGE SINCE PREVIOUS REPORT

Permanent land protection has increased since 2015, with 873 acres added, almost all of which (819 acres) is upland forest. Protection and restoration of forested land, particularly in buffer areas near waterways, is a current priority of the Center and its partners, and this is reflected in the data. Over 8.5 times as much money was put toward land conservation between 2016 and 2020 as in the previous 12 years. High land values for development contribute significant cost to conservation efforts.

Natural Habitat Protection and Restoration in the Inland Bays Watershed



Approximately 700 acres of shoreline, marsh, and forest on Angola Neck were conserved by Delaware Wild Lands between 1967 and 1973. This land is now managed as a nature preserve by the State of Delaware Division of Parks and Recreation. New trees planted by the Center for the Inland Bays to expand the creek buffer are seen in the foreground. Photo by Driscoll Drones

A restoration project within Delaware Wildlands' Great Cypress Swamp that included the planting of 10,000 native trees and shrubs. Photos by Andrew Martin (left) and Dennis Bartow (right)

INDIAN RIVER INLET TIDAL FLUSHING

FAIR

NO TREND

Before it was stabilized by rock jetties in the late 1930s, the inlet to Indian River Bay was shallow, and storms caused the opening to move along a two-mile stretch of coastline. Since then, the inlet has grown significantly deeper over time from scouring, with increasing volumes of water passing between the ocean and the Bay with the tides.

This has led to an increased tidal range and long-term rise in salinity in Indian River and Rehoboth Bays and has contributed to the degradation of marshes. However, increased flushing also helps remove and dilute nutrient pollution, leading to the improved water quality that has been observed in open areas of the Bays that are most influenced by the tide.

LONG-TERM TREND

In the late 1960s, the increase in tidal flushing accelerated, such that 20 years later the amount of water passing during one tide cycle had increased by more than four times.

CHANGE SINCE PREVIOUS REPORT

The cable-stayed bridge that currently spans the inlet, constructed in 2012, removed the piers that contributed to scouring. Measurements and modeling now show that inlet depth and the increase in tidal flushing volume have slowed significantly. Future sea-level rise, however, will continue to bring high water levels to the Bays, impacting flooding and salt marsh health.

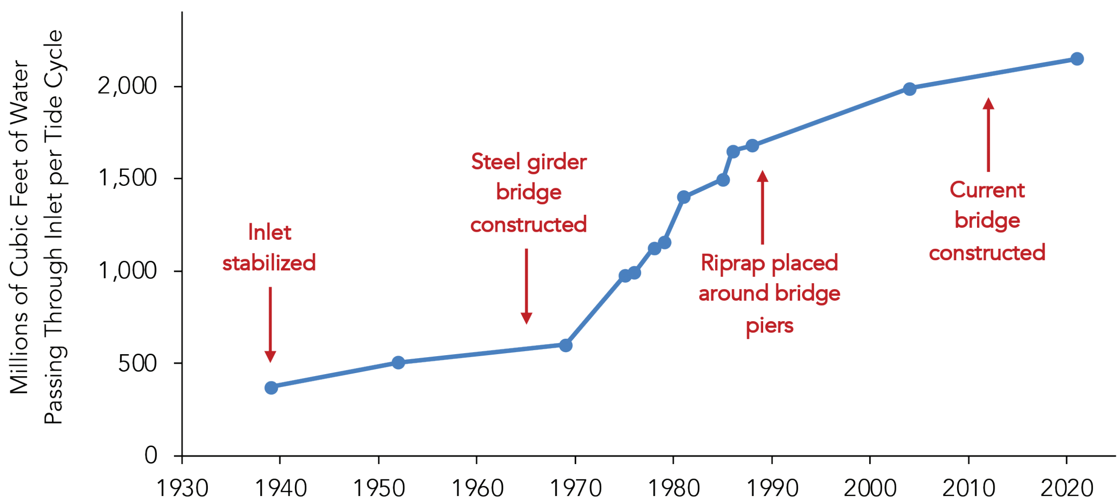
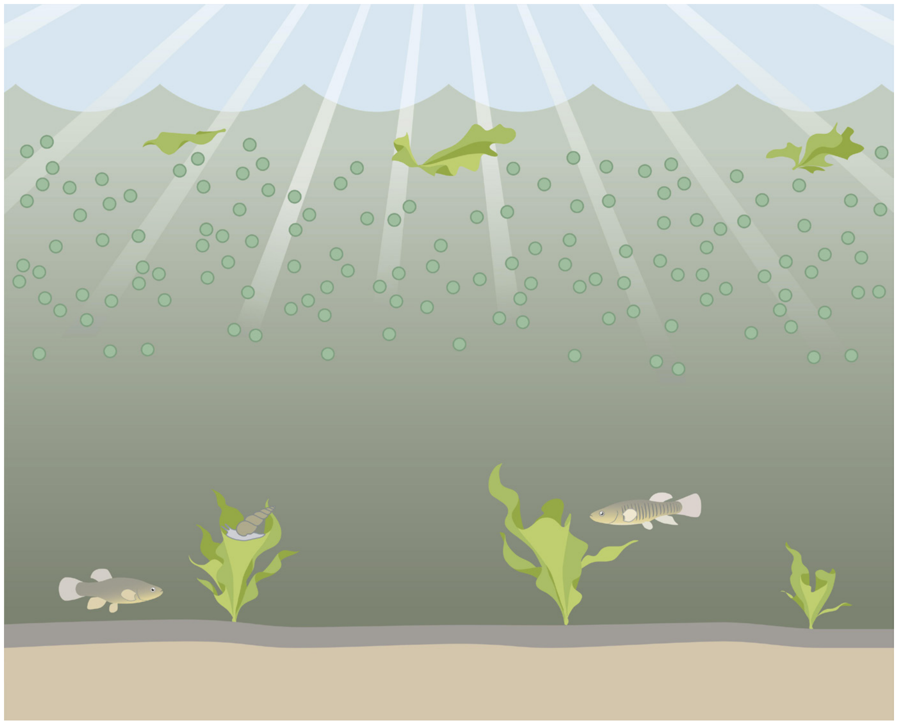


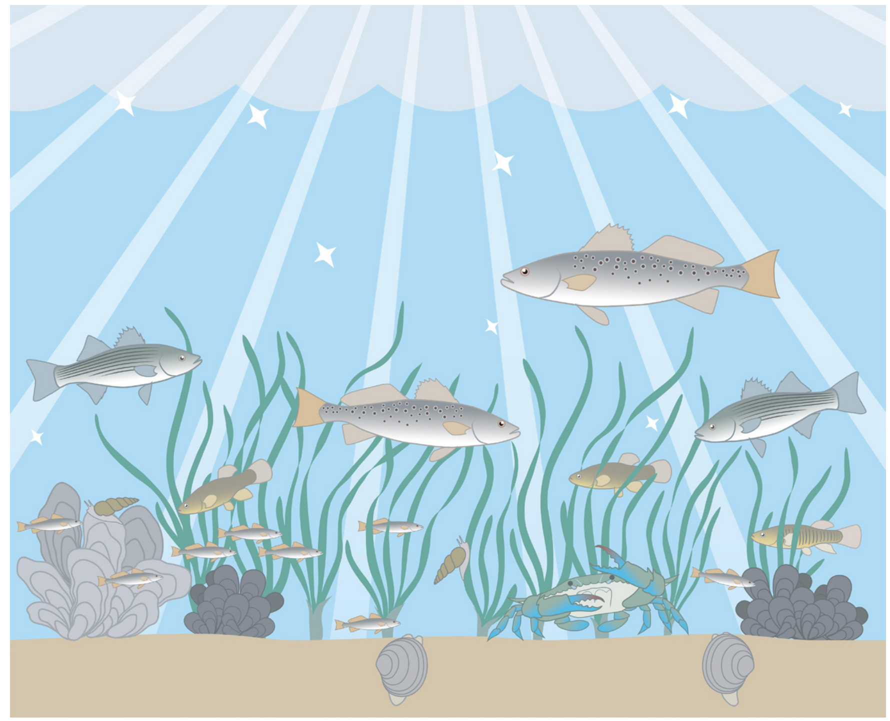
Photo by Chris Driscoll

Did you know?

The maximum velocity of tidal water rushing through the inlet is about **2 METERS PER SECOND OR ABOUT 4.5 MILES PER HOUR.** For comparison, this is 80% of the velocity of the Gulf Stream (5.5 mph)!



Excess nutrients from fertilizers, wastewater, and runoff cause blooms of microscopic algae. These, along with sediments in runoff, reduce water clarity which inhibits growth of baygrasses. Oxygen levels fluctuate naturally on a daily cycle in our shallow Bays. But when nutrient pollution is high, the cycles become extreme, and very low oxygen harms fish and invertebrates.



In a healthy bay, there is little algae, light reaches the bottom allowing baygrasses to grow, a greater diversity of fish and shellfish are present, and oxygen is plentiful and relatively stable.

MANAGING NUTRIENT POLLUTION

FAIR | NO TREND

Nutrient pollution remains the largest problem facing the Inland Bays.

Three main sources of excess nitrogen and phosphorus impact our surface waters:

> **Point source pollution** originates from a pipe, such as discharge from a wastewater treatment plant.
>
> **Nonpoint source pollution** originates from a variety of diffuse sources that enter the Bays through groundwater and surface runoff. These include fertilizers, septic systems, land application of wastewater, and stormwater runoff.
>
> **Atmospheric sources of pollution** include emissions from automobiles, agricultural operations, and power plants that later deposit directly onto the surface of waterways.

The maximum amount of nutrient pollution that a water body can receive and still support healthy environmental conditions is called its Total Maximum Daily Load (TMDL). In 1998, state regulations established target loads for the Inland Bays and their tributaries. The regulations required the complete elimination of point sources, a 40% to 85% reduction of nonpoint source loads, and a 20% reduction of loads from atmospheric sources. In 2008, DNREC enacted a Pollution Control Strategy (PCS) that laid out a series of regulatory and voluntary actions needed to meet the TMDLs enacted 10 years before.

In 2018, discharge from the City of Rehoboth Beach's wastewater treatment system was converted to an ocean outfall, meaning that all major point sources of nutrient pollution have now been removed from the Inland Bays—a major achievement.

However, nonpoint source nitrogen loads continue to remain far in excess of healthy limits in all three bays, with no decreasing trend. Inputs of phosphorus were within healthy limits, on average, in Rehoboth and Little Assawoman Bays. Yet phosphorus loads to Indian River Bay are still more than 50% higher than the TMDL goal.

Sussex County has made substantial progress in conversion of septic systems to central sewer, surpassing the pollution reduction goal by more than 20%. The County continues to implement new sewer districts and expand capacity.

Some progress was seen in voluntary implementation of agricultural nutrient management practices. Installations of practices to treat stormwater runoff in older communities, however, are far short of the PCS goal. There is a critical need for dedicated funding for both of these important restoration actions.

GOOD IMPROVING

INPUT OF NUTRIENTS FROM POINT SOURCES

In 2018, the discharge from the Rehoboth Beach wastewater treatment plant was removed from Rehoboth Bay and converted to an ocean outfall. This was the last major pollution point source in the Bays. All 13 point sources that existed 30 years ago in the Inland Bays have now been addressed. This is a major achievement.

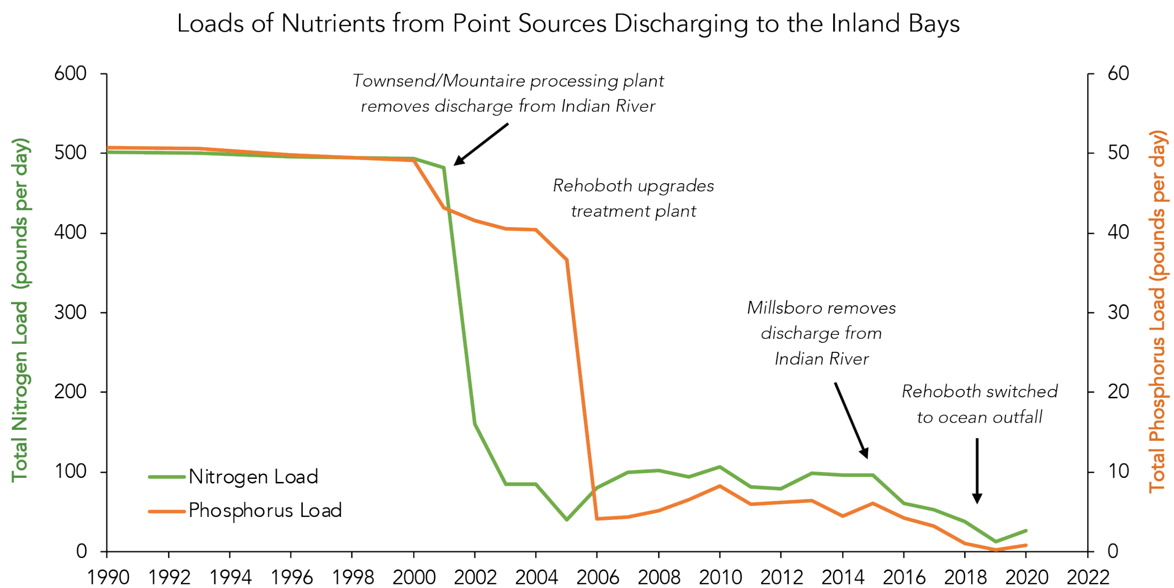
Only one small discharge remains at the Allen Harim/Pinnacle facility in Millsboro. The plant is awaiting a permit to convert its outfall in Wharton Branch to land disposal.

LONG-TERM TREND

As wastewater facilities improved treatment or removed their discharges, pollution to the Bays decreased dramatically. From 1990 to 2020, pollution loads from point sources decreased by 474 pounds per day of nitrogen (95%) and nearly 50 pounds per day of phosphorus (98%).

CHANGE SINCE PREVIOUS REPORT

Removal of the outfalls in Millsboro (in 2015) and Rehoboth Beach (in 2018) significantly decreased inputs of nitrogen and phosphorus to the Bays. In 2020, average daily inputs of nitrogen and phosphorus were only 26 pounds and 0.85 pounds, respectively.



Rehoboth Beach Wastewater Treatment Plant

Ribbon cutting to celebrate the construction of the Rehoboth Beach ocean outfall, eliminating the discharge of treated effluent from the treatment plant into the Lewes-Rehoboth Canal.

INPUT OF NUTRIENTS FROM THE ATMOSPHERE

GOOD

NO TREND

Nutrients are deposited from the atmosphere directly into surface waters during both wet and dry weather. Excess nitrogen in the atmosphere comes from a variety of sources, including coal-burning power plants, vehicle exhaust, and agriculture. Phosphorus in the atmosphere may originate from combustion, natural vegetation, blown soil particles, sea spray, and herbicides.

Deposition of nitrogen is of most concern for Bay health, and inputs of atmospheric nitrogen currently meet their pollution reduction goal. No pollution goal has been established by the state for atmospheric phosphorus.

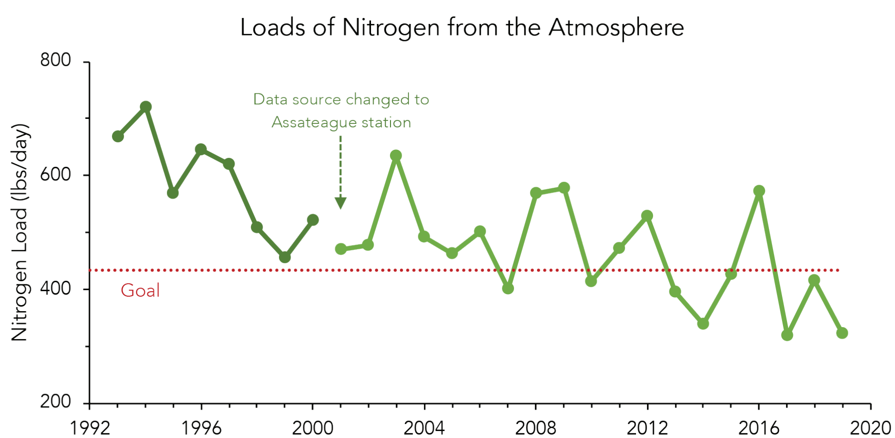
LONG-TERM TREND

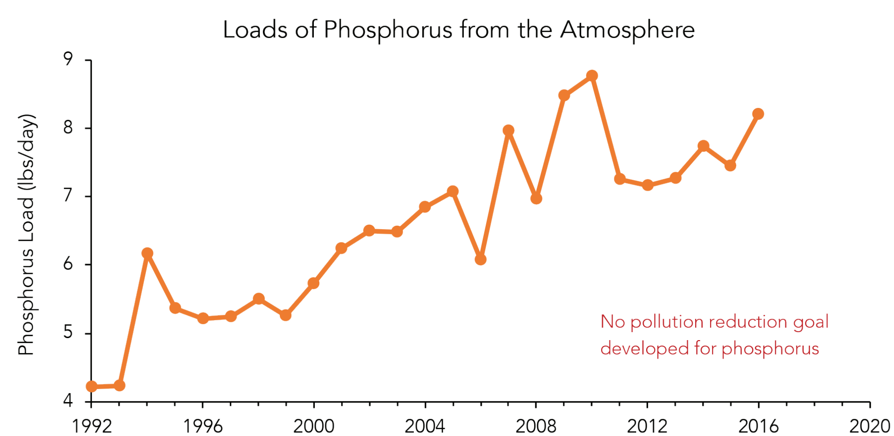
Since the early 1990s, atmospheric nitrogen loads have decreased, largely due to improved federal emission standards for power plants and automobiles. Phosphorus loads have increased slightly over time for unknown reasons.

CHANGE SINCE PREVIOUS REPORT

Atmospheric nutrient load data for the Inland Bays has, until recently, come from a monitoring station in Lewes. The Lewes station, however, was decommissioned in 2016. For the period 2001-2019, we used nitrogen data from a station in Assateague, Virginia, which shows trends similar to Lewes. Phosphorus load data are from the Lewes station.

Since the previous report, average atmospheric inputs of nitrogen have shown little change. No data were available for atmospheric phosphorus loads after 2016.





In 2009 and 2011, the NRG power plant in Millsboro was upgraded to meet higher emission standards.

INPUT OF NUTRIENTS FROM NONPOINT SOURCES

NITROGEN:
VERY POOR NO TREND

PHOSPHORUS:
FAIR NO TREND

Nonpoint source pollution comes from contaminated stormwater runoff or groundwater that transports fertilizers, animal wastes, and human wastewater to waterbodies. It is by far the largest source of nutrient pollution in the Inland Bays.

Inputs (or "loads") of nutrients from nonpoint sources are estimated by monitoring the major streams that drain to the Bays. Changes in nonpoint source loads can take years to detect, because precipitation and stream flow are variable, and groundwater carrying nutrients may take decades to reach streams and bays.

Nevertheless, current data show no significant progress in reducing nonpoint sources of nitrogen and phosphorus pollution in the Bays. Inputs of nitrogen remain far in excess of healthy limits in all three Bays. Indian River Bay, in fact, continues to have average loads more than six times the healthy limit. This is bad news for water quality in the estuary.

Inputs of phosphorus, on average, remained just within healthy limits in Rehoboth and Little Assawoman Bays. Phosphorus loads in Indian River Bay, however, continue to be nearly twice the healthy limit.

LONG-TERM TREND

The amount of nutrients that enter waterways can vary from year to year, due to differences in annual precipitation. In wet years, reflected in the figures as a blue stream flow line, more pollution enters the Bays through runoff and groundwater.

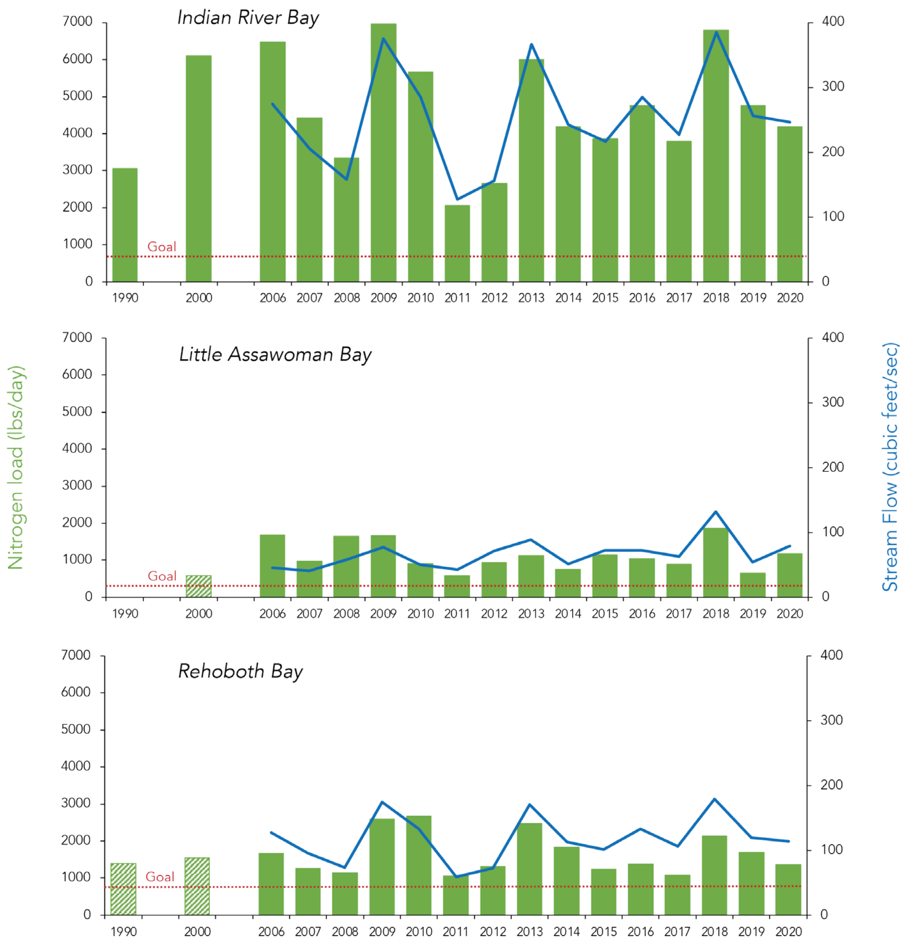
Yet more than two decades after TMDL regulations were enacted, no decreasing trend in nutrient loads to the Bays has been observed. This has been enough time for to allow much of the polluted groundwater to flush through aquifers into streams. Phosphorus loads to Little Assawoman Bay appear to have slightly increased.

CHANGE SINCE PREVIOUS REPORT

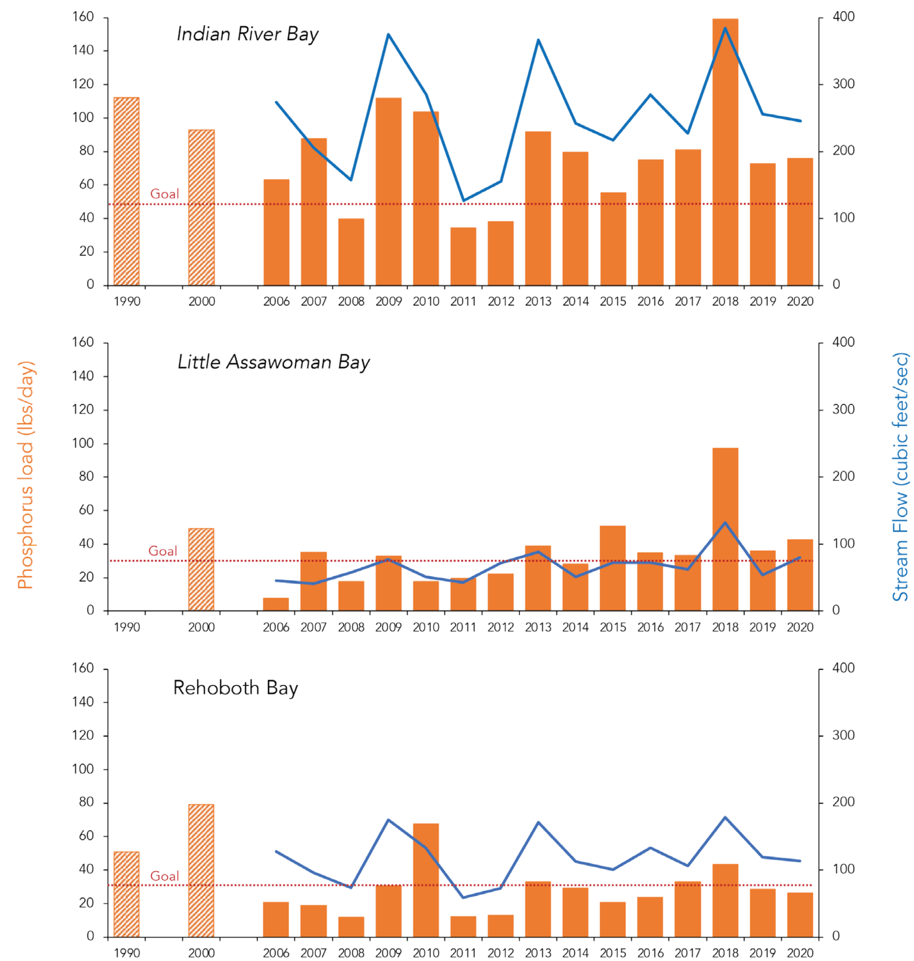
No short-term trends in either nitrogen or phosphorus loads to the Bays were observed.

Decreases are expected as cleaner water enters streams over time. However, significant improvement will depend upon implementation of all the actions of the PCS and the Center's Comprehensive Conservation and Management Plan.

Loads of Nitrogen from Nonpoint Sources



Loads of Phosphorus from Nonpoint Sources



POOR IMPROVING

AGRICULTURAL NUTRIENT MANAGEMENT PRACTICES

While farmland is steadily being lost to development, agriculture remains the largest land use in the watershed, and it contributes the most pollution through the unintentional loss of fertilizers to groundwater and surface waters. Best management practices on farms can significantly reduce nonpoint source pollution and improve soil health. Agricultural practices of the PCS account for more than 75% of the needed pollution reductions to meet TMDLs.

However, progress toward achieving the agricultural practice goals has been slow, and little progress has been made since the last report. Goals of the PCS have been met for nutrient management planning (a regulatory requirement) and construction of manure sheds and composters. In recent years, more than 11,000 tons of manure annually has been exported out of the watershed or put to an alternative use, achieving 56% of the PCS goal.

More focus must be given to implementing practices that will provide the highest nutrient reductions and improve soil health. Buffers, wetland restorations, and cover crops should be prioritized for funding and implementation. Better tracking of nutrient management practices also is needed.

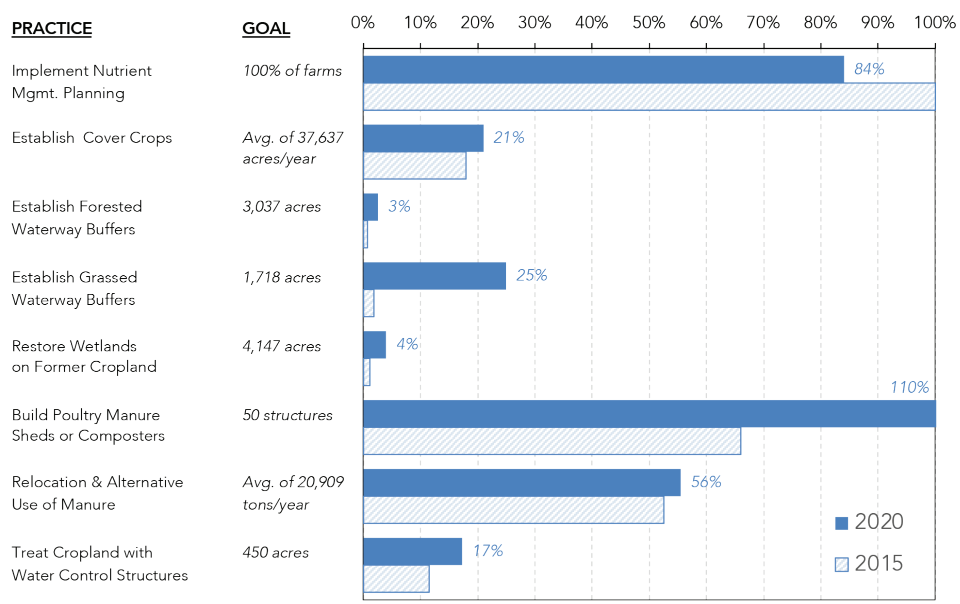
LONG-TERM TREND

Only two practices, implementation of nutrient management plans and construction of manure sheds, have met the long-term goals of the PCS.

CHANGE SINCE PREVIOUS REPORT

Delaware's Nutrient Management Law requires most farms to have a nutrient management plan. The Delaware Department of Agriculture Nutrient Management Section reported that the number of farms compliant with the law fell from 100% in 2015 to 84% in 2020. Very slow progress was made toward other nutrient management practice goals.

Progress Toward Pollution Control Strategy Nutrient Management Practice Goals
(since baseline year 2005)



Air seeder sowing cover crop into corn. Photo courtesy Edwin Remsberg and USDA-SARE

GOOD IMPROVING

SEPTIC SYSTEM CONVERSION TO CENTRAL SEWER

A properly maintained septic system releases an average of 10.6 pounds of nitrogen and 0.7 pounds of phosphorus to groundwater each year. When multiplied by the estimated nine to ten thousand active systems in the watershed, the total pollution contribution of septics is nearly 100,000 pounds of nitrogen yearly and 7,000 pounds of phosphorus. Poorly maintained or failing systems leach far more nutrient pollution.

Central sewer service allows a higher level of sewage treatment and eliminates pollution to the Bays from septic systems.

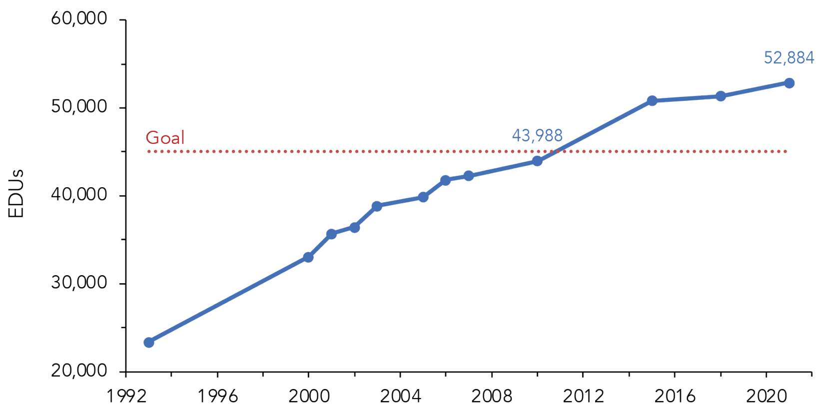
LONG-TERM TREND

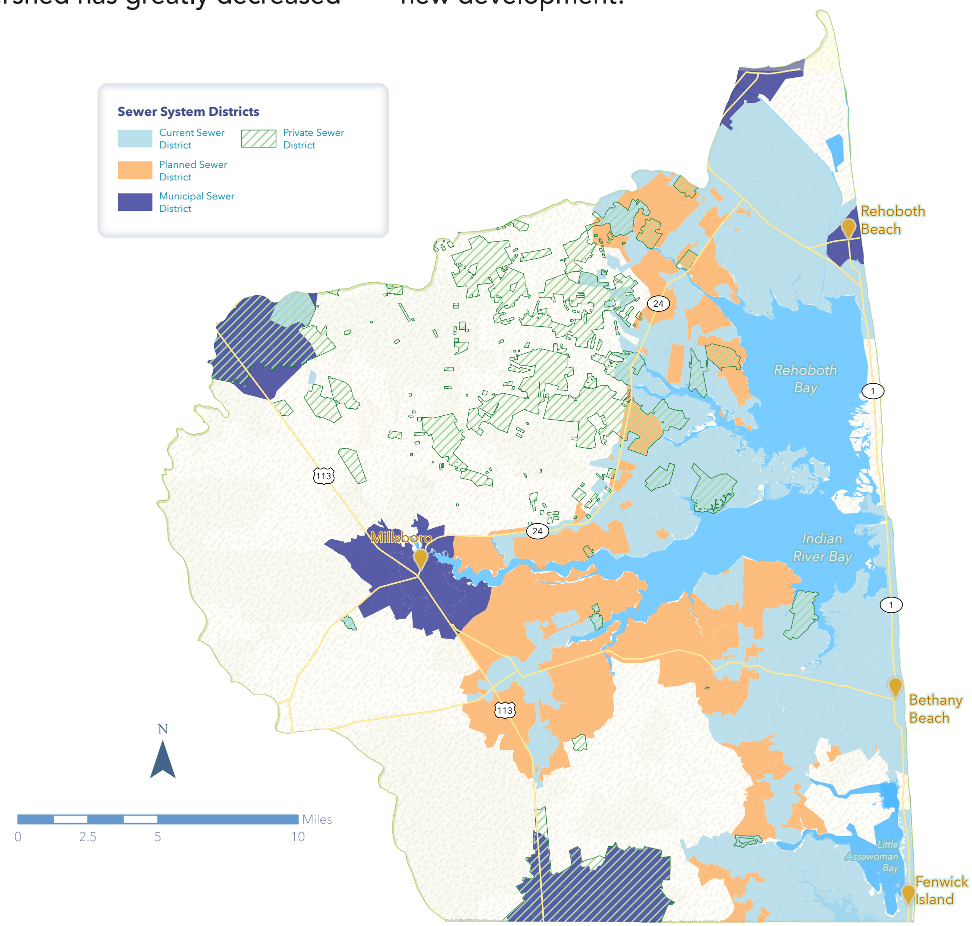
Since the 1970s, Sussex County has facilitated the conversion of an estimated 52,884 septic systems to central sewer. While new systems are still being permitted, the total number of septics in the watershed has greatly decreased with central sewer expansion. The PCS goal of 45,000 systems converted was surpassed by 2012.

CHANGE SINCE PREVIOUS REPORT

Since 2015, the equivalent of 2,083 additional single family homes have been connected to central sewer. The County continues to expand sewer service to more areas of existing and new development.

Cumulative Number of Equivalent Dwelling Units (EDUs) Converted from Septic to Central Sewer





Sussex County contractors installing central sewer pipes. Photo courtesy Sussex County Government

Pumping a septic tank.

POOR IMPROVING

STORMWATER RETROFITS

When runoff from storms moves over land, it picks up and carries pollutants from lawns, streets, and commercial facilities into streams and the Bays. Developments in Delaware constructed prior to 1990 were not required to control and treat stormwater, so they contribute high levels of stormwater pollution.

Stormwater retrofits are treatment facilities installed in locations where controls did not previously exist or were ineffective. The Inland Bays PCS calls for the construction of stormwater retrofits to treat 4,500 acres of land developed prior to 1990.

As of 2020, only 232 acres of the watershed have been treated by stormwater retrofits—far short of the goal.

The Center has worked with Delaware Department of Transportation and local towns and communities to install most of these retrofits. The Town of South Bethany contributed 110 acres to the PCS goal with the completion of the Anchorage Canal Drainage Area Retrofit Project.

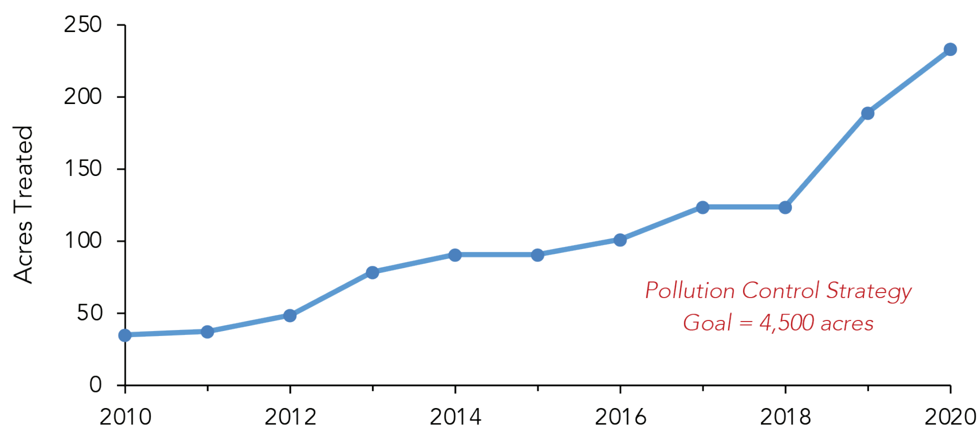
LONG-TERM TREND

Progress in implementing stormwater retrofits has been extremely slow and dependent largely upon grant funding. Flooding and resiliency concerns may help drive future installations.

CHANGE SINCE LAST REPORT

Since 2016, 131 additional acres have been retrofitted. These included a bioretention facility and outfall retrofits in Dewey Beach, a stormwater pond and wetland in Bethany Beach, and a bioswale at the Delaware Botanic Gardens at Pepper Creek.

Cumulative Area of Development Retrofitted
with Stormwater Controls



The Anchorage Canal Drainage Area Retrofit Project installed a suite of practices to restore water quality in Bethany Beach and South Bethany, including this stormwater pond and wetland constructed in 2021.

Bioretention facilty installed on Read Avenue, Dewey Beach, in 2020.

Bioretention retrofit installed in the median of Coastal Highway in South Bethany.

Seaweed washes up on this narrow strip of shoreline near a housing development on Indian River Bay. Both seaweed and microscopic algae flourish when concentrations of nutrients, like phosphorus and nitrogen, are high. Large algal blooms are problematic for water quality, as they decrease oxygen availability and reduce water clarity.

WATER QUALITY

FAIR TO POOR | NO TREND

Measures of water quality are the most basic indicators of bay health. They are key measures of the effectiveness of actions taken to reduce pollution to the Inland Bays.

The water quality indicators in this report are based on the minimum requirements necessary to support baygrasses and healthy dissolved oxygen levels. Each water quality indicator individually is useful in assessing changes in the health of the Bays, and collectively they provide a clearer picture of ecological conditions.

The water quality information used in this report comes from more than 30 long-term monitoring sites located in tidal portions of the Bays. Data are collected by both the Delaware Department of Natural Resources and Environmental Control and volunteers with the University of Delaware's Citizen Monitoring Program.

Overall, water quality in the Bays is poor to fair. A new Water Quality Index (WQI) was developed for the 2021 report that averages results for nutrient concentrations, algae concentration, and water clarity to provide an overall score, or grade. **The Bays currently receive a WQI score of only 63%, equivalent to a grade of "D."**

On the positive side, well-flushed, open water areas of the Bays have relatively good water quality, with some improving trends. Seaweed densities have remained low compared to the 1990s. Little Assawoman Bay has continued to show improvements in nutrient and algae concentrations, as well as water clarity. The recent appearance of scattered widgeon grass beds in Little Assawoman Bay is a sign of clearer, less polluted water there.

Water quality in tributaries and canals, however, continues to be poor. These areas consistently have unhealthy amounts of nitrogen and frequent summer algal blooms that deplete dissolved oxygen. Nitrogen concentrations in the Indian River and Guinea Creek are particularly high. Fewer sites meet standards for nitrogen concentration, water clarity, algae concentration, and dissolved oxygen than in 2015.

The Indian River and tidal creeks of the Bays are highly productive waterways, serving as nurseries for blue crabs, summer flounder, and other economically important species. Until nutrient inputs to the Bays decrease, water quality in these areas is likely to remain impaired, threatening the continued viability of these important species.

POOR NO TREND

WATER QUALITY INDEX

WQI

The Water Quality Index (WQI) combines four water quality indicators—nitrogen and phosphorus concentrations, algae concentration, and water clarity—into a single score, or grade. This provides an overall indicator of water quality.

Scores for the years 2016 to 2020 were averaged to provide a current status for each monitoring location in the Bays. These were then combined to produce an overall average score for the Inland Bays. A score of 100% is highest, meaning that all water quality standards were met consistently.

The Bays currently receive a "Poor" WQI score of only 63%

equivalent to a grade of **D**

The Bays currently receive a "Poor" WQI score of only 63%, equivalent to a grade of "D."

Of 24 monitoring sites in the Bays (see map), only 11 scored 70% or above. The rest received poor or very poor water quality scores.

Well-flushed, open water areas of the Bays have fair to good water quality, with some improving trends. The recent appearance of scattered widgeon grass beds in Little Assawoman Bay is a sign of improving water quality there.

However, high concentrations of nutrients continue to keep water quality in most tributaries very poor. The upper Indian River had particularly low WQI scores.

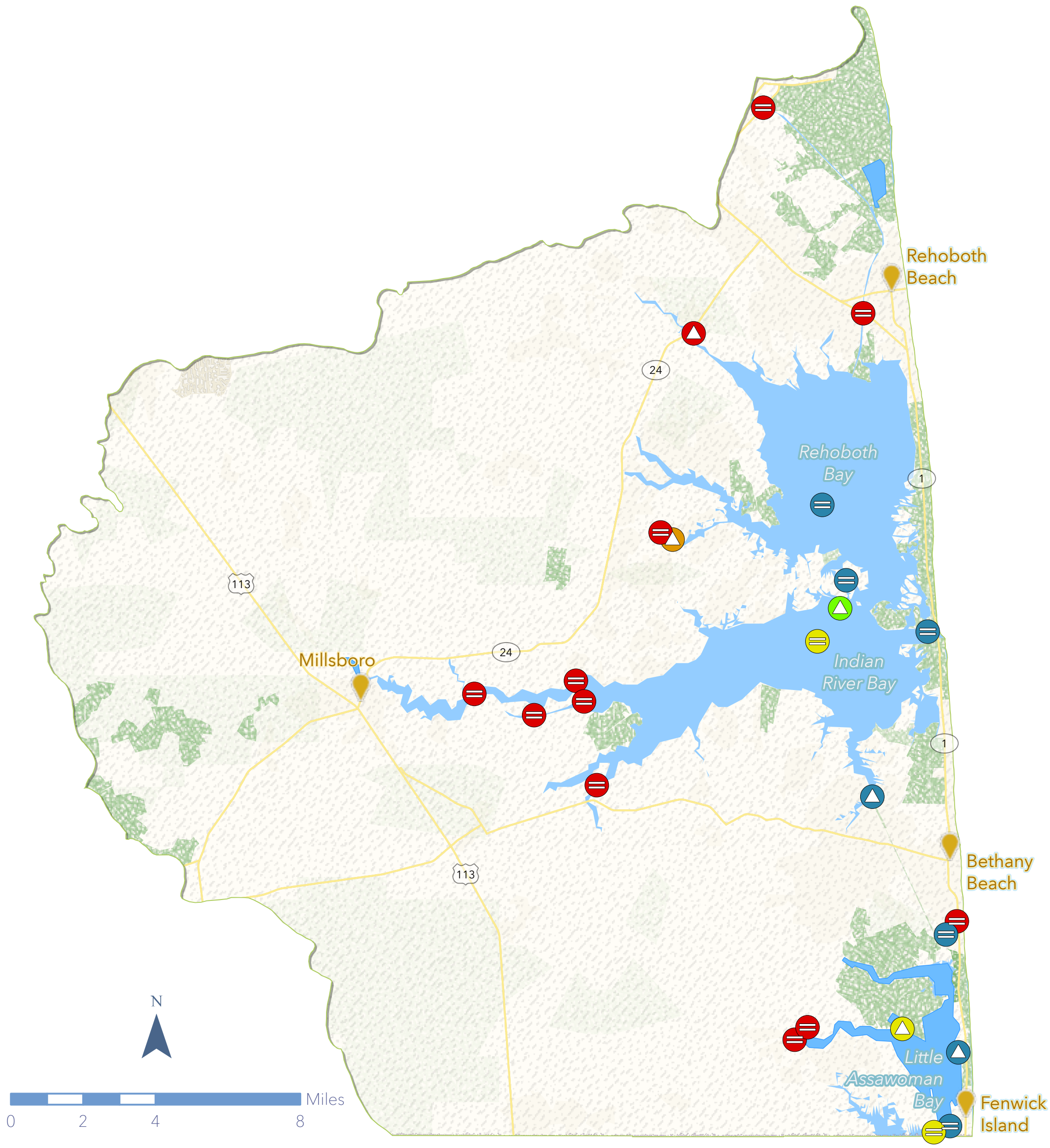
Nutrient pollution in Bay tributaries continues to fuel summer algal blooms that reduce water clarity and deplete the water of oxygen. This is extremely concerning, because these tidal creeks are critical nursery and feeding areas for many species of fish, blue crabs, and other bay life.

LONG-TERM TREND

Six monitoring stations in the Bays have shown long-term improvements in WQI scores. These include two sites in Little Assawoman Bay that were reported to have improving water quality five years ago.

CHANGE SINCE PREVIOUS REPORT

On average, the percentage of monitoring sites meeting healthy standards for water clarity and concentrations of nitrogen and algae has declined since 2015. Continued water quality improvements in Little Assawoman Bay, however, are encouraging.



Water Quality Index

Current Status and Trend of Water Quality Index Scores

The Water Quality Index is an average of the four main water quality indicators:

- Dissolved Inorganic Nitrogen
- Dissolved Inorganic Phosphorus
- Chlorophyll *a*
- Secchi depth

Score	
100 - 91%	*Excellent Water Quality*
90 - 81%	*Good Water Quality*
80 - 71%	*Acceptable Water Quality*
70 - 61%	*Poor Water Quality*
60 - 0%	*Very Poor Water Quality*

Trend
Improving
No Trend
Degrading
Insufficient Data

FAIR TO POOR NO TREND

CONCENTRATIONS OF NUTRIENTS

Nitrogen and phosphorus are nutrients necessary for the growth of beneficial baygrasses, seaweeds, and algae. But an excess of these nutrients has caused an overabundance of algae and seaweeds, murky water, low oxygen levels, and disappearance of baygrasses.

Nutrient concentrations in bay waters do not necessarily follow the same patterns as nutrient inputs, or loads. This is because many biological and chemical processes in the water can affect the actual concentrations of nitrogen and phosphorus that fuel algal blooms.

Studies have determined standards for nutrient concentrations that will result in healthy oxygen levels and clear waters that allow baygrasses to reestablish and flourish.

The overall status of nitrogen concentrations in the Bays currently is poor. During the most recent five-year period, only 50% of the monitoring sites met the healthy standard for dissolved inorganic nitrogen. Most of the sites with healthy nitrogen levels are located in open Bay areas near the Indian River Inlet and in Little Assawoman Bay.

With the exception of White Creek, tributaries still do not meet nitrogen standards, and concentrations in the Indian River and Guinea Creek are extremely high.

Fifty percent of stations met the healthy standard for phosphorus. More tributary sites meet the phosphorus standard than for nitrogen. Phosphorus concentrations are relatively low in Little Assawoman Bay, partly because its lower salinity keeps phosphorus bound to bay sediments and out of the water.

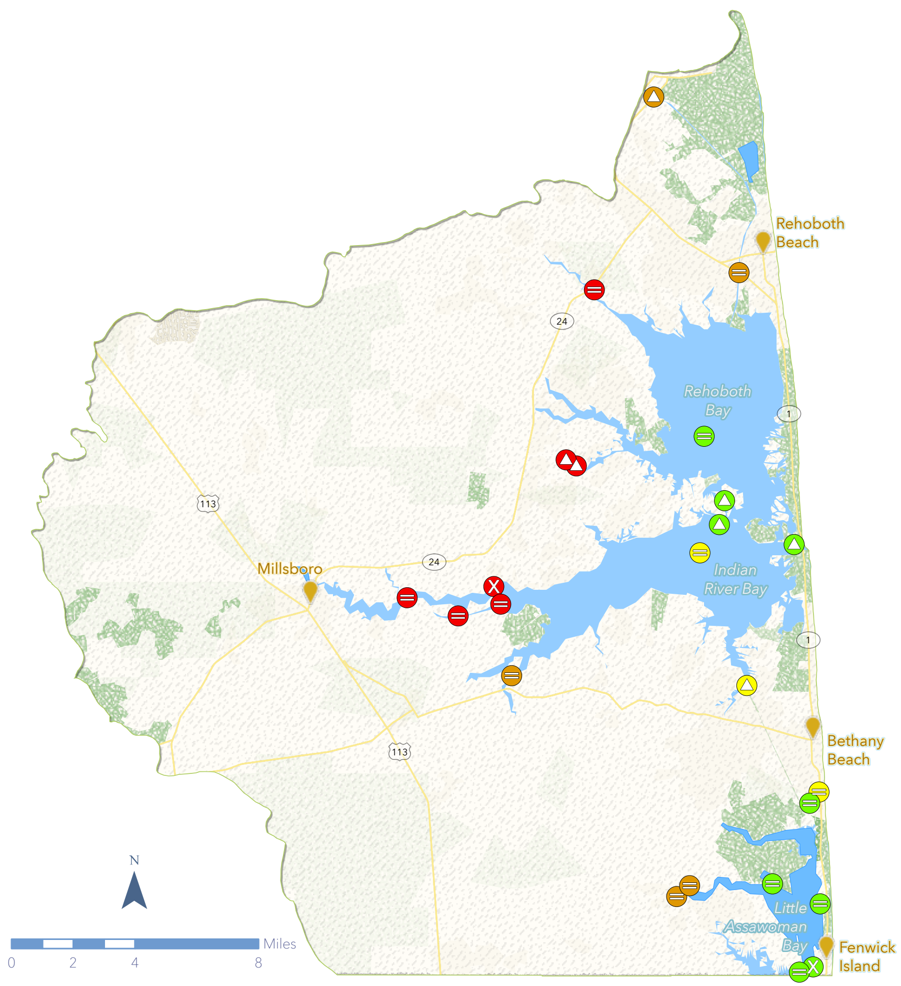
LONG-TERM TREND

Seven monitoring sites have shown long-term improving trends in nitrogen concentrations, meaning that nitrogen levels are decreasing over time at those locations.

CHANGE SINCE PREVIOUS REPORT

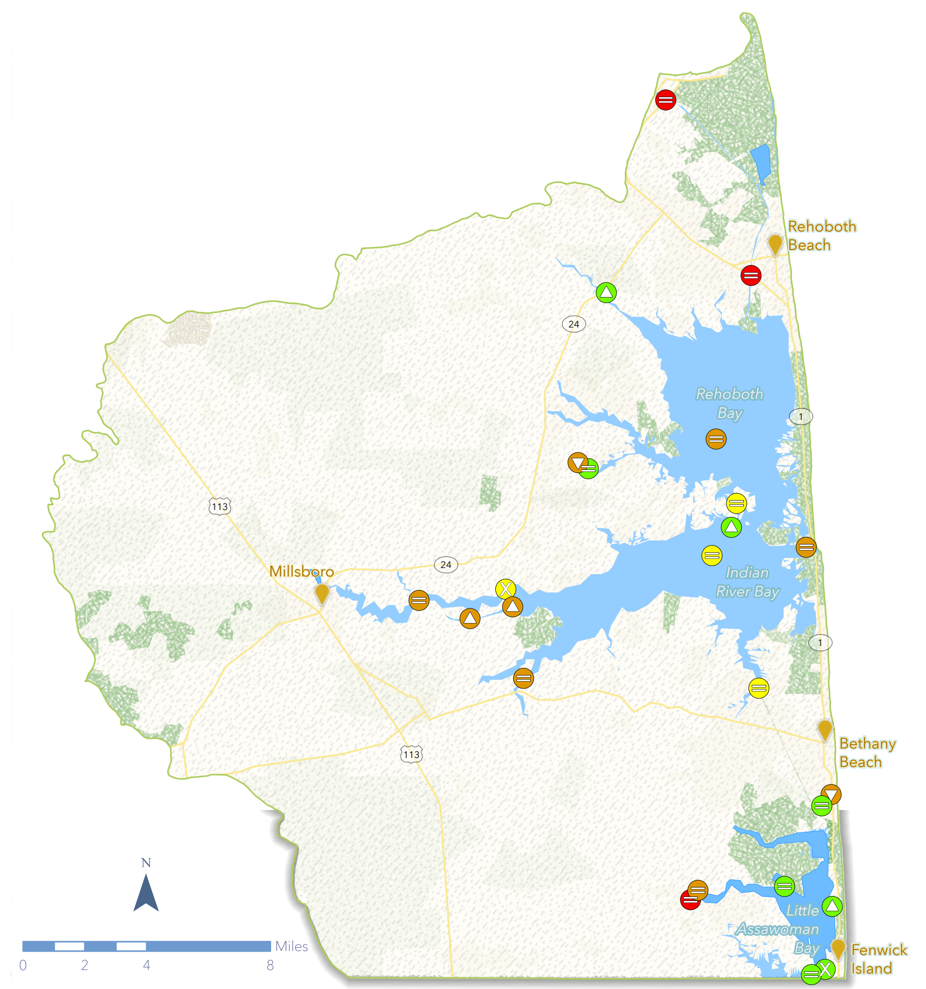
Since the previous report, nitrogen concentrations overall have increased. Slightly fewer stations meet the healthy standard than in 2015.

There are some signs of progress. Compared to five years ago, concentrations of phosphorus have moderately improved. Half of the sites now meet healthy standards. Only 36% did previously.



Dissolved Inorganic Nitrogen

Results			Trend
Much Better Than Standard	0 - 0.07 mg/L	*Low Levels of Nitrogen*	Improving
Meets or Better Than Standard	0.07 - 0.14 mg/L	*Acceptable Levels of Nitrogen*	No Trend
Worse Than Standard	0.14 - 0.28 mg/L	*Excess Nitrogen*	Degrading
Far Worse Than Standard	> 0.28 mg/L	*Very High Excess Nitrogen*	Insufficient Data



Dissolved Inorganic Phosphorus

Results			Trend
Much Better Than Standard	0 - 0.005 mg/L	*Low Levels of Phosphorus*	Improving
Meets or Better Than Standard	0.005 - 0.010 mg/L	*Acceptable Levels of Phosphorus*	No Trend
Worse Than Standard	0.010 - 0.020 mg/L	*Excess Phosphorus*	Degrading
Far Worse Than Standard	> 0.020 mg/L	*Very High Excess Phosphorus*	Insufficient Data

FAIR NO TREND

ALGAE CONCENTRATION

In a healthy estuary, floating microscopic algae—known as phytoplankton—provide food for fish, shellfish, and other invertebrates. When too many nutrients are added to the water, algae may grow out of control, creating algal blooms. If blooms persist, they cloud the water so that baygrasses are deprived of light and cannot grow. Very large blooms also deplete the water of oxygen.

Chlorophyll a is a green pigment in algae. Concentration of this pigment in the Bays indicates the abundance of algae. Levels below 15 milligrams per liter of water are considered healthy.

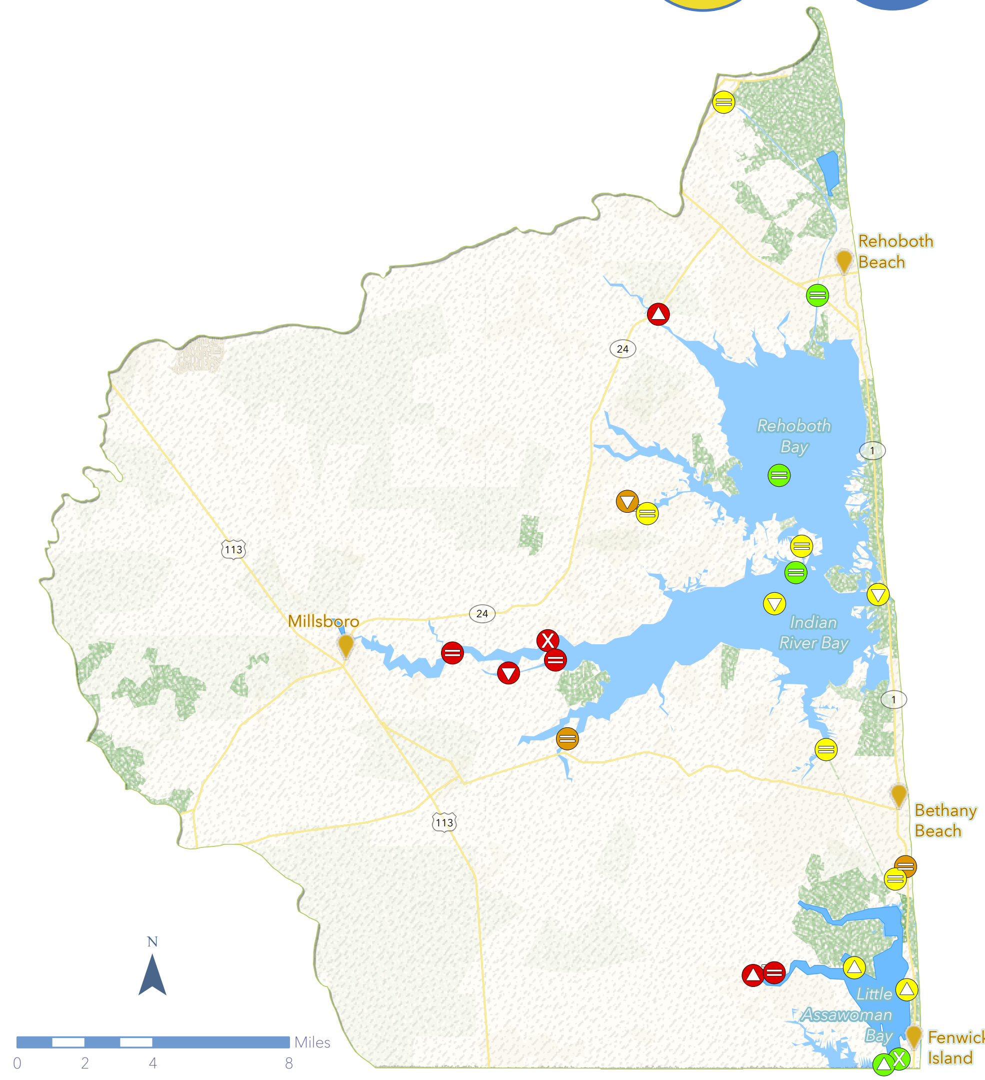
From 2016 to 2020, 58% of locations sampled in the Bays met, or were better than, this standard. Indian River, Love Creek, and Dirickson Creek, however, had high levels of algae that often were much worse than the healthy standard.

LONG-TERM TREND

Over the long-term, algae levels in Little Assawoman Bay have continued to improve. Conditions in Indian River, however, are degrading.

CHANGE SINCE PREVIOUS REPORT

Algae concentrations in some parts of the Bays have increased since the previous report was published. The number of sampling stations meeting the healthy standard decreased from 64% to 58%. This change was most notable in the Indian River, which has experienced large summer algal blooms.



Algae Concentration (as Chlorophyll *a*)

Results			Trend
Much Better Than Standard	0 - 7 µg/L	*Least Algae*	△ Improving
Meets or Better Than Standard	7 - 15 µg/L	*Healthy Levels of Algae*	☰ No Trend
Worse Than Standard	15 - 30 µg/L	*Unhealthy Levels of Algae*	▽ Degrading
Far Worse Than Standard	> 30 µg/L	*Very Unhealthy Levels of Algae*	X Insufficient Data

"Mahogany tide" algal bloom in the upper Indian River, summer 2019.

POOR

NO TREND

WATER CLARITY

Because all plants need sunlight to grow, clear water is essential for the reestablishment and health of baygrasses in the Inland Bays.

Algae, sediments, and organic matter floating in the water all reduce clarity and prevent sunlight from reaching the Bays' bottoms to support plant life.

Water clarity is measured by lowering a black and white Secchi disk into the water until its markings can no longer be seen. When all other conditions are right, baygrasses can grow in shallow waters with an average Secchi depth of at least 2.2 feet.

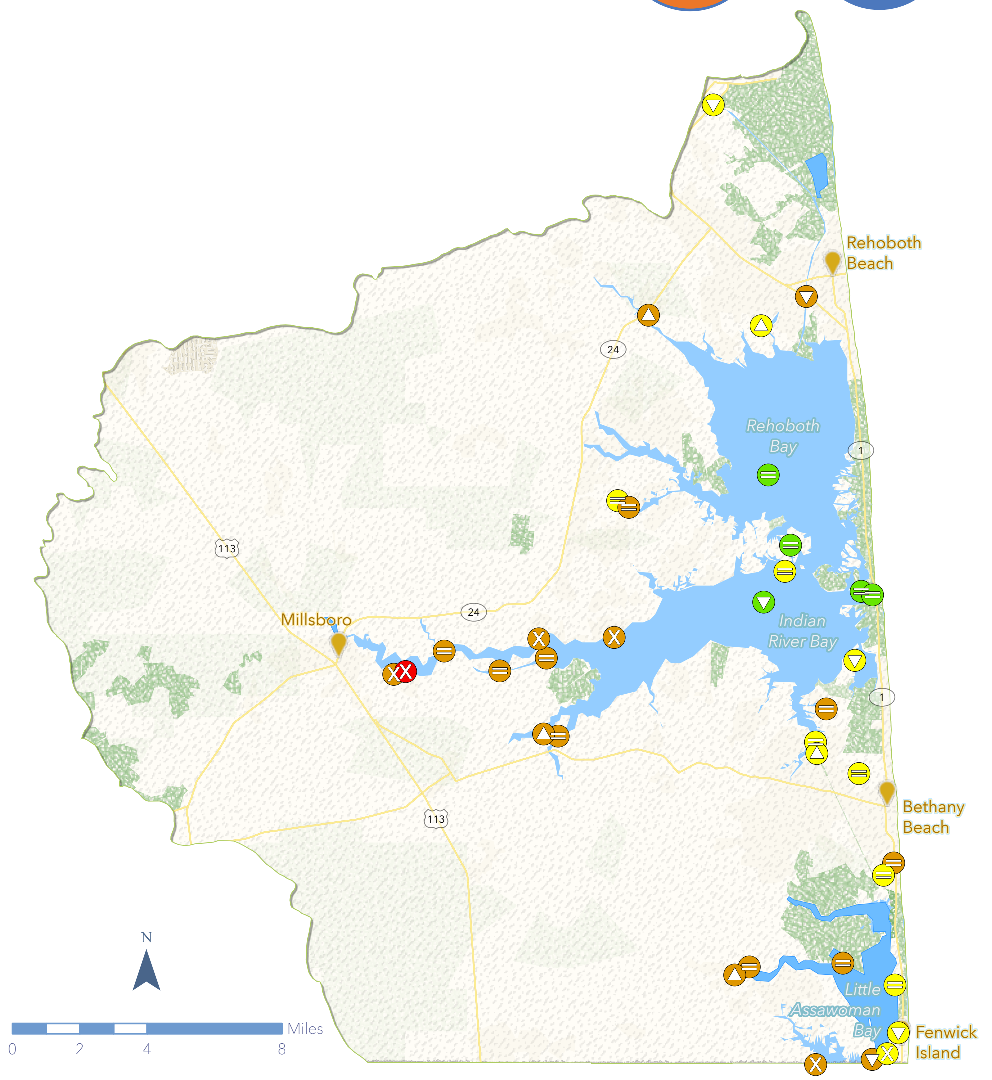
In the period 2016 to 2020, only 44% of water quality monitoring sites in the Bays met or exceeded this standard, down from 58% in 2015. Little Assawoman Bay, upper White Creek, and areas near the Inlet were clearest, while most tributaries were murky and below standard.

LONG-TERM TREND

Long-term trends are mixed. Six stations are degrading, but five sites (all in tributaries) have shown improvement in water clarity

CHANGE SINCE PREVIOUS REPORT

Fewer sites now meet the water clarity standard than in 2015.



Water Clarity (Secchi disk depth)

Results			Trend
Much Better Than Standard	> 3.3 ft	*Very Clear Water*	Improving
Meets or Better Than Standard	2.2 - 3.3 ft	*Clear Water*	No Trend
Worse Than Standard	1.3 - 2.2 ft	*Murky Water*	Degrading
Far Worse Than Standard	< 1.3 ft	*Very Murky Water*	Insufficient Data

Photo by Jane Thomas, Integration and Application Network (ian.umces.edu/media-library)

DISSOLVED OXYGEN CONCENTRATION

FAIR

NO TREND

Dissolved oxygen (DO) is the amount of oxygen in water that is available to aquatic organisms. All living creatures in the Bays need oxygen to survive. DO levels that are high and stable support diverse and healthy populations of underwater life.

DO in shallow bays naturally cycles over a 24-hour period. During the day, plants and algae release oxygen into the water through photosynthesis. At night, plants, algae, and animals continue to respire and draw oxygen out of the water, causing levels to drop slightly.

Nutrient pollution, however, makes these cycles extreme by fueling large algal blooms. Abnormally high concentrations of oxygen during the day are followed by nearly complete oxygen depletion at night. Fish and blue crab kills in the Bays are often tied to summer algal blooms and low DO.

The DO indicator shows the percent of summer mornings that oxygen measurements fall below the healthy standard of 4 milligrams of oxygen per liter of water. Zero to 10% of mornings is considered healthy. Higher percentages increasingly impact the feeding, growth, and survival of life in the Bays.

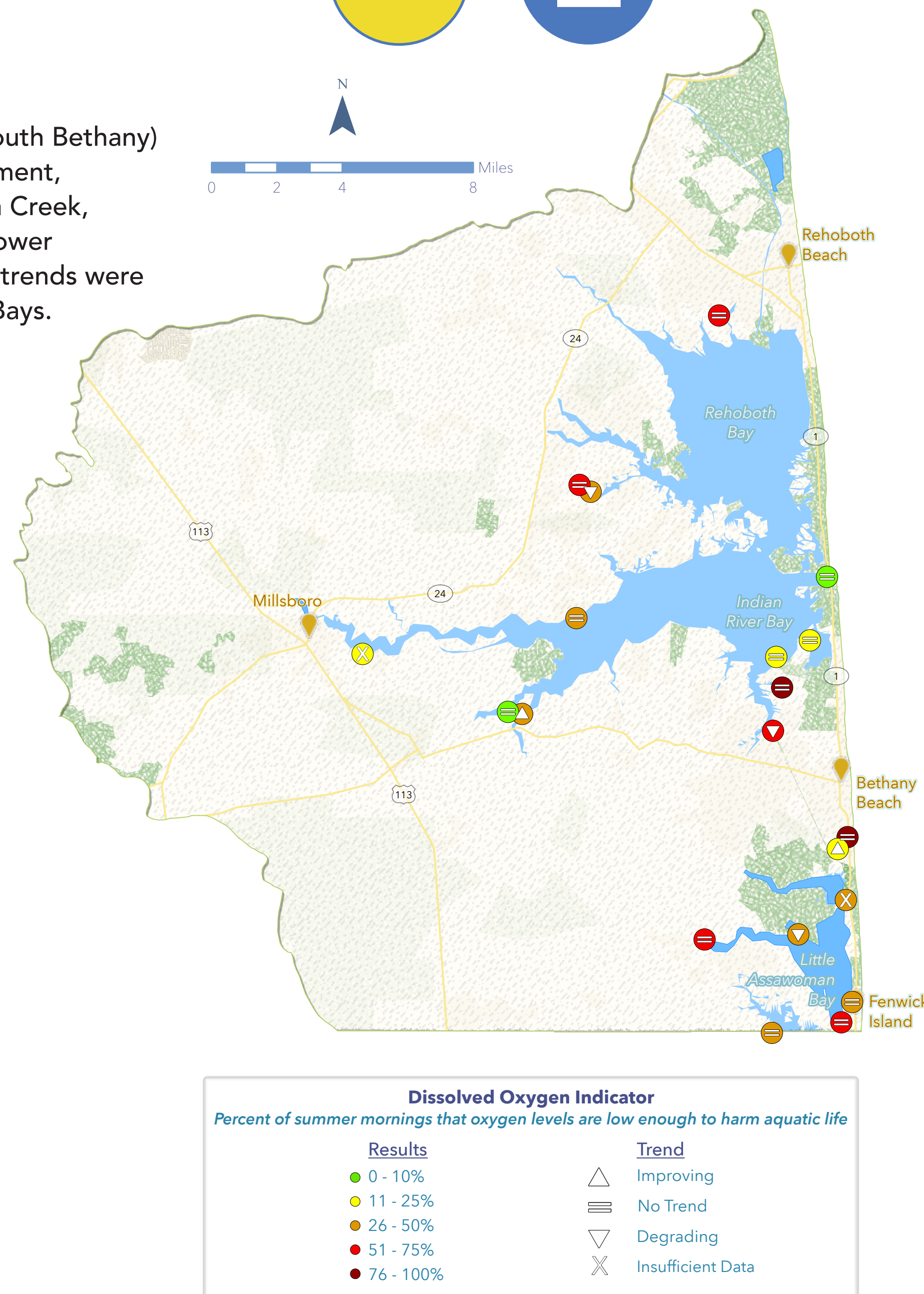
Oxygen levels in well-flushed, open water areas of the Bays meet the standard most of the time. However, tributaries and canals frequently have unhealthy oxygen levels.

LONG-TERM TREND

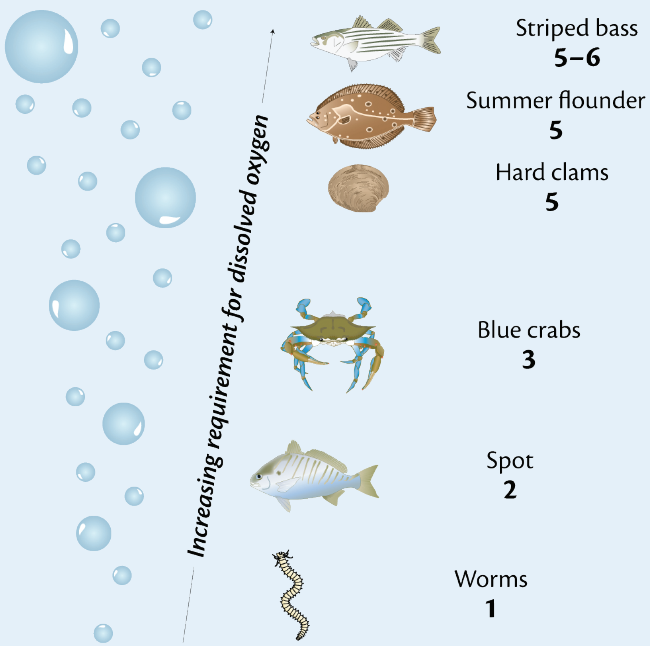
Two sites (in Vines Creek and South Bethany) have shown long-term improvement, while four (White Creek, Guinea Creek, Bethany Beach Salt Pond, and lower Dirickson Creek) degraded. No trends were observed in other areas of the Bays.

CHANGE SINCE PREVIOUS REPORT

Compared to the previous reporting period (2011–2016), concentrations have declined. Previously, 44% of sites had healthy levels of oxygen at least 90% of the time. Currently, only 10% meet this criteria. This change is partly due to the loss of several monitoring stations located in open water areas, where DO is generally better.

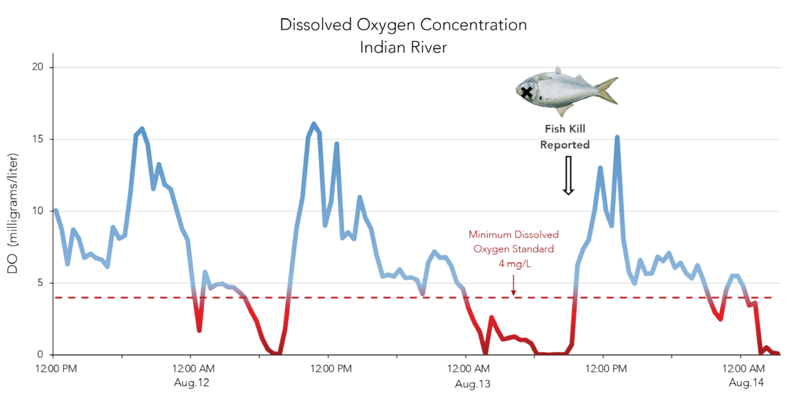


Dissolved oxygen criteria
Minimum amount of dissolved oxygen needed to survive (milligrams of dissolved oxygen per liter of water [mg L^{-1}])



Delaware's minimum standard for dissolved oxygen is 4 milligrams per liter of water. But many species, such as Striped Bass and Summer Flounder, need even more oxygen to survive.

Diagram courtesy of Jane Thomas, Integration and Application Network (ian.umces.edu/media-library)



This figure shows the change in dissolved oxygen over three days in August 2020.

A NEW LOOK AT OXYGEN IN BAY WATERS

Healthy levels of dissolved oxygen (DO) in the water are critical for maintaining balanced populations of fish, shellfish, and other aquatic life. However, the data used to assess DO status provides an incomplete picture of oxygen dynamics in the Bays.

Pollution from excess nutrients can stimulate large summer algal blooms, causing extreme daily fluctuations in DO. Extremely high, "supersaturated" oxygen levels during daylight hours alternate with extremely low "hypoxic" conditions at night. Short periods of low oxygen—a few minutes or an hour—generally are not harmful. Long periods of oxygen starvation, however, threaten bay life.

The DO measurements used in this and past reports come from single water samples collected weekly or monthly. These samples may or may not coincide with algal blooms and hypoxic events, and they provide no information on the duration of low-oxygen conditions.

Because dissolved oxygen is so important to aquatic life, the Center is partnering with University of Delaware scientists to install a network of sensors around the Bays that monitor DO and other water conditions every 30 minutes, 24 hours a day. This continuous monitoring data will provide a better understanding in the future of oxygen trends over hours, days, and months.

The new monitoring network already shows us that conditions in tributaries may be much worse than shown by single samples. Sensors placed in the upper Indian River in 2020 indicated that DO there failed to meet the state water quality standard 75% of the days in June, July, and August. On five occasions, oxygen remained at unhealthy levels for eight hours or longer. A hypoxic event the second week of August coincided with a report of 2,000 Atlantic menhaden killed in the river (graph). Continuous monitoring data such as this will help improve water quality indicators for the next State of the Inland Bays report.

GOOD NO TREND

SEAWEED ABUNDANCE

Seaweeds are a natural part of the Inland Bays ecosystem. They provide food and habitat for many invertebrates, fish, and waterfowl.

The amount of seaweed present in the Bays is a good indicator of nutrient pollution. When nutrients are in excess, seaweeds can grow rapidly and become overabundant. This was the case in the late 1990s when seaweeds bloomed so much that they smothered shellfish, depleted oxygen, killed baygrasses, and fouled beaches. Currently, far fewer dense blooms occur, but levels of seaweed are still high enough to prevent baygrasses from reestablishing in many locations.

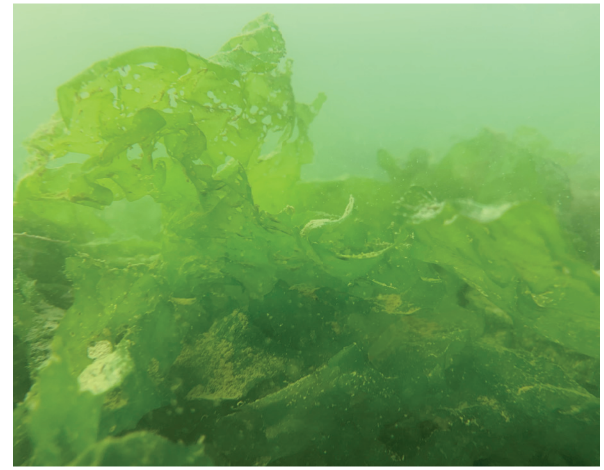
Since 2017, the Center has surveyed seaweed densities annually at six sites in Rehoboth and Indian River Bays.

LONG-TERM TREND

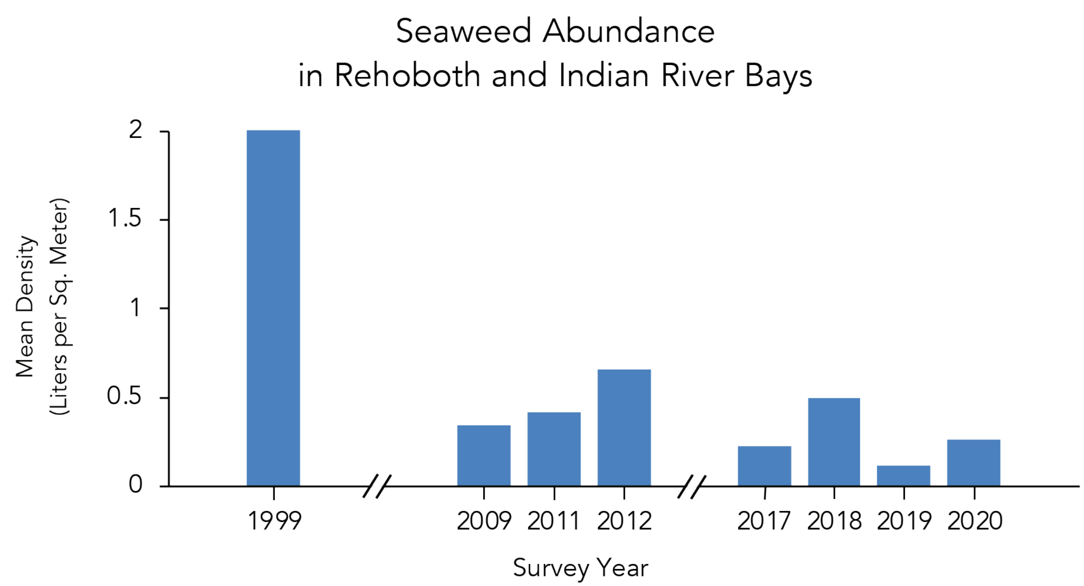
Seaweed abundance dropped significantly between 1999 and 2009, perhaps in response to decreases in phosphorus loads to the Bays. Densities have remained much lower since then.

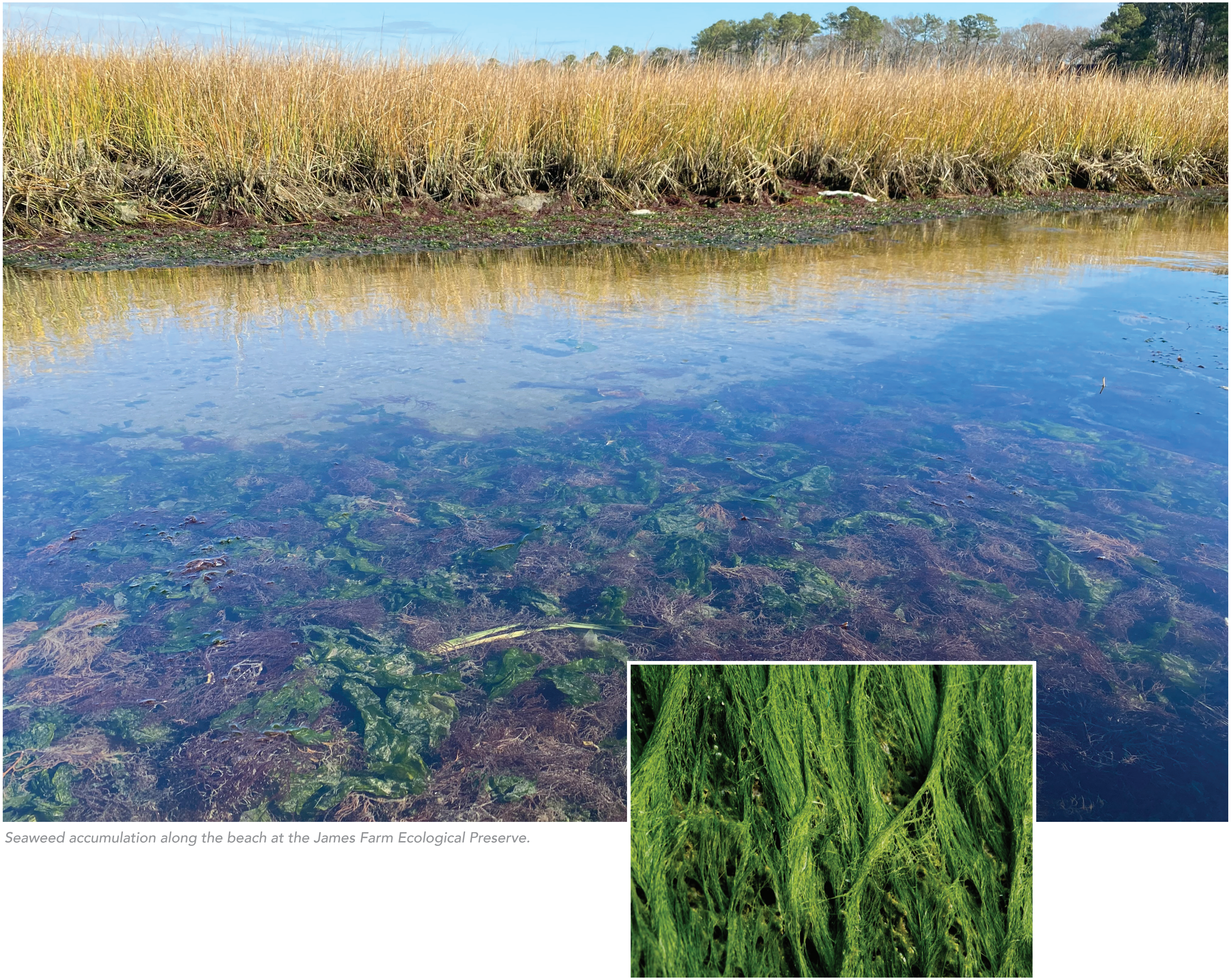
CHANGE SINCE PREVIOUS REPORT

Overall seaweed abundance has changed little over the past five years.



Center staff monitoring the abundance of seaweed in the Bays.





Seaweed accumulation along the beach at the James Farm Ecological Preserve.

Juvenile glass eels. Photo by Zach Garmoe

LIVING RESOURCES

FAIR | NO TREND

Shifts in the abundance of baygrasses, birds, fish, and shellfish in the Inland Bays are noticeable signs of environmental changes in the Bays. These living resources are useful indicators of shifts in water quality, habitat, and climate.

Since the 2016 State of the Inland Bays report was published, the status of living resources indicators continues to be mixed.

On the positive side, bald eagle and osprey nesting activity in the watershed has rebounded—from the impacts of pesticide pollution—and is increasing. The commencement of commercial shellfish aquaculture in the Bays is benefitting water quality and the local economy. Populations of blue crabs are stable, and several fish species, including bay anchovy, spot, and summer flounder, had good reproductive success during the past five-year period.

The status of other indicators is not good, however. Poor water quality continues to fuel algal blooms in tributaries and canals that deprive the water of oxygen, resulting in a record number of fish kills reported in 2021. While discovery of new, small beds of widgeon grass in Little Asswoman Bay is a good sign, baygrasses remain very rare. Eelgrass—the most ecologically valuable baygrass species—no longer exists in the Bays. Both commercial and recreational fisheries were adversely impacted by the COVID-19 pandemic and economic downturns.

Lack of progress in reducing nutrient pollution to the Bays, combined with impacts of climate change, will present ongoing challenges for many of the estuary's living resources.

VERY POOR SLIGHTLY IMPROVING

BAYGRASSES

Underwater meadows of baygrasses create rich habitats that add oxygen to the water, absorb excess nutrients, store greenhouse gasses like carbon dioxide, anchor sediments, and protect shorelines from erosion. They provide refuge and nurseries for important fish and shellfish. Many migratory waterfowl also depend on them for food.

Thriving baygrasses are a good indicator of water quality, since these plants need relatively clear water with low nutrients to grow and survive.

Eelgrass is one of the most highly valued baygrasses, but it is also the most sensitive to poor water quality and warming waters. In the 1930s, eelgrass declined dramatically due to disease and rising pollution levels. By the mid-1980s, eelgrass and most other baygrass species could not be found in the Inland Bays.

In 2020 and 2021, the Center surveyed all three Bays for baygrass meadows. In total, only 10.7 acres of baygrasses were observed, consisting of two large beds of horned pondweed in upper Love Creek and some small areas of widgeon grass in Little Assawoman Bay.

No eelgrass remains in the Inland Bays. Yet similar coastal bays in Maryland and New Jersey support thousands of acres of eelgrass.

A Baygrass Suitabiity Index was developed that combines data on nutrient concentrations, algae concentrations, and water clarity into an integrated measure of whether conditions are present to support the reestablishment of eelgrass. The index ranges from 0 (water quality much too poor for eelgrass) to 1.0 (water quality likely to support eelgrass when other conditions allow). A map of this index suggests that some areas of the Bays may now have good enough water quality to consider restoration efforts for baygrasses.

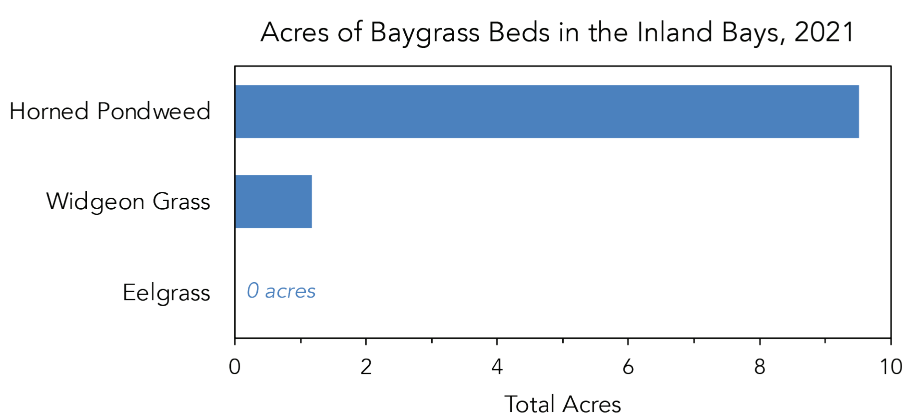
The Center is currently collaborating with state partners to restore widgeon grass to more areas of the estuary using seed collected from existing beds.

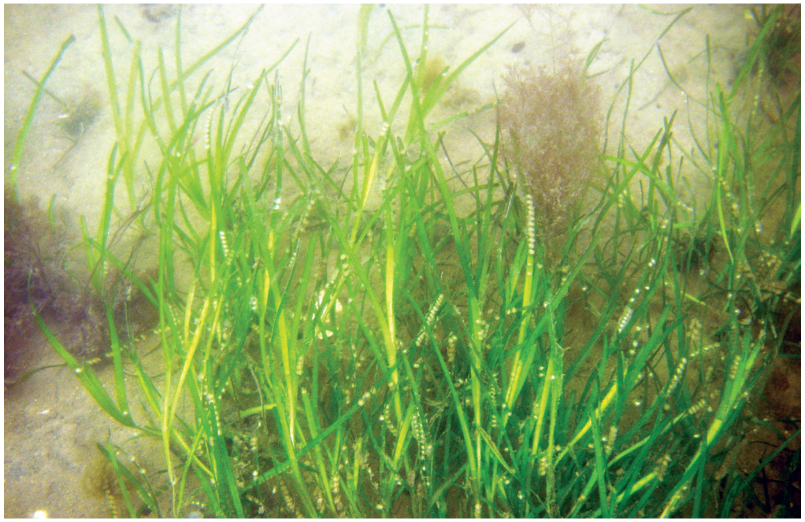
LONG-TERM TREND

Eelgrass in the Bays has remained nearly nonexistent since the mid-1980s. A bed of horned pondweed was discovered in Love Creek in 2010, and it has grown slightly in size.

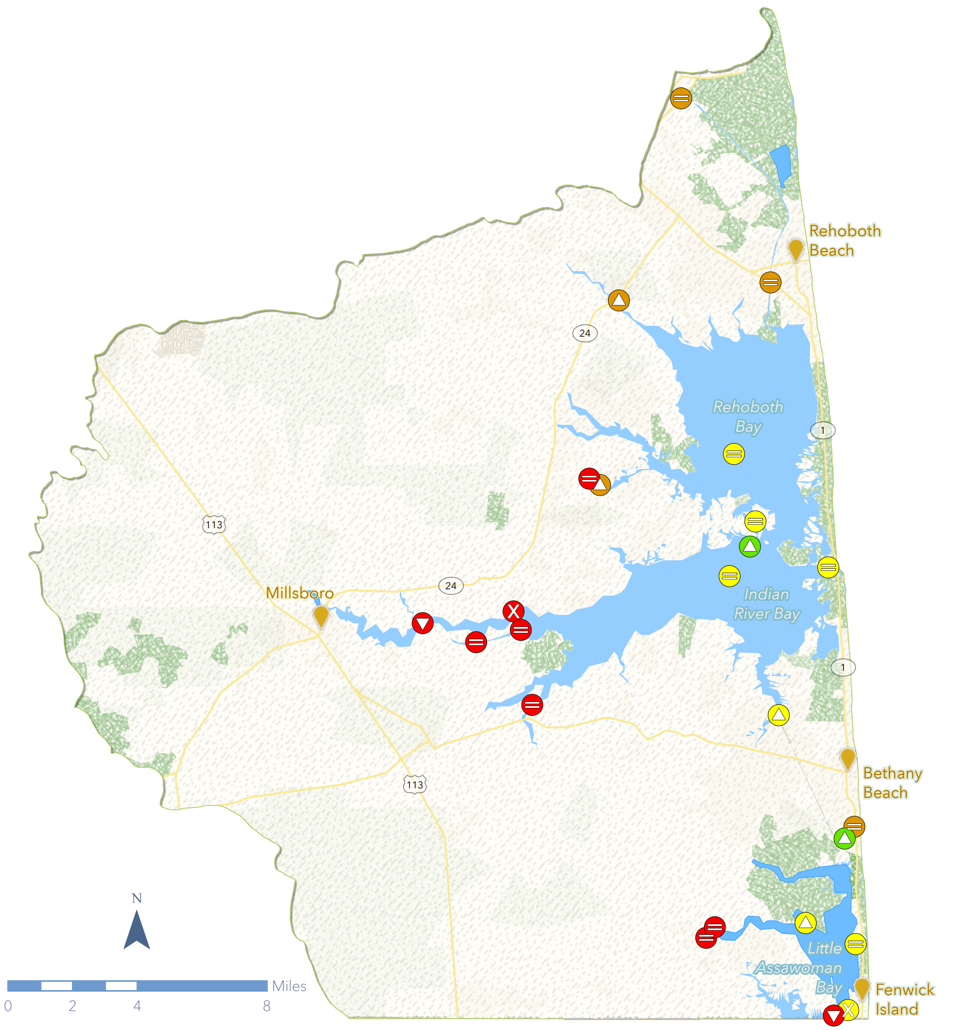
CHANGE SINCE PREVIOUS REPORT

Widgeon grass beds have appeared in recent years in South Bethany's canals and some areas of Little Assawoman Bay, likely due to continued water quality improvements in these locations.





Eelgrass—these no longer exist in the Inland Bays



Baygrass Suitability Index

Results			Trend
Best Water Quality	1.0	*Supports Baygrass Reestablishment*	Improving
Fair Water Quality	0.9 - 1.0	*May Support Reestab. and Growth*	No Trend
Poor Water Quality	0.9 - 0.75	*Does Not Support Reestab. or Growth*	Degrading
Very Poor Water Quality	< 0.75	*Not Even Close*	Insufficient Data

Widgeon grass seed collection in South Bethany, spring 2021.

VERY GOOD IMPROVING

EAGLE AND OSPREY NESTING

Bald eagles and ospreys are good indicators of environmental quality because they are at the top of the food chain. In a process called biomagnification, the birds ingest chemicals that may accumulate in the fish that they eat.

The Department of Natural Resources and Environmental Control (DNREC) estimates bald eagle populations through aerial surveys of nests. The number of eagle nests in the Inland Bays watershed has stabilized at 12 to 14 each year. The most recent survey in 2018 found 14 active nests.

The state also conducted surveys of active osprey nests, but these surveys were discontinued in 2014. To assess the current status of osprey nesting, the Center engaged volunteers in 2021 to survey the watershed for active nests.

A total of 279 active osprey nests were counted in 2021, a significant increase from 2014. These numbers are not directly comparable, however, because different survey methods were used. Nevertheless, numbers of ospreys breeding around the Bays show continuing recovery.

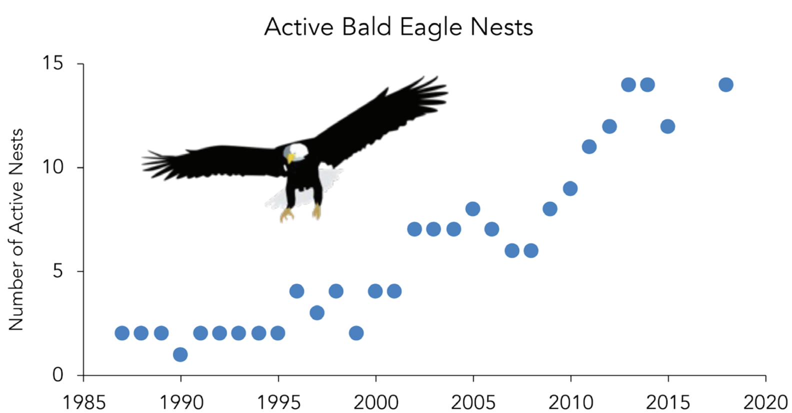
LONG-TERM TREND

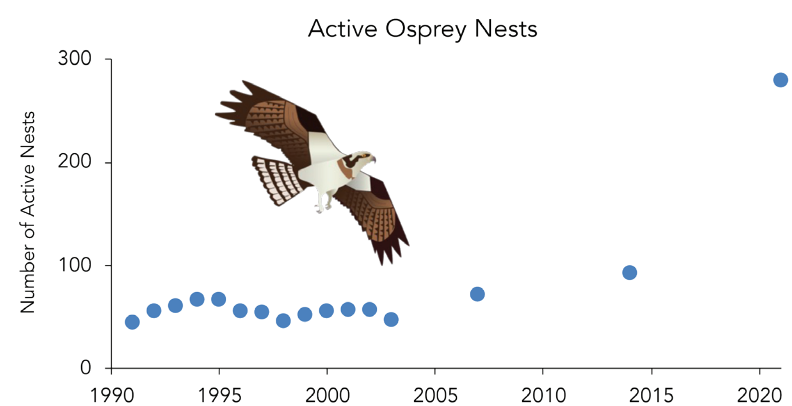
Both species have rebounded significantly following the 1972 ban on the use of DDT pesticides, which caused the collapse of many raptor populations due to thinning eggshells.

Active nests of both bald eagles and ospreys around the Inland Bays have increased over time, with a significant trend upward since the early 2000s.

CHANGE SINCE PREVIOUS REPORT

The number of active bald eagle nests has remained stable. The number of osprey nests in the watershed has continued to increase. Both species now are commonly seen around the Bays.





WINTER WATERFOWL

FAIR

NO TREND

Tens of thousands of wintering ducks, geese, and swans depend upon the Bays' wetlands, waters, and nearby fields for survival. Thus, long-term trends in winter counts are an indicator of the health of these habitats. These seasonal visitors draw birders and hunters that contribute to the local culture and economy.

Waterfowl populations are counted through aerial surveys conducted along the entire Atlantic Flyway in early January. Resource managers use these counts to make informed decisions about habitat management and hunting.

Comparing local counts of three particularly sensitive waterfowl species to counts from the Atlantic Flyway can help us understand the responses of waterfowl to changes in the Bays and surrounding habitats. Hunting pressure, weather patterns, and impacts to habitat found at northern breeding grounds also can influence the numbers of migratory waterfowl found on the Bays in winter.

Since the early 1970s, 29 species of waterfowl have been observed in the Bays during the annual surveys. Over 25,000 individuals of 19 species were counted in 2019. The U.S. Fish and Wildlife Service ceased collection of Atlantic Flyway data after 2016.

Atlantic brant in the Indian River Bay.

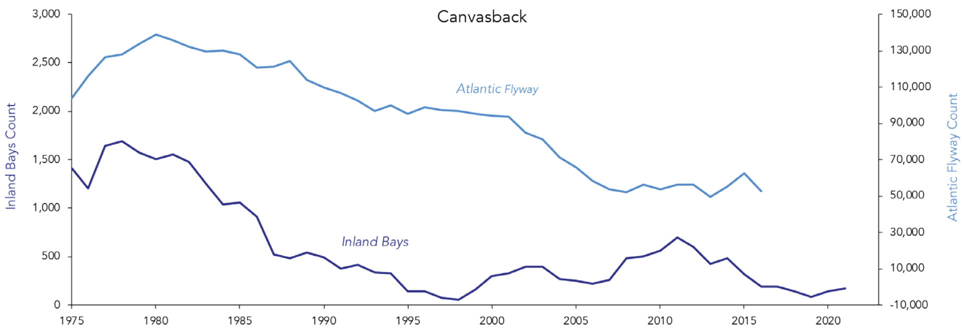



Photo by Linda Steelers

CANVASBACK

Historically, the Bays' marshes and baygrass meadows supported large numbers of wintering canvasback ducks, a species prized by hunters. Despite a brief increase after 2005, canvasback numbers are again very low, in the hundreds. Nearly all of them are found on Silver Lake in Rehoboth Beach.

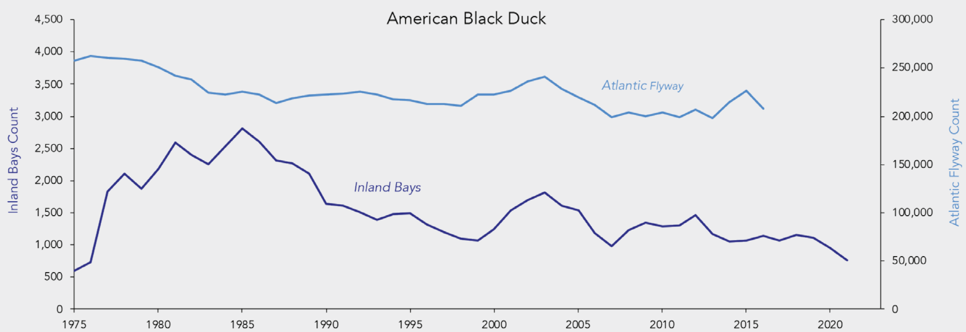



Photo by D. Fletcher

AMERICAN BLACK DUCK

The Inland Bays watershed hosts both year-round and migratory winter populations of American black ducks. Atlantic Flyway numbers decreased sharply beginning in the mid-twentieth century, likely due to loss of marsh habitat, hunting pressure, and interbreeding with mallards. Data suggest that, since 2016, both local and regional wintering populations have stabilized, although numbers remain low.

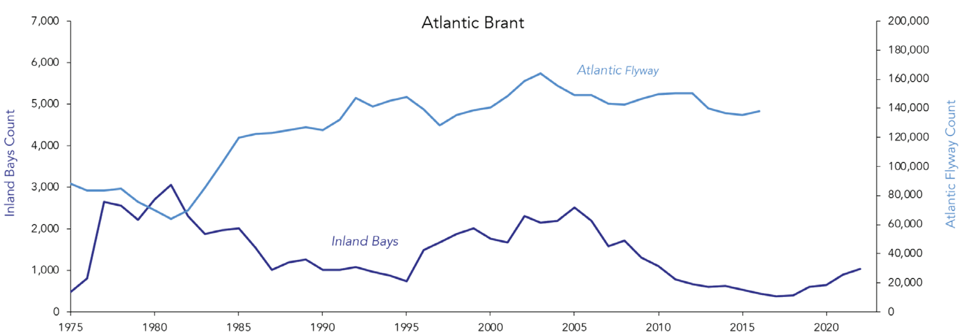



Photo by Pamela Fisher

ATLANTIC BRANT

Atlantic brant winter in coastal environments where eelgrass, a staple of their diet, is plentiful. In the 1930s, a sudden die-off of eelgrass along the Atlantic coast led to a collapse of the brant population. Since then, brant adapted their diets to include other foods, and Atlantic Flyway populations have stabilized. Yet, Inland Bays populations were low and declining. However, there has a been a slight upturn since 2016.

FAIR NO TREND

BLUE CRAB ABUNDANCE

Blue crabs are a summer delicacy in Delaware, and catching them is popular with local residents and vacationers. They also play a key role in the ecology of the Inland Bays as an important link in the food chain. Crabs are scavengers and predators, eating live or dead fish, clams, snails, and aquatic vegetation. In turn, they provide food for birds, fish, and diamondback terrapins.

Populations of crabs in the Bays are highly variable from year to year, partly in response to the severity of winter temperatures. Other factors such as habitat availability, oxygen levels, predation, and harvest pressure also impact populations.

There is no commercial harvest of blue crabs in the Inland Bays.

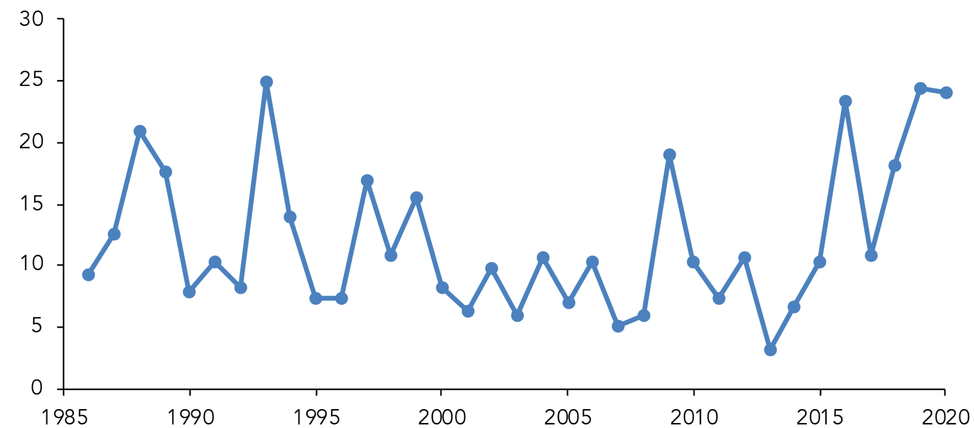
LONG-TERM TREND

From 1986 to the mid-2000s, annual trawl surveys conducted in Rehoboth and Indian River Bays showed a long-term decrease in the average catch of crabs per trawl. Reasons for this decline are uncertain, but numbers have since stabilized, with no overall long-term trend.

CHANGE SINCE PREVIOUS REPORT

Overall abundance of blue crabs in the Bays has been relatively high in recent years, indicating a positive trend for the species. However, numbers of first-year juvenile crabs–particularly in 2019 and 2020–have been low. It is not known how this may affect abundance of adult blue crabs in future years.

Blue Crabs in
Rehoboth and Indian River Bays



Photos by Caitlin Chaney

Did you know?

The scientific name for blue crabs is *Callinectes sapidus*, which means "beautiful savory swimmer."

GOOD TO FAIR NO TREND

FISH ABUNDANCE

The Inland Bays are home to at least 112 species of fish. The shallow waters and wetlands of the Bays provide protection and food, and serve as nurseries for species valued by both recreational anglers and commercial fisheries.

DNREC conducts annual trawl surveys at twelve open water locations on the Inland Bays to assess fish populations. Trends in the number of fish caught may indicate changes in the environment of both the Bays and nearby coastal waters of the Atlantic Ocean. For this report, only numbers of 'young-of-the-year' fish (less than one year old) are used. This provides an indicator of reproductive success each year.

Fish numbers can vary widely from year to year, influenced by variables such as ocean currents, weather patterns, food availability, and land use and habitat changes. Climate change will influence fish populations in the future as Bay waters warm.

Protection of wetlands and shorezone habitat in the Bays is critical to maintaining healthy populations of species that use these areas.

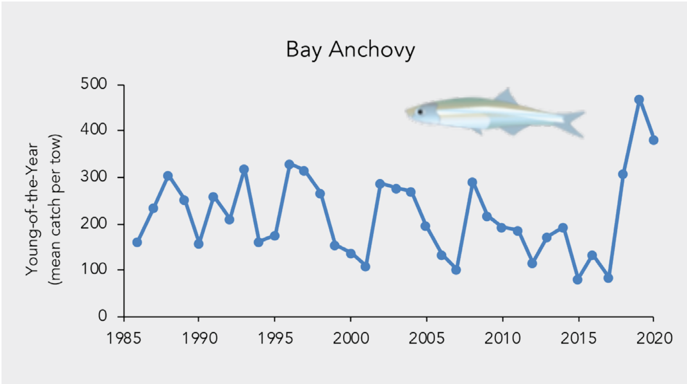
LONG-TERM TREND

Large year-to-year differences in the abundances of many species are common. Bay anchovy numbers have declined significantly over the past 30 years. The numbers of other indicator fish species have remained fairly stable in the Bays.

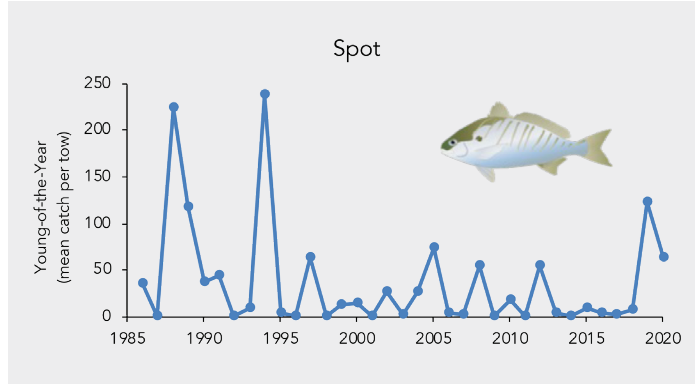
CHANGE SINCE LAST REPORT

Bay anchovy, spot, and summer flounder had strong peaks of reproductive success between 2016 and 2020.

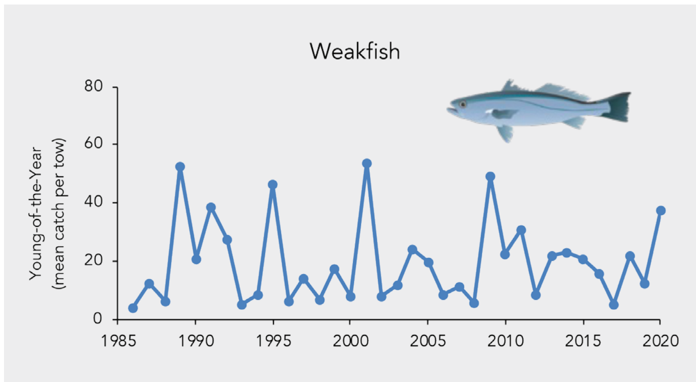
Center staff and volunteers conduct a Shorezone Fish & Blue Crab survey, spring 2022.



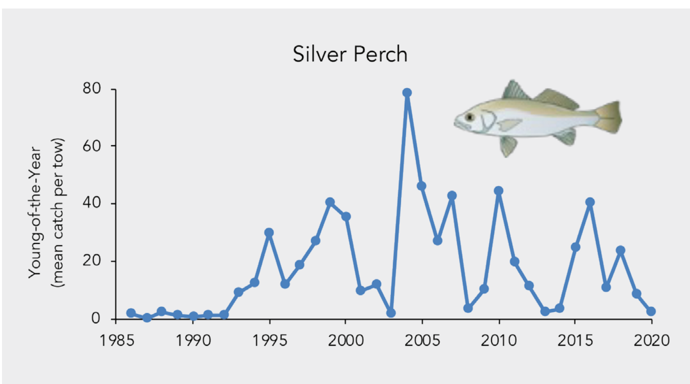
Bay anchovy are the most plentiful fish caught in the trawl survey. Using the Bays to grow and feed from spring through fall, this silvery forage fish is a critical link in the food chain between plankton and bigger fish. Bay anchovy had been declining slightly over the long-term, but numbers of young fish were higher than normal the past few years.



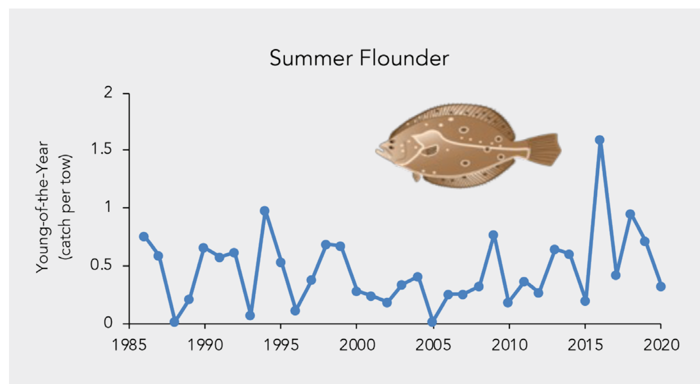
Used for both bait and food, spot are an important species in the Inland Bays. Because the Bays are at the northern range of this species' distribution, the population here is subject to large fluctuations influenced by the currents and weather of a particular year.



Weakfish spawn in and near the Bays. Juveniles concentrate in tidal creeks where they feed and then migrate offshore in the fall. Formerly plentiful, weakfish populations dramatically decreased in the late 1980's and early 1990's. Numbers in the Inland Bays are low but stable.



Silver perch are a lesser known fish that have increased in abundance since the 1990s. In spring and summer, they spawn in the Bays where the young grow from two to six inches before migrating offshore in late fall.



Summer flounder support a significant recreational fishery in the Inland Bays, annually ranking among the top five in recreational landings. Young fish feed in the shorezone and move into the deeper waters of the estuary as they grow. Higher than average numbers of juvenile fish were noted in 2016 and 2018.

FAIR DEGRADING

SHOREZONE FISH

Since 2011, the Center has conducted a volunteer-led survey of fish and blue crab populations in the shallow waters near shorelines. These productive areas are important nurseries for the young of many fish species. The small fish and crabs that live in the shorezone also are a critical food source for larger fish that inhabit the Bays.

The Inland Bays shorezone is dominated by four species: Atlantic silverside, mummichog, striped killifish, and sheepshead minnow.

The composition of fish communities in the shorezone can be an indicator of both water quality and habitat quality. Menhaden, bay anchovy, and spot, for example, are sensitive to low oxygen resulting from nutrient pollution. Striped killifish, mummichog, and sheepshead minnow have a higher tolerance for low oxygen levels.

Did you know?

Over the past ten years, volunteers have counted 81 species and nearly 500,000 individual fish and blue crabs in the Center's shorezone survey!

LONG-TERM TREND

Decreases in populations of mummichog and sheepshead minnow have been observed over the past nine years. The reasons for this decline are not clear. Deterioration of salt marshes and hardening of shorelines with development may play a role.

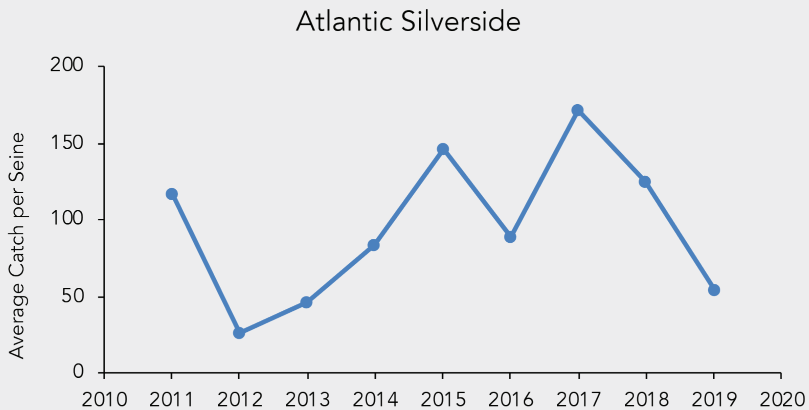
CHANGE SINCE PREVIOUS REPORT

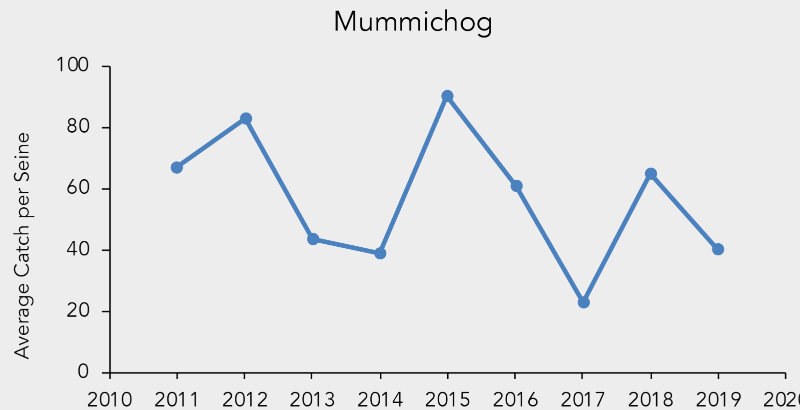
Overall numbers of fish caught were down in 2019. No surveys were conducted in 2020 because of the COVID-19 pandemic, so it is unclear whether this represents a trend.

Silver perch. Photo by Caitlin Chaney

Striped killifish. Photo by Caitlin Chaney

Photo by Robert Bachand





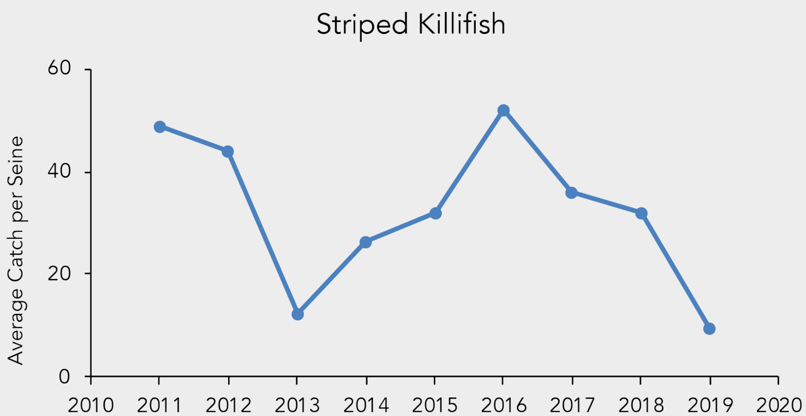


Photo by Robert Bachand

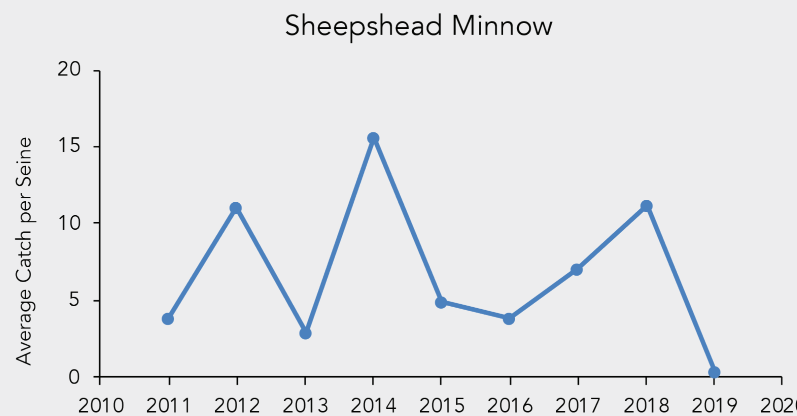


Photo by Robert Bachand

POOR NO TREND

RECREATIONAL FISHING

The Bays and their tributaries offer many opportunities for recreational fishing. A recent study found that outdoor recreation, including boating and fishing, contributes over $200 million to the local economy each year and supports more than 2,300 jobs.

Angler surveys are used to estimate the total catch of fish from the Inland Bays. These surveys indicate trends in recreational fishing, the abundance of adult fish, and perhaps skill of the anglers.

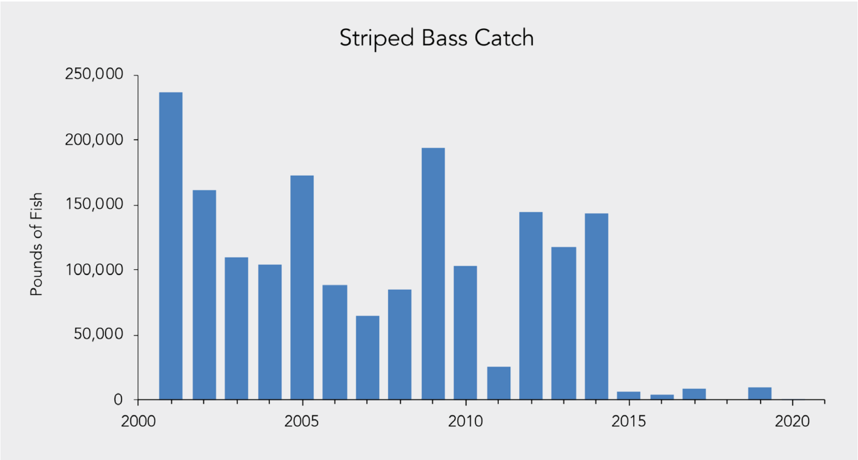
Economic conditions affecting personal income and leisure time influence recreational fishing. Fish population changes and potential shifts in species distributions with climate change also have an influence on catches.

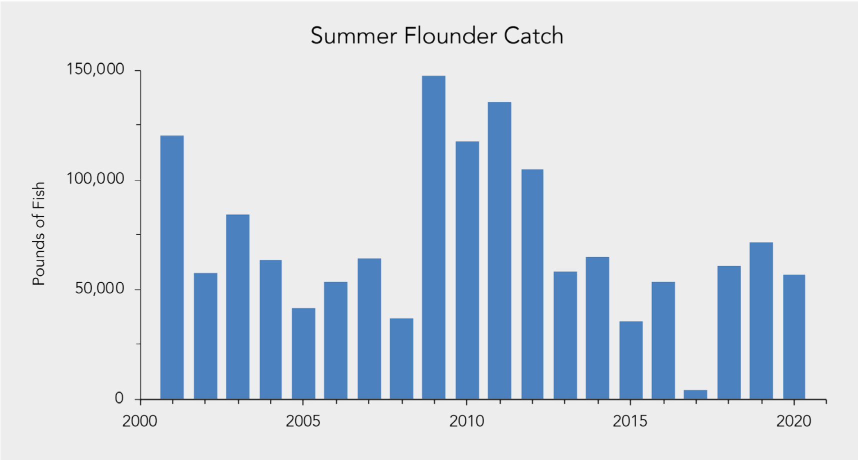
LONG-TERM TREND

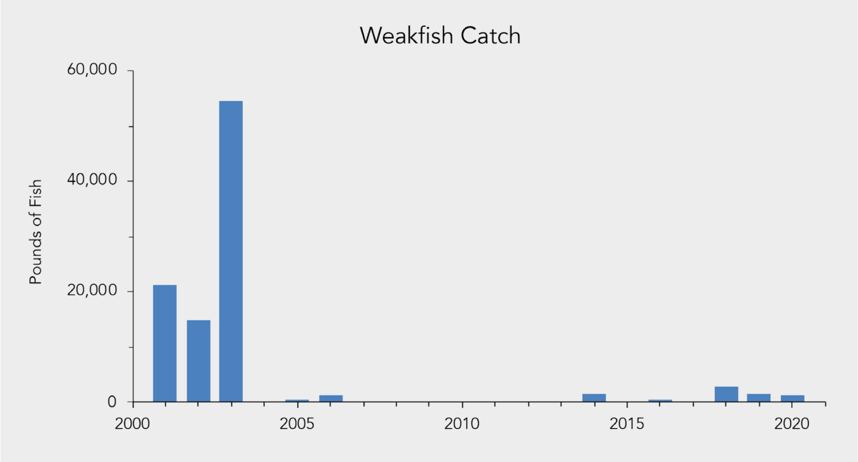
Fishing trips in the Bays increased through the 1990s and into the early 2000s, but then declined back to mid-1990s levels by 2015. Catches of recreationally important fish generally reflect this decline. Harvest of weakfish has been minimal since 2004.

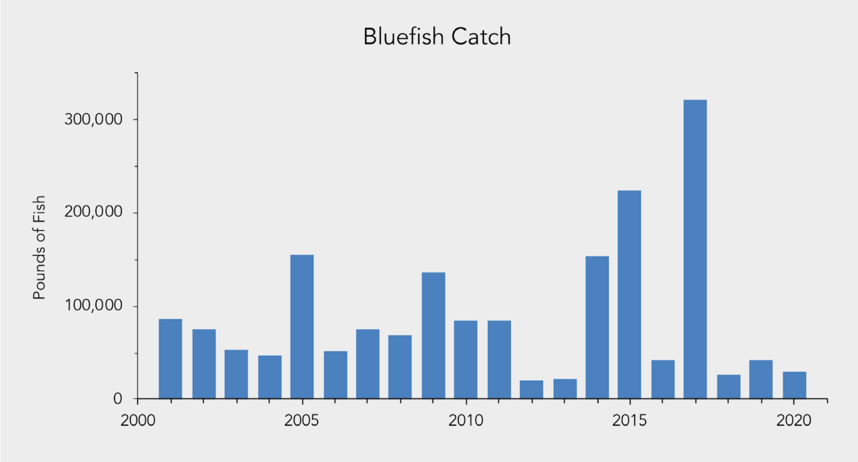
CHANGE SINCE PREVIOUS REPORT

No recent data are available on numbers of fishing trips in the Bays. A major decline in striped bass catch has continued since 2015. No short-term trends in catch of other species were observed.


Striped Bass Catch
Pounds of Fish
250,000
200,000
150,000
100,000
50,000
0
2000
2005
2010
2015
2020


Summer Flounder Catch
Pounds of Fish
150,000
100,000
50,000
0
2000
2005
2010
2015
2020


Weakfish Catch
Pounds of Fish
60,000
40,000
20,000
0
2000
2005
2010
2015
2020


Bluefish Catch
Pounds of Fish
300,000
200,000
100,000
0
2000
2005
2010
2015
2020

POOR NO TREND

HARD CLAM LANDINGS

Hard clams are harvested in the Inland Bays by both commercial and recreational clammers.

Commercial landings of hard clams from Rehoboth and Indian River Bays peaked at nearly 18 million in the mid-1950s, when disease began decimating the oyster industry. The fishery has since declined steadily. Current harvest is well under a million clams per year.

Clams improve water clarity by filtering suspended particles from the water. Bay bottoms composed of shell or mud support the highest densities of hard clams.

LONG-TERM TREND

The decline in commercial harvest reflects combined effects of historic over-harvesting, closure of harvest areas, changes in clamming equipment used, and declining numbers of commercial clammers. The number of active commercial harvesters in the Inland Bays decreased from 60 in 2000 to only 13 in 2019.

A 2011 study found that clam densities in the Bays had remained stable since 1976, with Rehoboth Bay showing the highest densities. In addition, the number of clams harvested per day by each commercial clammer has also remained fairly stable.

CHANGE SINCE PREVIOUS REPORT

The number of clams harvested commercially has continued to decline over the past five years, from nearly a million in 2019 to less than 330,000 in 2020. This is not an indicator of hard clam population in the Bays, but instead reflects the health of the fishery, which continues to lose clammers annually.

Annual Commercial Hard Clam Landings in the Inland Bays

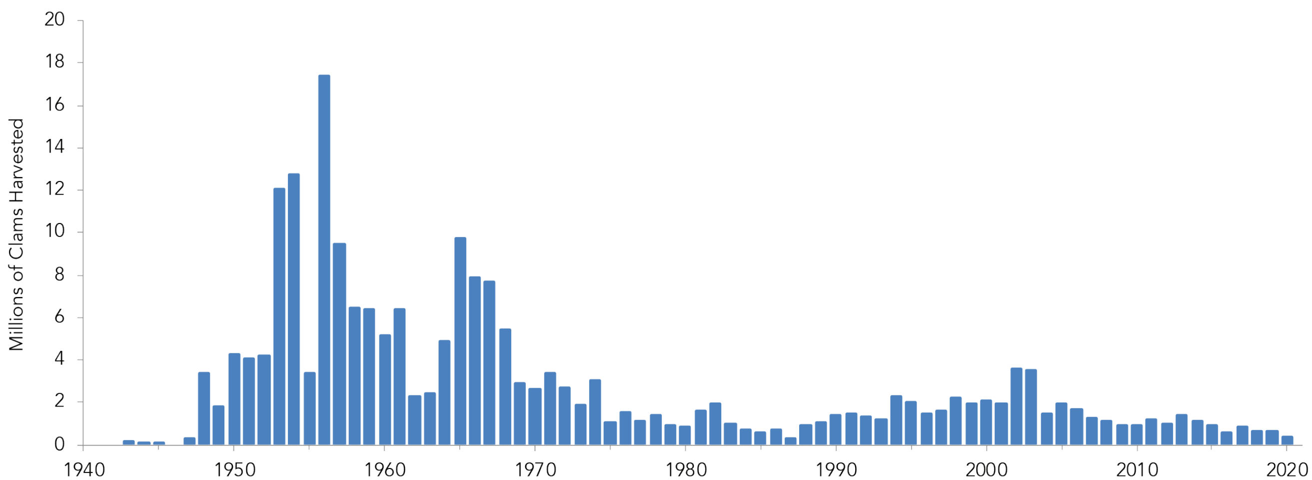


Photo by Ken Sigvardson

Did you know?

Hard clams are popularly known as quahogs, little necks, cherrystones or chowder clams. The different names are based on clam size.

SHELLFISH FARMING

FAIR

IMPROVING

Thriving populations of native oysters and clams are critical for restoring and maintaining good water quality and healthy ecosystems in the Bays. Farmed oysters filter nitrogen and phosphorus from the water at rates comparable to wild shellfish, and a portion of these nutrients are completely removed from the Bays when they are harvested.

Recognition of both the environmental and economic benefits of shellfish aquaculture led to passage of legislation in 2013 that allows shellfish farming in the Inland Bays. The first aquaculture leases were issued in December 2017. Oyster farming is allowed in all three Bays. Clams may only be grown in Little Assawoman Bay.

The taste of Inland Bays oysters is highly valued, and demand for them is expected to grow. This is good news for water quality in the Bays. The Center has conservatively estimated that if all available leased acres were actively farmed, over 5,000 pounds of polluting nitrogen and phosphorus would be removed from bay waters annually.

TREND

The Inland Bays shellfish farming industry was heavily impacted by the COVID-19 pandemic. Growth has been slow, but oyster production is slowly increasing. In 2021, ten growers harvested and sold over 400,000 oysters. Clam farming in Little Assawoman Bay has yet to take hold.

Year	Total Growers	Total Acres Leased		Number of Shellfish Harvested	
		Oysters	Clams	Oysters	Clams
2019	10	43	5	111,652	0
2020	13	37	5	184,033	0
2021	10	22	0	431,589	0

Photo by Caitlin Chaney

Photo by Caitlin Chaney

FAIR NO TREND

HORSESHOE CRAB SPAWNING

Every year in May and June, on the nights around the full and new moons, tens of thousands of horseshoe crabs gather on Inland Bays shores to mate and lay their eggs in the sand. These ancient animals play a key ecological role in coastal bays. The billions of green eggs deposited on bay beaches each spring provide a critical food and energy source for migrating shorebirds and also support many resident birds such as the large colonies of laughing gulls that nest in Rehoboth Bay, and many species of crabs and fish.

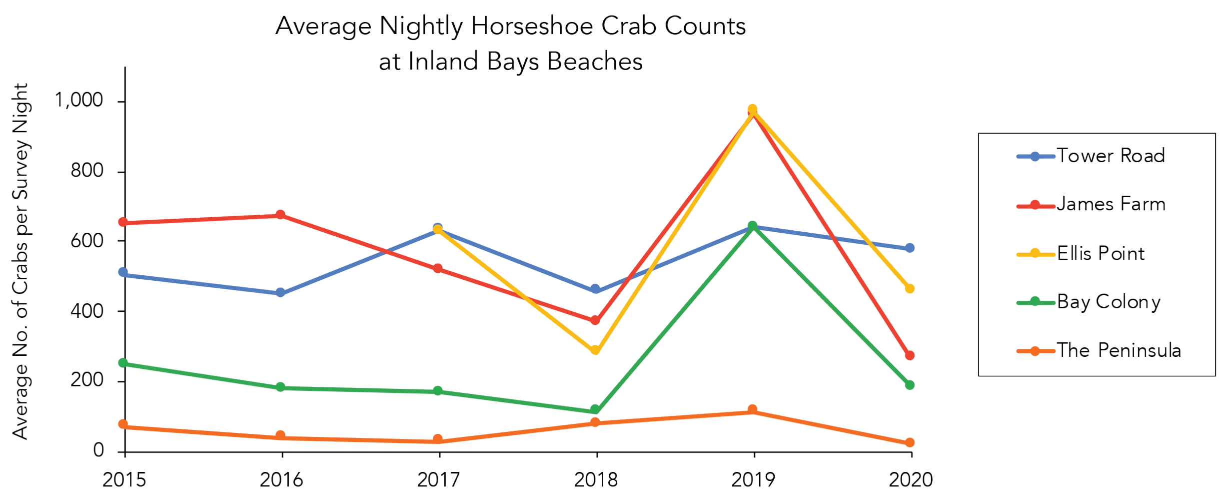
Horseshoe crabs also have considerable economic importance. They are harvested commercially as bait for whelk and eels. Their unique blue blood also contains a substance that is used to test drugs and medical equipment for the presence of harmful bacteria.

Each year close to 200 volunteer citizen scientists conduct surveys of spawning horseshoe crabs at sites around the Inland Bays. The Center also partners with the U.S. Fish and Wildlife Service on a tagging program, which has shown that Inland Bays horseshoe crabs are an important component of a larger regional Delaware Bay population, with spawning densities comparable to those on Delaware Bay beaches.

Overharvesting of horseshoe crabs resulted in a 90% decline in the Atlantic Coast population since the early 1990's. In 1998, an interstate management plan was created. Due to harvest restrictions, the population has stabilized but has shown no signs of growth.

TREND

Horseshoe crab spawning is a new indicator for the Bays. Data collected since 2015 show that population levels have neither declined nor increased. However, the numbers of crabs using the Inland Bays are still far below what they were years ago. This has major implications for migratory shorebirds and other species that depend upon healthy populations of horseshoe crabs to survive.



POOR DEGRADING

NUMBER OF FISH KILLS

Fish kills are an indicator of stress in the bay environment, usually caused by a combination of nutrient pollution and weather conditions. Excess nutrients in the water stimulate algal blooms that can cause oxygen levels to drop low enough to kill fish. Disease sometimes also plays a role.

Most fish kills happen in mid- to late summer when there are abundant algae, high temperatures, low oxygen, and high numbers of fish. The majority of fish killed in the Bays are Atlantic menhaden, which feed in large schools where algae is plentiful.

Roughly 58% of reported fish kills have occurred in tidal creeks and rivers, 38%% in residential canals and lagoons, and 4% in open waters of the Bays. Fish kills in poorly-flushed residential canals typically impact larger numbers of fish, sometimes in the hundreds of thousands to millions. Many smaller fish kills may go unreported.

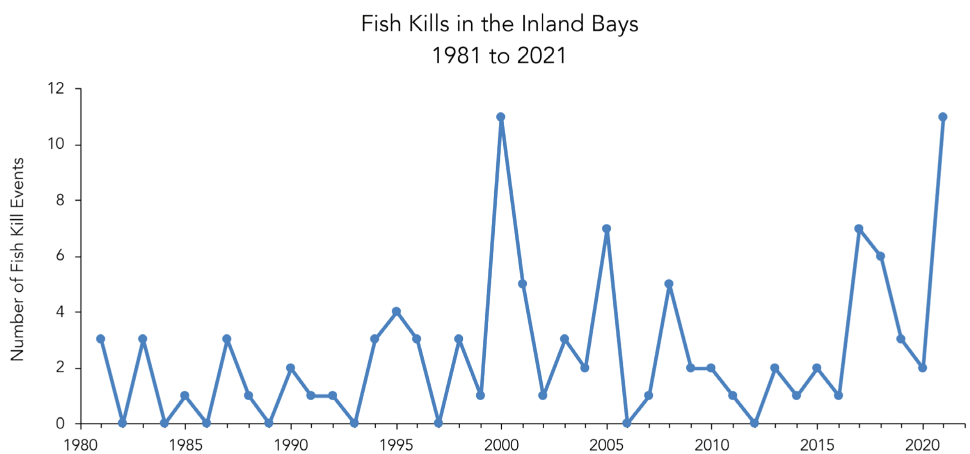
Lack of progress in reducing nonpoint sources of nutrient pollution to the Bays, combined with warming bay waters due to climate change, may lead to more fish kills in future years.

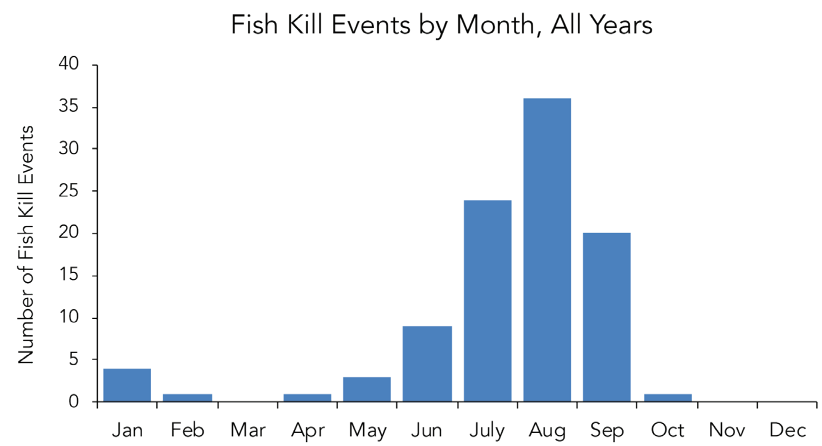
LONG-TERM TREND

The number of fish kills investigated by the Delaware Department of Natural Resources and Environmental Control varies greatly from year to year. A peak occurred in 2000, when more than 5,000,000 Atlantic menhaden were reported killed.

CHANGE SINCE PREVIOUS REPORT

The number of fish kills reported in the Bays increased during the past five years. In 2021, over 1.8 million Atlantic menhaden and gizzard shad were reported dead in eleven events.





Fish kill event in a canal off of Rehoboth Bay, June 2021

Photo by Driscoll Drones

HUMAN HEALTH RISKS

FAIR | NO TREND

Water recreation, including catching and eating fresh seafood, draws residents and visitors alike to the Inland Bays. It also drives much of the local economy. However, water quality conditions in many areas of the Inland Bays may pose a health risk.

Pathogens—bacteria, viruses, and parasites that cause illness—can enter water from many sources, including waste from wildlife, humans, and domestic animals. Exposure to these pathogens through water contact or consumption of contaminated raw shellfish has the potential to cause acute gastrointestinal illness or infect open wounds.

Many areas of the Bays are generally safe for water activities with low risk of immersion, such as boating or wading. However, risk of infections is greater in upper tributaries and poorly flushed canals, which regularly fail to meet the bacteria standard for primary contact activities such as swimming. Overall, slightly fewer monitoring stations met this standard than in 2016.

Currently, 61% of the Inland Bays are approved for shellfishing year-round. An additional 6.5% are approved for shellfish harvesting only from December to April. This has not changed in the last five years.

Chemical pollutants from a variety of industrial, urban, and agricultural sources can also enter surface waters, where they may accumulate in fish. Mercury and polychlorinated biphenyls (PCB's) have been identified as 'contaminants of concern' present in migratory bluefish and striped bass caught in the Inland Bays, though the chemicals likely are picked up elsewhere. Both species continue under consumption advisories.

Pollutants of 'emerging concern,' such as microplastics and per-and polyfluoroalkyl substances (PFAS), require future study to understand impacts to the Bays, aquatic life, and human health.

FAIR SLIGHTLY DEGRADING

BACTERIA POLLUTION

Most bacteria in the Bays are harmless to humans. However, disease-causing bacteria, viruses, and parasites (pathogens) may be introduced to bay waters by pollution, especially from human or animal feces. Some bacteria that live naturally in the Bays may, in rare cases, cause infection, particularly in people with compromised immune systems.

Bacteria of the genus *Enterococcus* are used as indicators of fecal contamination because they are found in the intestinal tracts of warm-blooded animals. High numbers of *Enterococcus* bacteria in water indicate that pathogens might also be present and pose a health risk to people coming into direct contact with the water.

Bay waters are tested regularly for levels of *Enterococcus*. The concentrations measured are compared to recreational water quality standards set by the U.S. Environmental Protection Agency. Two different standards are set based on level of exposure—"primary contact" or "secondary contact." Primary contact refers to activities likely to result in full immersion, such as swimming, diving, or water skiing. Secondary contact contact activities are less likely to result in immersion. Examples include boating, kayaking, and wading.

Summer samples collected from 2016 to 2020 show that many areas of the Bays meet the standard for secondary contact, meaning that risk from harmful bacteria is low while boating or wading. Well-flushed, open bay areas also typically are low-risk for primary contact activities.

However, most tributaries and residential canals fail to meet the standard for primary contact. Upper reaches of tributaries frequently fail to meet secondary contact standards as well. Risk of infection while swimming is higher in these areas.

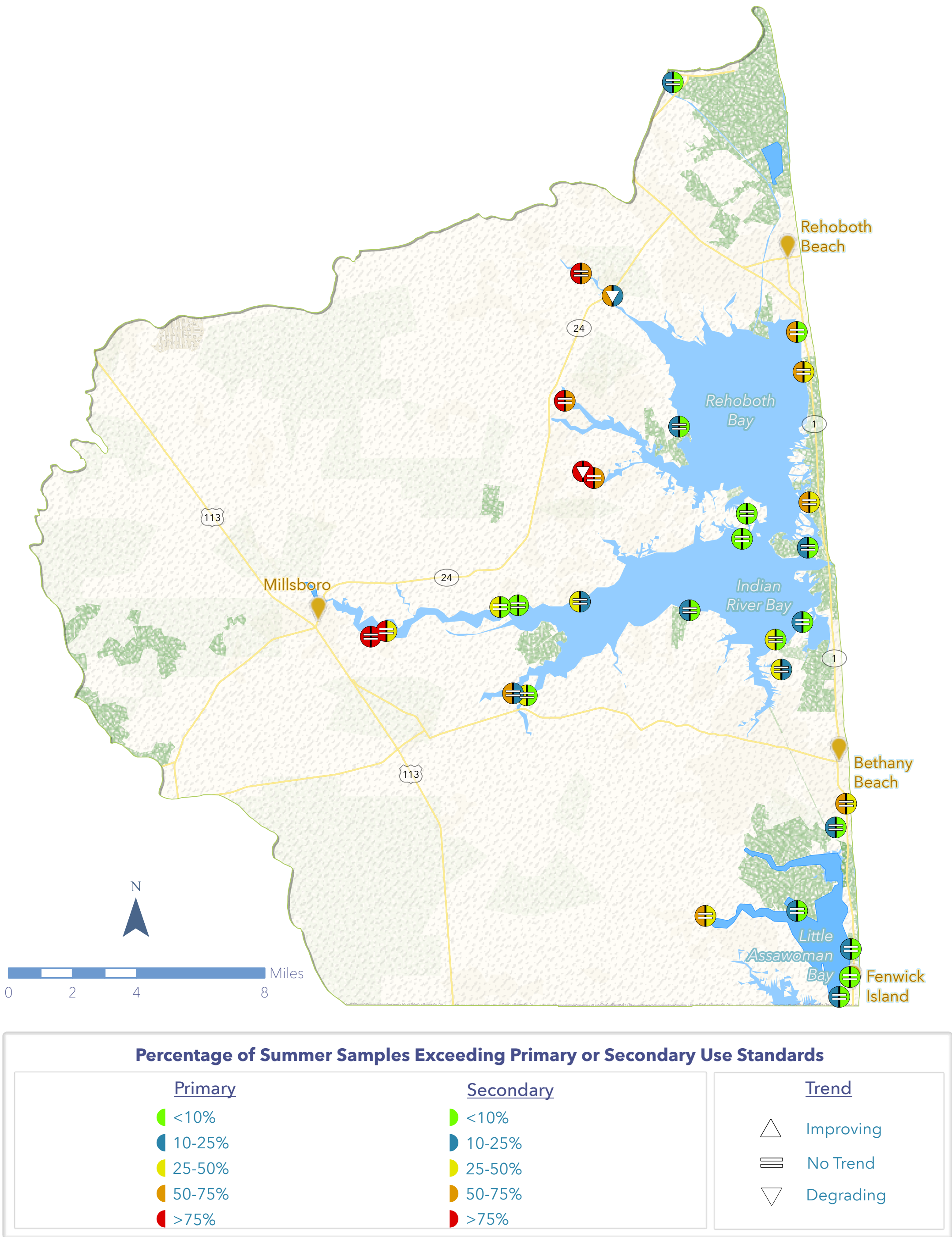
In the Inland Bays, fecal contamination of water often comes from birds and other wildlife, rather than human sources. While wildlife sources are lower risk, routine monitoring cannot distinguish between them.

LONG-TERM TREND

Of the twelve stations that have long-term data, two (in Guinea Creek and Love Creek) have had significantly increasing bacteria levels over time. Other areas show no trend.

CHANGE SINCE PREVIOUS REPORT

On average, fewer locations met the primary contact standard than reported in 2015.



WHAT ABOUT VIBRIO BACTERIA?

Bacteria in the genus *Vibrio* occur naturally in estuaries and usually are harmless to humans. A small percentage, however, can cause serious food-borne illness or wound infections.

The species *Vibrio vulnificus* is responsible for 95% of U.S. seafood-borne fatalities. It is also associated with very rare, but life-threatening, infections when cuts or sores are exposed to water containing the bacteria.

The presence of this bacteria species is not related to fecal pollution. It tends to be found in higher concentrations from April through October when bay waters are warm and algal blooms are common.

Most healthy people are not at risk from *Vibrio* infection. Most at risk are people with compromised immune systems, liver disorders, and other chronic conditions.

To reduce risk of infection, cook seafood well, and avoid exposing open wounds to bay water.

FAIR NO TREND

APPROVED SHELLFISH HARVEST AREAS

Clams, oysters, and mussels are filter-feeders and can accumulate bacteria, viruses, and other pollutants as they feed. The risk of illness from consuming contaminated shellfish is much greater than from other seafood because shellfish are often eaten raw.

The Delaware Department of Natural Resources and Environmental Control (DNREC) designates areas of the Bays approved for shellfishing, based primarily on proximity to potential pollution sources such as wastewater discharges and marinas. Unusual events that pose risk, such as pollution spills, may result in temporary closures.

In 2021, the harvest of shellfish was prohibited in 32% of the Inland Bays. An additional 7% of total waterways were approved for harvest only seasonally (December 1st to April 15th).

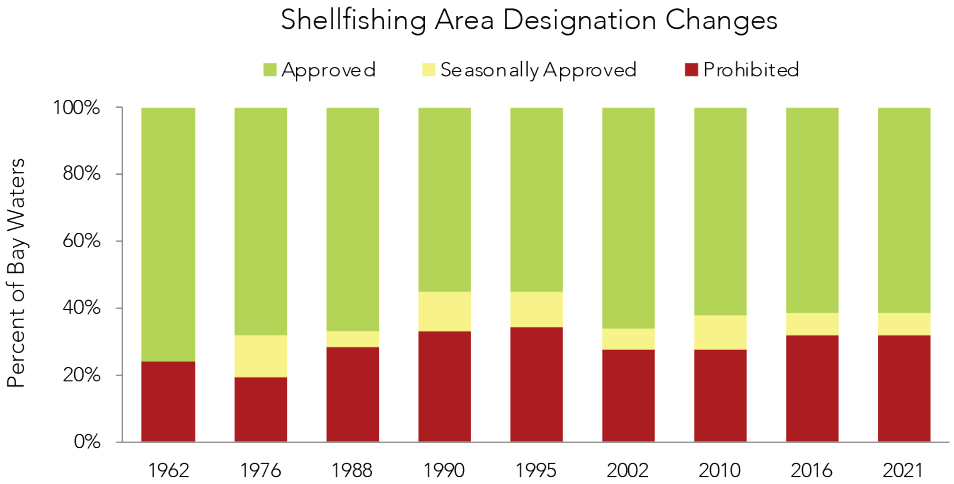
LONG-TERM TREND

Construction of marinas and elevated bacteria concentrations led to an increase in prohibited and seasonally-approved areas between 1960 and 1990. Some previously prohibited areas were reopened in the early 2000s; small changes have been made since then.

CHANGE SINCE PREVIOUS REPORT

No changes in designation have been made since 2016.

In late December 2021, a sewage spill resulted in a 21-day emergency closure of Rehoboth Bay to shellfish harvest. Oyster farmers with leases in the Bay were unable to sell their product during the busy holiday season.



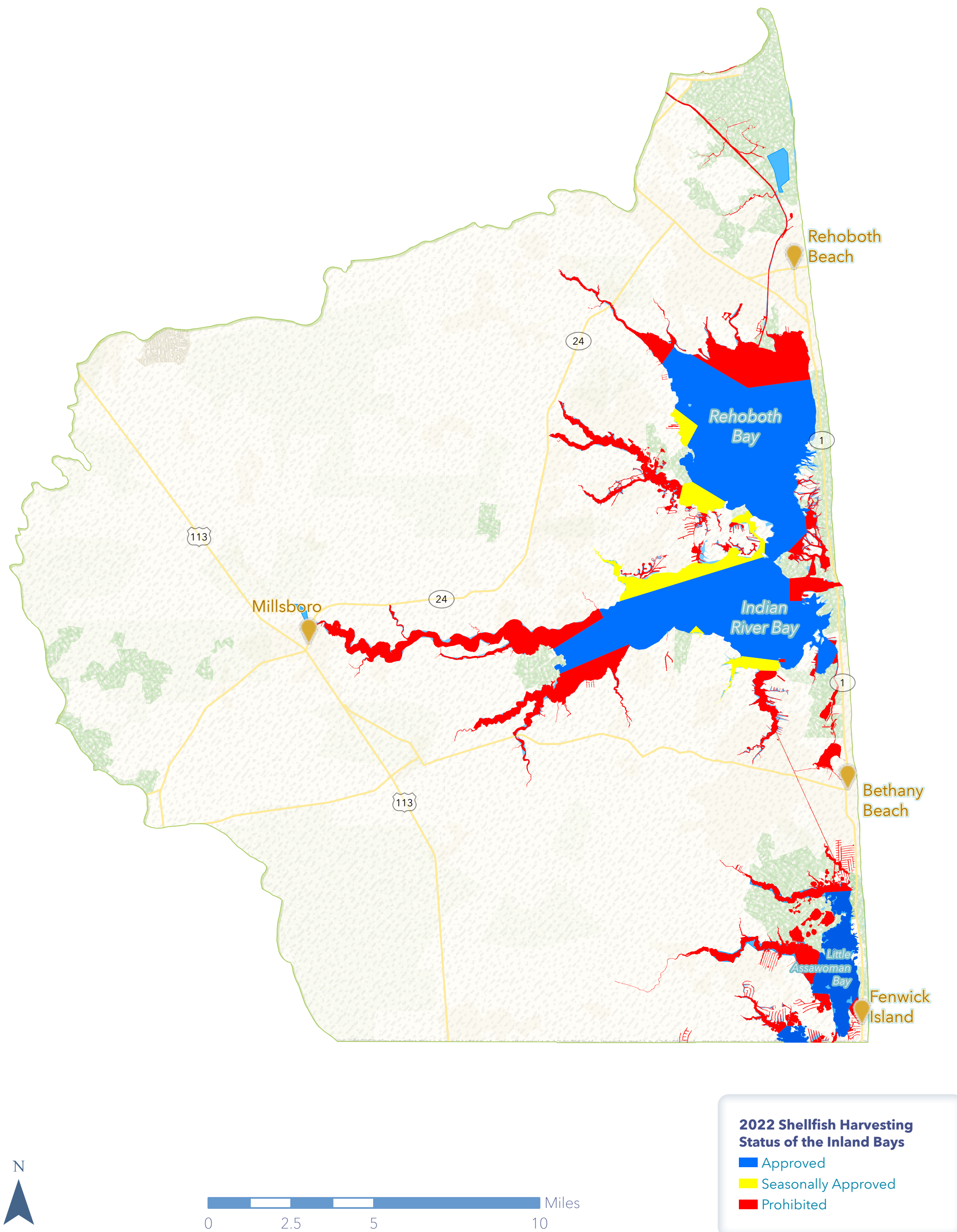


Photo by Ken Sigvardson

CLAMMING

Clamming is a popular recreational activity in the Bays. It is important to be certain of where shellfishing is allowed to minimize risk of food-borne illness from shellfish consumption.

Visit de.gov/shellfish for information on current closures and shellfish safety tips.

FAIR | NO TREND

FISH CONSUMPTION ADVISORIES

Consumption advisories are in effect for bluefish and striped bass caught in the Inland Bays due to elevated concentrations of polychlorinated biphenyls (PCBs) and mercury. An advisory is a recommendation to limit consumption to specified quantities, species, and sizes of fish to minimize the risk from contaminants.

These migratory fish generally pick up the pollutants in areas other than the Inland Bays.

PCBs are organic chemicals now banned from manufacture, but they still persist in the environment. Mercury continues to enter the environment from many sources, including the burning of fossil fuels. Their accumulation in fish depends on the species, size, age, and feeding area of the fish. Both contaminants have negative effects on the health of people including neurological and developmental disorders.

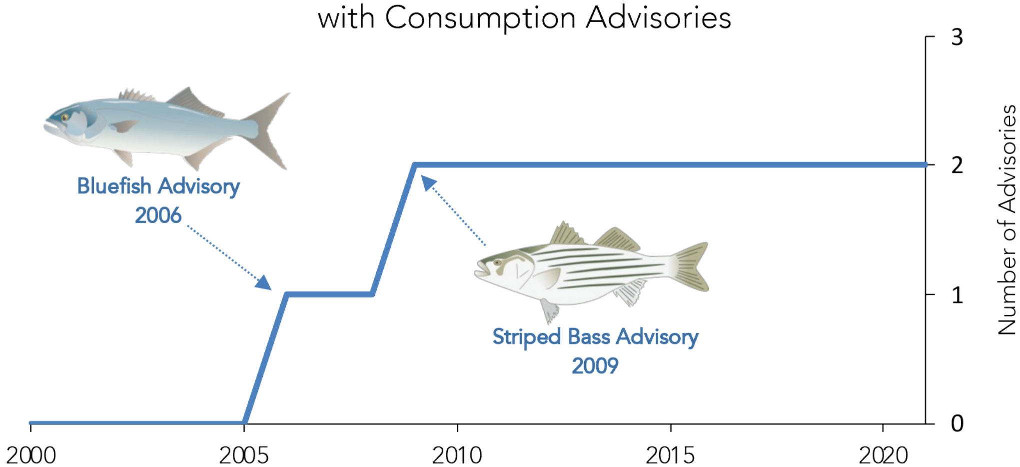
LONG-TERM TREND

Consumption advisories were first issued for bluefish beginning in 2007 and for striped bass in 2009.

CHANGE SINCE PREVIOUS REPORT

Some statewide advisories were lifted in 2018 due to declining PCB and mercury levels. However, both bluefish and striped bass remain under advisory in the Inland Bays.

Number of Inland Bays Fish Species with Consumption Advisories



POLLUTANTS OF EMERGING CONCERN

There is growing awareness that a variety of chemicals—including pharmaceuticals, personal care and household cleaning products, microplastics, and others—end up in our waterways and may harm aquatic life. Humans may be at risk as well if these pollutants end up in drinking water.

A group of substances known as per-and polyfluoroalkyl substances (or PFAS), are of particular concern. PFAS have been used in manufacturing, firefighting foams, food packaging, and other consumer products for many decades. Because they do not readily break down and can bioaccumulate in the environment, they are often referred to as "forever chemicals." Studies have shown that PFAS can be found in the majority of Americans' blood, and exposure to these substances can cause serious health effects.

The extent of contamination in Delaware waterways is not yet known. DNREC is monitoring PFAS in drinking water systems and surface waters in the state. DNREC scientists also sample fish and shellfish tissues to determine if future consumption advisories are needed.

Photo by Chris Bason

Photo by Driscoll Drones

CLIMATE

POOR | DEGRADING

Increasing concentrations of greenhouse gasses in the atmosphere are bringing significant changes to our weather and climate. Sea levels are rising at an accelerated rate. The past decade was the hottest on record in southern Delaware. Heavy rainfall associated with severe storms is becoming more frequent.

As the lowest-lying coastal state, Delaware (and in particular Sussex County) is particularly vulnerable to these changes. Rapid development and population growth puts people and infrastructure at risk from flooding and other damage from coastal storms. Agriculture and drinking water supplies are threatened by saltier groundwater.

The Inland Bays also are changing in response to climate change. Tidal wetlands are degrading due to sea-level rise and erosion. Rising temperatures mean that the growing season will continue to lengthen and the Bays will be warmer for a longer period each year. The timing and degree to which migratory fish and birds use the estuary is changing; species of plants and animals may shift in favor of those that prefer or tolerate warmer weather. More rainfall and runoff could increase the transport of nutrients to the Bays, which can lead to conditions that create oxygen-depleting algal blooms.

Delaware is taking steps to address the causes and consequences of climate change. An updated *Climate Action Plan* focuses on strategies for reducing greenhouse gas emissions and preparing communities for the climate change impacts. The Center and its partners also are engaged in actions to mitigate and adapt to the impacts of warming climate and rising seas on the Bays and their watershed.

POOR DEGRADING

CARBON DIOXIDE CONCENTRATION

Greenhouse gasses act like a blanket around the earth, trapping heat in the atmosphere. Carbon dioxide, an abundant and powerful greenhouse gas, is produced from burning fossil fuels, deforestation, and agriculture. Its concentration in the atmosphere is a good indicator of global climate change.

Global atmospheric carbon dioxide is measured at Hawaii's Mauna Loa Observatory, located in a remote area far from industry and urban traffic. Levels increased from 315 parts per million (ppm) in the late 1950s to 418 ppm in 2021. Carbon dioxide in the atmosphere is now more than 50% higher than pre-industrial levels.

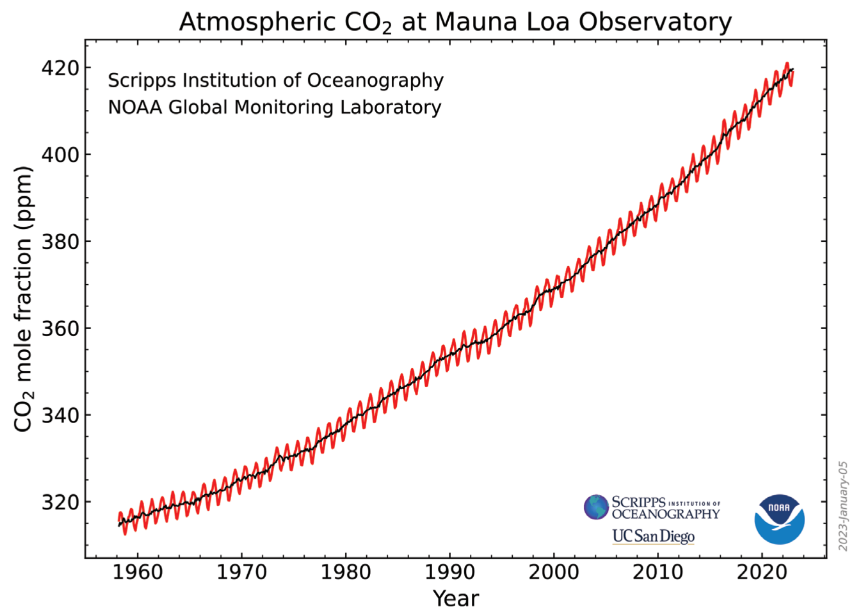
Global greenhouse gas emissions will continue to increase in the future unless actions are taken to reverse the trend.

LONG-TERM TREND

Average concentration of carbon dioxide in the atmosphere has risen 101 ppm (32%) since 1960. Furthermore, the rate of increase is accelerating.

CHANGE SINCE PREVIOUS REPORT

Global atmospheric carbon dioxide levels continue to increase, rising 16 ppm (4%) between 2016 and 2021.



Monthly average atmospheric carbon dioxide measurements.
Credit: National Oceanic and Atmospheric Administration (gml.noaa.gov)

Just one typical passenger vehicle emits 4.6 metric tons of carbon dioxide every year. Automobiles also emit smaller amounts of methane, nitrous oxide, and hydrofluorocarbons.

Clean, renewable forms of energy, like wind and solar power, can help reduce greenhouse gas emissions to levels that will avoid the worst impacts of climate change. Photo (left) courtesy University of Delaware

SEA LEVEL RISE

POOR

DEGRADING

Excess greenhouse gasses in the atmosphere are causing the world's oceans to absorb more heat. Warmer water temperatures raise the sea level by expanding ocean water and causing land-locked ice to melt into the oceans. Sea-level rise at the Lewes tide gauge has risen over one foot since 1900.

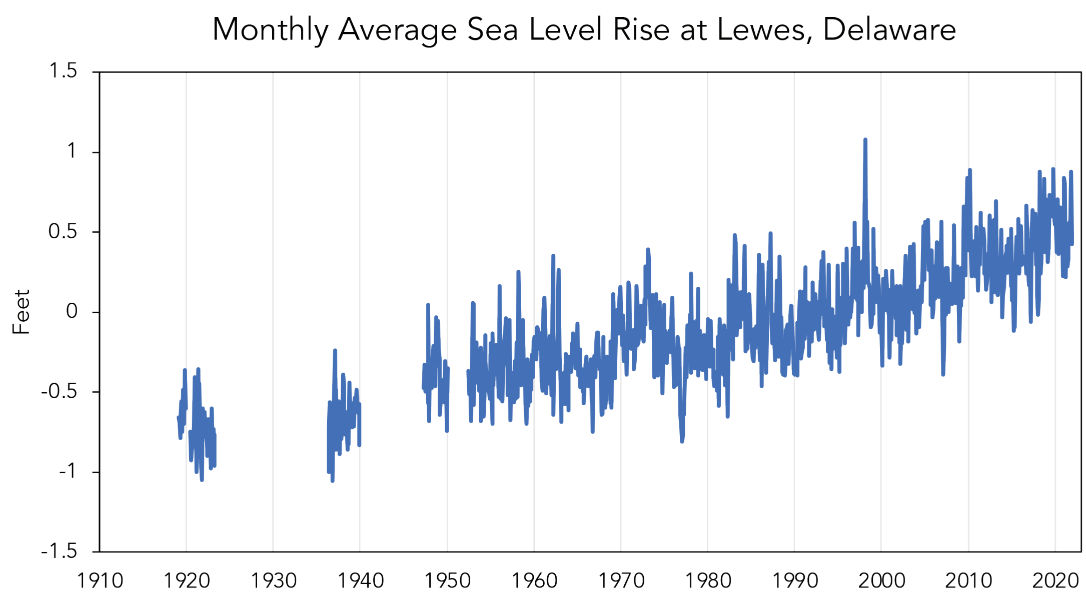
A combination of rising water, sinking lands, and very low elevation makes the Inland Bays watershed particularly vulnerable to the effects of sea-level rise. The Bays already are experiencing effects from sea-level rise, including increased flooding, shoreline erosion, saltwater contamination of groundwater, and loss of tidal wetlands.

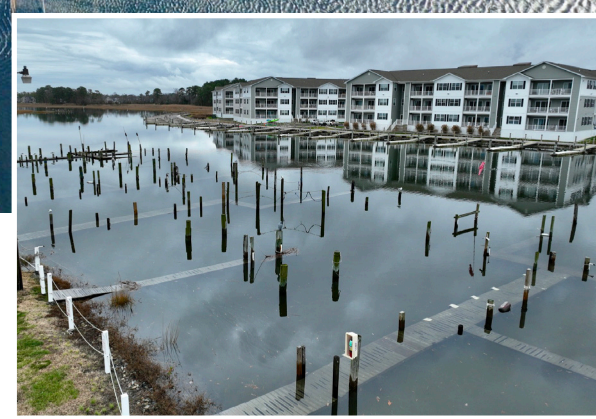
LONG-TERM TREND

Sea level on Delaware's coast has risen at an estimated rate of 0.3 feet per century over the past 1,000 years. The rate has accelerated in the last 100 years, with a total rise of nearly 16 inches since 1900. By 2050, sea levels are projected to rise up to an additional 2 feet, and up to 5 feet by 2100.

CHANGE SINCE PREVIOUS REPORT

The annual average for sea level measured at Lewes increased nearly 2 inches since 2015.





Photos by Driscoll Drones

AIR TEMPERATURE

POOR

DEGRADING

Average annual air temperatures are rising as a result of greenhouse gas emissions. Climate models suggest that average summer air temperature in southern Delaware could increase eight degrees Fahrenheit by the end of the century.

Warmer air causes more evaporation, leading to increasing precipitation in many areas. It can also intensify droughts.

Warming air also means warmer water, especially in shallow systems such as the Inland Bays. Warmer water holds less oxygen and may intensify algal blooms that cause further oxygen depletion. Increasing temperatures will affect the abundance and migration patterns of many aquatic species.

LONG-TERM TREND

Average annual temperatures in southern Delaware have risen almost three degrees Fahrenheit since the late 1890s. The rate of warming has increased over the past 50 years.

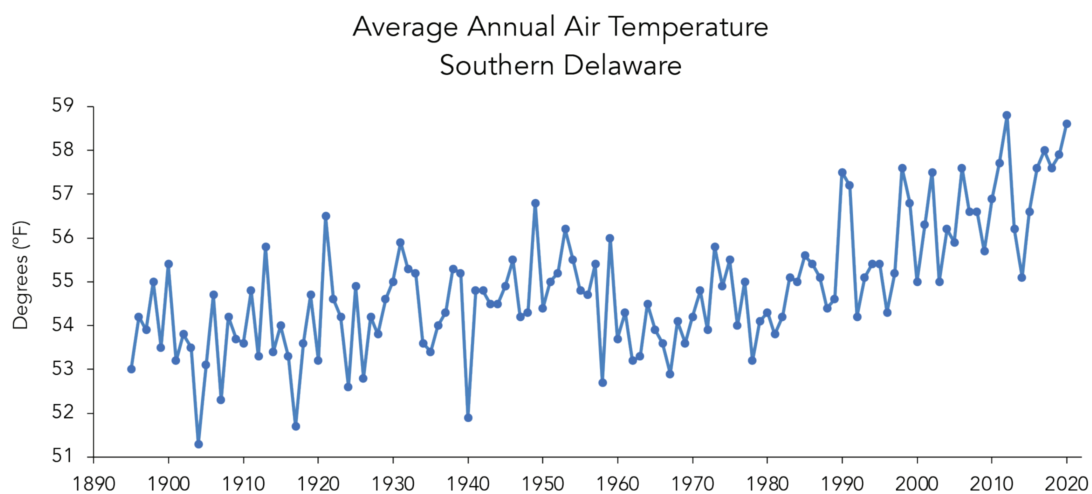
There are more very hot days over 90°F than in the past. Near Lewes, the number of days with minimum temperatures below freezing has decreased by seven days per decade.

CHANGE SINCE PREVIOUS REPORT

The five highest average annual temperatures on record (since 1880) in southern Delaware have all occurred since 2012. 2020 had the second highest recorded annual temperature.

Did you know?

The Town of Millsboro is one of only two cities in the United States that holds the record for both the highest and lowest temperatures in a state (Warsaw, Missouri is the other). The hottest day, 110° F, was recorded in Millsboro on July 21, 1930. The coldest day, -17° F, was Jan 17, 1893.



GROWING SEASON LENGTH

The growing season is the period between the last frost in spring and the first frost in fall or winter. Changes in growing season length affects the Bays by causing shifts in the ranges of species and stimulating growth of excessive algae and invasive species. Terrestrial habitats in the watershed also are affected.

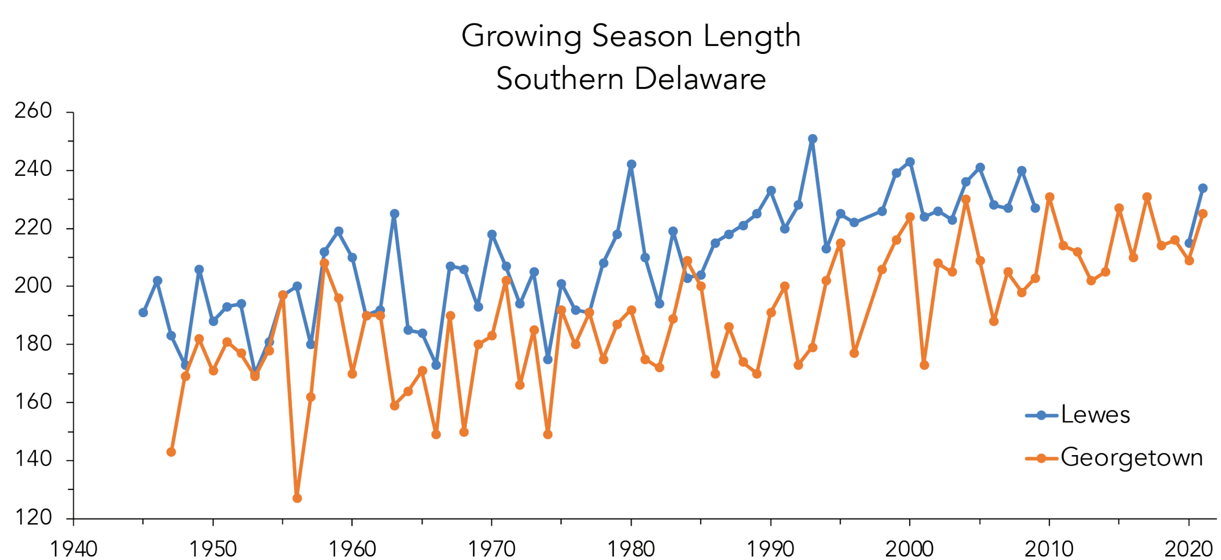
Local data for estimating growing season length are available from Lewes and Georgetown, where the averages currently are around 230 and 215 days per year, respectively. The annual frost-free period in Lewes, on average, is about 25 days longer than in Georgetown due to its proximity to the ocean.

LONG-TERM TREND

Growing season length in the Inland Bays watershed has increased by 54 days (more than 30%) since 1945. The frost-free period is lengthening by more than 7 days per decade.

CHANGE SINCE PREVIOUS REPORT

The growing season has continued to lengthen, with an earlier "last freeze" date in the spring and a later "first freeze" date in the fall. By 2050, the growing season in Delaware is expected to lengthen by at least another 20 days.



Photos by Driscoll Drones

PRECIPITATION

FAIR DEGRADING

Rising air temperatures cause more evaporation to occur from land and waterbodies. More moisture in the air alters the amount and timing of precipitation, which, in turn, impacts the flow of freshwater to the Bays. Changes in precipitation can alter pollution inputs, salinity, and circulation patterns in the estuary, affecting the types of plants and animals that can survive.

Precipitation varies greatly from year to year, so trends must be assessed through long-term measurements. The record includes a very wet period from 1932 through 1939 and an exceptionally dry period during the 1960s. On average, the state of Delaware receives 45 inches of precipitation annually.

Rising temperatures and shifting rainfall patterns are likely to increase the intensity of both floods and droughts.

LONG-TERM TREND

While highly variable, average annual precipitation in southern Delaware has increased about 3 inches over twelve decades. The greatest increase has occurred in rainfall from autumn tropical storm systems.

CHANGE SINCE PREVIOUS REPORT

Average annual precipitation in Southern Delaware between 2011 and 2020 was 47.1 inches, which is higher than the long-term average of 44.2 inches.

Average Annual Precipitation
Southern Delaware

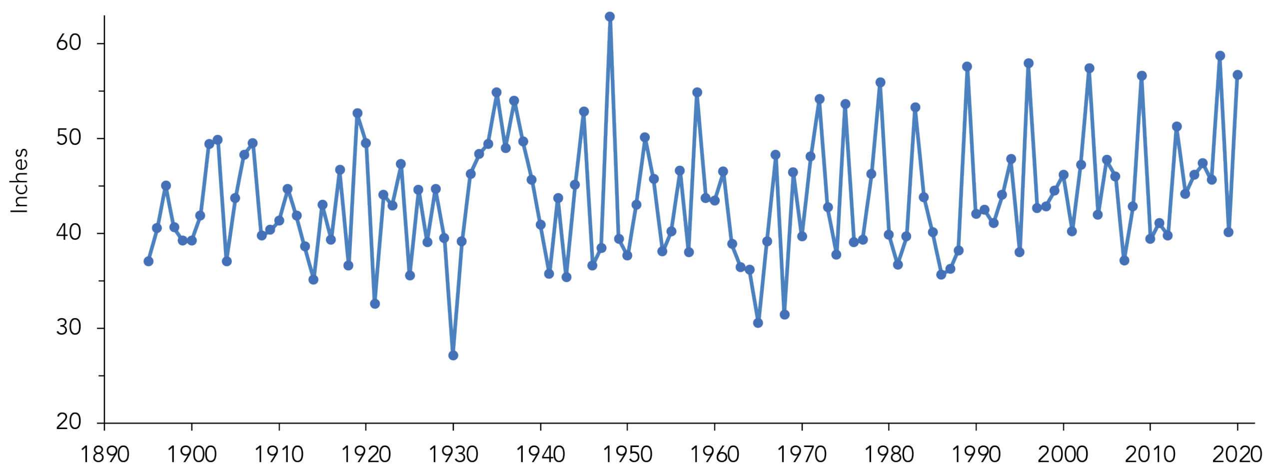
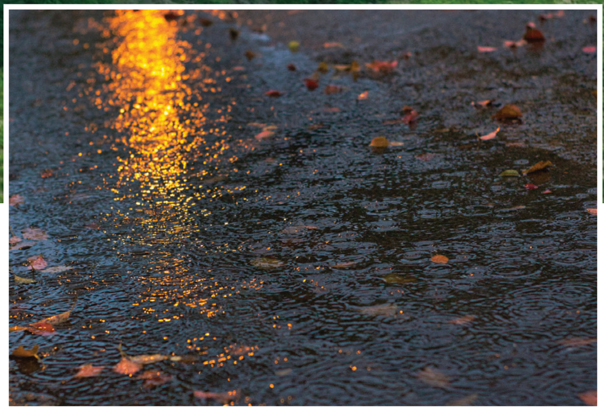


Photo by Driscoll Drones



FAIR DEGRADING

COASTAL STORMS

Nearby sea surface temperatures are very important to Delaware's weather and climate. Warming waters can intensify tropical storms, as well as alter their path and how fast they develop.

As a small, low-elevation coastal state, Delaware is greatly impacted by coastal storm events, including hurricanes. As development and population continue to increase in the Inland Bays watershed, the risk of significant damages from winds and flooding grows.

Coastal storms are most common in March. However, some of the most damaging storms occur during late summer and autumn. During the winter months, coastal storms can also be associated with heavy snowfall or ice accumulations.

LONG-TERM TREND

The frequency of coastal storms has varied greatly, with a minimum during the 1980s. No long-term trend in the number of storms is apparent. However, the frequency of intense storms that bring high winds and precipitation is increasing.

CHANGE SINCE PREVIOUS REPORT

Larger numbers of coastal storms have occurred during the last decade.

Did you know?

Sea surface temperature must be at least 82°F for tropical cyclones to form and be sustained.

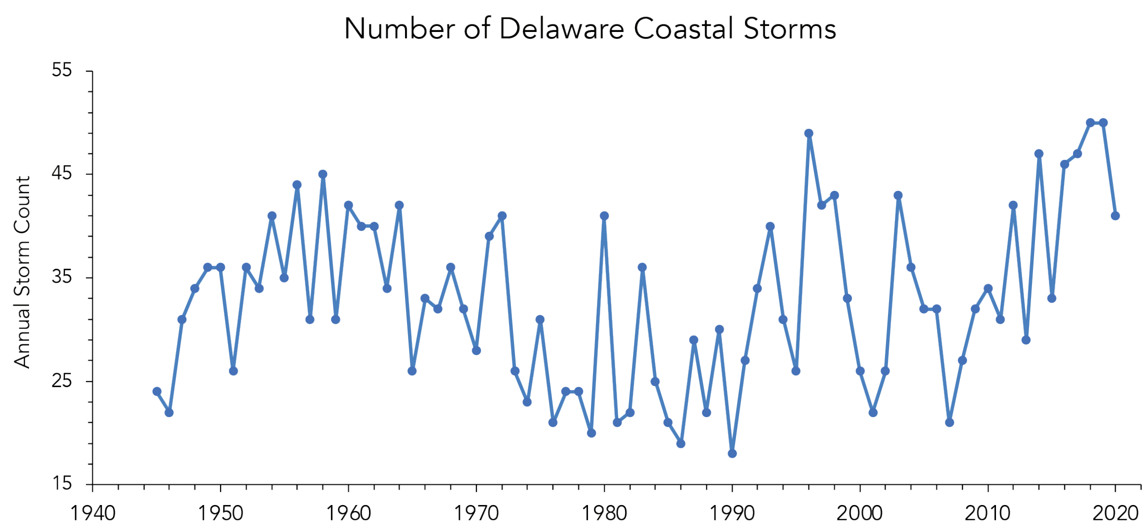


Photo by Driscoll Drones

FAIR DEGRADING

OCEAN ACIDIFICATION

As levels of atmospheric carbon dioxide increase, the amount of carbon dioxide absorbed by oceans and bays also increases. Once absorbed, carbon dioxide reacts with water molecules, producing carbonic acid and lowering the ocean's pH (raising its acidity).

Since the Industrial Revolution began, the pH of ocean surface waters has fallen by 0.1 pH units. While this sounds small, the pH scale is logarithmic, meaning that this change represents a 30% increase in acidity.

This process of acidification alters ocean chemistry and has many implications for marine life.

For example, creatures that produce calcium carbonate skeletons and shells—such as corals, oysters, and mussels—are vulnerable to increasing acidity. Rising acidity can damage shells and slow the growth of new shells, threatening the survival of these organisms.

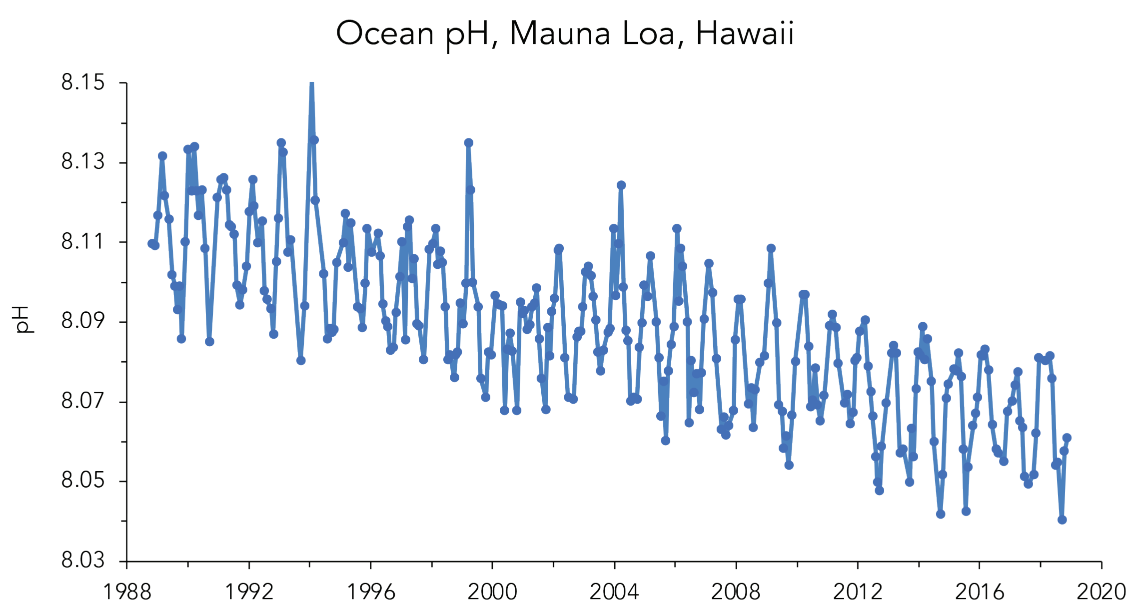
Acidification in estuaries is more complex than in the open ocean and is less understood. Oceans are expected to become more acidic as climate change continues. What this means for estuaries such as the Inland Bays is uncertain.

LONG-TERM TREND

Measurements at the Mauna Loa Observatory in Hawaii provide a good indicator of ocean acidification. There the average ocean pH has dropped about 0.05 pH units since 1988. This means that the ocean has become 12% more acidic in 30 years. The up-and-down pattern shows the influence of seasonal variations.

CHANGE SINCE PREVIOUS REPORT

The average ocean pH units has dropped 0.01 pH unit in the past five years.



ACIDITY

The acidity of water is measured on a pH scale, which ranges from 0 to 14. A pH of 7 is neutral, a pH less than 7 is acidic, and a pH greater than 7 is basic. The pH scale is logarithmic and as a result, each one-unit change in the pH scale corresponds to a ten-fold change in acidity. For example, pH 6 is ten times more acidic than pH 7, and 100 times more acidic than pH 8.

The ocean's average pH is now around 8.1, which is basic (or alkaline), but as the ocean continues to absorb more carbon dioxide, the pH decreases and the ocean becomes more acidic.

As ocean and bay waters become more acidic, carbonate ions—a key building block for oysters, clams, and other shellfish to build their shells—becomes less available. This not only impacts shell development but threatens the growth and survival of these organisms as well.

The Delaware Center for the Inland Bays is a nonprofit organization and a National Estuary Program. It was created to promote the wise use and enhancement of the Inland Bays watershed by conducting science-based education and outreach, developing and implementing restoration projects, encouraging scientific inquiry and sponsoring needed research, and establishing a long-term process for the protection and preservation of the Inland Bays watershed.

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DELAWARE CENTER FOR THE
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Research. Educate. Restore.