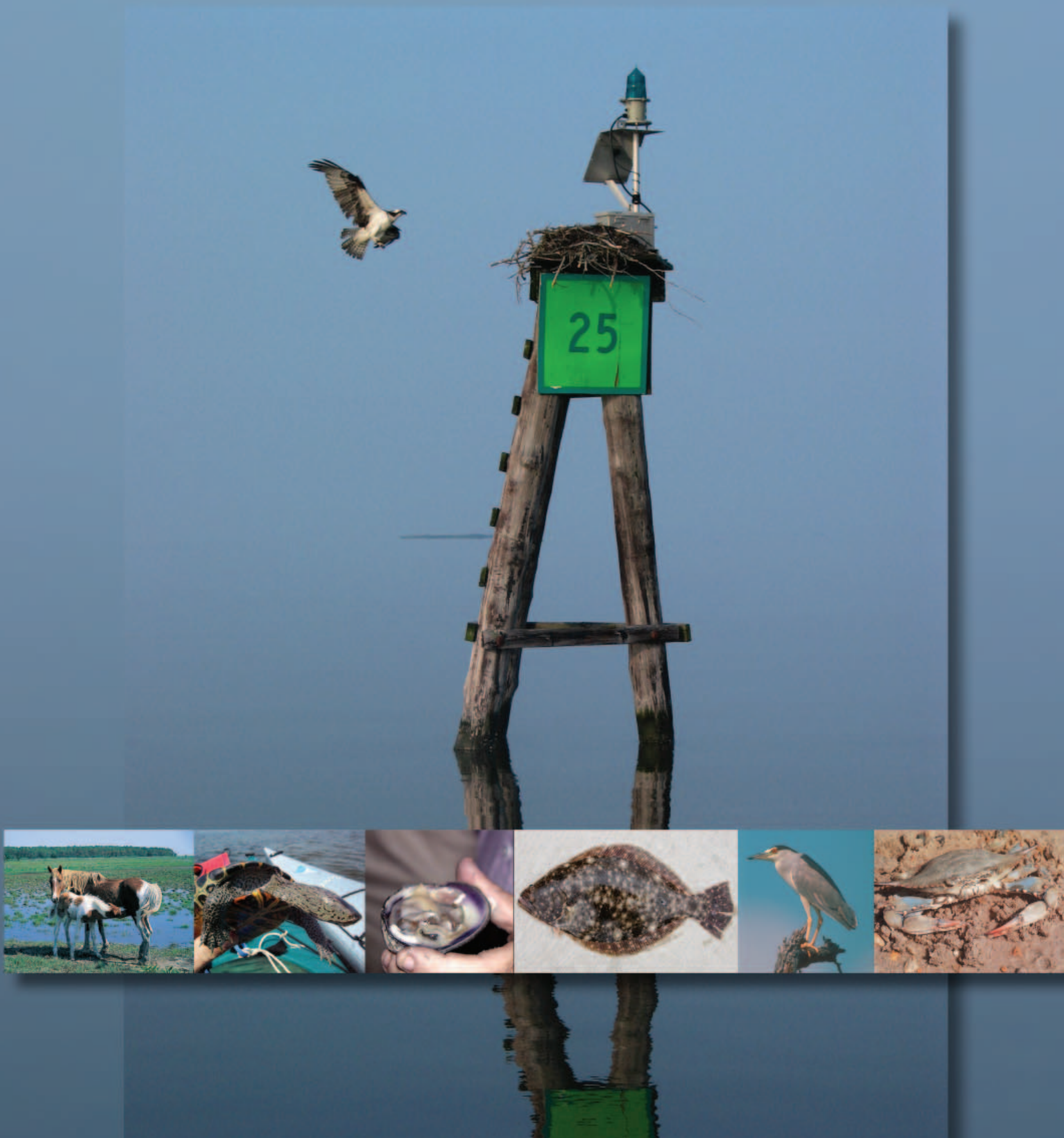
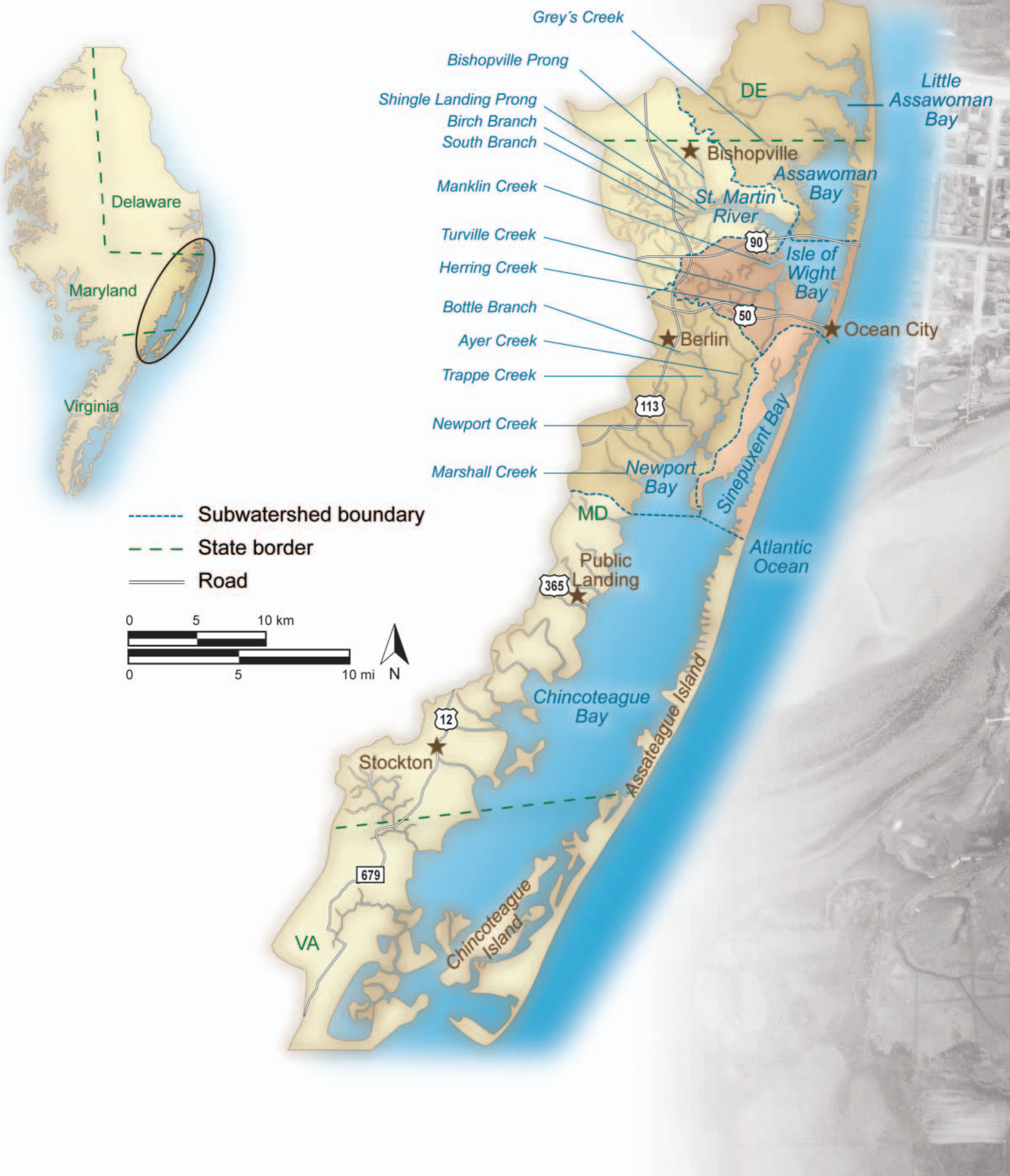
State of the Maryland
COASTAL BAYS



2004

Detailed locator map



Executive summary

Maryland's Coastal Bays, the shallow lagoons nestled behind Ocean City and Assateague Island, comprise a complex ecosystem. These estuarine bays, at the interface between fresh and saltwater, provide habitat for a wide range of aquatic life. But like many coastal systems, they face threats from intense development, nutrients, sediments, and other stresses associated with human activities. This report documents the most up-to-date status of the water quality and living resources in the Coastal Bays and highlights the management steps being taken to preserve them.

Like many estuaries, Maryland's Coastal Bays display differences in water quality ranging from generally degraded conditions within or close to tributaries to better conditions in the more open, well-flushed bay regions. Showing the strain of nutrient enrichment, the Coastal Bays exhibit high nitrate levels in the freshwater reaches of streams, excess algae, chronic brown tide blooms, macroalgae blooms, and incidents of low dissolved oxygen. Although seagrass coverage has leveled off over the past three years, large increases in seagrass area have taken place since the 1980s.

Like water quality, the status of Coastal Bays living resources is mixed. While the bays still support diverse and abundant populations of fish and shellfish, human activities are affecting their numbers. Forage fish, the major prey item for gamefish, have been in steady decline since the 1980s and reports of fish kills, usually the result of low oxygen levels, are increasing. Hard clam densities are lower than historic levels but have been generally stable over the past 10 years. Blue crab populations are fluctuating but do not appear to be in decline, despite a relatively new parasite causing summer mortality in some areas. Oysters, which were historically abundant in the Coastal Bays, remain only as small, relict populations. Bay scallops have recently returned after being absent for many decades and are now found throughout the bays, although numbers are low.

In terms of overall water quality, living resources, and habitat conditions, the bays were given the following ranking from best to worst: Sinepuxent Bay, Chincoteague Bay, Assawoman Bay, Isle of Wight Bay, Newport Bay, and St. Martin River.

In response to these changes, dozens of organizations, community groups, and agency partners have implemented a wide range of management activities. Fishery management plans, nutrient reduction goals, shoreline restoration, land conservation, and sewage upgrades along with several hundred other initiatives are serving and will serve to improve the condition of the Coastal Bays. In addition, ongoing monitoring programs now track status and trends in the coastal ecosystem, and new research is aiding the quest for solutions.

This report presents an overview of the current state of the Coastal Bays and should help serve as a guide for preserving this ecosystem. However, human population is expected to climb steadily in the Coastal Bays watershed and the associated impacts of this growth will present future challenges to the health of the bays. Maintaining an active and vigorous environmental management program will be essential to preserve this fragile estuary.

The Maryland Coastal Bays Program

The Maryland Coastal Bays Program is a cooperative effort between Ocean City, Berlin, Worcester County, the state of Maryland, the United States Environmental Protection Agency (EPA), and a host of state and federal agencies which have brought together scientists and diverse groups, including the agriculture, golf, tourism, fishing and development industries, to produce a Comprehensive Conservation and Management Plan (CCMP) for the Coastal Bays.

Embarked upon in 1996 and completed in 1999, the community-driven CCMP derives its direction from the local citizenry. It includes sections on Water Quality, Fish & Wildlife, Recreation & Navigation, and Community & Economic Development. The program and its partners are implementing the activities called for in each of these sections.

The Coastal Bays Program exists under the umbrella of the EPA's National Estuary Program, designed to protect the most economically and environmentally significant estuaries in the United States. The Coastal Bays behind Assateague Island and Ocean City make up one of only 29 estuaries nationwide that has received this special attention. In these regions, the health of the economy is closely linked to the health of the environment.

Maryland Coast Day

To volunteer, contribute or simply read about program activities please visit www.mdcoastalbays.org. To learn more about the National Estuary program, visit www.epa.gov/nep.

Authors: Catherine Wazniak[1], Matthew Hall[1], Carol Cain[2], David Wilson[2], Roman Jesien[2], Jane Thomas[3], Tim Carruthers[3], William Dennison[3]

1 Maryland Department of Natural Resources
2 Maryland Coastal Bays Program
3 University of Maryland Center for Environmental Science, Integration and Application Network

Editorial Board: Catherine Wazniak[1], David Goshorn[1], Matthew Hall[1], David Blazer[2], Roman Jesien[2], David Wilson[2], Carol Cain[2], William Dennison[3], Jane Thomas[3], Tim Carruthers[3], Brian Sturgis[4]

1 Maryland Department of Natural Resources
2 Maryland Coastal Bays Program
3 University of Maryland Center for Environmental Science, Integration and Application Network
4 United States Department of the Interior, National Park Service

Project Coordinator: Catherine Wazniak, Maryland Department of Natural Resources

Graphic Design and Layout: Gerald Gerlitzki, Gerlitzki Design, Inc.

Conceptual Diagram and Map Art: Jane Thomas, University of Maryland Center for Environmental Science, Integration and Application Network

Map Production and Finishing: Anthony Burrows and Linda Wiley, Maryland Department of Natural Resources

Offset Printing: Whitmore Printing and Imaging, Inc.

Contributing Authors: Jim Casey[1], Steve Doctor[1], Darlene Wells[1], Dan Boward[1], Niles Primrose[1], Ellen Friedman[1], Bill Romano[1], Mark Trice[1], Jim Hill[1], Celia Dawson[1], Tom Parham[1], Mike Naylor[1], Lee Karrh[1], Margaret McGinty[1], David Bleil[1], Lamere Hennesse[1], Peter Tango[1], Walt Butler[1], Mitch Tarnowski[1], Walter Boynton[2], Jon Dillow[3], Bob Orth[4], Denise Clearwater[5], Chris Luckett[5], Bruce Nichols[6], Roberto Llanso[7], Gretchen Messick[8], Jack Kumer[9], Doug Miller[10], Jill Brown[10], and Chris Spaur[11].

1 Maryland Department of Natural Resources
2 University of Maryland Center for Environmental Science
3 United States Geological Survey
4 Virginia Institute of Marine Science
5 Maryland Department of the Environment
6 United States Department of Agriculture, Natural Resources Conservation Service
7 Versar, Inc.
8 National Oceanographic and Atmospheric Administration, National Ocean Service
9 United States Department of the Interior, National Park Service
10 University of Delaware, Graduate College of Marine Studies
11 US Army Corps of Engineers

Table of contents

National Estuary Day Cruise

Battle for the Bays

Isle of Wight Cleanup

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This report serves as a summary of "Maryland's Coastal Bays: An Ecosystem Health Assessment", Maryland Department of Natural Resources, 2004." available online at: www.dnr.maryland.gov/coastalbays/cbaystechreport04.pdf.

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Correspondence: Cathy Wazniak, cwazniak@dnr.state.md.us • Matthew Hall, mhall@dnr.state.md.us • Carol Cain, technical@mdcoastalbays.org

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Page 11– Boat courtesy of Cathy Wazniak
Monitor deployment courtesy of Tim Carruthers
Stream testing courtesy of Jane Thomas
Page 13 – Fish drawings courtesy of David Neely
Page 14 – Bug drawings courtesy of JoAnn Wheeler
Page 16 – Marshall Creek courtesy of Andy Serrell
Page 18 – DataFlow Unit courtesy of Mark Trice
Page 23 – Cladophora courtesy of Margaret McGinty
Ulva courtesy of Cathy Wazniak
Ectocarpus courtesy of Mark Luchenbach
Page 24 – Macroalgae images courtesy of Margaret McGinty
Algae collection courtesy of Jane Thomas
Page 25 – Algae cell images courtesy of Walt Butler
Page 27 – Marsh splash courtesy of Adrian Jones
Skyline and condos courtesy of Jane Thomas
Page 28 – Marsh close-up courtesy of Adrian Jones
Ocean Pines aerial courtesy of Andy Serrell
Page 29 – Flounder courtesy of "The Coastal Fisherman"
Other fish species images courtesy of Margaret McGinty
Page 30 – Spot, silversides, menhaden and anchovy courtesy of Margaret McGinty
Fish kill courtesy of Adrian Jones
Page 31 - Big crab image courtesy of Mark Odell, Governor's office
Page 32 – Worm courtesy of Margaret McGinty
Benthic drawings courtesy of JoAnn Wheeler
Children with starfish courtesy of Discovery Cruises
Page 34 – Scallops courtesy of Mitch Tarnowski
Page 35 – Shore crab courtesy of Jim Casey
Deadman's Fingers Macroalgae courtesy of Jill Brown
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Working to improve water quality

Nutrient and chemical inputs into the Coastal Bays are the two biggest factors affecting water quality. Phosphorus and nitrogen from development, farming and the burning of fossil fuels are decreasing oxygen levels and light penetration. Erosion and the loss of natural filtering processes are compounding these problems as the terrain loses its ability to absorb nutrients and sediments before they enter the bays.
Below are a few of the activities program partners are undertaking to curb nutrient pollution.

Local volunteer monitoring supplements state and local programs.

The **Maryland Coastal Bays Program** has coordinated a local volunteer water quality monitoring program for seven years. The data collected by these citizens supplements existing monitoring programs at the state and federal level. The **Maryland Department of Natural Resources** launched the Eutrophication Monitoring Program to coordinate agency water quality monitoring efforts in 2001.

Worcester County has established the "Voluntary Golf Course Guidelines" booklet to help maintenance professionals meet chemical and nutrient reduction goals on their courses. To reduce water quality and wildlife impacts from chemical pollution, the county has also promoted a policy change to encourage larvicide over aerial adulticide spray for mosquitoes.

From 1997 to present, the **United States Geological Survey** has conducted several studies to improve understanding of nutrient concentrations and loads from both groundwater and tributaries to the Maryland Coastal Bays. Currently, the agency is collaborating with the **National Park Service** at **Assateague Island National Seashore** to monitor and determine nitrate loads in stream flow to Newport and Chincoteague bays.

Earth Day tree planting
Shoreline restoration helps reduce erosion and lower nutrient and sediment inputs to the bays

The **Maryland Department of the Environment's** new Stormwater Design Manual promotes environmentally sensitive design measures that provide incentives for the creation of buffers and natural conservation areas to help reduce the volume of runoff that needs to be treated. **Ocean City** and **Worcester County** have been implementing many of the manual's recommended best management practices.

A **"Builders for the Bay"** program has been initiated to identify rules and regulations that can be made flexible enough to save developers money while protecting natural resources. Locally, the coordination between stormwater management, sediment control, grading, permits and inspection has been simplified to benefit developers and protect natural resources. To aid both developers and the environment, **Worcester County** has decreased road width requirements and in **Ocean City**, pilot projects are using porous pavers and permeable surface materials to reduce nutrient and sediment runoff. As an additional effort, the **MD State Highway Administration** has incorporated the use of vegetated swales with native plants and has created dozens of new wetlands for wildlife and water quality.

With guidance from the **Maryland Department of Agriculture**, 68 percent of farm operators within Worcester County have completed their nutrient management plans to address fertilizer inputs. In the past five years, more than 6,250 tons of excess poultry litter has been transported from the watershed for uses elsewhere, thus ridding the basin of additional nutrients.

Sinepuxent Bay

The Maryland Department of the Environment (MDE) has established Total Maximum Daily Loads (TMDLs) limits for nutrient inputs to the northern Coastal Bays and Newport Bay. The limits establish maximum nitrogen and phosphorus standards to meet fishable and swimmable Clean Water Act rules. Implementation activities to meet these goals will follow. Already, MDE is working with local applicants to eliminate surface discharges and to use tertiary treatment to recycle more treated wastewater as part of irrigation projects. In addition, Worcester County is in the process of instituting a septic tank tracking system to track the location and frequency of septage pumping. The system will enable the county to notify homeowners when it is time to pump.

Protecting fish & wildlife

Tri-colored heron

Habitat loss and changes in water quality affect local wildlife. Protecting the abundance of fish and shellfish species, waterfowl and other wildlife has required establishing sustainable harvest measures and preserving, restoring and creating habitat essential to their survival. Below are a few of the activities program partners are undertaking to help protect wildlife.

In an effort to maintain optimum fish and shellfish stocks the **Maryland Department of Natural Resources** and the **Maryland Coastal Bays Program** have completed fishery management plans for blue crab and hard clam populations in local waters. Additionally, the duo coordinates yearly to produce and distribute size and creel signs and brochures for popular sport fish within the Coastal Bays.

Marbled salamander

The Rural Legacy Program has protected some 6,000 acres and over eight miles of shoreline in the southern coastal bays along Chincoteague Bay. The **Lower Shore Land Trust**, the state, and the Conservation Fund permanently protect the farmland and forest with the acquisition of conservation easements from willing landowners.

Maryland legislation now prohibits the hydraulic excavation of underwater seagrasses during clam dredging. **Natural Resource Police** have deployed buoys delineating grass beds to alert boaters and jet-skiers to use caution. Boat mooring recommendations and jet-ski studies have helped curb impacts. The **Virginia Institute of Marine Science** undergoes a comprehensive aerial survey of the seagrass every year and the **University of Maryland Center for Environmental Science** has established a site in Chincoteague that is part of the Global Seagrass Watch Network to monitor seagrass productivity on a global scale.

Ghost crab

Diamondback terrapin

Worcester County is working with interested property owners in Chincoteague, Newport and Sinepuxent bays as part of the Watershed Restoration Action Strategy to gauge the potential for future restoration projects in the watersheds. The **Army Corps of Engineers** has already constructed saltmarsh restoration projects in Ocean Pines and on the Isle of Wight Wildlife Management Area.

Assateague Coastal Trust has established a two-acre oyster bed in the St. Martin River and another one-acre bed in Chincoteague Bay with the assistance of 65 citizen oyster gardeners and others who have helped to raise and offload 2.25 million baby oysters. The trust also helped begin a terrapin monitoring program which rescues imperiled terrapins and protects the turtles' nests.

The **Ocean City Artificial Reef Foundation** has deployed 12 reef structures near 3rd Street to act as fish habitat.

In 2003 the **Maryland General Assembly** enacted a comprehensive resource protection program to establish land use policies for development in the 1,000-foot Critical Area which buffers tidal waters. The purpose is to minimize adverse impacts on water quality that result from pollutants from surrounding land uses as well as to conserve fish, wildlife, and plant habitat along the shores of the bays.

The **Worcester County Natural Resources Conservation Service** has created over 10,000 acres of tree and grass buffers along waterways and restored over 1,000 acres of wetlands in the coastal bays watershed over the past five years.

Bag limits and preservation areas help maintain waterfowl populations.

Improving recreation & navigation in the bays

Due to the relatively shallow nature of the Coastal Bays and the constant influx of sand and sediment, the maintenance of navigable waterways to support recreational and commercial boating is a critical regional need. Balancing a myriad of uses including boating, hunting, fishing, clamming and birdwatching requires preservation of the sensitive resources that support these activities while minimizing user conflicts. Some examples of this work are below.

The **US Army Corps of Engineers'** Ocean City Water Resources Study identified seven projects to improve navigation and habitat: Ocean City Harbor and Inlet deepening, Assateague short-term and long-term sand replenishment, Dog Island Shoals and the South Point spoils island restorations and two completed saltmarsh restoration projects. Additional shoreline restoration projects are being identified for the St. Martin River.

The **Maryland Coastal Bays Program** produced the *Boater's Guide to the Coastal Bays* which includes information regarding shoreline access, boat launch facilities, boating safety, clean boating practices, pollution prevention tips and sensitive areas to avoid.

The **Maryland Department of Natural Resources** heads the Clean Marina Initiative which provides marina operators with a comprehensive pollution prevention manual and an awards program to recognize environmentally responsible marinas. Currently 12 of 19 local marinas (63%) are participating in the Clean Marina Program.

The **Environmental Protection Agency** and **Department of the Environment** have designated all tidal waters north of the Inlet as a No Discharge Zone for boat sewage.

The **US Coast Guard Auxiliary, MD Department of Natural Resources**, and the **US Power Squadron** offer multiple courses year-round on boater safety and how to be an environmentally friendly skipper. Participants who receive safety education credit can then apply for a 10% reduction on insurance premiums.

Inlet dredging

Ocean City has established the Coastal Resources Legislative Committee to follow and address natural resource issues such as flooding, beach replenishment, dune stabilization, and dredging, around the resort.

Canoe Cleanup

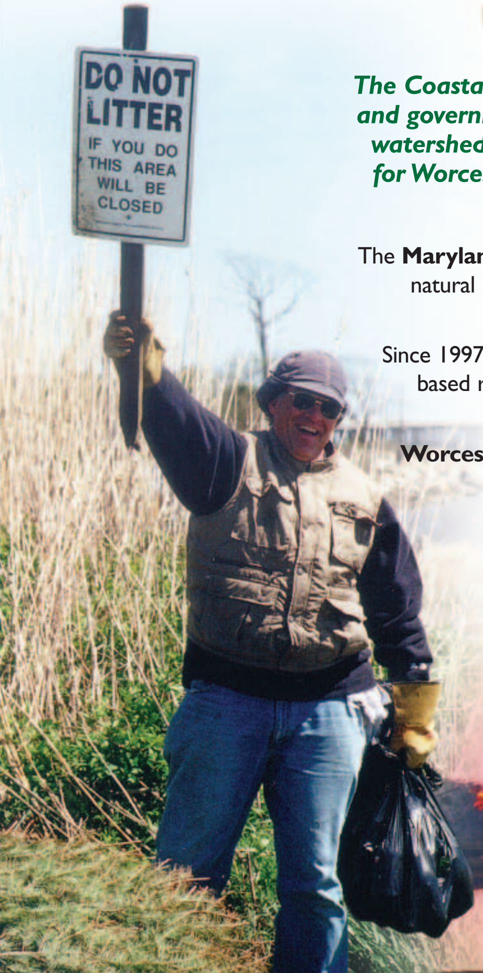
The **Maryland Coastal Bays Program** has conducted five years of bay clean-ups resulting in nearly 20 tons of trash removed from the bays with the help of over 800 volunteers.

The **Maryland Department of Natural Resources** led the development of the Coastal Bays Sensitive Areas initiative. This consensus-based plan will blend the work of scientists, who delineated important sensitive habitats, with citizens' concerns and suggestions regarding impacts to the bays from recreation uses and conflicts.

The **University of Delaware Sea Grant**, with help from the **US Coast Guard, Natural Resources Police** and others, has twice conducted a "Water-Use Assessment Survey" to gauge the satisfaction levels of recreational boaters in the Coastal Bays. These surveys collected information about boaters' activity patterns, satisfaction levels and environmental concerns. Management activities are being streamlined based upon the participants' views and opinions.

West Ocean City Harbor

Enhancing community & economic development



The Coastal Bays watershed is expected to double in population by the year 2020. The ability of citizens and government to concentrate growth in and around existing infrastructure will determine whether the watershed will remain economically and environmentally viable. Developing and implementing a vision for Worcester County that promotes tourism, agricultural preservation and natural resource protection will insure a sustainable future. A few examples of current efforts to help do that follow.

The **Maryland Department of Natural Resources** conducted an assessment of the economic value of the Coastal Bays natural resources to the economy of Worcester County. The value of recreational activities and natural resources were estimated to be over $500 million per year.

Since 1997 **Maryland Coastal Bays Program** has provided nearly a half million dollars in grant funding for community-based restoration and educational activities, as well as for scientific studies of the watershed. The **US Environmental Protection Agency** has provided $3.65 million in grant funds to the Coastal Bays Program since 1995.

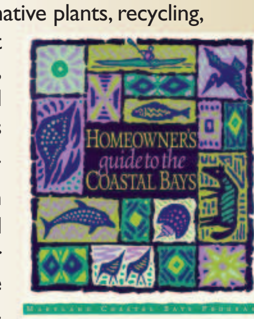
Worcester County sponsored a seminar series on sustainable planning - a thought provoking commentary on growth management, urban design, economic development and quality of life issues. The county also held Community Visioning exercises to help locals gauge how and where they wanted Worcester County to grow. To help residents have an additional say in the future of their community, the county enlisted the help of the **MD Department of Planning** to conduct an Alternative Futures workshop which revealed the consequences of various land use choices.

Ocean City has organized and supported the nonprofit OC Development Corporation which is dedicated to the revitalization of downtown Ocean City. Innovative public and private sector partnerships collaborate to maximize available resources while preserving the areas' character and charm. The Town is participating in the MD Smart Codes Program, including adoption of the MD Rehabilitation Code, Community Legacy Program and the Neighborhood Conservation Program.

The Coastal Bays region was one of the first areas in Maryland where the **MD Department of Natural Resources'** Light Detection and Ranging (LIDAR) flights collected high-resolution topographic data. This information will be used to update flood maps, identify areas subject to sea level rise, provide a shoreline inventory and identify potential wetland restoration areas. This will assist local jurisdictions in meeting requirements for flood and disaster mitigation planning.


Ocean Pines

The **Maryland Coastal Bays Program** produced the "Homeowner's Guide to the Coastal Bays" detailing watershed facts, household and garage hazards and tips,native plants, recycling, septic maintenance, responsible pet ownership, water and energy conservation, canal issues, local wildlife species and the local planning process. Some 10,000 residents have received the books.



Ocean City has instituted a "Clean Streets/Clean Waters" program to remind residents and visitors to be mindful of litter and pollution prevention. This campaign slogan can be found on bumper stickers, trash receptacles and city buses.

Regional efforts between MD, DE, and VA have included: the Delmarva Tri-State Conference, Hurricane Planning, Water Quality and Macroalgae Assessments, Delmarva Conservation Corridor, Dead End Canals workshop, and the MD/DE Invasive Species inventory.

www.mdcoastalbays.org

The Coastal Bays are different from the Chesapeake Bay

The Maryland Coastal Bays have less intense impacts but are more vulnerable than the Chesapeake Bay.

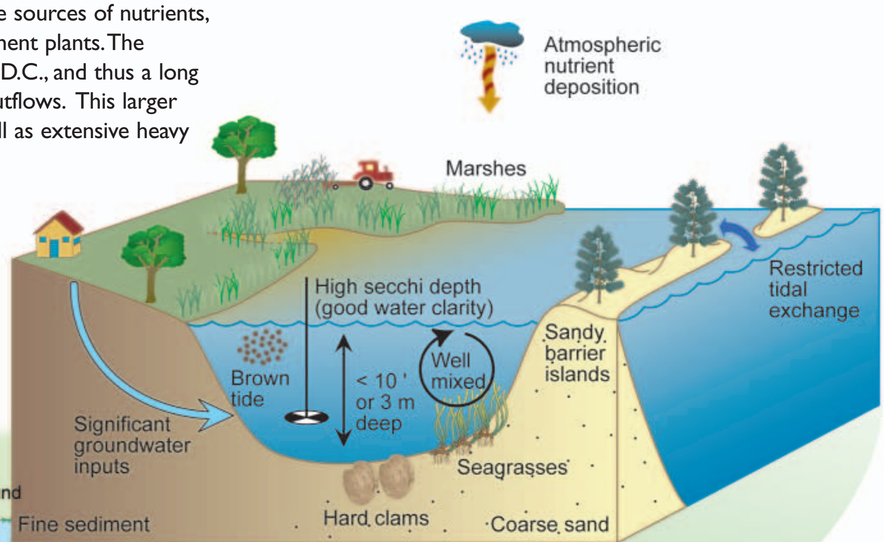
Maryland's Coastal Bays are shallow water bodies (less than 10 feet deep) and uniform in depth, occurring between a small coastal watershed (175 sq. miles) and sandy barrier islands. Tidal exchange is limited, mainly through the Ocean City and Chincoteague inlets. River input is low and groundwater is an important source of freshwater inflow. Wind blowing across these shallow waters results in very strong mixing, meaning oxygen levels usually remain high in open areas.

The Chesapeake Bay is deeper (70 feet), has a large watershed (64,000 sq. miles) and high inputs of turbid river water. The Chesapeake also has a large opening to the ocean and therefore greater tidal influence. These features provide the potential for stratification (layers in the water of different salinity or temperature) that can lead to low oxygen levels when high amounts of nutrients are present.

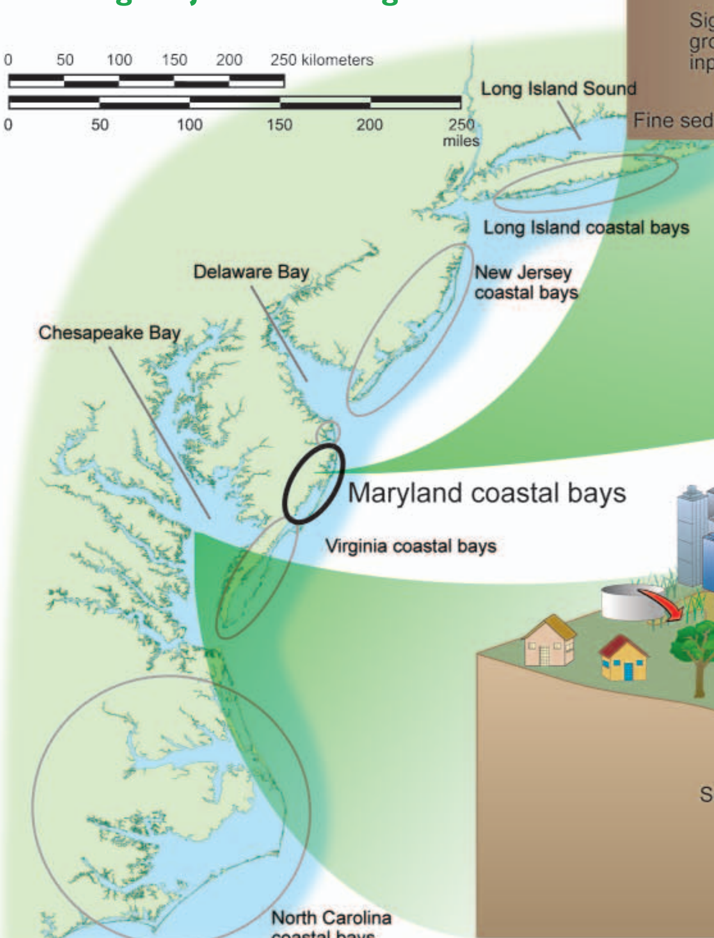
In terms of human impacts, Maryland's Coastal Bays have diffuse sources of nutrients, from septic systems to agricultural inputs to wastewater treatment plants. The Chesapeake has large cities, such as Baltimore and Washington D.C., and thus a long history of high populations and point source treated sewage outflows. This larger watershed means that much more agriculture is present, as well as extensive heavy industry and associated toxicants.

Overall, Maryland's Coastal Bays have fewer human impacts than the larger, deeper Chesapeake Bay. However, limited water exchange in the Coastal Bays makes them more sensitive to inputs.

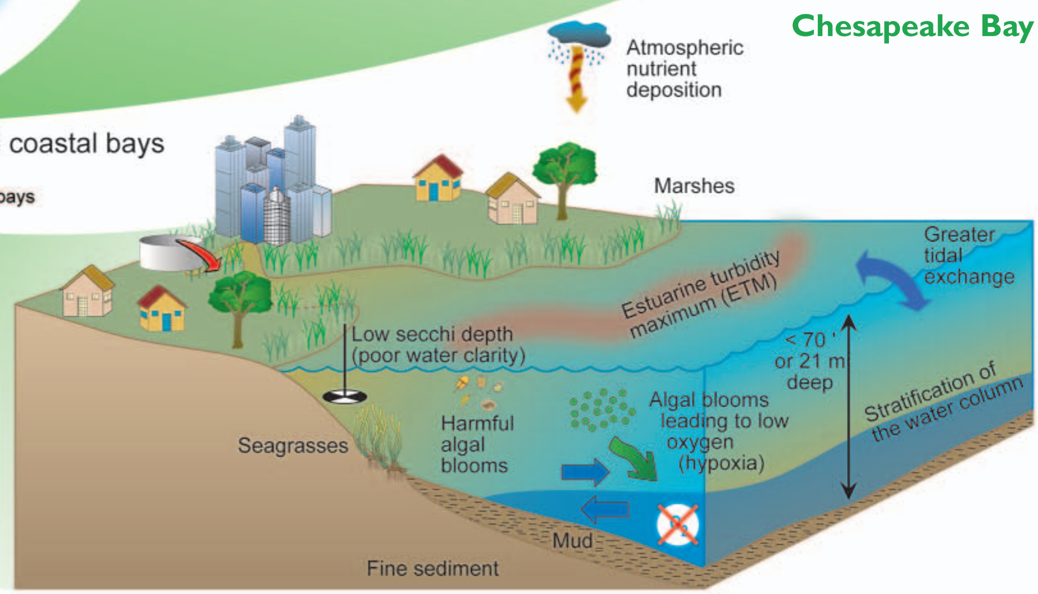
Maryland Coastal Bays



Map of the United States East Coast showing major coastal lagoons.



Chesapeake Bay



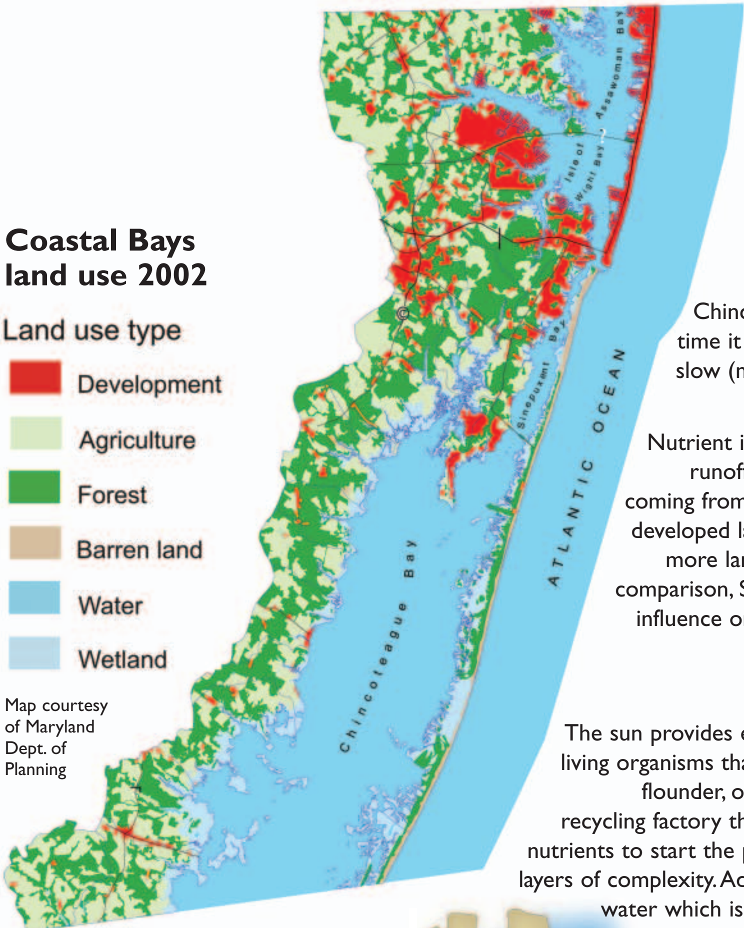
The Maryland Coastal Bays

Maryland's Coastal Bays are coastal lagoons.

The Coastal Bays are lagoonal estuaries: areas where freshwater mixes with saltwater. Due to a flat landscape and sandy soils, rainwater seeps into the ground quickly and groundwater serves as the major pathway of freshwater to the bays. Salinities in the open bays are close to seawater while small portions of the upstream reaches of rivers and creeks remain fresh. Circulation in the bays is controlled by wind and tides. Tidal exchange with the Atlantic Ocean is limited to two inlets. Tidal range near the Ocean City Inlet is more than 3.4 feet, while it drops to 0.4 feet in the middle of Chincoteague and 1.5 feet in Assawoman Bay. Flushing in the bays (the amount of time it takes to replace all of the water by freshwater and ocean exchange) is very slow (months). This means contaminants such as nutrients, sediment, and chemicals entering the bays tend to stay in the bays.

Nutrient inputs to the Coastal Bays are dominated by non-point sources (e.g., surface runoff, groundwater, atmospheric and shoreline erosion). The amount of nutrients coming from an area is largely dependent on the predominant land use - agriculture and developed land versus wetlands and forests. Newport and Isle of Wight bays have much more land compared to water than the other bays (8.5 and 8 times, respectively). In comparison, Sinepuxent Bay has a ratio of 0.9. This means that land use would have more influence on water quality. **Hence, the health of the bays is largely influenced by activities that occur on land.**

Coastal Bays land use 2002

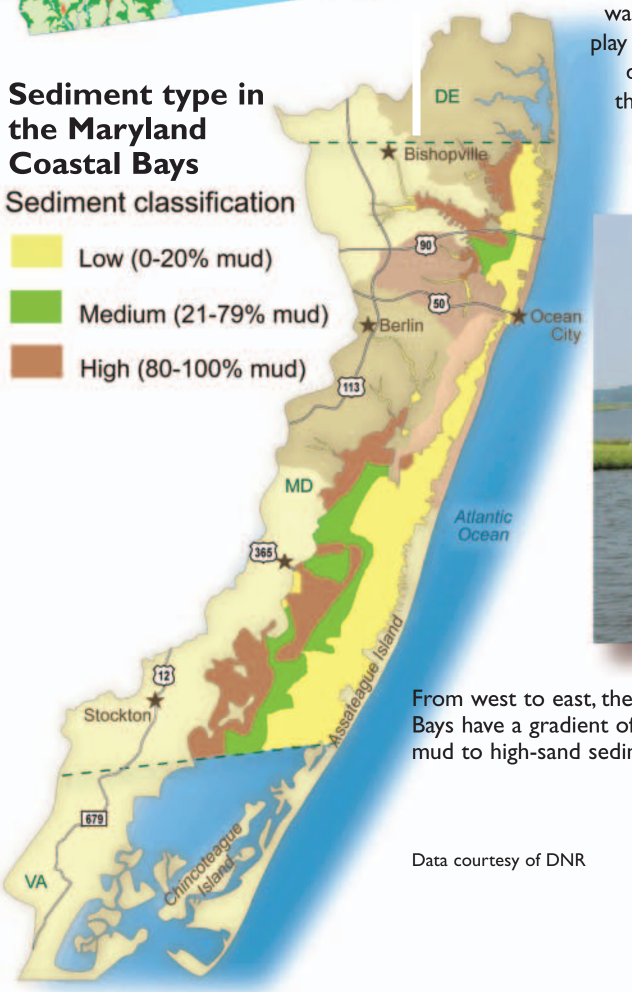


Map courtesy of Maryland Dept. of Planning

How the Coastal Bays function

The sun provides energy for algae and plants to turn carbon and nutrients in the water to the living organisms that forms the basis of the complex food web. The food includes plants, clams, flounder, osprey, humans and everything in between. This web is the manufacturing and recycling factory that turns simple nutrients into complex living organisms then back to simple nutrients to start the process again. Physical and chemical interactions with the organisms provide layers of complexity. Additional layers are supplied by the interface between land and water which is a mix of freshwater, coastal waters, and ocean waters that all play a hand in shaping the Coastal Bays ecosystem. Added to this mix are the distinctly human activities that can unbalance the system by overwhelming the recyclers with excess nutrients, altering habitats, overfishing, and adding other stresses associated with human activity.

Sediment type in the Maryland Coastal Bays



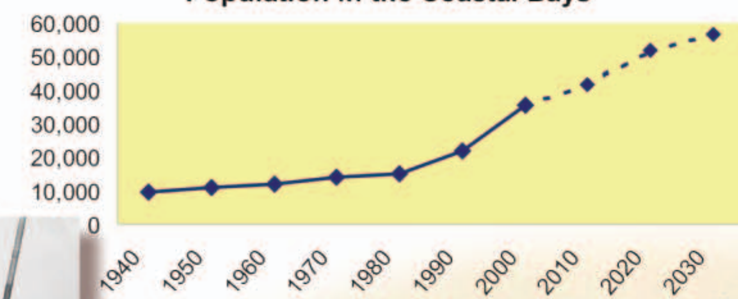
From west to east, the Coastal Bays have a gradient of high-mud to high-sand sediments.

Data courtesy of DNR

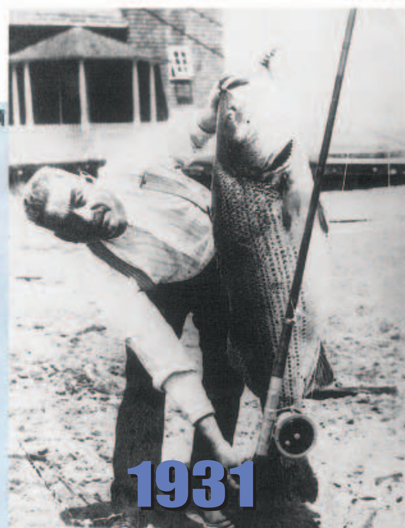
Time line

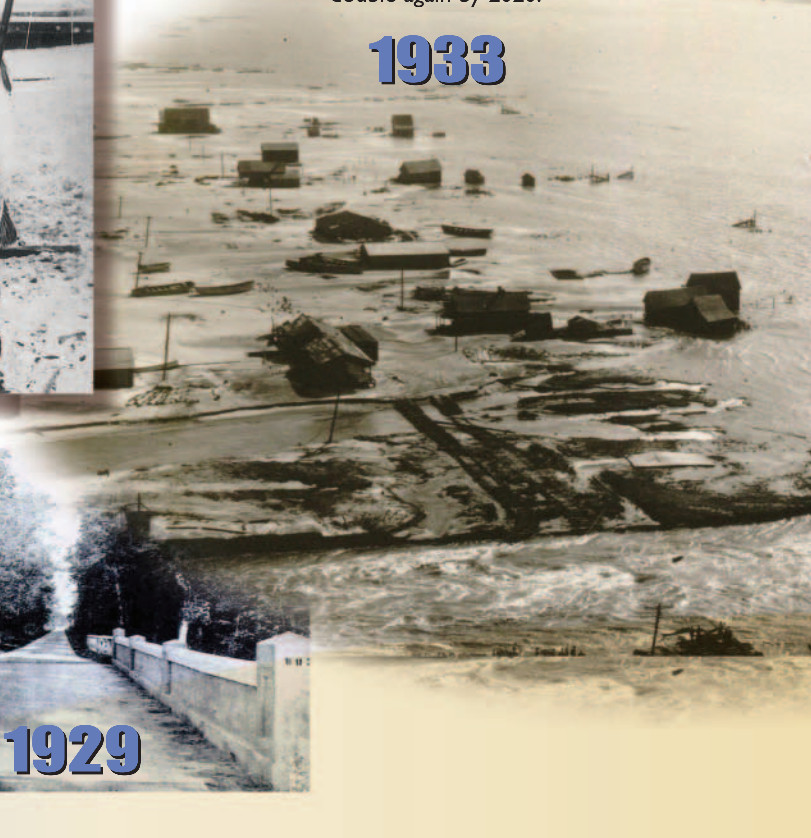
1928 State begins commercial landings survey of shellfish from bays.
1930 Seagrass "wasting disease" begins destroying grass beds.
1933 Storm surge opens Ocean City inlet.
Inlet stabilized by US Army Corps of Engineers.
1935 West Ocean City Harbor Created by Army Corps of Engineers
1948 First dredging of Sinepuxent and Isle of Wight bays
1958 Heyday of leased oyster beds. Oyster disease first reported.
1962 Ash Wednesday Nor'easter devastates Atlantic coast.
1964 Assateague State Park established.
1965 Assateague Island National Seashore established.
1968 Ocean Pines begins to be built.
1970 Enactment of tidal wetlands law.
1972 Carousel Hotel built. Maryland Department of Natural Resources (DNR) Fisheries Service begins routine trawl and seine surveys for finfish and blue crabs. Federal Clean Water Act passed.
1982 Seagrasses begin to recover.
1983 Last commercial oyster harvest. Maryland Department of the Environment intensive surveys commence.
1986 Observed decline in recreational flounder fishing. Virginia Institute of Marine Science and National Park Service begin monitoring seagrasses.
1987 US Park Service begins routine water quality monitoring in Newport, Sinepuxent, and Chincoteague bays. Establishment of National Estuary Program through the Clean Water Act.
1988 Coordinated beach replenishment (Army, State, local) commences.
1989 Enactment of non-tidal wetland law.
1990 Federal Environmental Monitoring and Assessment Program begins (through 1992).
1991 Non-native green crabs (*Carcinus maenus*) invade coastal bays.
1993 DNR Molluscan Inventory begins. Federal joint assessment of Maryland, Delaware and Virginia Coastal Bays begins.
1995 Maryland Coastal Bays nominated to National Estuary Program.
1996 Maryland Coastal Bays Program established. Japanese shore crabs (*Hemigrapsus sanguineus*) first documented.
1997 DNR plants bay scallops. Federal Mid-Atlantic Integrated Analysis begins (through 1998). Volunteer Water Quality monitoring program begins.
1998 Brown tide first detected. DNR begins routine monitoring for *Pfiesteria* at 29 stations in Isle of Wight and Newport bays. DNR plants bay scallops.
1999 Comprehensive Conservation and Management Plan (CCMP) adopted. Macroalgae present in large masses.
2000 National Coastal Assessment (continuation of EMAP) begins (continued through 2004).
2001 DNR begins routine water quality monitoring at 45 stations throughout the bays and tributaries. Blue crab Fisheries Management Plan goes into effect.
2003 Coastal Bays watershed included in Critical Areas Law.
2004 CCMP phase II begins - 2004 State of the Bays Report released.
2009 CCMP phase III to begin - 2009 State of the Bays Report anticipated.

Population in the Coastal Bays



Population has steadily increased and is expected to double again by 2020.





Historical summary

Where are we coming from?

From the early native Americans who hunted and fished the creeks and began to farm the lands, to the Europeans who settled later, to pirates and smugglers looking for hideouts among the perplexing coves and thick marshes, to most recently, the retirees and vacationers in search of more genteel escapes, Maryland's Coastal Bays have beckoned with abundant natural scenery and resources. The human population has gradually risen and, along with natural fluctuation, has promoted change as a common theme within the Coastal Bays ecosytem. Storms come and go, battering the islands and blasting inlets for Atlantic waters, which, if not stabilized, are soon closed by sandy sediments. Stocks of fish and shellfish fluctuate, forcing the waterman and recreational angler alike to be flexible. Other natural factors also constantly change. Eelgrass thrived prior to 1930, only to be reduced by a mysterious wasting disease and then return years later. Shorelines crumble under the unrelenting force of wind and wave, often returning as shoals far from their origin. Algal populations, microscopic cells drifting unnoticed most of the time, can swell in blooms so massive as to change the clarity and color of the water in every direction. As these communities move through this century, changes in the ecosystem both natural and, more increasingly, human-caused will shape the future of the Coastal Bays.

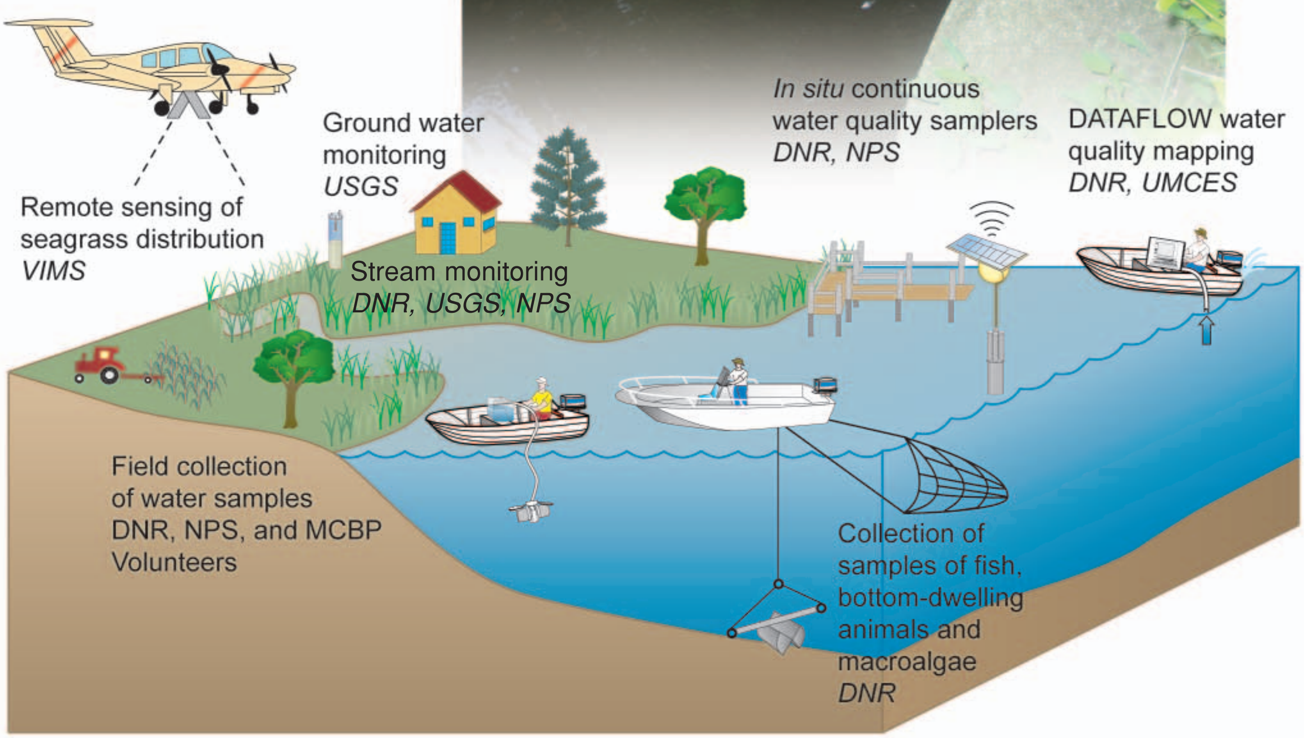
Who is monitoring?

Many agencies cooperate to monitor the Coastal Bays.

Monitoring programs in the Coastal Bays are used to assess the conditions of natural resources and to track changes over time. The Coastal Bays Eutrophication Monitoring Program measures key components of the ecosystem, including pollutant inputs, water quality, habitat and living resources. This program, in place since 2001, builds on historical monitoring efforts and is coordinated with other state and federal agencies. The information is vital for evaluating the progress of management actions aimed at restoring the Coastal Bays and their tributaries, for determining attainment of water quality criteria and for providing guidance on future actions. Monitoring data are also used for research and modeling the Coastal Bays ecosystem.

Many agencies participate in monitoring the Coastal Bays ecosystem. The Maryland Department of Natural Resources (DNR), National Park Service at Assateague Island and the Maryland Coastal Bays Program volunteers all routinely monitor water quality. The University of Maryland Center for Environmental Science (UMCES) provides expertise in water quality mapping (DATAFLOW). The United States Geological Survey (USGS) analyzes ground water inputs to the estuary. Maryland DNR also monitors stream health, sediment quality and harmful algae blooms. Habitat monitoring is conducted by the Virginia Institute of Marine Science through an annual aerial surveys of seagrass bed distribution, while Maryland DNR keeps track of macroalgae abundance and tracks shoreline change. The Maryland Department of the Environment (MDE) teams with DNR to collect data on wetlands. Fish, blue crabs, shellfish and bottom-dwelling, or benthic, animal populations are surveyed by DNR, while fish kills are monitored by MDE and exotic species abundances are tracked by the University of Delaware.

www.dnr.maryland.gov/coastalbays/res_protect/ccmp.html



What is being measured?

Monitoring in the Coastal Bays

Aquatic Ecosystem	Indicator Component	Threshold values (mg=milligrams L=liter)	Monitoring Frequency
Stream Health	Stream nitrate	Less than 1 mg/L	Highly varied
	Stream bottom-dwelling animal index1	Less than or equal to 2.8	Annually
	Stream bottom-dwelling animal index2	Less than or equal to 4	Every 5 years
	Freshwater fish index	Greater than or equal to 4	Every 5 years
Water Quality	Total Nitrogen	No more than 0.65 mg/L for seagrass growth; No more than 1 mg/L as set by STAC*	Monthly
	Total Phosphorus	No more than 0.037 mg/L for seagrass growth; No more than 0.01 mg/L as set by STAC*	Monthly
	Chlorophyll a	No more than 15 micrograms/L to prevent low dissolved oxygen; No more than 50 micrograms/L as set by STAC*	Monthly, as well as continuous monitoring and water quality mapping (the latter two measure total chlorophyll)
	Dissolved Oxygen	No less than 5 mg/L to prevent effects on aquatic life; No less than 3 mg/L as set by STAC*	Monthly, as well as continuous monitoring and water quality mapping
	Water Quality Index	Greater than 0.6	Calculated by combining values from all water quality indicators
Sediment Quality	Excess Organic Carbon	Less than or equal to 1%	Periodically
	Mean Apparent Effects Threshold	None	Calculated from sediment contaminant data (2000-2003)
	Ambient Toxicity	Significant difference from uncontaminated sediment	Annually 2000 - 2003
Harmful Algae	Harmful Algae Blooms	Species specific thresholds	As needed, when water quality indicates algae at high levels
Habitat	Seagrass	Goal acreage in development	Annual survey
	Macroalgae	None	Not routinely monitored
	Shoreline	Percent natural shoreline	Not routinely monitored
	Wetlands	No net loss	Not monitored directly
Living Resources	Phytoplankton	None	Monthly – weekly
	Fish	No decreasing trend in forage fish index	Monthly Trawl: April – Oct Seine: June and Sept.
	Fish kills	None	As needed
	Shellfish (clams, scallops, oysters)	None	Clams – annual survey
	Blue crabs	None	Monthly with fish survey
	Benthic animals	Federally-mandated index values	Annually 2000 - 2003
	Exotic species	Presence	Survey 2003

* Scientific and Technical Advisory Committee of the Maryland Coastal Bays Program

A variety of indicators and thresholds were used to assess estuarine health.

One of the most ambitious long-term goals of the Maryland Coastal Bays Program (MCBP) is to help identify and track a set of **regional environmental indicators and related threshold levels.** Aquatic environmental indicators developed by the MCBP Scientific and Technical Advisory Committee, in addition to some new draft indicators, were used in this report to assess the health of the bays. **Environmental indicators** are used to describe the status and trends of our natural resources, environmental health, and ecological condition. They help raise awareness about important issues, inform environmental policy decision-makers, and serve as tools for evaluating the effectiveness of management actions. Environmental indicators are similar to many of the economic and social indicators ingrained into our culture, such as the Dow Jones Industrial Average. Just as the Dow gives investors a general picture of the state of the market, environmental indicators give scientists and managers a picture of the state of our ecosystems. Like the Dow, **threshold values** (for each indicator) were developed. These **goals** provide benchmarks which measure the health of the Coastal Bays.

This report uses environmental indicators to measure the health of the Coastal Bays and will serve as a baseline for measuring an assessment of progress made toward implementing the priority actions of the Comprehensive Conservation and Management Plan (CCMP) created in conjunction with the EPA designation. **This report attempts to capture the major elements of the bays health that reflect the current knowledge of scientists, managers and citizens as to what constitutes the state of the bays.**

www.dnr.maryland.gov/coastalbays

Stream living resources

Fish and benthic, or bottom-dwelling, animals indicate most streams in the Coastal Bays are degraded.

To report overall stream health, researchers use the diversity and abundance of freshwater fish and benthic organisms. In the Coastal Bays watershed, this "Index of Biological Integrity" (IBI) is calculated for all sites with adequate data. These IBIs rate stream health according to the species of fish or invertebrates found there.

Most animals found in Coastal Bays watershed streams were classified as pollution-tolerant. Stream benthic index results from 59 sites rated most sites as either poor (15%) or very poor (75%) while the remaining sites rated fair (10%). The freshwater fish index results from 12 sites rated most sites as poor (14%) or very poor (43%), with 43% rated fair. Impacts to the biota of Coastal Bays streams are likely the result of physical habitat modifications (e.g., ditching). Ditched streams generally have less habitat diversity and lower flows than minimally-altered streams that retain a more natural wetland character.

The benthic community indicated a strong improvement in water quality from the very poor to lower fair range at the Bishopville Prong and the South Branch stations (see graphics on next page). Both sites showed an improvement in number of species, biotic and diversity indices. The benthic community indicated no significant trend in the fair water quality at Birch Branch.

The benthic communities at both Bottle Branch and Trappe Creek stations showed a slight improvement in water quality from the poor to the lower fair range over the years sampled. Both sites showed an increase in numbers of species, and Bottle Branch also showed an improvement in the biotic index values (see graphic on next page).

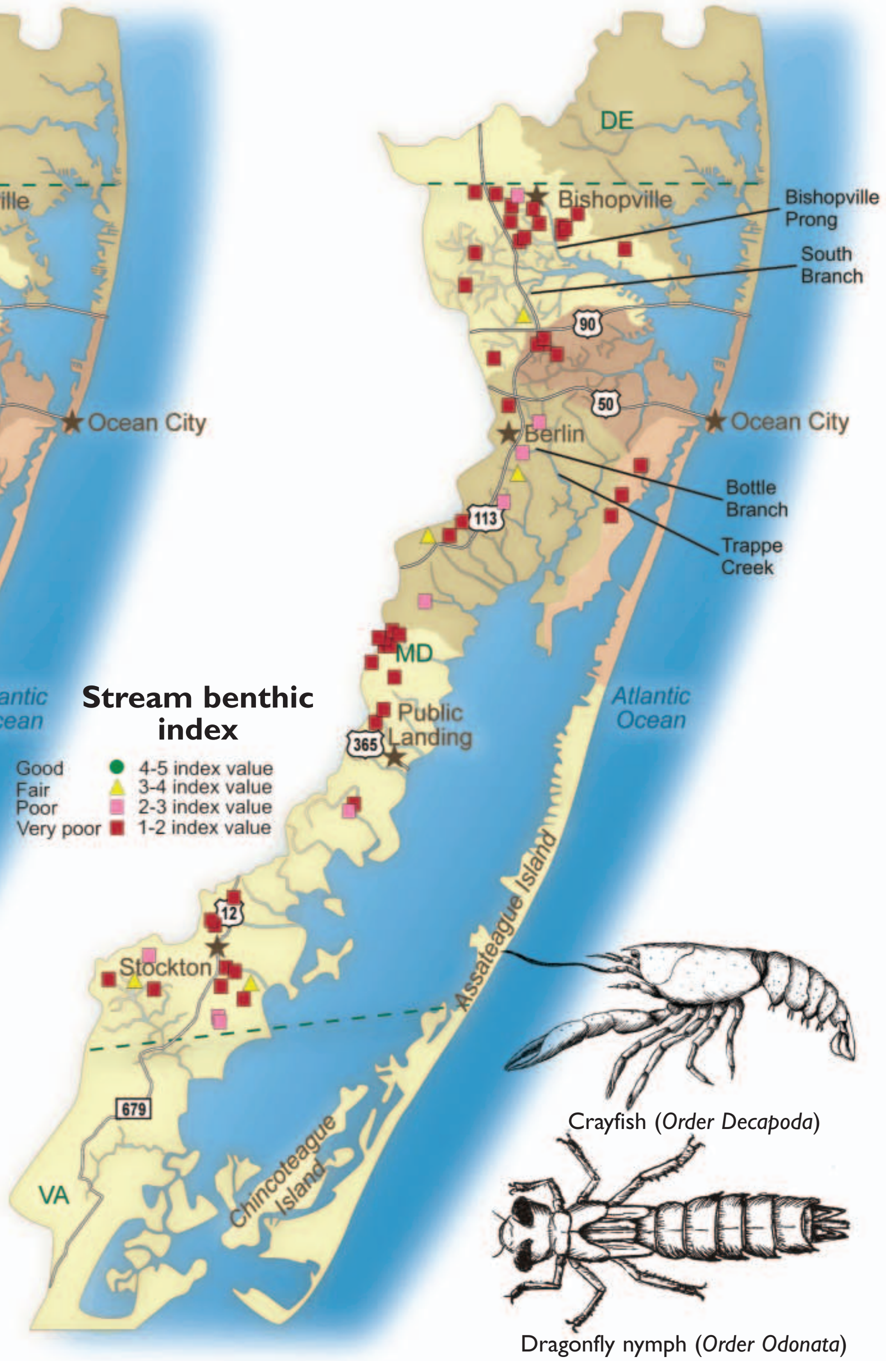
www.dnr.maryland.gov/streams/mbss/index.html.

Data courtesy of DNR

Management objective:
Healthy stream fauna
Indicator 1:
Freshwater fish index greater than 4
Indicator 2: *Stream benthic index greater than 4*

American eel (*Anguilla rostrata*)

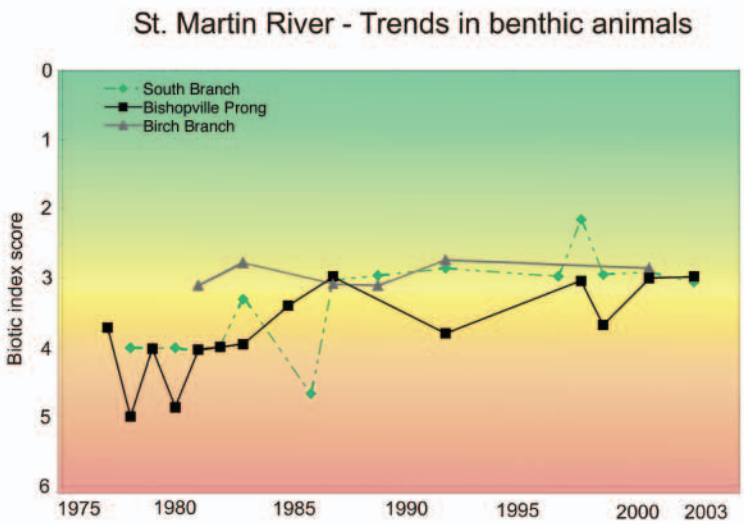
Pumpkinseed (*Lepomis gibbosus*)

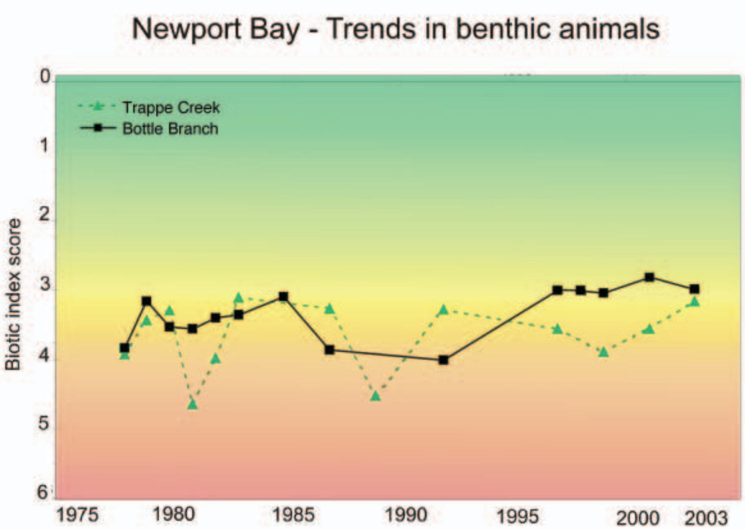


Crayfish (*Order Decapoda*)

Dragonfly nymph (*Order Odonata*)

Stream nutrients





Data plots courtesy of E. Friedman, DNR

High stream nitrate has been observed in all Coastal Bays segments.

Stream nitrate is a relative measure of nutrients entering the system. High levels indicate excess inputs from human activities. These inputs are transported to the bays via surface runoff (water running over land to creeks, rivers and streams) and groundwater (water that flows below the earth's surface). Streams and small creeks are often the initial receptors of pollutants which then travel down to the bays.

Most streams are degraded with excess nutrients. A majority of streams failed base flow conditions suggesting human inputs are high. Additionally, streams with more intensive monitoring programs have caught the more sporadic stormwater-type inputs and overall had higher concentrations of stream nitrate. Many tributaries, even in Chincoteague Bay watershed, have stream nitrate values indicating enrichment from human activities.

Extensive ditching of many tributaries and creeks may be allowing groundwater to enter streams faster thus decreasing the filtration it would naturally encounter as it traveled through wetlands and underground to the bays. Higher stream nutrients, sooner or later, will result in nutrient enrichement and degradation of the bays.

Upper tributaries are severely nutrient enriched. St. Martin River and northern Assawoman Bay are also highly enriched. Streams flowing into Sinepuxent Bay and northern Chincoteague Bay have the lowest total nitrogen.

Maximum stream nitrate (1999-2001)

Meets objective	●	0-0.6 mg/L
	▲	0.6-1 mg/L
Does not meet objective	■	1-2 mg/L
	■	2-3 mg/L
	⬟	3-5 mg/L
	⬟	Greater than 5 mg/L

Management objective:
Decrease nitrogen loading to streams

Indicator 1: *Stream nitrate less than 1.0 mg/L*

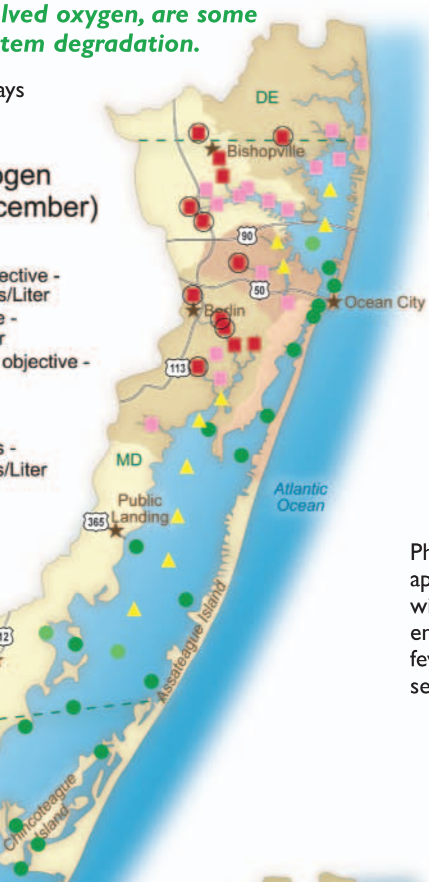
Data courtesy of DNR, USGS. NPS

Water quality

Nutrient overenrichment is a threat to the bays.

Increased nutrients (nitrogen and phosphorus) to the Coastal Bays lead to degraded water quality and ecosystem health. Increased phytoplankton blooms (measured as water column chlorophyll a) and related swings in dissolved oxygen, are some of the symptoms of ecosystem degradation.

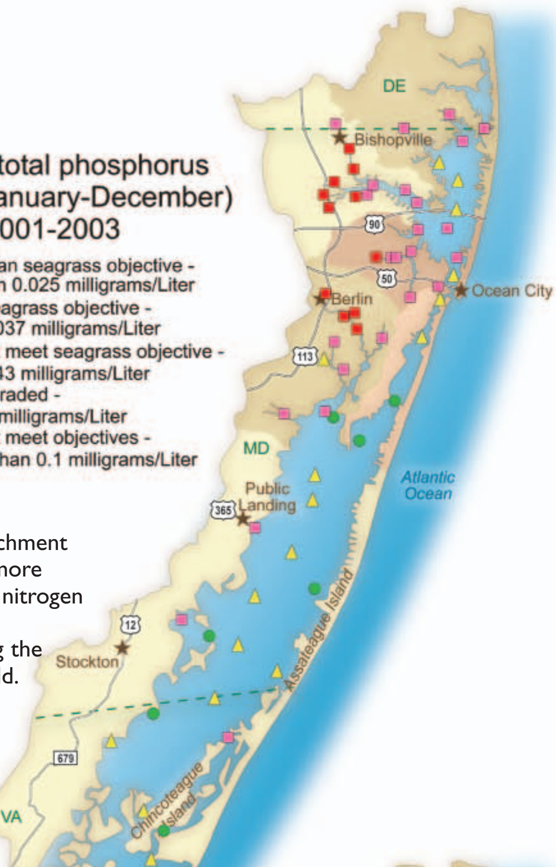
www.dnr.maryland.gov/coastalbays/water_quality/index.html.



Median total nitrogen Annual (January-December) 2001-2003

- Better than seagrass objective - Less than 0.55 milligrams/Liter
- Meets seagrass objective - 0.56-0.64 milligrams/Liter
- Does not meet seagrass objective - 0.65-1 milligrams/Liter
- Very degraded - 1-2 milligrams/Liter
- Does not meet objectives - Greater than 2 milligrams/Liter
- Non-tidal station

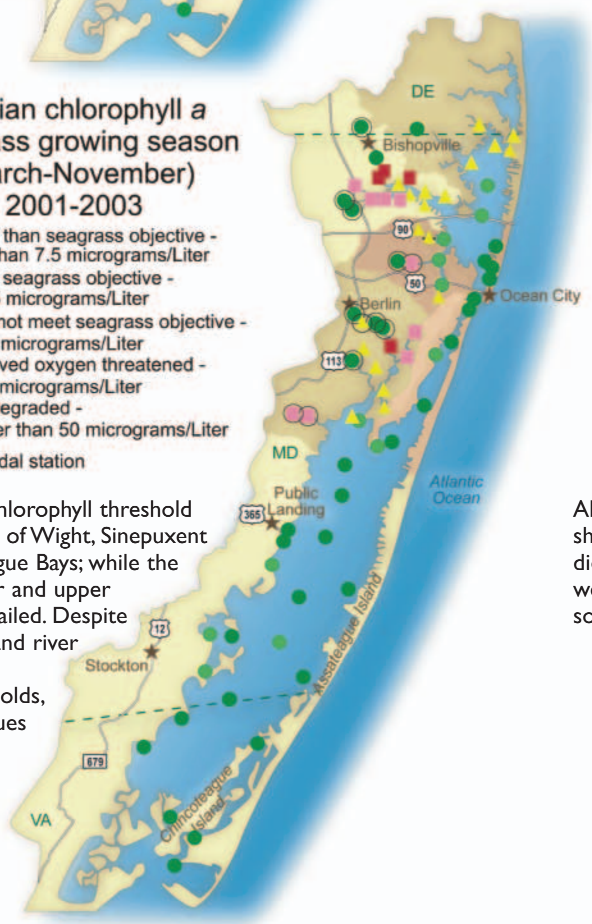
The upper tributaries, mostly in the northern Coastal Bays and Newport Bay, are severely enriched in nitrogen. The southern Coastal Bays, Sinepuxent and Chincoteague, have the lowest total nitrogen concentrations.



Median total phosphorus Annual (January-December) 2001-2003

- Better than seagrass objective - Less than 0.025 milligrams/Liter
- Meets seagrass objective - 0.026-0.037 milligrams/Liter
- Does not meet seagrass objective - 0.38-0.043 milligrams/Liter
- Very degraded - 0.44-0.1 milligrams/Liter
- Does not meet objectives - Greater than 0.1 milligrams/Liter

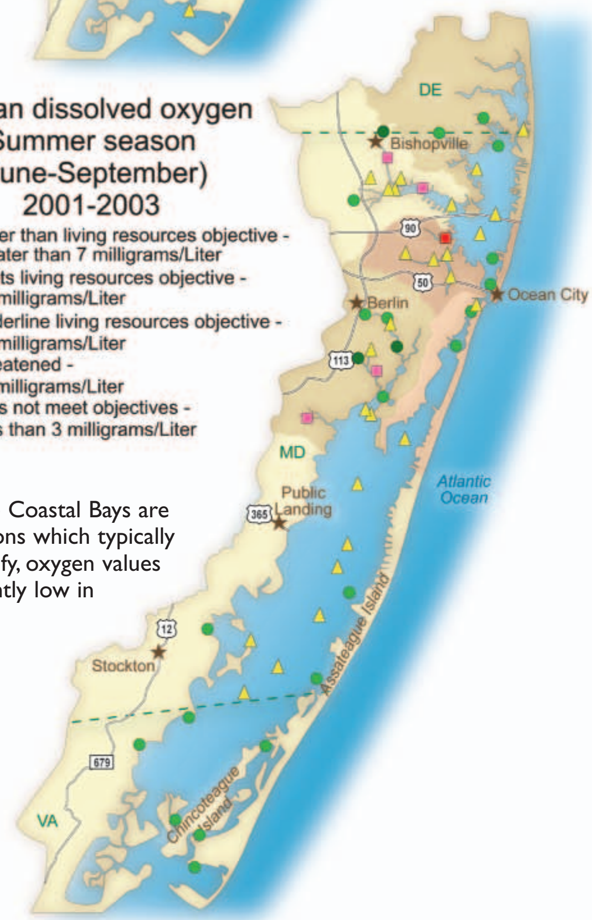
Phosphorus enrichment appeared to be more widespread than nitrogen enrichment with few sites meeting the seagrass threshold.



Median chlorophyll *a* Seagrass growing season (March-November) 2001-2003

- Better than seagrass objective - Less than 7.5 micrograms/Liter
- Meets seagrass objective - 7.5-15 micrograms/Liter
- Does not meet seagrass objective - 15-30 micrograms/Liter
- Dissolved oxygen threatened - 30-50 micrograms/Liter
- Very degraded - Greater than 50 micrograms/Liter
- Non-tidal station

The seagrass chlorophyll threshold was met in Isle of Wight, Sinepuxent and Chincoteague Bays; while the St. Martin River and upper Newport Bay failed. Despite many inshore and river areas failing nutrient thresholds, chlorophyll values were generally low in the open bays.



Median dissolved oxygen Summer season (June-September) 2001-2003

- Better than living resources objective - Greater than 7 milligrams/Liter
- Meets living resources objective - 6-7 milligrams/Liter
- Borderline living resources objective - 5-6 milligrams/Liter
- Threatened - 3-5 milligrams/Liter
- Does not meet objectives - Less than 3 milligrams/Liter

Although the Coastal Bays are shallow lagoons which typically did not stratify, oxygen values were frequently low in some areas.

Water quality index

Water quality is degraded in the tributaries and better in the open bays.

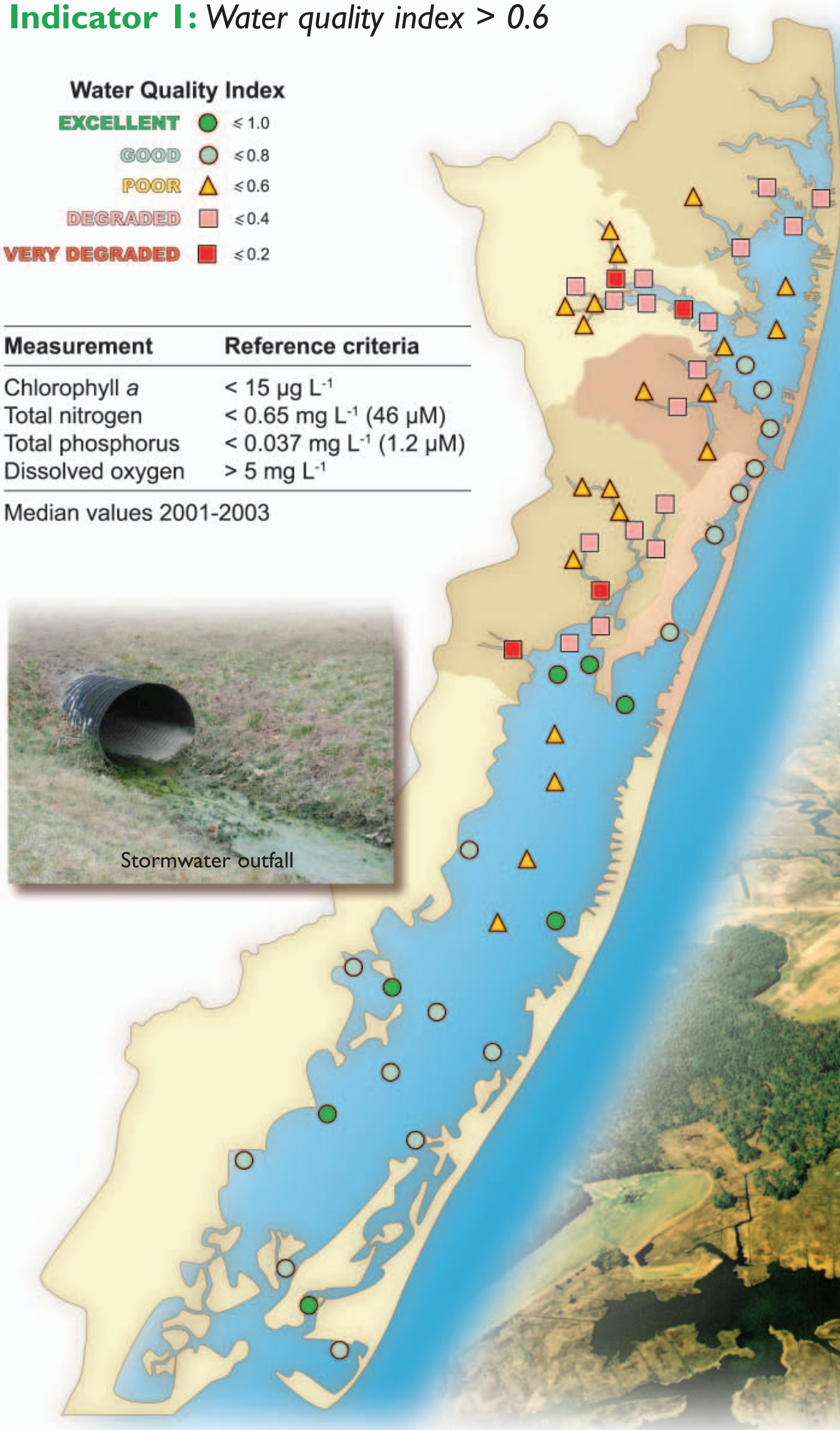
The Water Quality Index synthesizes the status of the four water quality indicators: chlorophyll *a* (algae), total nitrogen, total phosphorus, and dissolved oxygen into a single indicator of water quality. This indicator is similar to the Dow Jones Index, which compiles information on multiple stocks and provides a simple number to track over time.

The Water Quality Index compares measured variables to values known to maintain fisheries and seagrasses. The Index joins these together into one number between zero and one. A score of 0.8 and above indicates habitat conditions considered good for fish and seagrass survival, while scores of 0.4 and below indicate unsuitable habitat for either fish or seagrasses. Intermediate values indicate the system is variable and that some ecosystem functions (seagrass beds or fish) may be expected to be present some of the time. Currently, tributaries generally show poor to very degraded water quality largely due to high nutrient inputs, while the open bays have good to excellent water quality. Also, the northern bays are generally in poorer condition than the southern bays.

Management objective:
Maintain suitable fisheries and seagrass habitat
Indicator 1: *Water quality index > 0.6*

Water Quality Index

- EXCELLENT ≤ 1.0
- GOOD ≤ 0.8
- POOR ≤ 0.6
- DEGRADED ≤ 0.4
- VERY DEGRADED ≤ 0.2



Measurement	Reference criteria
Chlorophyll *a*	< 15 µg L^{-1}
Total nitrogen	< 0.65 mg L^{-1} (46 µM)
Total phosphorus	< 0.037 mg L^{-1} (1.2 µM)
Dissolved oxygen	> 5 mg L^{-1}

Median values 2001-2003

Stormwater outfall

Marshall Creek in Newport Bay

Continuous monitoring and...

New and automated monitoring technologies coupled with traditional monitoring programs are allowing natural resource managers and the public to better understand, evaluate, preserve and restore the health of Maryland's water and living resources.

Intensive temporal monitoring provides more information on the duration of water quality problems.

While monthly sample collections provide important information on annual patterns of water quality variation, they can often miss events occurring on smaller time scales or during times of the day when it is impractical to deploy field crews. Monthly sampling cannot provide data on the duration of poor water quality events. In order to assess these smaller time scales, four continuous monitoring sites have been sampled in the Coastal Bays. The monitors measure a suite of water quality parameters every 15 minutes and transmit these data to a website for viewing (www.eyesonthebay.net). This real-time technology allows scientists, managers and the public to view important water quality data the same day it is collected. Continuous monitoring data also allows scientists to learn more about these river systems by tracking daily fluctuations in dissolved oxygen, chlorophyll content, and other parameters. By tracking these changes, a better understanding of the conditions surrounding events such as fish kills and harmful algae blooms can be gained.

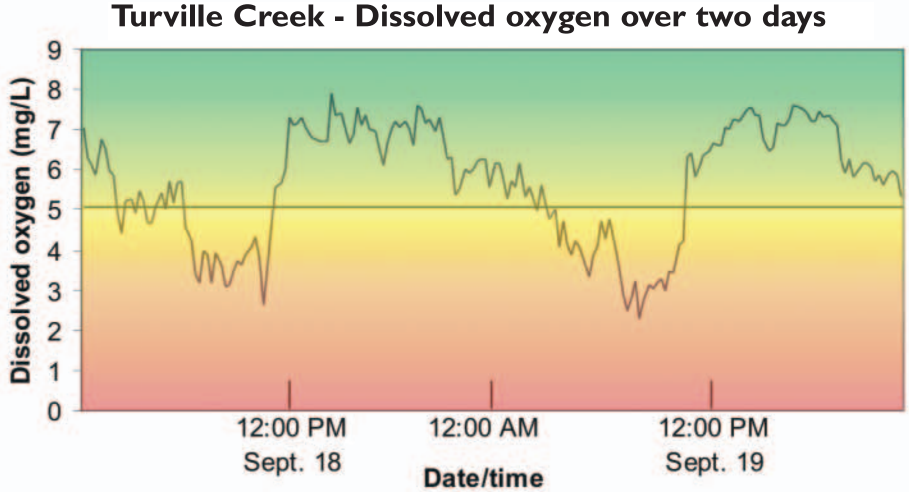
Continuous monitor	Indicator and threshold level (µg=micrograms, mg=milligrams, L=liter)	2002	2003
Bishopville Prong (March through November)	Chl > 50 µg/L	84%	46%
	Chl > 30 µg/L	94%	68%
	Chl >15 µg/L	98%	88%
	DO < 5 mg/L	59%	66%
	DO < 3 mg/L	30%	47%
Turville Creek (March through November)	Chl > 50 µg/L	34%	7%
	Chl > 30 µg/L	70%	36%
	Chl >15 µg/L	94%	75%
	DO < 5 mg/L	39%	39%
	DO < 3 mg/L	7%	11%

This table shows the percentages of time that each threshold level (water quality goal) for chlorophyll concentration (Chl) and dissolved oxygen concentration (DO) were not met during 2002 and 2003. The same thresholds used for monthly water quality monitoring (see previous water quality section) apply to continuous monitoring data.

Data courtesy of DNR

This map shows the locations of continuous monitoring stations. The two monitors north of Ocean City are maintained by DNR, and the two south of Ocean City are maintained by NPS.

Turville Creek - Dissolved oxygen over two days



This chart shows dissolved oxygen values over a two-day period collected by continuous monitors deployed at Turville Creek. The living resources threshold is indicated by the horizontal line. Note the daily fluctuation in dissolved oxygen concentration below the threshold value.

Data courtesy of DNR

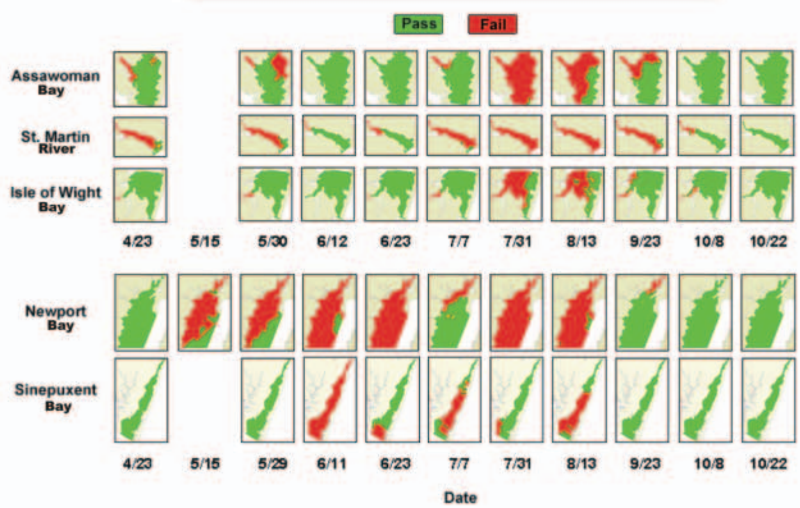
Deployment of continuous monitor (left). Specialized sensors are installed on an outboard boat to collect intensive water quality data over a large area in a short time (below).

Intensive spatial monitoring provides more information on the extent of algal blooms.

Traditional monitoring programs have collected periodic data at a small number of fixed sampling locations, often in the deeper channel areas. These measurements provide a good baseline for watershed assessment and long-term trends, but may miss small-scale gradients in water quality and neglect shallow water habitats that are critical habitat for seagrasses and other living resources. In response to these shortcomings, scientists at the Maryland Department of Natural Resources (DNR) in conjunction with the University of Maryland Center for Environmental Science (UMCES) utilize water quality mapping. This monitoring is conducted by field staff in a small outboard boat equipped with specialized sensors. These sensors record water quality data on a suite of indicators every three to five seconds as well as Global Positioning Satellite (GPS) coordinates for each sample as the boat moves along a prescribed track. These data can then be fed into Geographic Information System (GIS) software to produce spatially intensive water quality maps. In turn, these maps can be used to identify localized areas of water quality concern within watersheds, such as areas of low dissolved oxygen that can cause fish kills. The maps also identify possible linkages with nearby land usage. Data can also be used to aggregate watershed units to aid in the evaluation of entire systems. In the Coastal Bays, water quality mapping was used to evaluate algal concentrations as measured by chlorophyll concentration in the water.

Management objective: *Provide better spatial resolution to water quality indicators*
Indicator: *Seagrass chlorophyll threshold (15 micrograms per liter)*

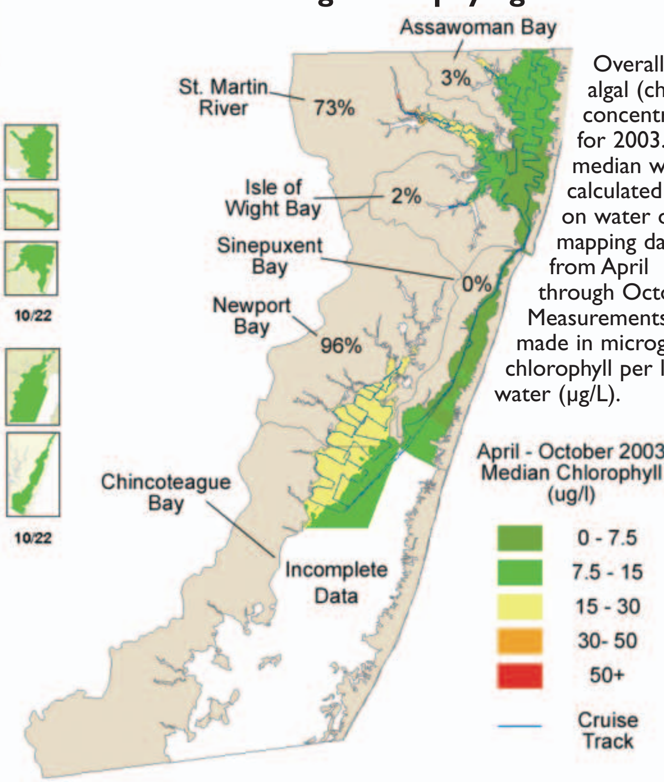
www.mddnr.chesapeakebay.net/eyesonthebay/index.cfm



Spatial monitoring gives better resolution of algae blooms and shows large scale 'pulses' in some bays. The maps above show the progression of the algae bloom over time, as measured by chlorophyll concentration in each segment during 2003.

Data courtesy of DNR & UMCES

Areas not meeting chlorophyll goals for seagrass



Overall median algal (chlorophyll) concentrations for 2003. The median was calculated based on water quality mapping data from April through October. Measurements were made in micrograms of chlorophyll per liter of water (µg/L).

Water quality trends

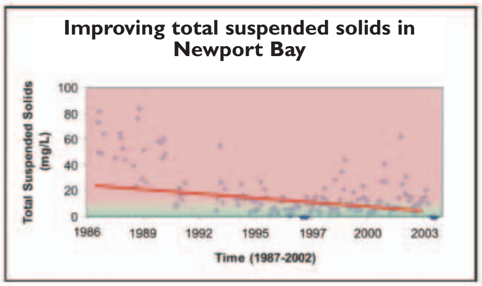
There are few overall trends in the southern bays.

Trend analyses (either improving or degrading water quality) allow us to track changes over time to determine if management actions are helping to improve conditions in the bays. Ten years of data are preferred to discriminate true trends due to annual fluctuations in rainfall and other factors. For this reason, only the National Park Service (NPS) water quality data, sampled since 1987, was assessed for trend. Four indicators were analyzed for trends: chlorophyll *a*, total suspended solids, total nitrogen, and total phosphorus. A significant positive trend (slope line going up; see graphic) indicates degrading conditions, since concentrations would be increasing. Conversely, a significant negative trend (slope line going down; see graphic) indicates improving conditions.

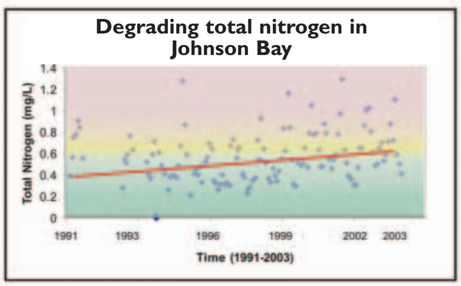
Overall, there were few significant trends at the NPS stations. Based on these trend analyses, water quality is thought to be generally staying the same or improving slightly in the southern bays, although two stations in Chincoteague Bay have degrading conditions in some indicators (see graphic). No long-term data sets are currently available for trends analyses in Isle of Wight Bay, St. Martin River or Assawoman Bay.

Lack of data, variability of parameters, and distribution of trends all lend to our inability to make an overall statement on trends. However, Chincoteague Bay, long thought to be the least impacted of the bays, has several alarming trend indicators that warrant further scrutiny. Continued monitoring of the additional water quality stations added in 2001 will allow us to evaluate trends throughout the bays in coming years. The following three graphs are examples of significant trends.

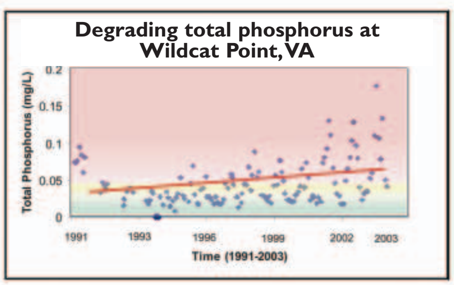
Improving total suspended solids in Newport Bay

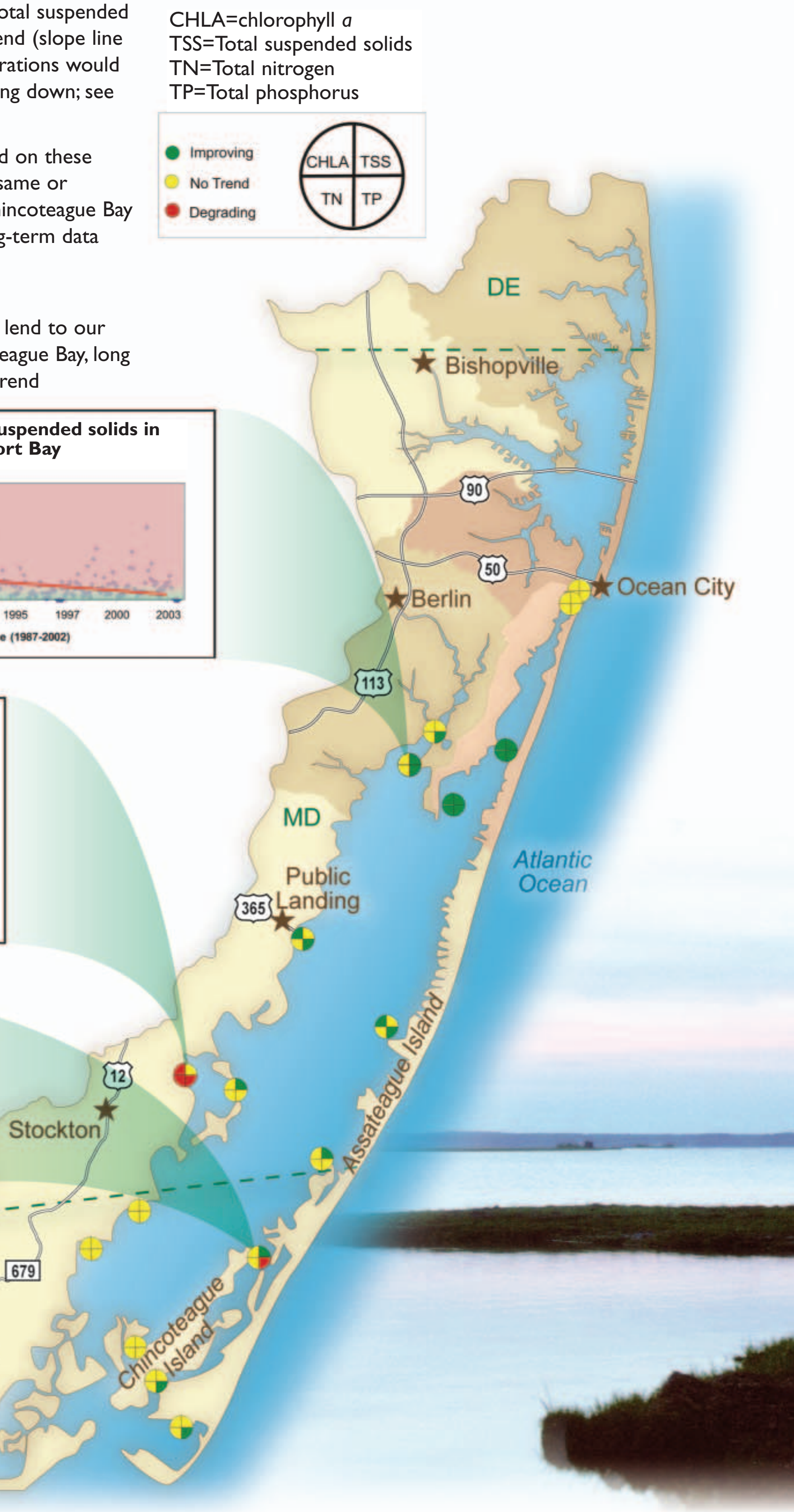


Degrading total nitrogen in Johnson Bay



Degrading total phosphorus at Wildcat Point, VA





Management objective:

Improving trends

Indicator: *Significant positive trend*

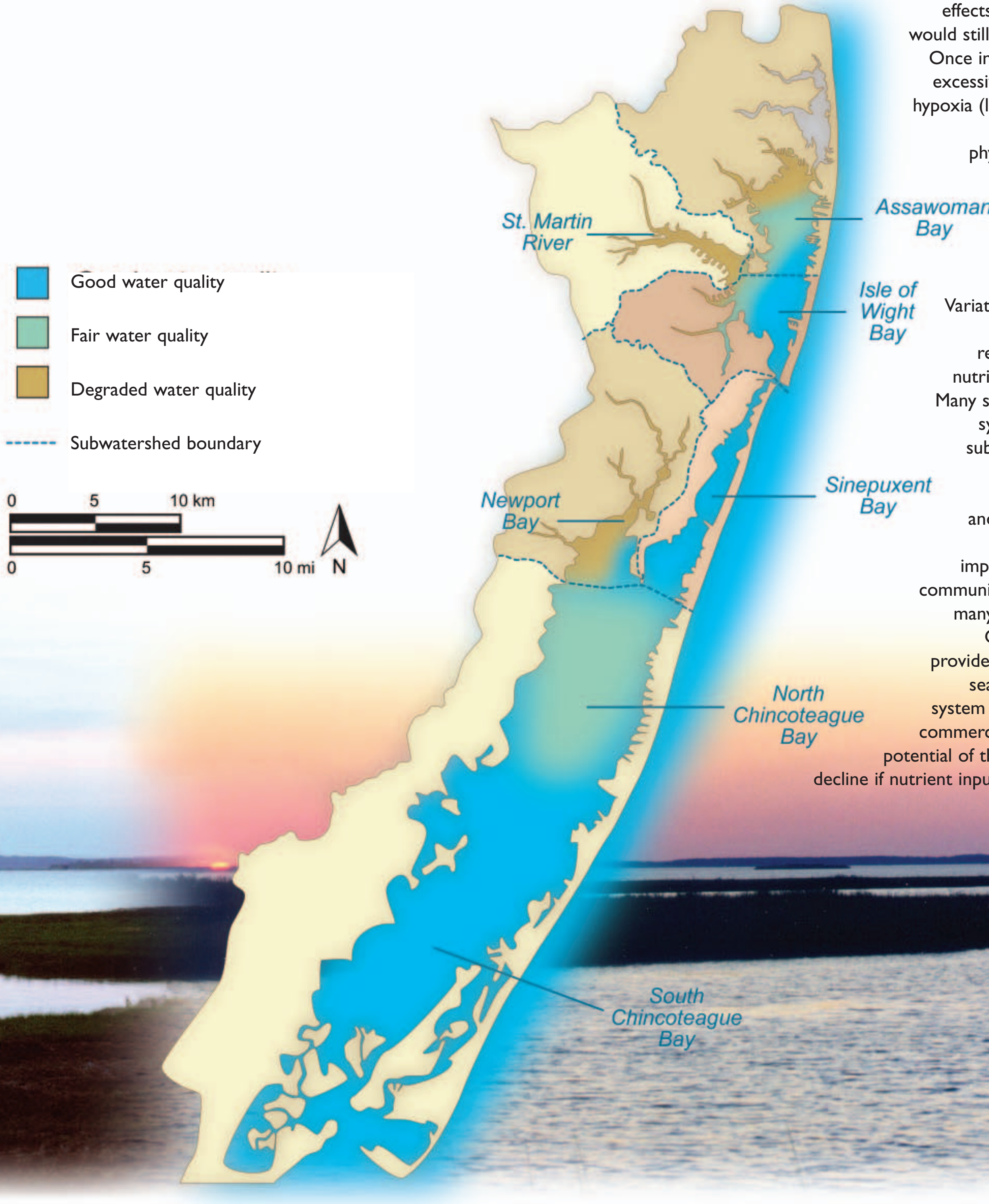
Trend analyses courtesy of DNR

Water quality summary

Nutrient loading is showing measurable impacts on the ecosystem.

Within the Coastal Bays, water quality shows many warning signs of ecosystem change, even though some areas currently still have good water quality. In general, water quality is degraded within and close to the major tributaries in the north (Assawoman Bay, St. Martin River, Isle of Wight Bay and Newport Bay). Isle of Wight Bay fares slightly better than the other northern bays due to better conditions in open water stations (see map on page 16). North Chincoteague Bay is in good condition generally, with slightly worse conditions through the central channel. In the more highly flushed regions of Sinepuxent Bay and south Chincoteague Bay, water quality is currently excellent. However, even south Chincoteague is not pristine, with many sites having high phosphorus concentrations.

Excess nutrients (nitrogen and phosphorus) cause degraded water conditions. These nutrients, which are transported across the surface of the ground as well as through groundwater, come from septic tanks, agricultural runoff, atmospheric input, and to a lesser extent, wastewater treatment plants. Water may take up to 10 years from the time it falls as rain until it reaches the bays via groundwater; if septic and agricultural runoff were ended today, effects from groundwater would still be seen over time. Once in the water column, excessive nutrients lead to hypoxia (low oxygen), limited fish survival, and phytoplankton (single-celled algae) blooms which limit seagrass growth in many areas.



Variation in water quality between regions is reflecting variation in nutrient concentrations. Many sites throughout the system are displaying subsequent ecosystem effects of high phytoplankton and reduced dissolved oxygen. This has implications for aquatic communities, suggesting that many regions within the Coastal Bays do not provide suitable habitat for seagrasses or fish. The system is changing, and the commercial and recreational potential of the Coastal Bays will decline if nutrient inputs are not reduced.

Seagrass abundance

Seagrass distribution is related to water quality.

Seagrasses are an important part of the Coastal Bays ecosystem. Not only do seagrasses improve water quality, they also provide food and shelter for waterfowl, fish and shellfish. The presence of healthy seagrass beds is an indicator of good water quality and a healthy coastal ecosystem.

Two species of seagrass occur in the Coastal Bays. Eelgrass (*Zostera marina*) is the most common, followed by widgeon grass (*Ruppia maritima*). Both thrive in the high salinity water of the bays. Almost 85 percent of all seagrasses in the bays occur along the Assateague Island shoreline. Distribution is a factor of water quality, sediment type, and wave energy. Sinepuxent and Chincoteague bays have the greatest amount of bottom area covered with seagrass (36 and 32 percent, respectively).

Widgeon grass (*Ruppia maritima*)

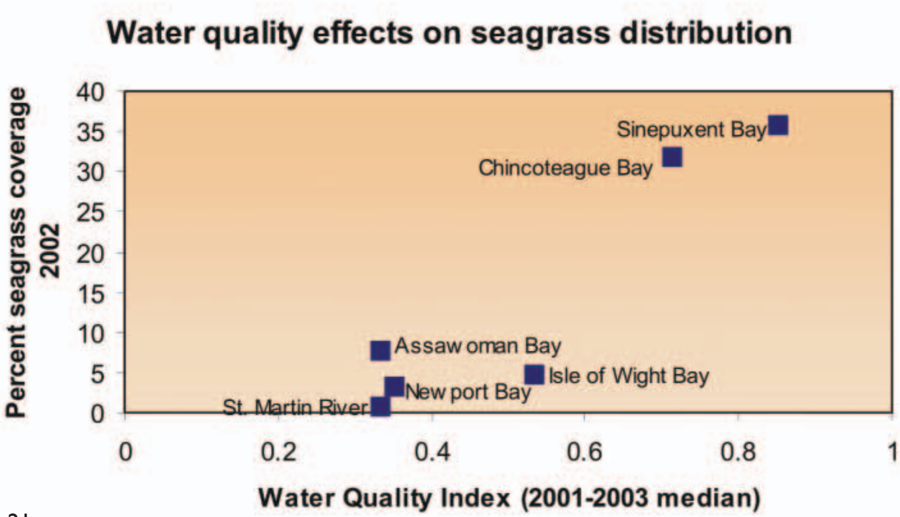
Eelgrass (*Zostera marina*)

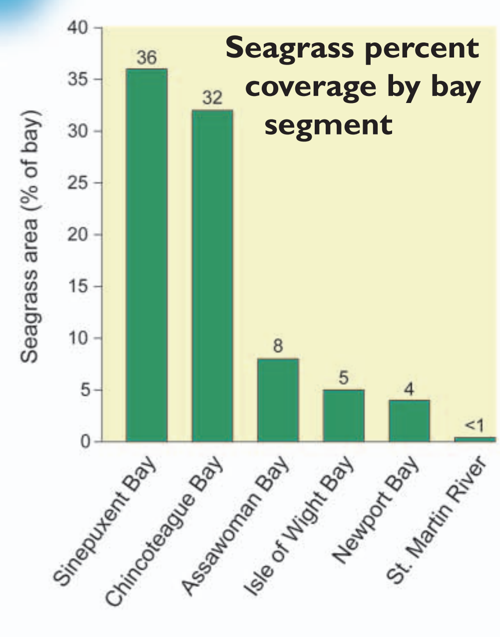
Water quality plays a critical role in seagrass distribution. Light availability is the primary water quality habitat criterion for aquatic plants and is affected by nutrient and sediment inputs. Excess nutrients cause algal blooms which block sufficient sunlight from reaching seagrasses.

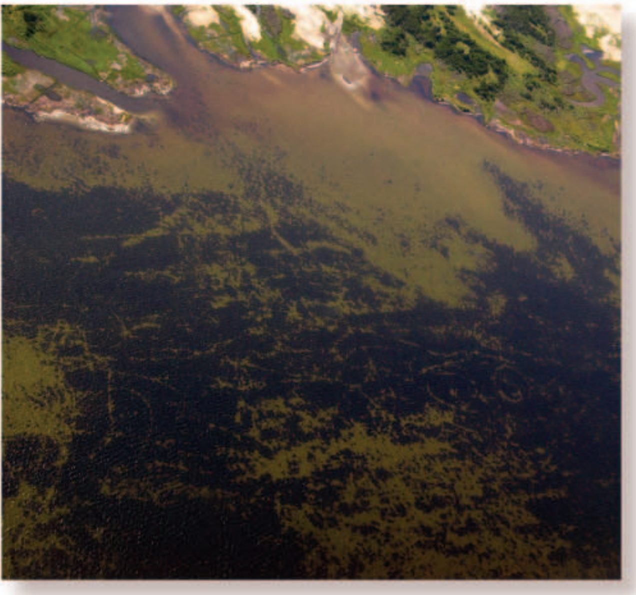
www.dnr.maryland.gov/coastalbays/living-resources/coast_bay_grasses.html

Data courtesy of Virginia Institute of Marine Science

The plot below shows the effects of water quality on percent seagrass coverage in each of the Coastal Bays. The Water Quality Index values are the same as reported on page 16.







Aerial photo of Sinepuxent Bay showing seagrass distribution. Dark areas are seagrass.

Seagrass trends

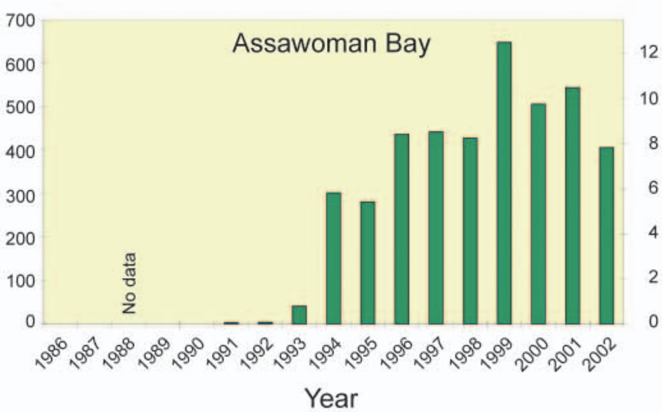
Seagrasses have been increasing in the Coastal Bays.

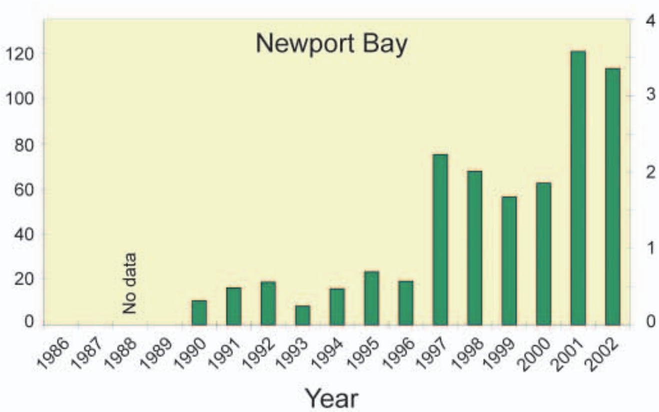
Seagrasses have been increasing since monitoring began in 1986. General consensus among the scientific community is that, despite recent increases documented by the aerial survey, seagrass coverage is considerably less than in the early 1900s. A disease virtually eliminated eelgrass (*Zostera marina*) from the Coastal Bays in the 1930s, leading to drastic declines in the acreage covered by seagrasses in general.

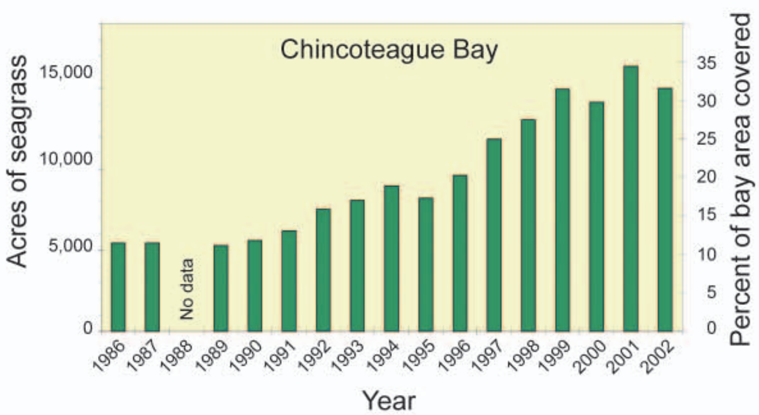
The 2002 acreage in the Coastal Bay represents a 320 percent increase since annual data began to be collected in1986. Even though the 2002 numbers generally show a decrease from 2001, seagrass acreage in Maryland's Coastal Bays has exhibited a steady increase since annual monitoring began. Although seagrasses are found in all four major segments of Maryland's Coastal Bays, they are not distributed evenly.

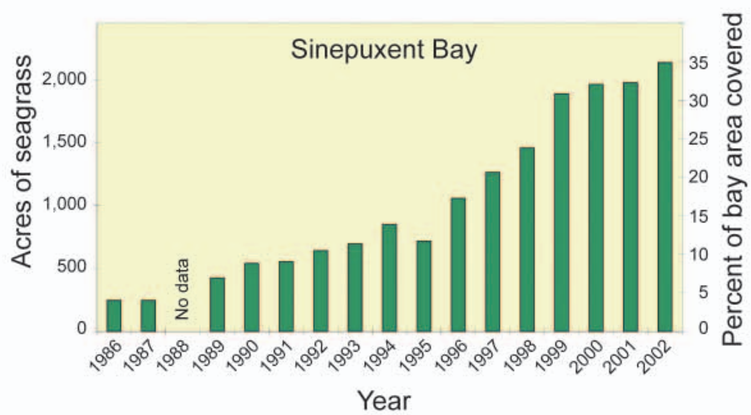
www.vims.edu/bio/sav

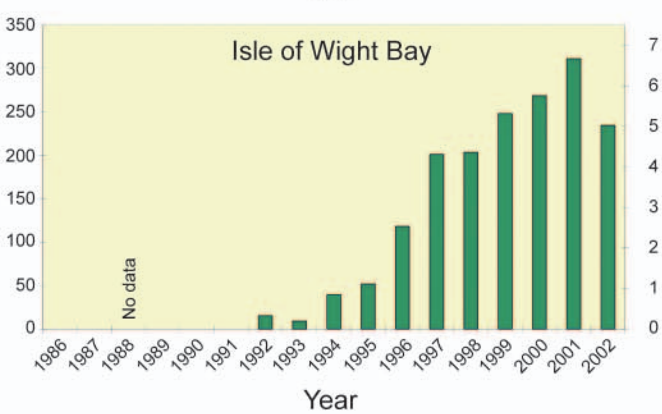
Management objective: *Increasing seagrass abundance*
Seagrass indicator: *Acres of seagrass*

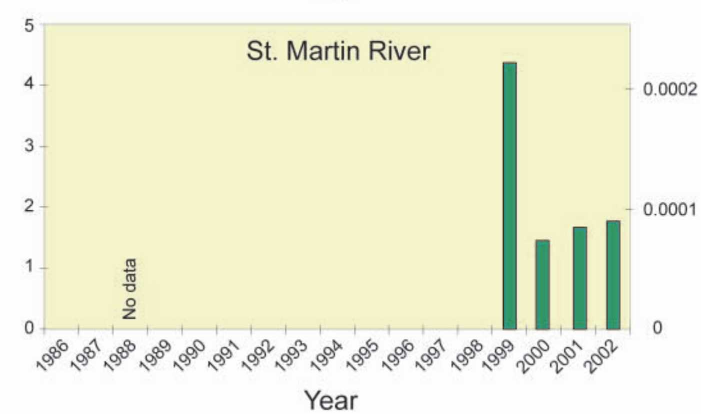












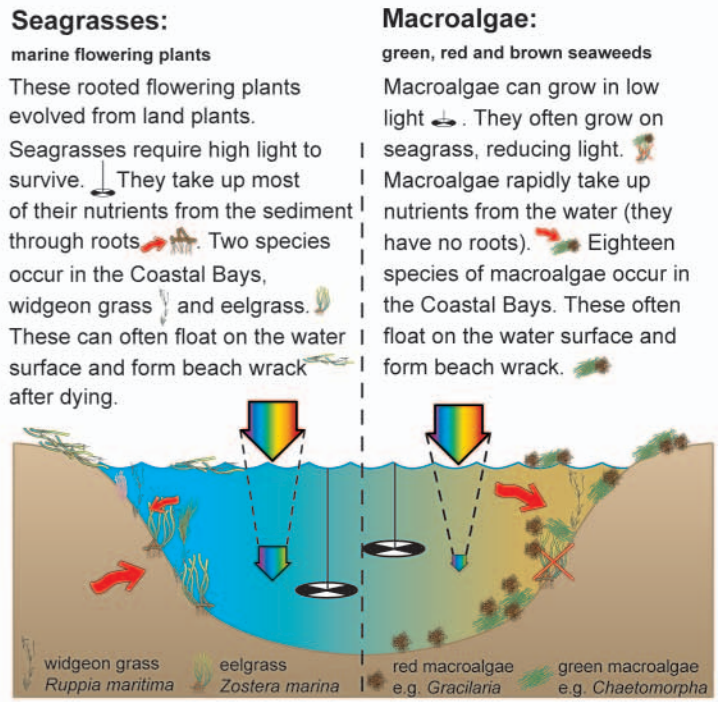
Macroalgae abundance

Macroalgae, also known as seaweeds, are abundant and distributed throughout the bays.

Estuarine ecosystems with generally well-illuminated shallow bottoms and moderate to high nutrient loadings can be optimal environments for the development of high concentrations of macroalgae. Macroalgae (seaweeds) are large plant-like structures found in coastal waters worldwide. Three main types, divided by coloration, are present along the Atlantic coast – green, red, and brown. Experts believe that a shift in the dominant primary producers (i.e., organisms at the base of the food chain that convert sunlight to energy), from slower growing seagrass to faster growing macroalgae to even faster growing phytoplankton, is indicative of eutrophication (i.e., excessive nutrient concentration) in a system. The presence of macroalgae blooms may be a sign of a system's progression toward a degraded state.

Macroalgal distribution and biomass were investigated in tidal locations throughout the Coastal Bays during the winter, spring, summer, and fall seasons from 1998-2003. Eighteen genera of macroalgae were identified in Maryland's Coastal Bays including six green macroalgae, eight red macroalgae, and four brown macroalgae. There was no statistical difference in the abundance of macroalgae among seasons; however, there were distinct seasonal shifts in which genera were dominant. The amount of macroalgae averaged 4.3 grams per liter (g/L) for all samples, with peak biomasses of 316 g/L in Turville Creek and 444 g/L in Chincoteague Bay.

Nutrient responsive species were accountable for 39 perent of the overall biomass and were dominant in the northern Coastal Bays and in seagrass beds in Chincoteague Bay. Biomass estimates revealed that the relative dominance of primary producers in each bay segment shifted from seagrass to macroalgae to phytoplankton with increasing nutrient loads.



Characteristics of macroalgal genera commonly found in the Coastal Bays

Cladophora (green macroalgae)

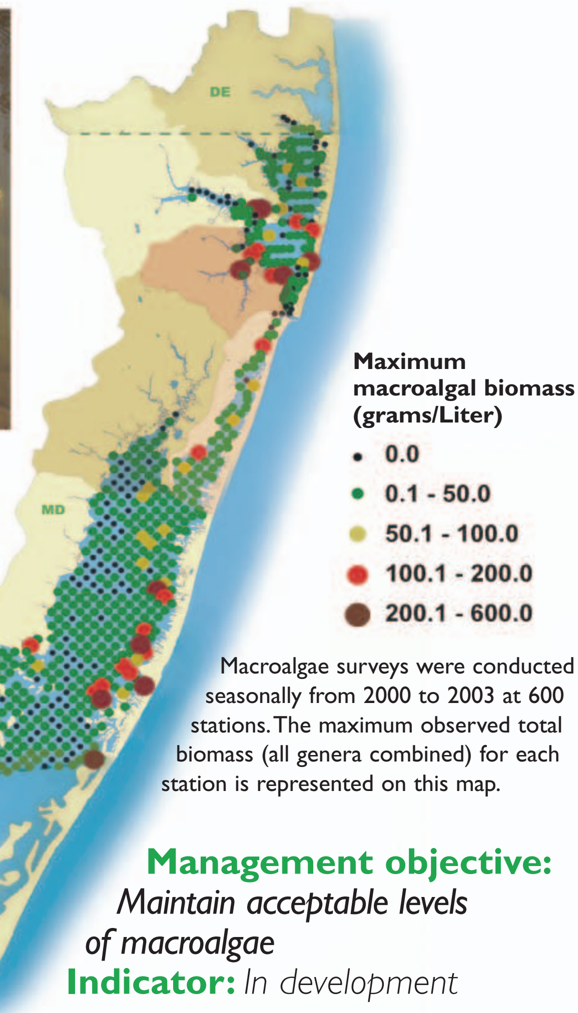
- Grows in masses of green, branched, hair-like fronds
- Prefers shallow water with high light penetration
- Often found in dead-end canals

Ulva (sea lettuce; green macroalgae)

- Bright green algae with broad, flat blades and ruffled edges
- Takes up nitrogen quickly and often outgrows other plants
- Can be attached or free-floating

Ectocarpus (brown macroalgae)

- Common worldwide
- Often found in soft brown tufts along jetties and other structures
- Tolerant of metal pollution



Macroalgae surveys were conducted seasonally from 2000 to 2003 at 600 stations. The maximum observed total biomass (all genera combined) for each station is represented on this map.

Management objective:
Maintain acceptable levels of macroalgae
Indicator: *In development*

Map data courtesy of DNR

Nuisance macroalgae

Some macroalgae are occurring at harmful levels.

Although macroalgae are part of any healthy estuarine ecosystem, an excess of macroalgae can be problematic for aquatic life (bay animals can be impaired or killed as a result of decreased oxygen levels when algae die and decompose) as well as to boaters (prop fouling), citizens and tourists (odor). This can particularly be a problem in dead-end canals where high nutrient loads and limited flushing make ideal environments for some macroalgae species. Such excessive levels are categorized as Harmful Algae Blooms (HABs).

Macroalgae are considered harmful when they produce dense overgrowth in localized areas, such as coastal embayments receiving excessive nutrient loads. Accumulations can be so high as to cover the bottom, excluding other life. Also, when such large masses of macroalgae begin to die, excessive oxygen consumption associated with the decomposition process can rob the water of oxygen.

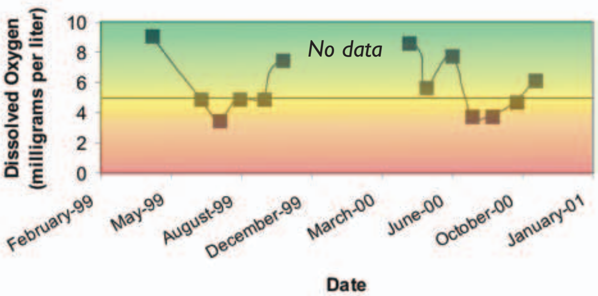
Two genera of macroalgae qualify as harmful algae blooms in two areas of the Coastal Bays under the definition instituted by the National Oceanographic and Atmospheric Administration. First, *Gracilaria* in Turville Creek was so dense from 1999 through 2001 that it caused the Department of Natural Resources (DNR) fishery monitoring program to relocate its 25+ year monitoring site in this tributary. This system is prone to low dissolved oxygen levels that are probably influenced by these blooms. *Chaetomorpha* levels in Chincoteague Bay were extremely dense from 1998 through 2001. This is believed to have impacted seagrass density in some areas and scallop restoration efforts.

www.dnr.maryland.gov/coastal bays/living-resources/macroalgae.html

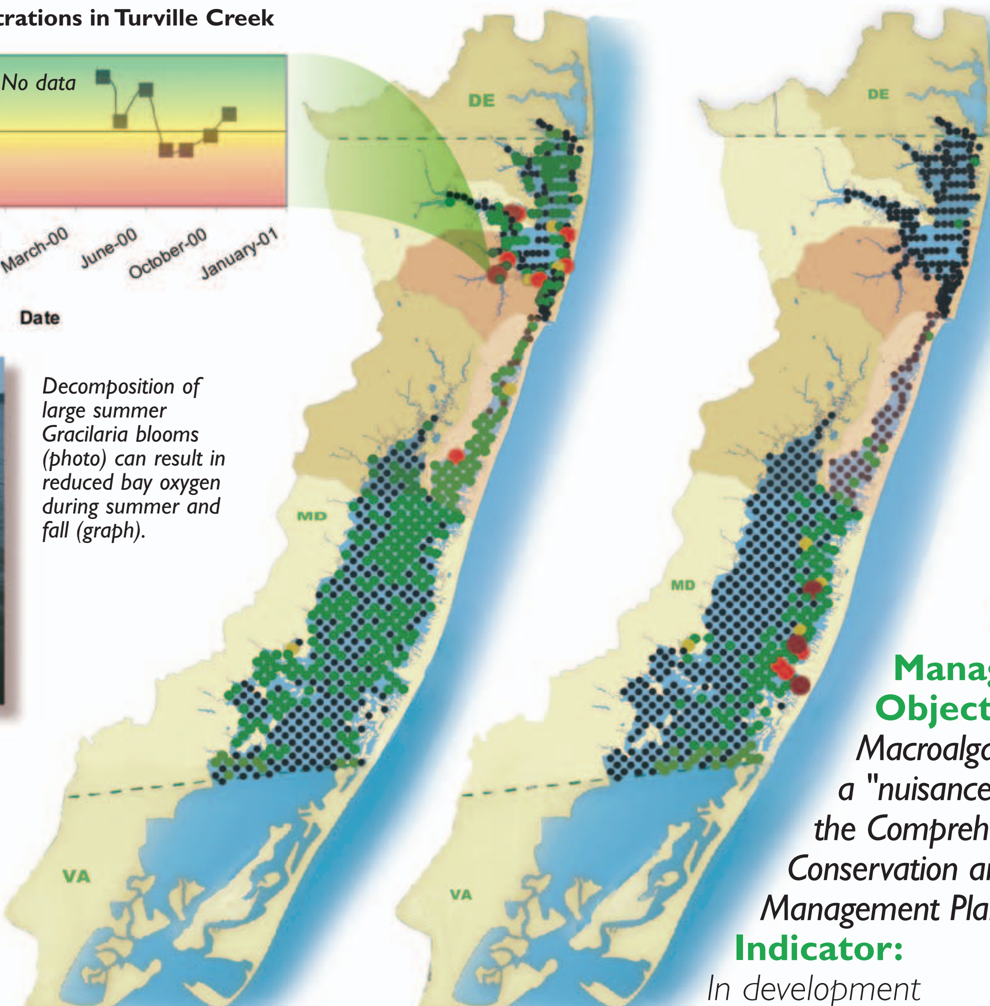
Chaetomorpha (green macroalgae)

Gracilaria (red macroalgae)

Dissolved oxygen concentrations in Turville Creek



Decomposition of large summer Gracilaria blooms (photo) can result in reduced bay oxygen during summer and fall (graph).



Maximum *Gracilaria* biomass (grams/liter)
- 0.0
- 0.1 - 50.0
- 50.1 - 100.0
- 100.1 - 200.0
- 200.1 - 500.0

Maximum *Chaetomorpha* biomass (grams/liter)
- 0.0
- 0.1 - 50.0
- 50.1 - 100.0
- 100.1 - 200.0
- 200.1 - 500.0

Management Objective:
Macroalgae are listed as a "nuisance species" in the Comprehensive Conservation and Management Plan (CCMP)

Indicator:
In development

Map data courtesy of DNR and NPS

Harmful algae blooms

Harmful Algae Blooms (HABs) are a potential problem in nutrient-impacted waters.

Algae are important components of aquatic ecosystems, forming the base of the food chain by converting sunlight to energy (photosynthesis). Certain types of algae may become harmful if they occur in an unnaturally high abundance (termed an HAB) or if they produce a toxin that can harm aquatic life or humans. HABs are increasing worldwide. Many have been related to increases of nutrients from human activities. Blooms of harmful algae have the potential to cause economic loss related to decreased recreational and commercial fishing and tourism.

Twelve potentially harmful algae taxa have been identified in the Coastal Bays: *Aureococcus anophagefferens* (brown tide), *Pfiesteria piscicida* and *P. shumwayae, Chattonella* spp., *Heterosigma akashiwo, Fibrocapsa japonica, Prorocentrum minimum, Dinophysis* spp., *Amphidinium* spp., *Pseudo nitzchia* spp., *Karlodinium micrum* and two macroalgae genera *(Gracilaria, Chaetomorpha).* Some of these algae species have complex life cycles and may produce toxins only during certain life stages. Therefore, the presence of HAB species does not always indicate toxic effects. Presence of species is richest in the tributaries of St. Martin River and Newport Bay.

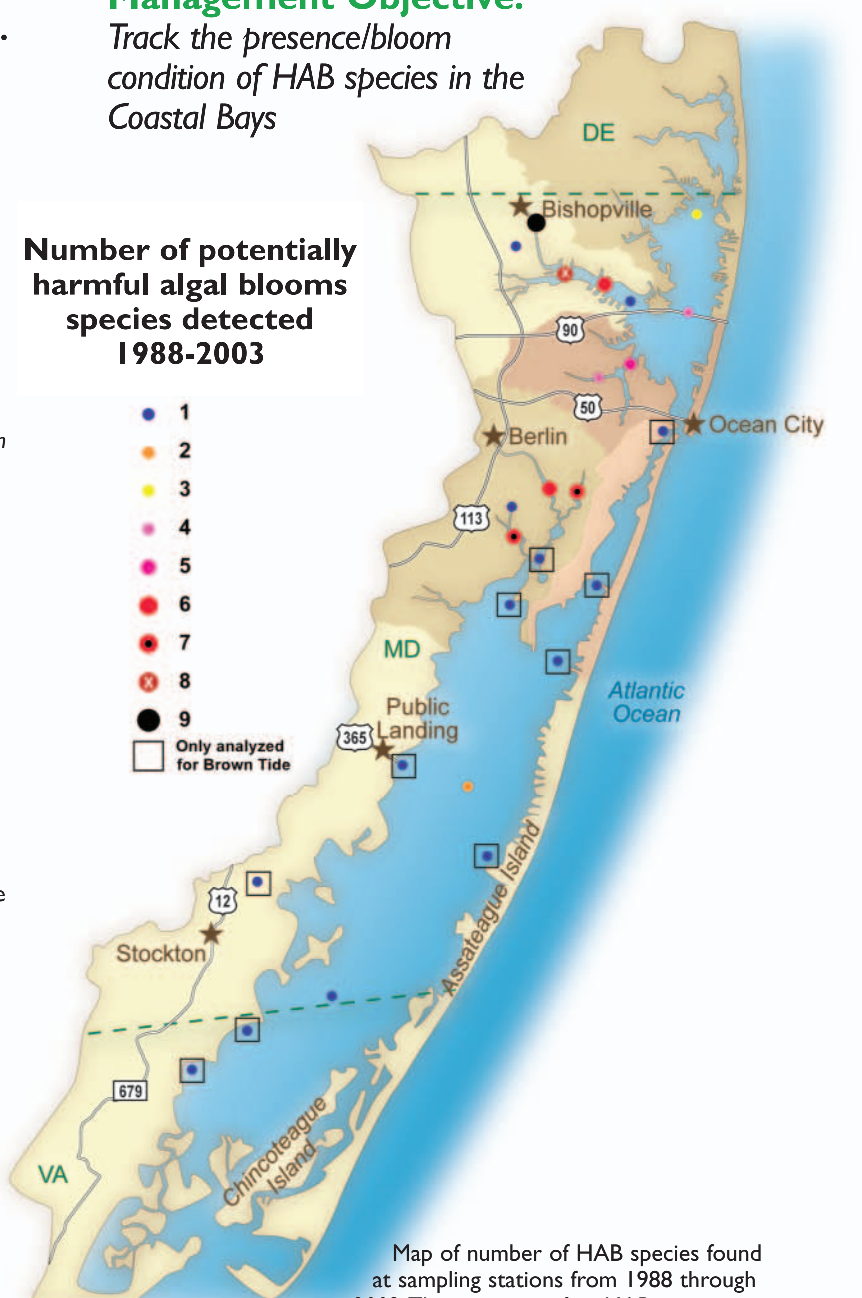
Approximately 5% of the phytoplankton species identified in Maryland's Coastal Bays represent potential HAB species. The HABs are recognized for their potentially toxic properties and, in some cases, their ability to produce large blooms negatively affecting light and dissolved oxygen resources. Brown tide *(A. anophagefferens)* has been the most widespread and prolific HAB species in the area in recent years, producing growth impacts to juvenile clams in test studies and potential impacts to seagrass distribution and growth. Macroalgal fluctuations may be evidence of a system balancing on the edge of a eutrophic (nutrient-enriched) state.

No evidence of toxic activity has been detected among the Coastal Bays phytoplankton. However, species such as *Pseudo nitzschia seriata, Prorocentrum minimum, Pfiesteria piscicida, Dinophysis acuminata* and *Karlodinium micrum* have produced positive toxic bioassays or generated detectable toxins in Chesapeake Bay. *Chattonella* cf. *verruculosa* was implicated in a large fish kill and persistent toxins detected in Delaware's Rehoboth Bay during 2000. Tracking potential HAB species diversity, abundance, distribution and toxic activity through time provides important indicators of environmental change for the Coastal Bays.

www.dnr.maryland.gov/bay/hab/index.html.

Management Objective:

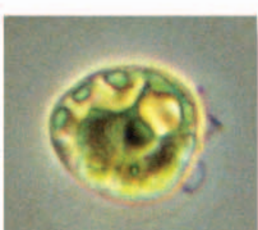
Track the presence/bloom condition of HAB species in the Coastal Bays



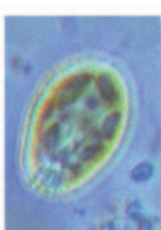
Map of number of HAB species found at sampling stations from 1988 through 2003. The presence of an HAB species does not necessarily indicate a harmful algae bloom as these species are present in non-threatening background concentrations.

Map data courtesy of DNR

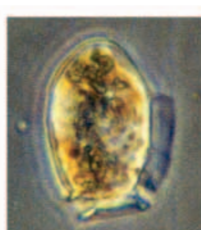
Harmful algae under the microscope (~.05mm)



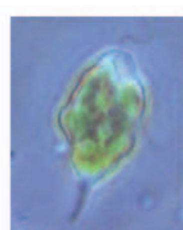
Prorocentrum minimum



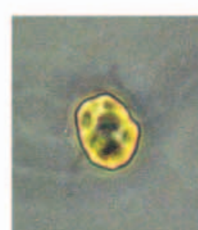
Fibrocapsa japonica



Dinophysis acuminata



Chattonella cf. verruculosa



Heterosigma akashiwo

Brown tide

Indicator: *Exceedance of brown tide category one (occurrence of category two or three blooms)*

Brown tide is a problem in the Coastal Bays.

Brown tide, *Aureococcus anophagefferens,* blooms can have serious impacts on shellfish populations (scallops, hard clams and mussels) and seagrasses. *Aureococcus* was first identified in the United States in northeast coastal embayments in 1985 and was discovered in Maryland during 1998, though research suggests it was present in the bays back to 1993. Brown tide blooms have been categorized based on their potential impacts to living resources:

Category 1: Less than 35,000 brown tide cells/milliliter (mL)
- No observed impacts

Category 2: 35,000 to 200,000 brown tide cells/mL
- Reduction in growth of juvenile hard clams
- Reduced feeding rates in adult hard clams
- Growth reduction in mussels and bay scallops

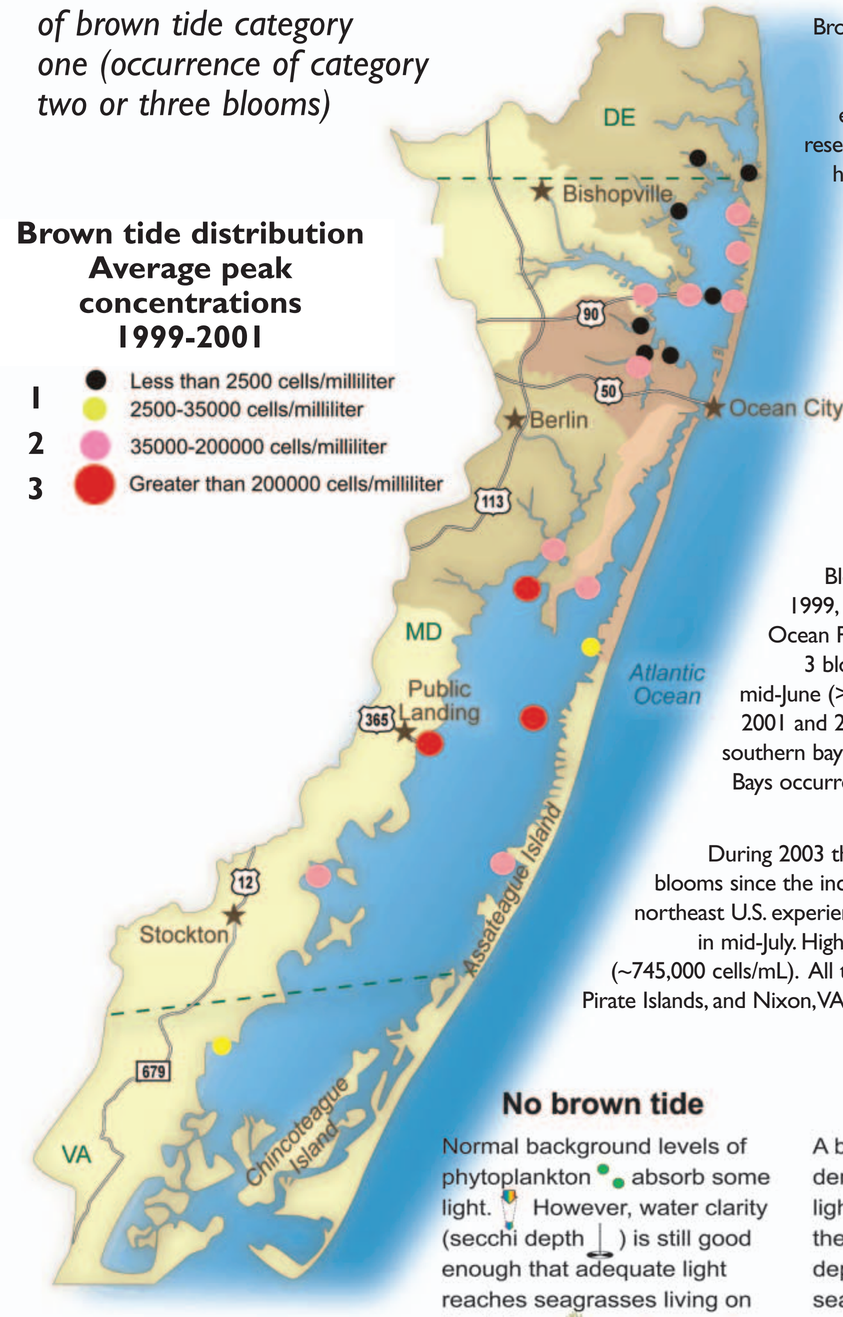
Category 3: Greater than 200,000 brown tide cells/mL
- Water becomes discolored yellow-brown
- Feeding rates of mussels severely reduced
- Bay scallops fail to reach maturity
- No significant growth of juvenile hard clams
- Negative impacts to seagrass due to algal shading
- Copepod production reduced and negative impacts to protozoa

Bloom intensity and distribution varied annually across the Coastal Bays. In 1999, Category 2 blooms were broadly distributed, including Montego Bay and Ocean Pines canals in Isle of Wight Bay and all of the southern bays. A Category 3 bloom in Newport Bay produced the highest concentrations of the year in mid-June (>450,000 cells/mL); lowest concentrations were found in Virginia. In 2000, 2001 and 2003 no significant blooms were observed in the northern bays while the southern bays experienced Category 3 blooms. Peak concentrations for the southern Bays occurred at Public Landing in Chincoteague Bay during 2000 (May 29: ~900,000 cells/mL) and 2001 June 13: ~680,000 cells/mL).

During 2003 the southern bays were hit by the most spatially and temporally extensive blooms since the inception of the monitoring program in a year where no other areas in the northeast U.S. experienced a significant brown tide event. The bloom peaked in June and ended in mid-July. Highest concentrations were at Green Point in Chincoteague Bay on June 10 (~745,000 cells/mL). All time highs were observed at Ferry Landing, Green Point, Taylor's Landing, Pirate Islands, and Nixon, VA, all in Chincoteague Bay. Only during 2002 were widespread Category 2 blooms found in northern and southern bays.

www.dnr.maryland.gov/bay/hab/brown-tide.html.

Brown tide distribution Average peak concentrations 1999-2001

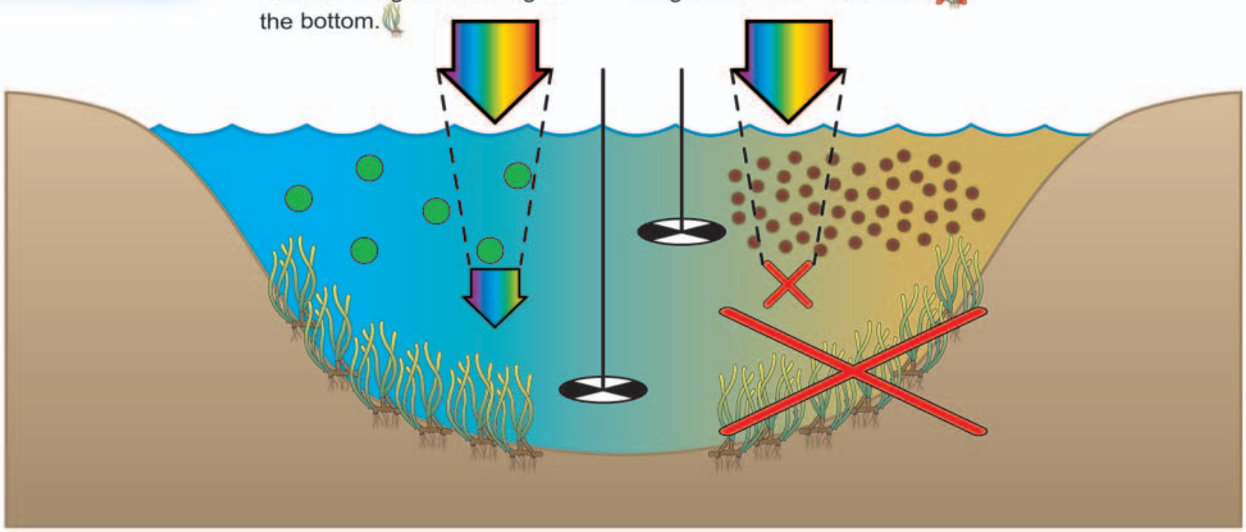


No brown tide

Normal background levels of phytoplankton absorb some light. However, water clarity (secchi depth) is still good enough that adequate light reaches seagrasses living on the bottom.

With brown tide

A brown tide bloom can be so dense that it absorbs most of the light in the water. This reduces the water clarity (lower secchi depth) beyond the level that seagrasses need to survive.



Our changing shoreline

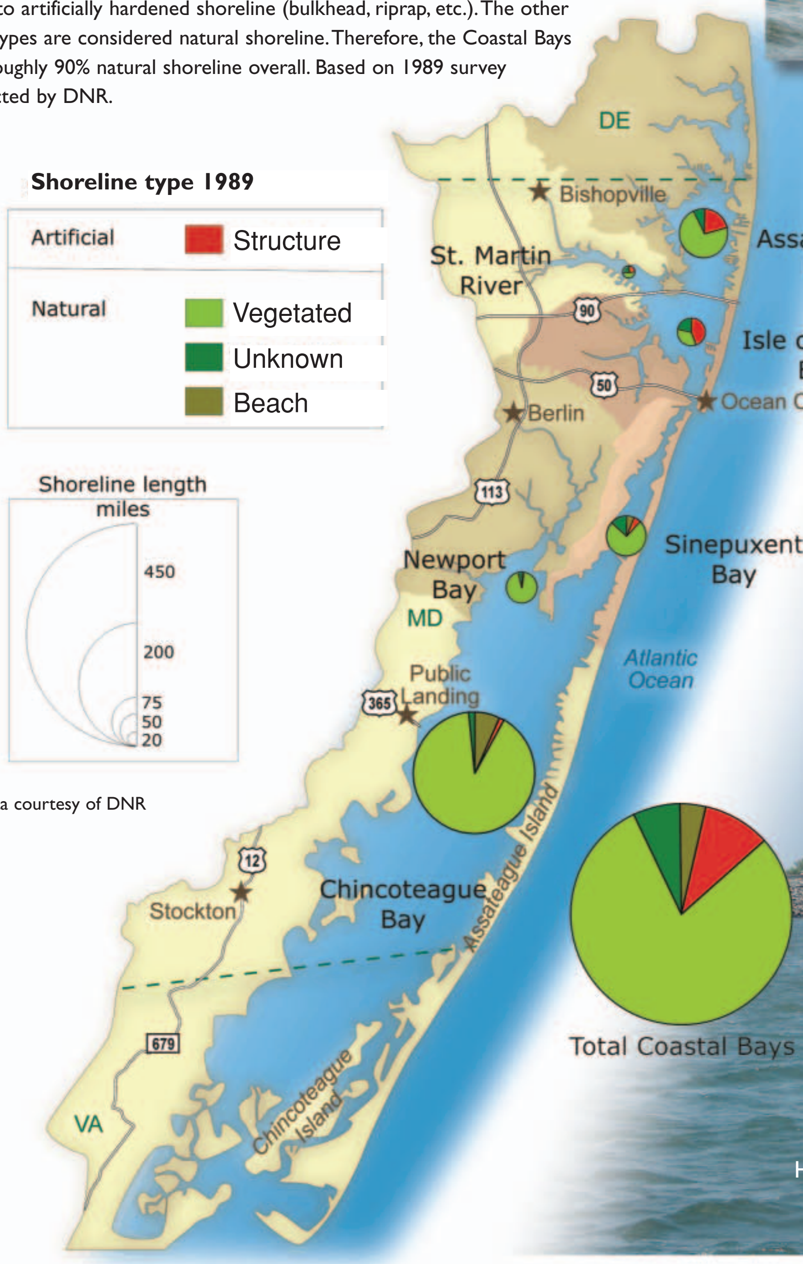
Natural shoreline habitat loss is prevalent in the Coastal Bays.

Natural shoreline is important habitat for fish, shellfish, and horseshoe crabs, as well as birds.

The northernmost Coastal Bays (Assawoman Bay, Isle of Wight Bay, and the St. Martin River) have the greatest percentage of disturbed shoreline, ranging from 21 to 44 percent. Little shoreline disturbance has occurred in the three southernmost bays, Sinepuxent Bay, Newport Bay, and Chincoteague Bay. The percentage of hardened shoreline may be greater, particularly in the northern bays, due to shortcomings in shoreline classification and aerial photography. A more precise and current shoreline inventory is currently being developed by the Virginia Institute of Marine Science.

Boat wakes accelerate shoreline erosion

Map showing percentages of shoreline type in each Coastal Bays segment as well as for the total Coastal Bays. The total number of shoreline miles is also indicated. Structure refers to artificially hardened shoreline (bulkhead, riprap, etc.). The other three types are considered natural shoreline. Therefore, the Coastal Bays have roughly 90% natural shoreline overall. Based on 1989 survey conducted by DNR.



Map data courtesy of DNR

Hardened shoreline near the entrance of Sinepuxent Bay

Wetland Area per Coastal Bays Watershed

Coastal Bays segment	Total watershed area (acres)	Wetlands area (acres)	Percent wetlands
Assawoman Bay	6,104	2,746	45%
Isle of Wight Bay	36,077	5,648	16%
Sinepuxent Bay	6,598	4,023	61%
Newport Bay	27,923	6,546	23%
Chincoteague Bay	34,842	15,530	45%

Ribbed mussels (*Modiolus demissus*) naturally protect the shoreline.

Wetlands in the Coastal Bays have decreased substantially, especially in the northern bays.

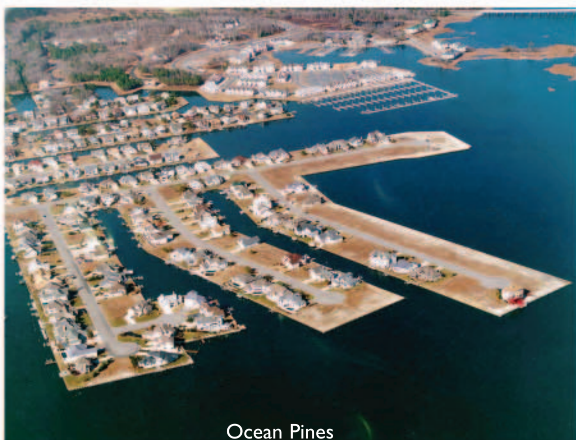
Wetlands drained and cleared for agriculture, development, and other human uses decrease habitat for wildlife and adversely affect the land's nutrient and sediment absorbing potential (e.g. buffering capability). Although slowed considerably by federal and state laws restricting impacts to wetlands, losses still occur from human-induced changes in land use, sea level rise and natural processes (erosion).

The Coastal Bays watershed has lost an estimated 254,778 acres of wetlands since settlement. Wetland loss and alteration has occurred from various activities. Many tidal and nontidal wetlands have been drained by a network of ditches. Tidal wetlands have also been lost due to construction of canals and bulkheads or other hard shoreline stabilization projects. Conversion of wetland to agriculture and development has also resulted in extensive wetland loss.

The most recent mitigation guidelines place high weight on restoring wetlands according to needs of the watershed. Attention needs to be paid to the condition of existing wetlands, not just to their supposed existence on a map.

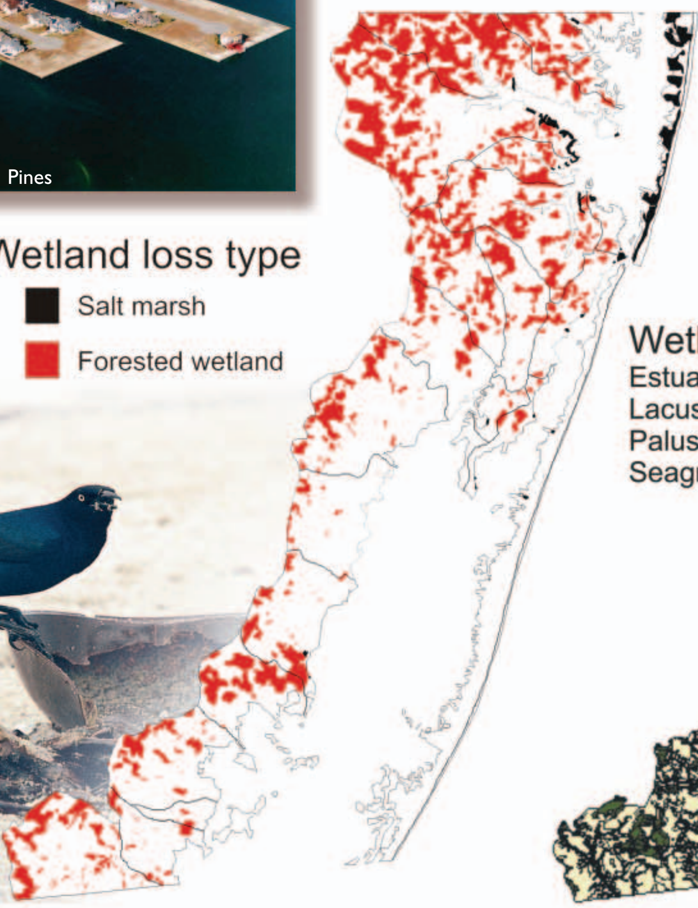
Management objective:

Restore 10,000 acres of wetlands



Ocean Pines

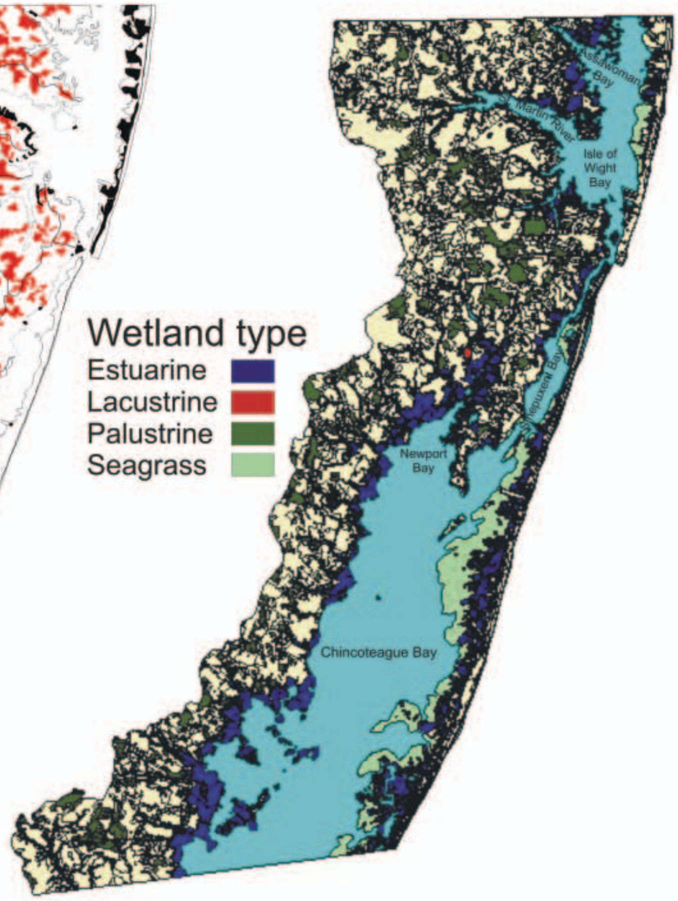
Map showing areas of estimated loss of wetlands to development and agriculture. Salt marsh refers to wetlands irregularly flooded by saltwater from the bays. Forested wetland refers to seasonally saturated and temporarily flooded forested land.



Map courtesy of US Army Corps of Engineers

The boat-tailed grackle lives exclusively in tidal wetland areas.

Map showing existing wetlands as of 2000. Estuarine wetlands are tidally influenced and contain salt or brackish water. Lacustrine wetlands are lakes or deep ponds. Palustrine wetlands are tidal and non-tidal freshwater wetlands located on floodplains associated with rivers and streams, upland depressions, and in flats between drainage systems. Seagrass beds were considered wetlands for the purposes of this report.



Map courtesy of DNR

Finfish

Finfish in the Coastal Bays are diverse.

Finfish stocks in the Coastal Bays continue to support a diverse finfish population. These shallow waters are ideal nursery and forage habitat for over 140 species of finfish. Additionally, well over 120 species of epibenthic and benthic invertebrates (organisms living on or near the bottom) have been identified, many of which serve as prime forage for juvenile and adult finfish of commercial and recreational value.

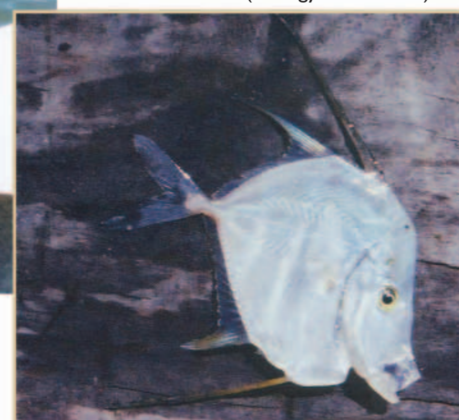
Most of the region's most valuable commercial finfish are composed of estuarine-dependent types like summer flounder, bluefish, weakfish, spot, tautog, black sea bass and others. Recreational fishermen seek summer flounder, bluefish, weakfish, croaker, tautog, and striped bass. Both recreational and commercial fishing are important economic activities in the region, supporting many auxiliary businesses.

The Maryland Coastal Bays are important habitat for **summer flounder** (*Paralichthys dentatus)* as they use the area to feed and grow. Summer flounder are a very popular target for recreational fishermen, sustaining harvest of 40,000 to 135,000 individuals (100,000 to 250,000 pounds) annually. This species has been managed by the Atlantic States Marine Fisheries Commission since populations collapsed coast-wide in 1989. Maryland, along with the other Atlantic states, cooperates in the management of the species though commercial quotas and recreational harvest limits. Since interstate management of the species began, the stock has recently recovered to the level where no longer considered overfished, although target levels of abundance have not been reached.

Northern sea robin (*Prionotus carolinus*)

Weakfish (*Cynoscion regalis*)

Atlantic needlefish (*Strongylura marina*)



Lookdown (*Selene vomer*)

Most abundant finfish
Maryland Department of Natural Resources seine survey 2003

Below Ocean City Inlet

1. Atlantic needlefish (*Strongylura marina)*
2. Summer flounder (*Paralichthys dentatus)*
3. Silver perch (*Bairdiella chrysura)*
4. Spot (*Leiostomus xanthurus)*
5. Winter flounder (*Pseudopleuronectes americanus)*

Above Ocean City Inlet

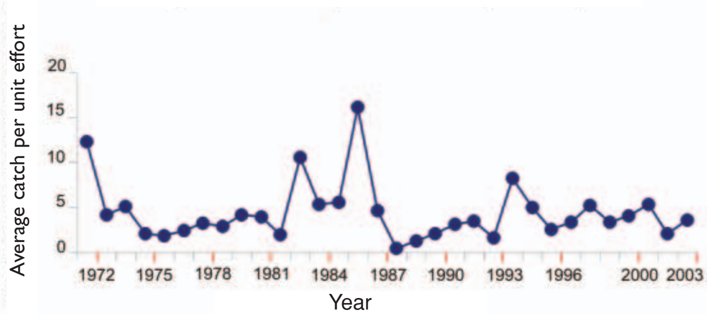
1. White mullet (*Mugil curema)*
2. Winter flounder (*Pseudopleuronectes americanus)*
3. Bay anchovy (*Anchoa mitchilli)*
4. Atlantic menhaden (*Brevoortia tyrannus)*
5. Silver perch (*Bairdiella chrysura)*

Inshore lizardfish (*Synodus foetens*)

Black drum (*Pogonias cromis*)

Catch per unit effort of summer flounder
Maryland Coastal Bays trawl index

This plot shows the average catch per unit effort of flounder from 1972 through 2003 during the Maryland Department of Natural Resources Fishery Independent Trawl Survey. Catch per unit effort refers to the total number of fish caught divided by the number of trawls completed.



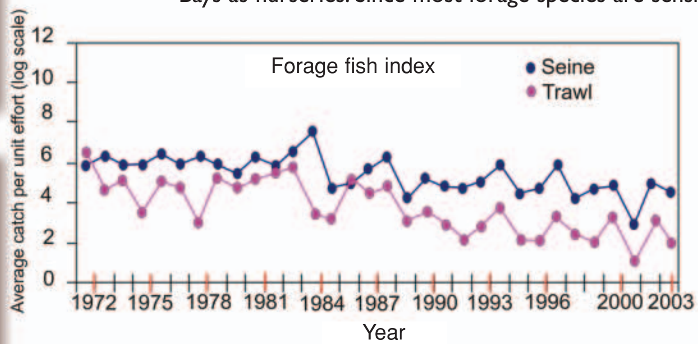
Data plot courtesy of DNR

Bluefish (*Pomatomus saltatrix*)

Forage fish

The forage fish index is declining over time.

Forage fish are food for larger fish species often sought for commercial and recreational purposes. Forage fish are a necessity for survival of juvenile finfish that use the Coastal Bays as nurseries. Since most forage species are sensitive to maintenance of a high quality habitat, they are often indicators of environmental decline.



Data plot courtesy of DNR

A forage fish index has been developed and adopted as a measure of food availability in the bays. This index is based on the abundance of four species - bay anchovy (*Anchoa mitchelli*), menhaden (*Brevoortia tyrannus*), spot (*Leiostomus xanthurus*) and Atlantic silverside (*Menidia menidia*). These species represent the most common forage species in Maryland's Coastal Bays. Since 1972, the Maryland Department of Natural Resources (DNR) has monitored this resource through annual trawl and seine surveys. Despite annual fluctuations, the forage index from both trawl and seine surveys has shown a slow downward trend since the mid-1980s.

Indicator: *Forage Fish Index*


Spot (*Leiostomus xanthrus*)


Atlantic silversides (*Menidia menidia*)


Atlantic menhaden (*Brevoortia tyrannus*)


Bay anchovy (*Anchoa mitchelli*)

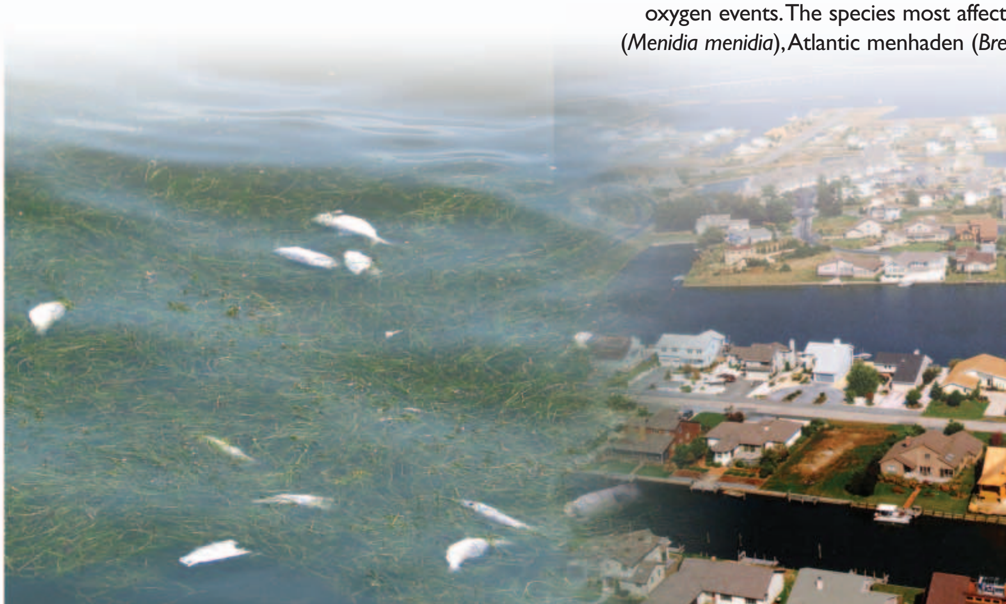
Fish kills

Sporadic fish kills due to low oxygen are apparently increasing in frequency.

Fish are analogous to "canaries in coal mines". As such, fish kills are usually indications of unusual stress in the environment. There have been 51 reported fish kills and 49 confirmed or probable fish kills in the Coastal Bays Region since 1984. Collectively they represent approximately 3.3 million mortalities. The majority of fish kills occur in the summer months when there are abundant algal blooms, lower oxygen solubility, increased temperatures, increased oxygen demand from the breakdown of organic matter in the water, and larger fish stocks in the bays.

Low dissolved oxygen is implicated in two thirds of all fish kills where the cause is known in the Coastal Bays. Entrapment in man-made structures accounts for half of all low dissolved oxygen kills. The remaining causes include unknown (26.5%), thermal stress (14%), discards (11%), pollution (2.8%), storm winds (2.8%) and pond management (2.8%). Of the estimated 3,302,300 fish mortalities in the Coastal Bays, approximately 98% died in low dissolved oxygen events. The species most affected are schooling species, such as Atlantic silversides (*Menidia menidia*), Atlantic menhaden (*Brevoortia tyrannus*), and striped mullet (*Mugil cephalus*).

The vast majority (97.9%) of mortalities occurred within dead-end canals. Fish can become trapped in these canals where hypoxia (low oxygen) caused by a combination of natural and human-induced factors can cause kills. The second most common habitat for fish kill reports is tidal creeks and rivers. Of the 16 reports from creeks and rivers, all but one occurred in smaller creeks near tidal headwaters.



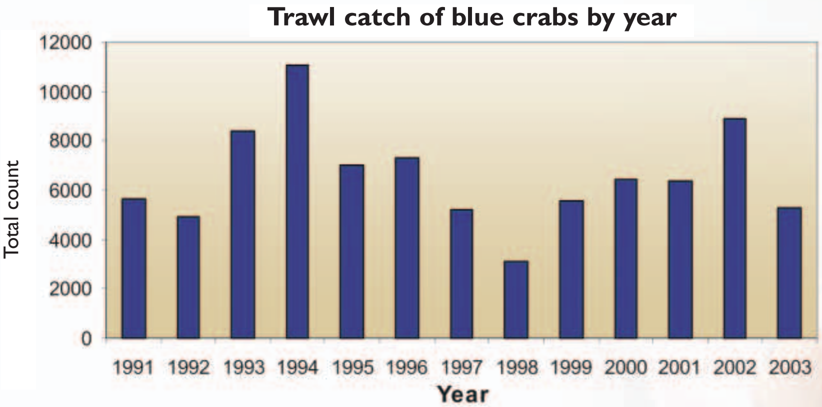
Blue crabs

Blue crab abundance is fluctuating without trend.

The blue crab (*Callinectes sapidus)* is a valuable resource in the Coastal Bays, supporting a steady commercial and recreational fishery. Blue crabs are most likely recruited from other places into these bays.

Surveys suggest that blue crab abundance fluctuates without an apparent trend, yet there is still a successful annual commercial fishery that even attracts crabbers from the Chesapeake Bay. Environmental and hydrographic factors play a key role in blue crab recruitment (movement into the Coastal Bays). The major factor influencing blue crab populations in the Coastal Bays is a parasite that kills crabs in August. Blue crabs may also be threatened by the presence of invasive species such as green and Asian shore crabs (*Carcinus maenas* and *Hemigrapsus sanguineus*).

Since 1990, commercial landings for crabs have averaged from 0.5 to 1.5 million pounds. Preliminary commercial landings for 2003 were 1.15 million pounds. Unlike Chesapeake Bay landings data, coastal bays landings appear to fluctuate without trend. During 2003, the fishery-independent trawl and seine survey caught a total of 6,754 blue crabs. An examination of 2,627 legal blue crabs taken by trawl net over a 13-year period indicates no decline in average size, suggesting minimal increases in fishing pressure. Like commercial landings, these catches have generally fluctuated without trend.

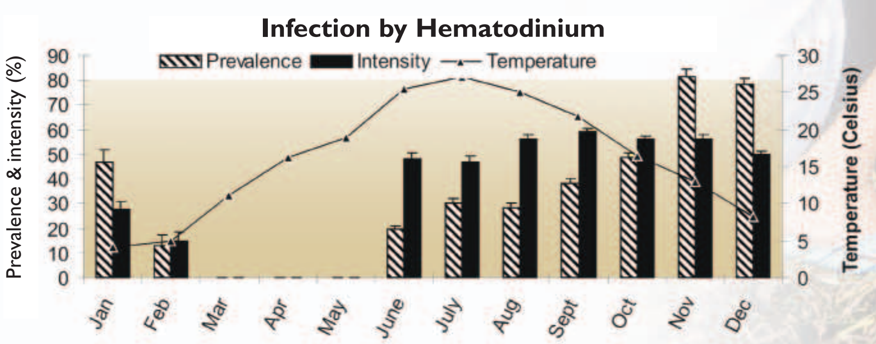


Blue crab catch varies per year with no apparent trend. The Maryland Department of Natural Resources conducted blue crab trawl surveys throughout the Coastal Bays. The number of trawl surveys conducted did not vary significantly per year. The proportion of legally sized crabs caught never exceeded 5.5% in any given year.

Data plot courtesy of DNR

Parasitic infection.

Hematodinium spp. is a parasitic single-celled organism that infects and kills blue crabs. Outbreaks of disease caused by this parasite have been reported in several coastal states. In the Coastal Bays of Maryland and Virginia, parasite abundance followed a seasonal pattern with a sharp peak in late autumn. Infections were significantly more prevalent in crabs measuring less than 30 millimeters (mm) carapace width. Prevalence was highest in crabs collected from salinities between 26 and 30 parts per thousand (‰). No infected crabs were found in salinities below 11‰. Chincoteague Bay had the highest prevalence while stations with some of the lowest prevalence were located north of the Ocean City inlet and in tributaries. Intensity of infection did not vary among crab sizes, molt stages, or sexes. In general, *Hematodinium* spp. strikes non-migratory crab populations living in high salinity waters with little water exchange, high temperatures and seasonal hypoxia (low oxygen) – conditions found in the Coastal Bays. Mortality peaks in summer.



Hematodinium infection occurs in the summer and early fall, and increases concurrently with salinity. Prevalence refers to the percentage of crabs infected during a month; intensity is the average amount of *Hematodinium* parasite present per infected crab.

Data plot courtesy of National Oceanographic and Atmoshpheric Administration

www.dnr.maryland.gov/fisheries/education/crab/bluecrabfacts.html

Benthic communities

Polychaete worm

Benthic animals are faring poorly in creeks and better in open bays.

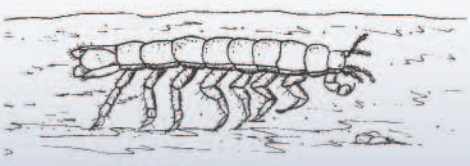
Benthic animals, or those that live on the bay bottom play an important role as food for fish and in cycling nutrients between the sediment and the water column. These bottom dwellers include worms, clams, crustaceans, and other invertebrates. Since these communities are generally not very mobile, they are good indicators of ecosystem health, providing an integrated sample over time.

Indicator: *Bay Benthic Index (value greater than 3)*

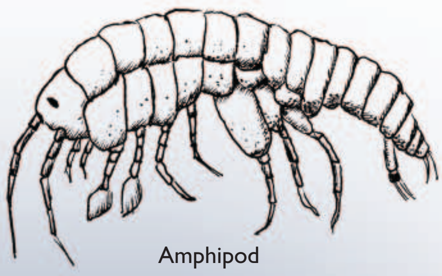
Benthic animals were sampled and identified in the laboratory. The bay benthic index was then calculated based on the abundance of species as well as the occurrence of pollution tolerant or intolerant species.

Open bays areas met the bay benthic index goal, while tributaries were degraded to severely degraded. Severely degraded sites either had few organisms and dominance of one species or had an unbalanced community heavily dominated by a small number of species, usually annelids (worms).

Regions subjected to large environmental fluctuations are best monitored over time to assess the long-term response of the community and the relative influence of human-induced factors over the natural range of variability.

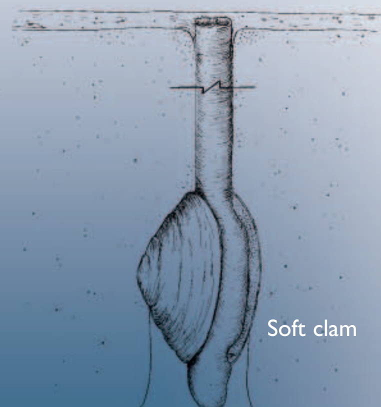


Isopod



Amphipod

Polychaete worms



Soft clam

Map data courtesy of Versar Inc.

Hard clams

Hard clams have declined over the past three decades compared to historical abundances, but have been relatively stable for the past 10 years.

Hard clams (*Mercenaria mercenaria*) have been historically important to the recreational and commercial shellfisheries of the bays, although the abundance of hard clams has dramatically declined during the past three decades.

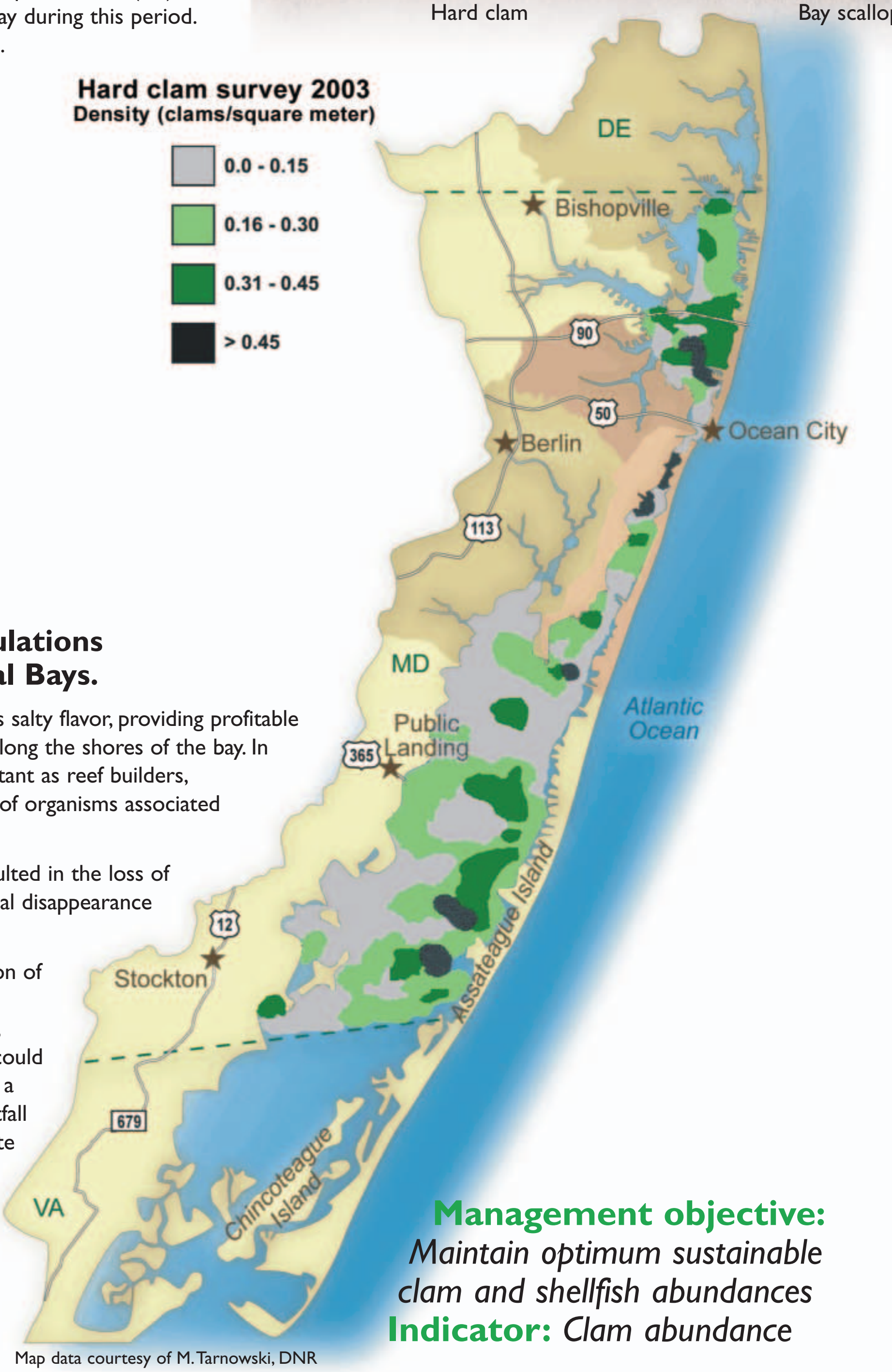
Current hard clam densities in all of the bays are lower than historic levels. Although closed to shellfish harvesting, the St. Martin River has the lowest clam densities in the Coastal Bays. Populations are dominated by older, larger clams, with recruitment (clams reaching maturity) generally low and sporadic in most areas except in parts of Sinepuxent and Isle of Wight bays.

Hard clam population densities have remained relatively stable over the past 10-year interval, with a modest increase observed in 2000, when Chincoteague Bay ranked first among the Maryland Coastal Bays. Densities over the past two years were somewhat lower than the 10-year average of 0.27 clams/square meter (m^2). Generally, clam densities were higher on the east side of the bay during this period. Boxes (recently dead clams) comprised 5.3% of the population.

Hard clam

Bay scallo

Hard clam



Map data courtesy of M. Tarnowski, DNR

Oysters

Presently there are no viable oyster populations inhabiting the subtidal bars of the Coastal Bays.

The Eastern oyster (*Crassostrea virginica*) was once prized for its salty flavor, providing profitable livelihoods to generations of watermen in the remote villages along the shores of the bay. In addition to its commercial value, oysters are ecologically important as reef builders, contributing structure and hard substrate to a rich community of organisms associated with them in an otherwise soft-bottom environment.

The demise of the Coastal Bays "Chincoteague" oyster has resulted in the loss of a critical functional component of the ecosystem and the gradual disappearance of a significant structural element as well.

Episodic natural events, in particular the opening and stabilization of the Ocean City Inlet, fundamentally changed the Coastal Bays ecosystem, creating higher salinities inwhich oyster populations, whether natural or cultured, and the industry they supported, could no longer exist. Small, relict populations still exist intertidally at a few locations throughout the Coastal Bays, with occasional spatfall on structures such as riprap, pilings, and bridge supports. Despite the long-term absence of significant oyster populations, two oyster diseases, Dermo (*Perkinsus marinus*) and SSO (*Haplosporidium costalis*), are still active in the Coastal Bays.

www.dnr.maryland.gov/coastalbays/living_resources/benthos.html.

Management objective:
Maintain optimum sustainable clam and shellfish abundances
Indicator: *Clam abundance*

Scallops

Eastern oyster

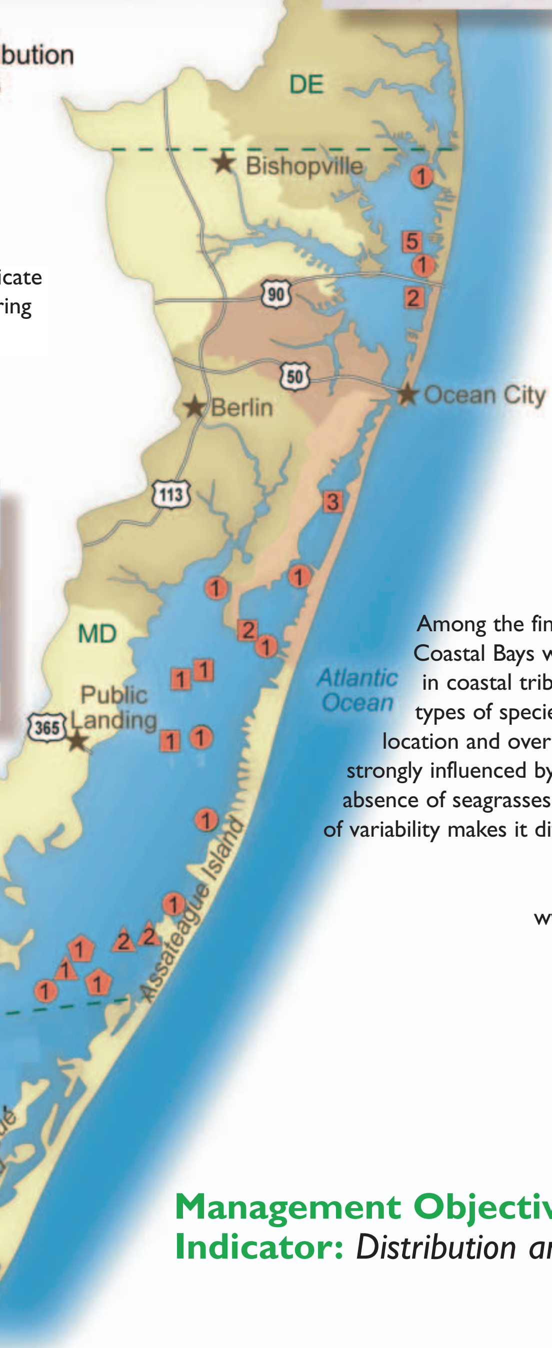
Bay scallops have been found in most bay segments, although in low numbers.

Bay scallops (*Argopecten irradians*) have relatively short life spans of only about 12 to 24 months, compared to the hard clam's 40-year maximum life span. This short life span makes them more susceptible to environmental impacts. Their preferred habitat is eelgrass beds (provided the beds are not too thick), although they can also be found on other firm substrates such as shell and hard sand.

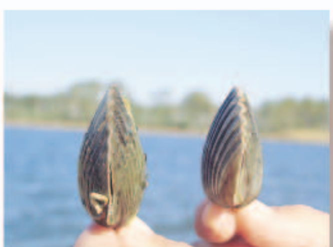
Bay scallop

Although low densities suggest that the long-term viability of the bay scallop population is still in question, the extraordinarily rapid range expansion is a major step toward their establishment in the Coastal Bays.

Evidence of former bay scallop populations in the coastal bays include ancient shells dredged up during hard clam surveys or scattered on the beaches of Assateague Island. During the 1920s bay scallops were the objective of a modest but lucrative fishery based in Chincoteague, Virginia. Generally, however, salinities in the other Maryland Coastal Bays during this period were too low to support scallops. Although the opening of the Ocean City Inlet in 1933 raised salinities to suitable levels, bay scallops were unable to exploit the new areas available to them because the seagrass beds had been largely eliminated by "wasting disease" during the early 1930s. Scallops made a brief return to the Coastal Bays during the late 1960s but soon disappeared, most likely because the recovering seagrass beds were not extensive enough to sustain a population. Scallops were caught at about 4 percent of the 2003 Hard Clam Survey stations, primarily in northern Chincoteague Bay, Sinepuxent Bay, and Isle of Wight Bay.



Numbers within the symbols indicate the number of scallops found during survey.



Bay scallop

Map data courtesy of M. Tarnowski, DNR

Shellfish community summary

Among the findings characterizing the molluscan shellfish communities of the Coastal Bays was high diversity in species, with significantly lower abundances in coastal tributaries than open bays. Coastal Bays shellfish communities (the types of species and number of animals) varied considerably from location to location and over time showing high annual variability. Community structure was strongly influenced by habitat conditions including the type of sediment, presence or absence of seagrasses, shell cover, and other biological communities. This high degree of variability makes it difficult to draw strong conclusions about the long-term trend in these communities.

www.dnr.maryland.gov/coastalbays/living_resources/shellfish.html.

Management Objective: *Foster fledgling bay scallop populations*
Indicator: *Distribution and abundance of bay scallops*

Aquatic exotic species

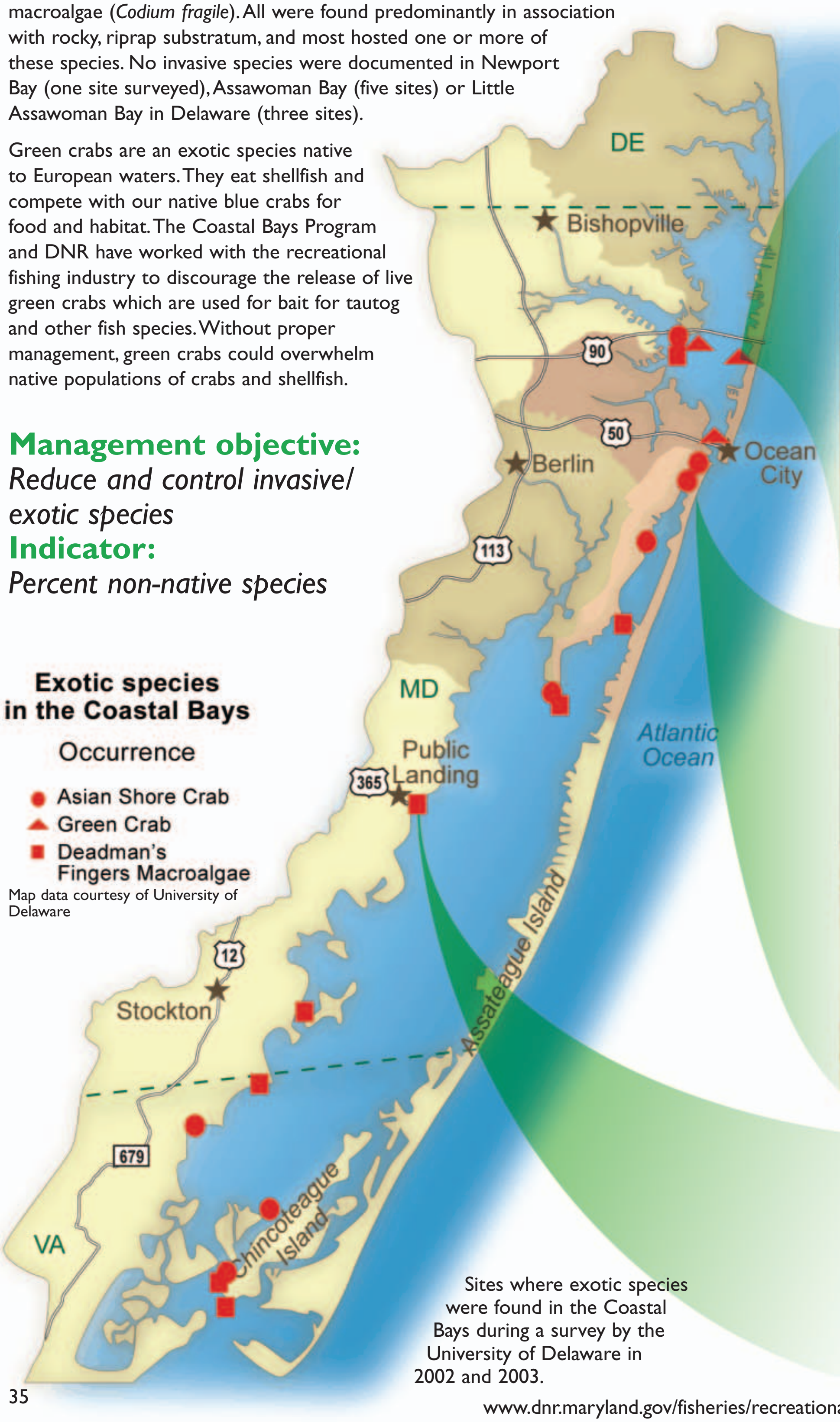
A variety of exotic species have been found in the Coastal Bays, particularly near human-made structures.

Exotic or non-native species can grow to population levels that threaten the health of the estuary when they are introduced in areas where they lack predators or other natural controls on their populations. They can take over food or habitat used by native species and thus displace the native species.

Three intertidal, marine invasive species have been documented in the bays: the Asian shore crab (*Hemigrapsus sanguineus*), the European green crab (*Carcinus maenas*), and deadman's fingers macroalgae (*Codium fragile*). All were found predominantly in association with rocky, riprap substratum, and most hosted one or more of these species. No invasive species were documented in Newport Bay (one site surveyed), Assawoman Bay (five sites) or Little Assawoman Bay in Delaware (three sites).

Green crabs are an exotic species native to European waters. They eat shellfish and compete with our native blue crabs for food and habitat. The Coastal Bays Program and DNR have worked with the recreational fishing industry to discourage the release of live green crabs which are used for bait for tautog and other fish species. Without proper management, green crabs could overwhelm native populations of crabs and shellfish.

Management objective:
Reduce and control invasive/ exotic species
Indicator:
Percent non-native species



Map data courtesy of University of Delaware

Sites where exotic species were found in the Coastal Bays during a survey by the University of Delaware in 2002 and 2003.

Green crab

Asian shore crab

Deadman's Fingers

www.dnr.maryland.gov/fisheries/recreational/articles/3exoticspecies.html.

Sediment quality

Higher contaminant levels were restricted to localized areas in tributaries in the northern bays and in Newport Creek.

Metals and organic contaminants are introduced into the Coastal Bays from run-off, direct discharge, and atmospheric deposition. Most contaminants tend to bind onto fine-grained particles that eventually settle to the bottom of the bays. Once in the sediments, the contaminants can have an adverse effect on the benthic organisms living in the sediments, resulting in lower biodiversity and/or abundance if contaminant concentrations are high enough.

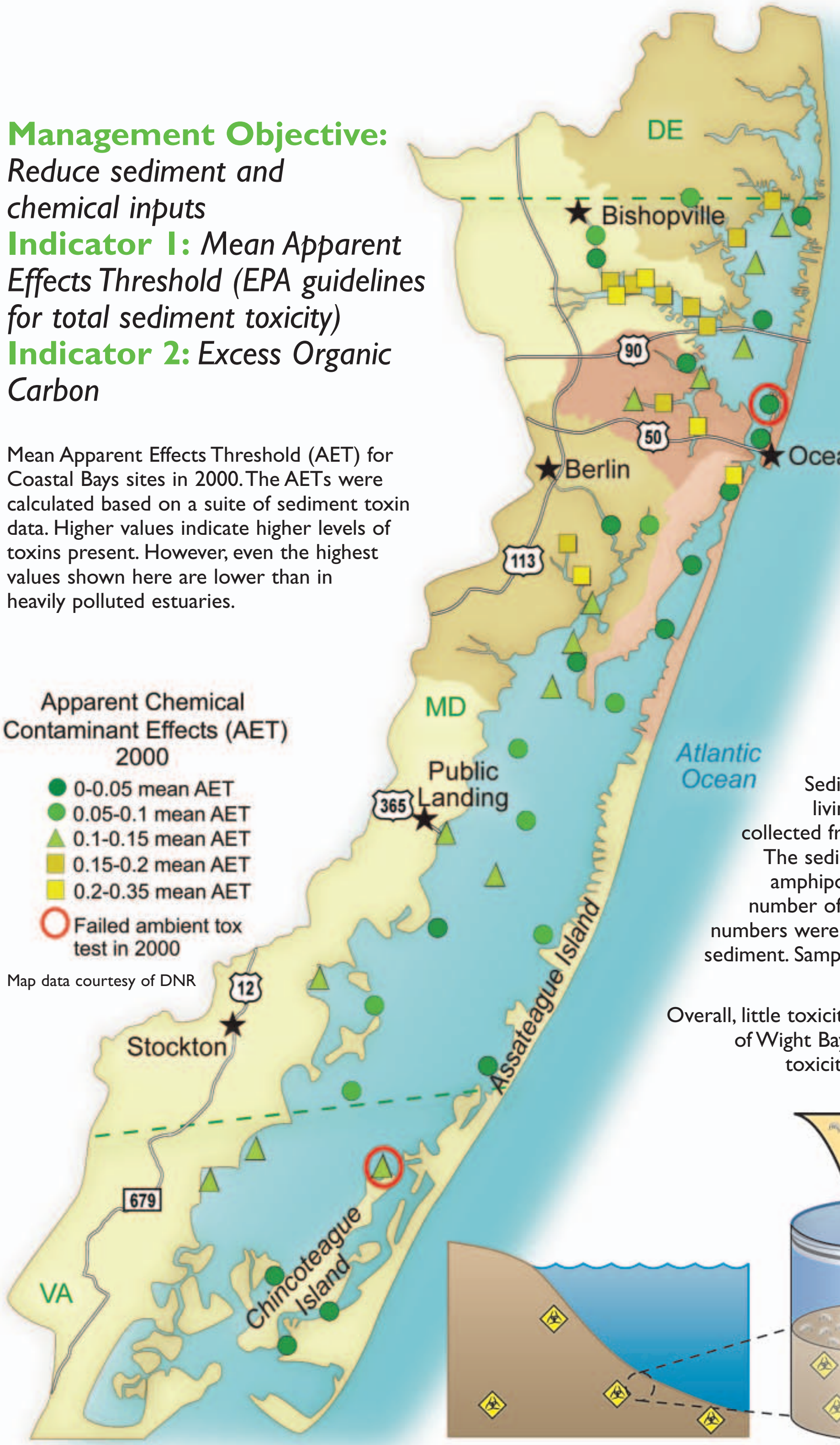
St. Martin River, Herring Creek (Isle of Wight Bay) and Newport Creek (Newport Bay) have excessively organic sediments, which may have an impact on benthic communities. Metals and other pollutants tend to attach to organic carbon, thereby keeping them in the estuary.

Based on the Environmental Protection Agency National Coastal Assessment 2000 contaminant data, bottom sediments in Maryland's southern Coastal Bays (Sinepuxent, Newport, and Chincoteague bays) and open water areas in Assawoman and Isle of Wight bays do not contain high levels of contaminants. Generally, concentrations for most metals were within background levels. Most individual organic contaminants were at trace levels or below detection limits. These areas were also high in total organic carbon.

The combined effect of multiple contaminants at low levels is not completely understood. The AET is a metric for the combined effect of many contaminants. This indicator is more sensitive to low levels of contaminants. The AET results for the bays show a higher potential for impacts to living resources from chemical contaminants in St. Martin River, Assawoman Bay, and Herring, Turville, and Newport creeks.

Management Objective: *Reduce sediment and chemical inputs*
Indicator 1: *Mean Apparent Effects Threshold (EPA guidelines for total sediment toxicity)*
Indicator 2: *Excess Organic Carbon*

Mean Apparent Effects Threshold (AET) for Coastal Bays sites in 2000. The AETs were calculated based on a suite of sediment toxin data. Higher values indicate higher levels of toxins present. However, even the highest values shown here are lower than in heavily polluted estuaries.

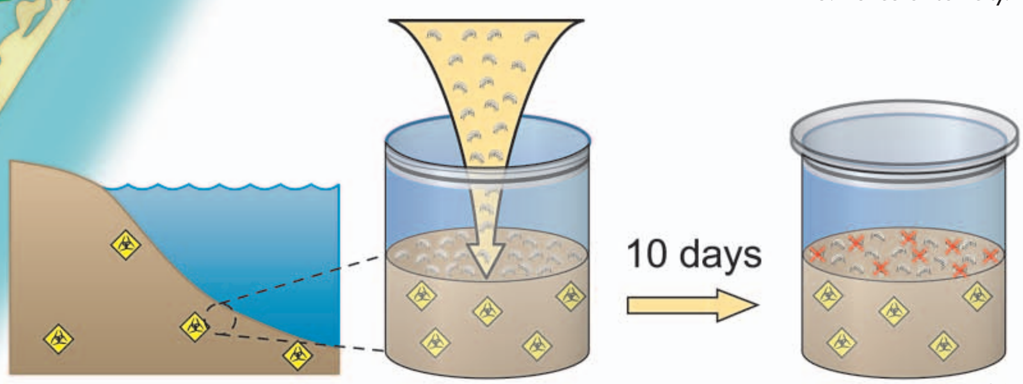


Map data courtesy of DNR

Toxicity bioassay

Sediment toxicity was determined by bioassay, using sediment-living organisms as indicators of toxic effects. Sediments were collected from bay sites as well as from a relatively clean control site. The sediments were placed in beakers and small crustaceans called amphipods (*Ampelisca abdita*) were introduced to each beaker. The number of dead amphipods was counted each day for 10 days. These numbers were compared between the sample sediments and the control sediment. Samples differing significantly from the control were considered to have significant toxicity.

Overall, little toxicity was observed in the Coastal Bays. One sample from Isle of Wight Bay and another from Chincoteague Bay showed evidence of toxicity in 2000 (see above map). In 2001, these sites showed no evidence of toxicity.



www.dnr.maryland.gov/coastalbays/water-quality/c2k_table9.html.

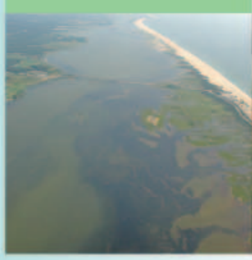
Coastal Bays summary

Coastal Bays summary

Estuarine health indicators comprised of water quality, living resources and habitat features were used to compare the different bay segments within the Maryland Coastal Bays. The selected estuarine health indicators are responsive to human activities and were measured throughout the Maryland Coastal Bays. Three water quality indicators (water quality index, brown tides, macroalgae), three living resource indicators (benthic index, hard clam abundance, sediment toxicity) and three habitat indicators (seagrass area, wetland area, natural shoreline) were used to rank the estuarine health in each embayment by a team of researchers and technical experts. The final rankings indicated the best to worst estuarine health in the following order: Sinepuxent Bay, Chincoteague Bay, Assawoman Bay, Isle of Wight Bay, Newport Bay and St. Martin River.

Sinepuxent Bay had the highest ranking due to its small, relatively undeveloped watershed and good oceanic flushing from the Ocean City Inlet, with high values for all water quality, living resources and habitat indicators.

Overall ranking: **Good**



Chincoteague Bay was the next highest overall ranking due to the relatively undeveloped watershed and flushing from both Chincoteague and Ocean City inlets, but the prevalence of brown tides and macroalgal blooms reduced its overall ranking.

Overall ranking: **Good**

Assawoman Bay had poor water quality and low seagrass area due to development activities in the watershed, compounded by relatively poor flushing. Grey's and Roy's creek and the ditch connecting to Little Assawoman Bay contributed the most to the reduced water quality.

Overall ranking: **Fair**

Isle of Wight Bay had reasonable water quality due to flushing from Ocean City Inlet, but extensive development in the watershed produced the poorest habitat indicators, reducing its overall ranking. Herring Creek, Turville Creek, and Manklin Creek had the worst conditions. In addition, Isle of Wight Bay is down-stream from St. Martin River.

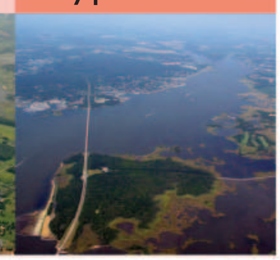
Overall ranking: **Fair**

Newport Bay had the next to lowest ranking due to a combination of very poor water quality, with high phytoplankton and chronic brown tides, reduced clam density, high sediment toxicity values and very little seagrass. Poor flushing and development activities in the northern part of the watershed contributed to the low overall ranking.

Overall ranking: **Poor**

St. Martin River had the lowest ranking due to very low values for almost all water quality, living resources and habitat indicators. The combination of poor flushing, high nutrient loads, and intensive land use (development and agriculture) led to this low overall ranking.

Overall ranking: **Very poor**

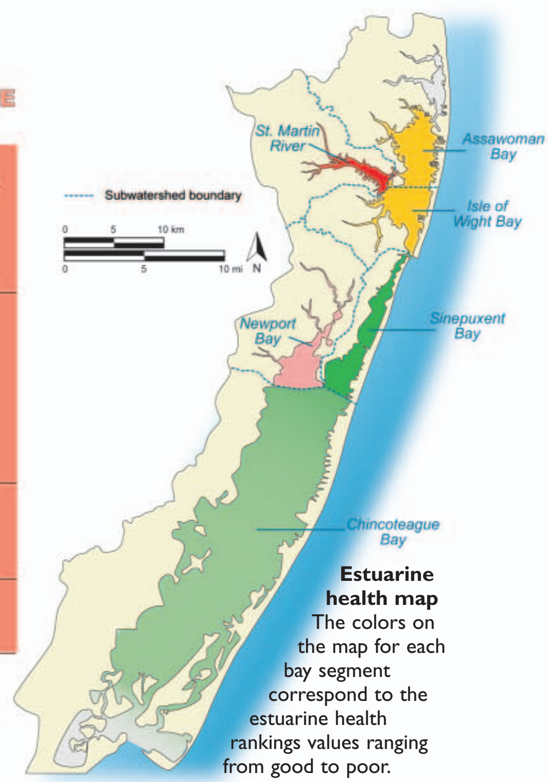


Estuarine health indicator values
Monitoring data collected over the past several years are summarized for water quality, aquatic living resources, and habitat categories. Maps of the data are available on previous pages of this document. This table provides the basis for ranking the overall estuarine health of the bay segments.

GOOD ESTUARINE HEALTH → POOR ESTUARINE HEALTH

	Sinepuxent Bay	Chincoteague Bay	Assawoman Bay	Isle of Wight Bay	Newport Bay	St. Martin River
Water quality						
Water quality index[1]	0.85	0.74	0.33	0.53	0.35	0.33
Chlorophyll *a* ($\mu g\ L^{-1}$)[2]	5	5	15	11	15	16
Total nitrogen ($mg\ L^{-1}$)[2]	0.35	0.54	1.19	0.84	2.08	1.93
Total phosphorus ($mg\ L^{-1}$)[2]	0.04	0.04	0.05	0.05	0.07	0.09
Dissolved oxygen ($mg\ L^{-1}$)[2]	6.1	6.1	6.1	5.6	6.0	5.5
Brown tide (max. cells μL^{-1})[3]	35-200	>200	35-200	35-200	>200	35-200
Macroalgal biomass (max. $g\ m^{-2}$)[4]	50	320	100	250	10	390
Living resources						
Benthic index[5]	3.5	3.6	3.4	3.1	3.4	2.2
Hard clam density (clams m^{-2})[6]	0.32	0.27	0.16	0.28	0.14	0.04
Sediment toxicity[7]	10	8	12	11	13	19
Habitat						
Seagrass area (% of bay)[8]	36	32	8	5	4	<1
Wetland area (% of watershed)[9]	61	45	45	16	23	16
Natural shoreline (% of total)[10]	81	98	72	35	96	52

1. Ranges from 0 (no reference criteria met) to 1 (all criteria met). Calculated from chlorophyll *a*, total nitrogen & phosphorus and dissolved oxygen (see page 16). **2.** Medians of monthly measurements from 2001 through 2003, from 57 sites (see page 16). **3.** Maximum values, monitored since 1999 at 15 sites (see page 26). **4.** Survey of 388 sites throughout the Coastal Bays in 2001 and 2003 (see page 23). **5.** Combines a range of benthic fauna measurements from 54 sites between 2000 and 2001. Range is from 1 (poor) to 5 (good) (see page 32). **6.** Averages from 1994-2000 from a total of 1499 sites (see page 33). **7.** Apparent Effect Threshold-combines critical levels of a range of toxicants, measured between 1991-1996 from > 900 sites (see page 36). **8.** 2002 aerial photographic survey (see page 21). **9.** Survey carried out in 1988 and 1989 (see page 28). **10.** Aerial photographic survey carried out in 1989 (see page 27).



Estuarine health map
The colors on the map for each bay segment correspond to the estuarine health rankings values ranging from good to poor.

Conceptual diagram legend

This legend applies to the conceptual diagrams on the following pages.

Key features

- Brown tide (*Aureococcus anophagefferens*)
- Macroalgae (*Chaetomorpha* sp.)
- Seagrass (*Zostera marina*)
- Macroalgae (*Gracilaria* sp.)
- Dissolved oxygen
- Secchi depth (water clarity)

Water quality components

- Nitrogen concentration
- Phosphorus concentration
- Water column algae (chlorophyll) concentration

Very low | Low | Moderate | High | Very high

Land use

- Agriculture
- Poultry houses
- Urban development
- Commercial development
- Condominiums and resorts
- Golf course
- Wastewater treatment plant
- Loblolly pine (*Pinus taeda*)
- Hardwood/ deciduous forest
- Campground
- Racetrack
- Airport
- Amusement park

Ecosystem Health Indices

- Bottom-dwelling animals index: Good, Poor
- Forage fish index: Stable, Declining
- Water quality index: Good, Fair, Poor

Processes

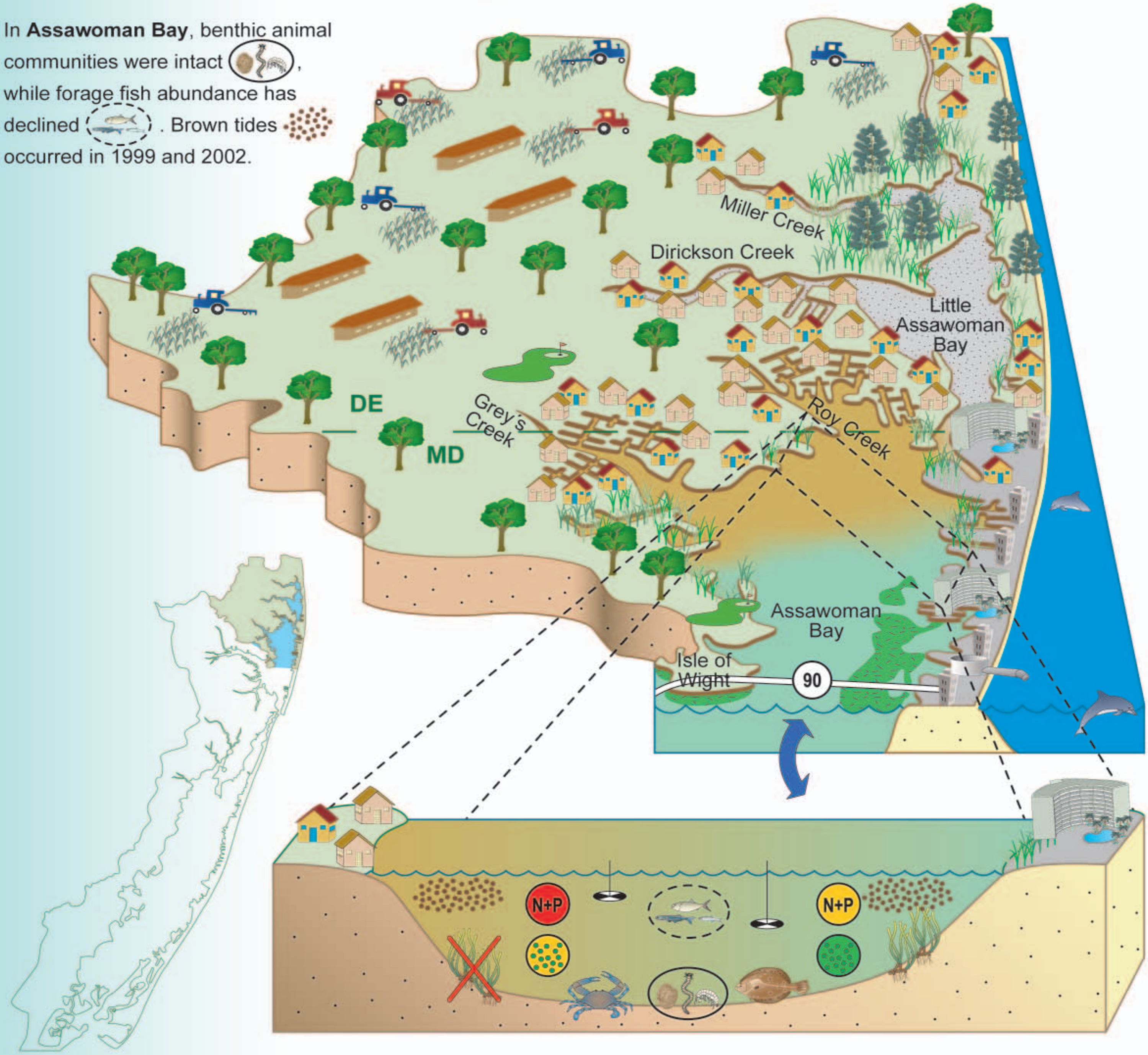
- Brown tide and algae input
- Seagrass loss
- Oceanic flushing

Other biota

- Salt marsh
- Overwintering horseshoe crab (*Limulus polyphemus*)
- Summer flounder (*Paralichthys dentatus*)
- Blue crab (*Callinectes sapidus*)

Assawoman Bay

In **Assawoman Bay**, benthic animal communities were intact, while forage fish abundance has declined. Brown tides occurred in 1999 and 2002.



North Assawoman Bay had poor water quality. Water quality was not monitored in Little Assawoman Bay. In the upper portions of Assawoman Bay, nitrogen and phosphorus concentrations were very high and chlorophyll (algal) concentrations were moderate, resulting in low water clarity (shallow Secchi depth). Seagrasses were absent from the northern areas of Assawoman Bay.

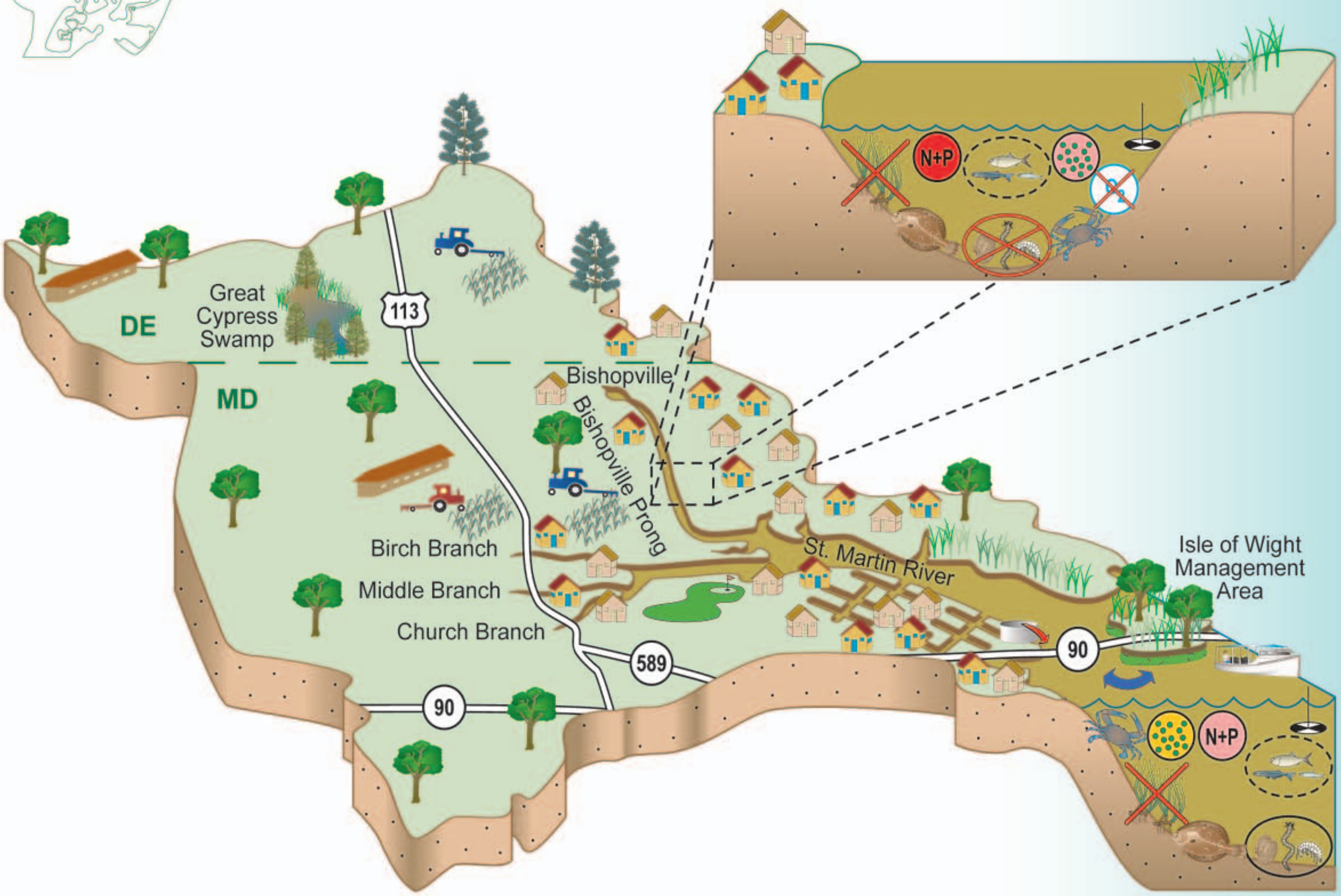
In **south Assawoman Bay**, water quality was fair. Closer to the Ocean City inlet, water quality was better, with nutrient concentrations decreasing to moderate, resulting in very low chlorophyll levels and higher water clarity. Seagrass distribution was low in Assawoman Bay and limited to southern areas. However, these seagrass beds have expanded since establishing within the last 10 years.

Legend page 38

St. Martin River

St. Martin River had generally poor water quality . Forage fish abundance has declined in St. Martin River.

In the **upper reaches of St. Martin River**, nitrogen and phosphorus levels were very high and chlorophyll (algal) levels were high resulting in very low water clarity (shallow Secchi depth) and low concentrations of dissolved oxygen . Benthic animal communities were degraded in the upper reaches of St. Martin River.



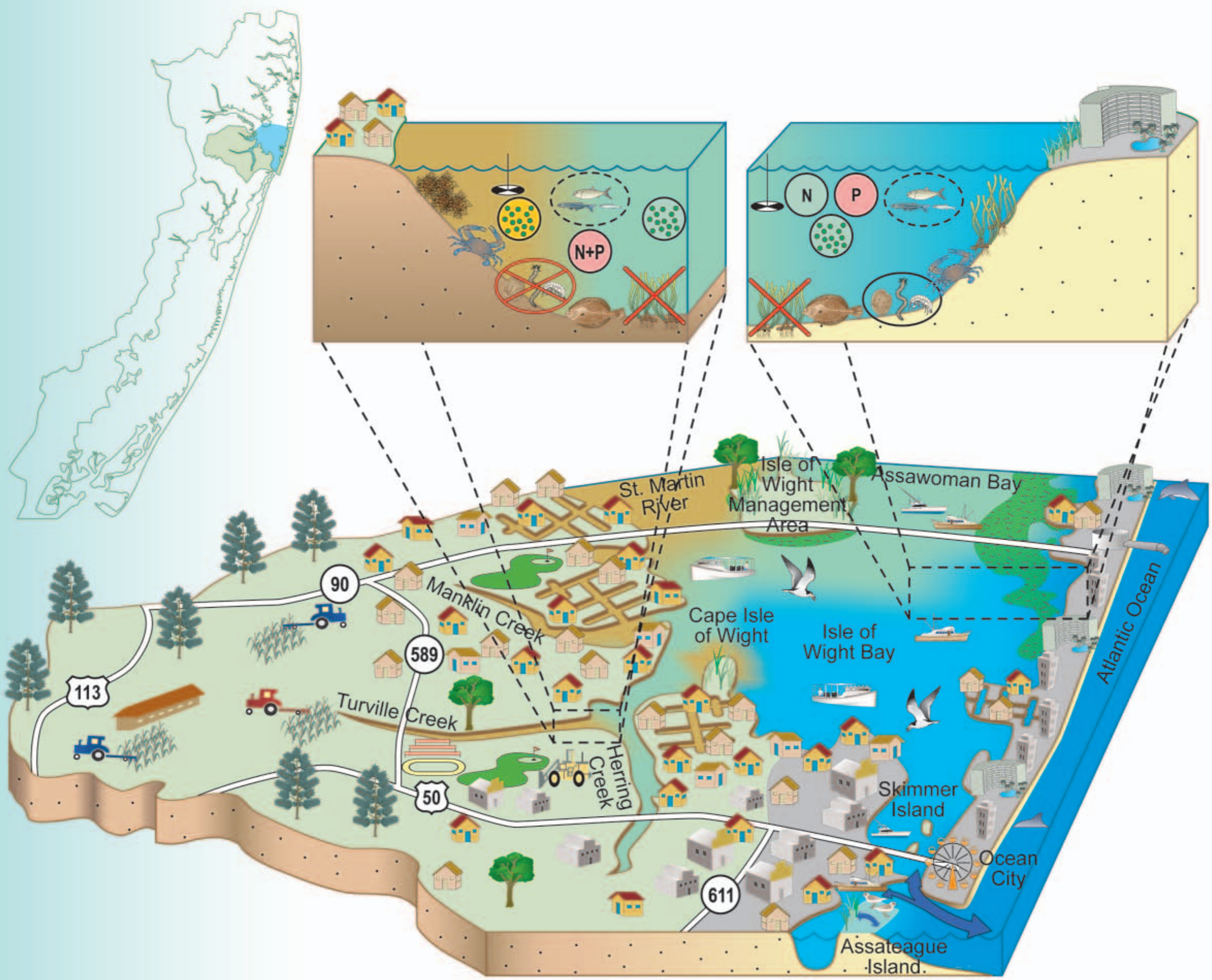
The mouth of St. Martin River received better flushing, resulting in slightly improved water clarity , however nutrient concentrations were still high and chlorophyll levels were moderate . Benthic animal communities were intact in the lower portions of St. Martin River. Seagrass distribution was limited to the Isle of Wight Management Area.

Isle of Wight Bay

In **Isle of Wight Bay**, forage fish abundance has declined.

In **west Isle of Wight Bay**, water quality was poor to fair in the western tributaries and adjacent to the mouth of St. Martin River. Nitrogen and phosphorus concentrations were high (N+P), resulting in moderate chlorophyll (algal) concentrations in the upper tributaries, and low downstream. Water clarity was low (shallow Secchi depth) throughout. Benthic animal communities were degraded in upper Turville Creek, Manklin Creek and Herring Creek. The macroalga *Gracilaria* was unusually abundant in Turville Creek. Seagrass was absent from the western areas of Isle of Wight Bay and the tributaries.

In **east Isle of Wight Bay**, water quality was fair in the open bay, improving to good closer to the Ocean City Inlet in the south. Phosphorus concentrations remained high (P), while nitrogen concentrations improved to low (N), resulting in low chlorophyll levels and moderate water clarity. Benthic animal communities were intact in the open bay and in lower Turville Creek. Seagrass abundance was low in Isle of Wight Bay, with distribution occurring mainly in areas behind Ocean City, as well as south of the Isle of Wight Management Area.



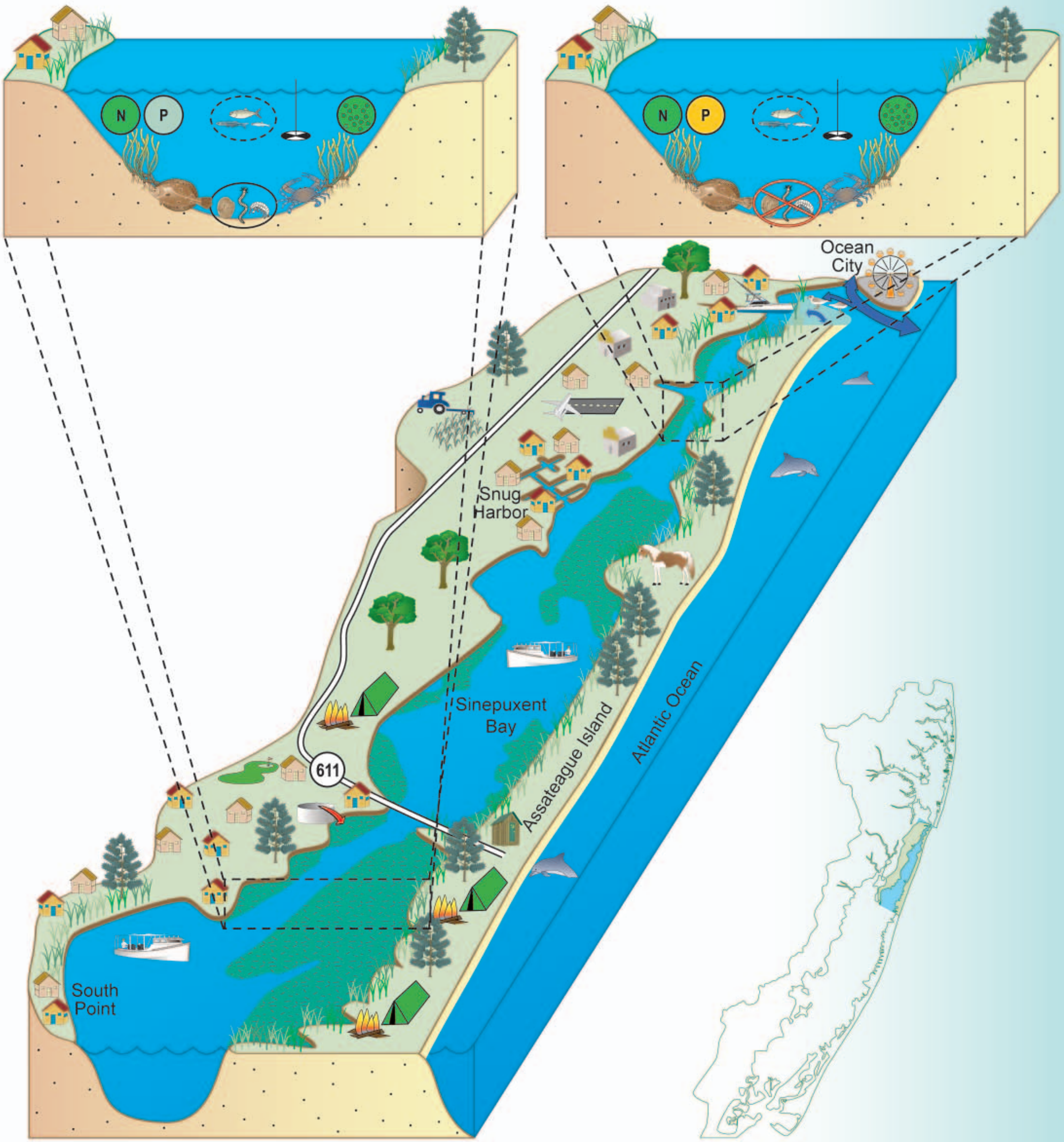
Legend page 38

Sinepuxent Bay

Sinepuxent Bay had good water quality. Seagrasses were widespread. Forage fish abundance has declined throughout Sinepuxent Bay.

In **southern Sinepuxent Bay**, nitrogen concentrations were very low and phosphorus concentrations were low, resulting in very low chlorophyll (algal) concentrations and very high water clarity (deep Secchi depth). Benthic animal communities in southern areas of Sinepuxent Bay were intact.

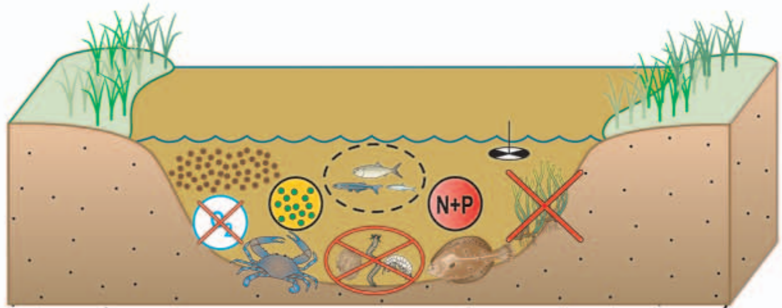
In **northern Sinepuxent Bay**, nitrogen concentrations were very low and phosphorus concentrations were moderate, resulting in very low chlorophyll (algal) concentrations and very high water clarity (deep Secchi depth). Benthic animal communities in northern areas of Sinepuxent Bay were degraded.

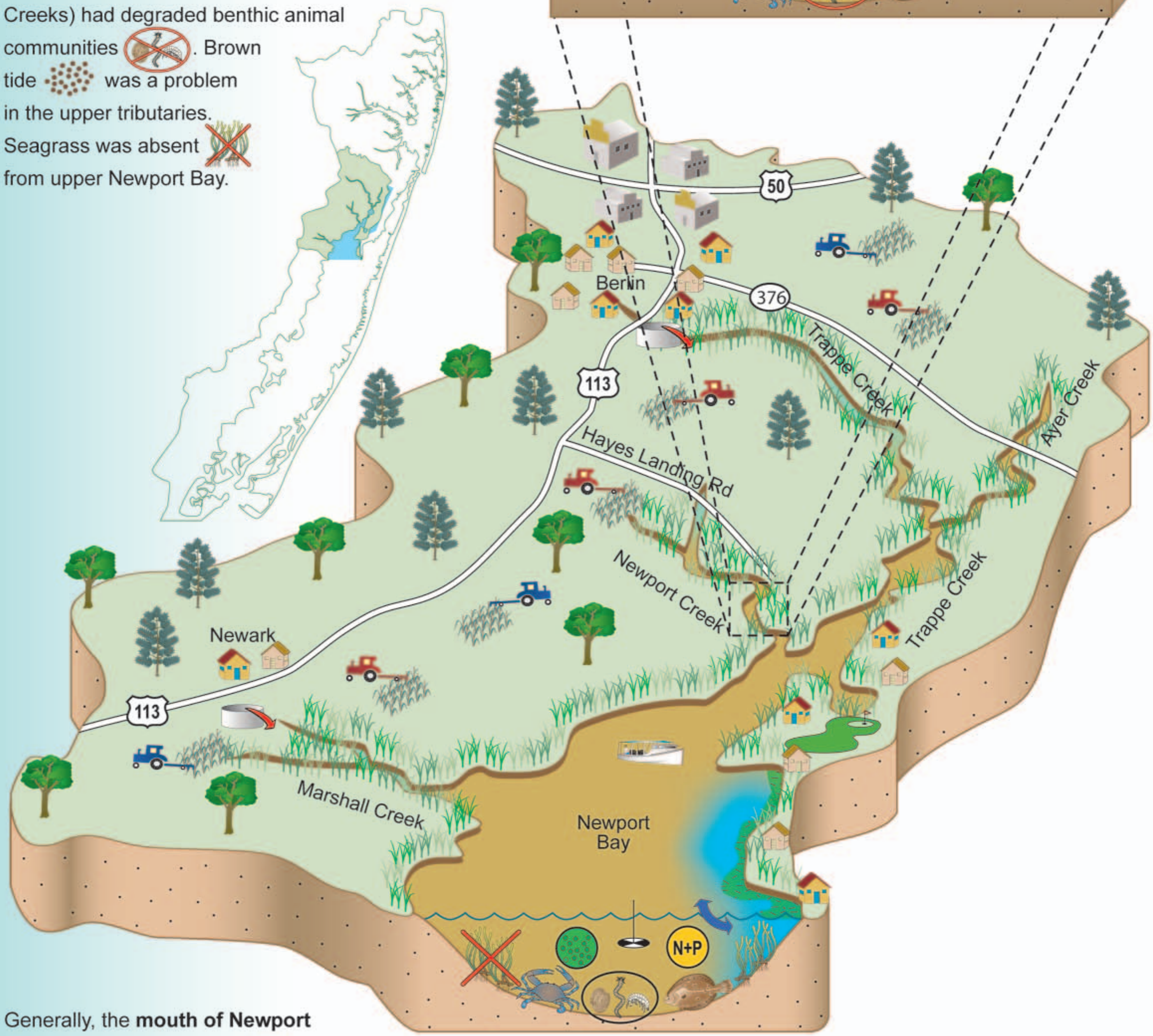


Newport Bay

In **Newport Bay**, forage fish abundance has declined.

Upper Newport Bay had poor water quality. Nitrogen and phosphorus concentrations in the upper portions of Newport Bay ranged from high to very high and chlorophyll (algal) concentrations were moderate, resulting in low water clarity (shallow Secchi depth) and low concentrations of dissolved oxygen. The upper tributaries (Ayer, Newport and upper Trappe Creeks) had degraded benthic animal communities. Brown tide was a problem in the upper tributaries. Seagrass was absent from upper Newport Bay.



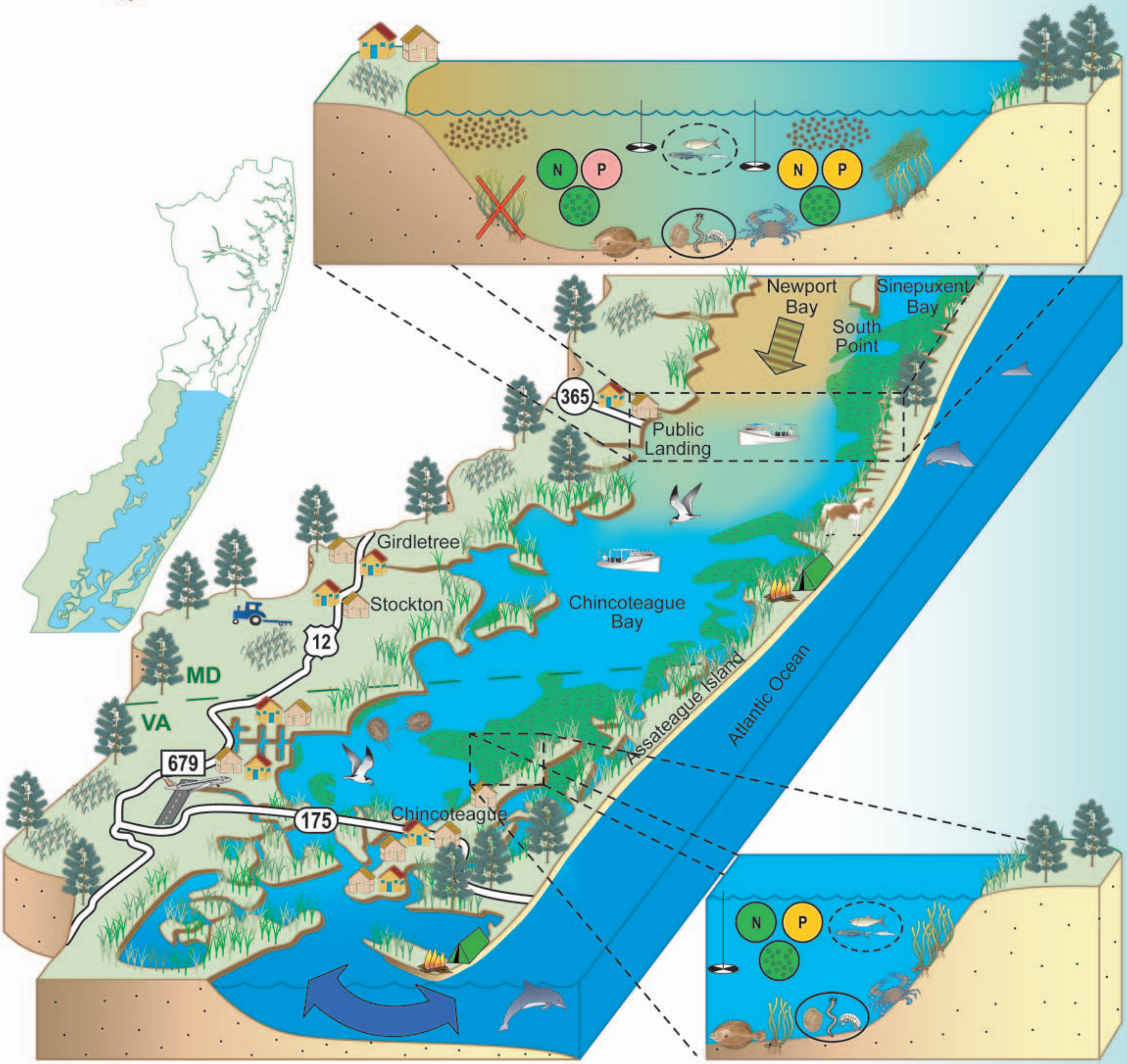


Generally, the **mouth of Newport Bay** had poor water quality, however in the south-east portion, water quality was good. Nutrient concentrations were moderate towards the mouth, resulting in very low algal levels and moderate water clarity. The lower areas of Newport Bay had intact benthic animal communities. Seagrass distribution was limited to the south-east portion of Newport Bay where water quality was the highest.

Chincoteague Bay

Chincoteague Bay benthic animal communities were intact, although forage fish abundance has declined. The macroalga *Chaetomorpha* was most abundant in the eastern portion of Chincoteague Bay, where it was associated with seagrass.

North Chincoteague Bay had moderate to poor water quality adjacent to the mouth of Newport Bay, and good water quality elsewhere. Nitrogen concentrations ranged from very low in the western portions to moderate in the east, while phosphorus concentrations ranged from high in western areas to moderate in the east. Chlorophyll (algal) concentrations were very low in north Chincoteague Bay. Water clarity (Secchi depth) was good in western areas, and very good in the east. Brown tides occurred in the north-western part of Chincoteague Bay, associated with the poorer water quality in this region.



South Chincoteague Bay had good water quality due to strong flushing through Chincoteague Inlet. Nitrogen concentrations were very low, while phosphorus concentrations were moderate, resulting in very low chlorophyll levels and very good water clarity.

Legend page 38

STATE OF MARYLAND
Robert L. Ehrlich, Jr., Governor
Michael S. Steele, Lt. Governor

MARYLAND DEPARTMENT OF NATURAL RESOURCES
C. Ronald Franks, Secretary
Resource Assessment Service
Tidewater Ecosystem Assessment Division
580 Taylor Avenue, D2
Annapolis, Maryland 21401
Internet Address: http://www.dnr.maryland.gov
Telephone Contact Information:
Toll free in Maryland: 1-877-620-8DNR ext. 8638
Out of State call: 410-260-8638
TTY users call via the Maryland relay

Maryland Coastal Bays Program
410-213-BAYS
www.mdcoastalbays.org

Integration & Application Network (www.ian.umces.edu)
University of Maryland Center for Environmental Science
PO Box 775
Cambridge, MD, 21613
www.umces.edu

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