NRDC Issue Paper
OCTOBER 2009

Seizing a Watershed Opportunity

NRDC's Plan to Clean Up the Chesapeake Bay and Its Beaches

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THE EARTH'S BEST DEFENSE

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Acknowledgments

NRDC wishes to acknowledge the generous support of The Morris & Gwendolyn Cafritz Foundation, The Campbell Foundation, The Linden Trust for Conservation, The Prince Charitable Trusts, The Red Crane Foundation, The Mary Jean Smeal Clean Water Fund, The Summit Foundation, and The Summit Fund of Washington.

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Executive Summary

Following NRDC's annual nationwide beachwater quality report this summer, *Testing the Waters*, this issue paper zooms in on the Chesapeake Bay. On the heels of reports from seven federal agencies commissioned by President Obama to clean up this national treasure, this issue paper delves into the sources of pollution that are undermining the health of the Bay and provides the solutions that Congress must take up to bolster the important work being carried out by the other branches of government. From dangerous algal blooms, to harmful bacteria at our beaches, plastic bags clogging tributaries, and economic hardships for the crabbing industry, the Chesapeake watershed and those who rely on it are in need of help. By acting on our recommendations, Congress can enact the comprehensive policies needed to make a lasting difference in improving the health of the nation's largest estuary.

A Treasure Worth Protecting

The Chesapeake Bay is the largest estuary in the United States and the third largest estuary in the world. Considered a national treasure, the Bay drains an immense 64,000 square miles in six states: New York, Pennsylvania, West Virginia, Delaware, Maryland, and Virginia, as well as Washington, D.C. (Figure 1). Two of these states, Maryland and Virginia, have 83 beaches along the shoreline of the Bay that are analyzed in this paper.

The Chesapeake Bay watershed is not only large in landscape, but also in population. The population of the area is growing by more than 170,000 residents annually. Development within the watershed that is associated with this increasing population affects the local water resources that eventually reach the shoreline and beaches of the Chesapeake Bay. Between 1990 and 2000, the population in the Bay watershed increased 8 percent, while developed areas increased by a disproportionate 41 percent.[1]

Measuring the Health of the Bay

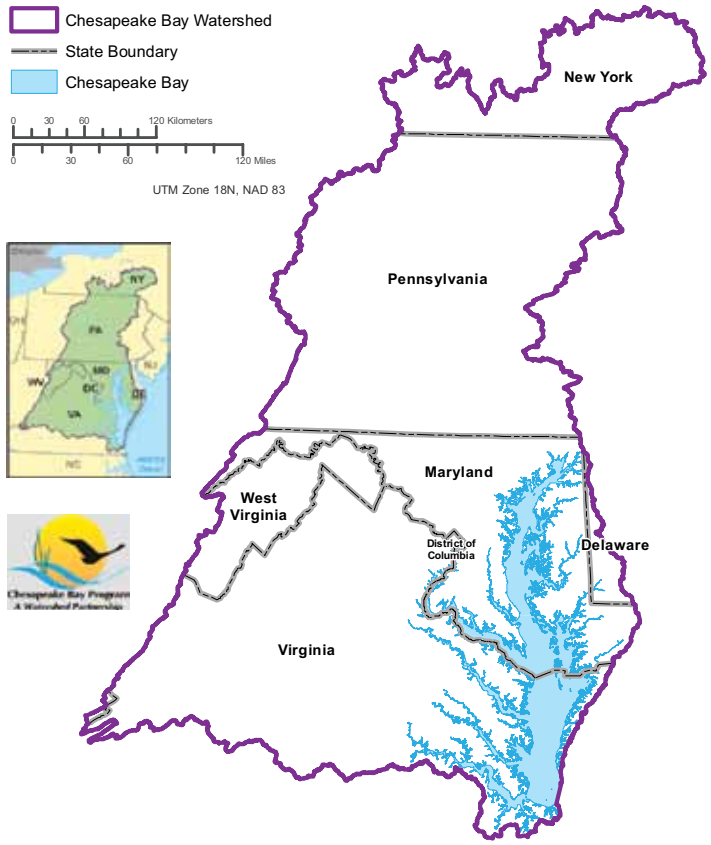
The University of Maryland Center for Environmental Science and the National Oceanic and Atmospheric Administration (NOAA) create an annual Chesapeake Bay report card evaluating the health of the Bay. This comprehensive report card analyzes indicators of the Bay's health, such as chlorophyll a, aquatic grasses, dissolved oxygen, benthic organisms, water clarity, and phytoplankton.[2] The Bay received a grade of a C- in 2008. The Chesapeake Bay Foundation also rates the health of the Chesapeake Bay in the "State of the Bay Report," and assigned the Bay a low 28 points out of 100 in the 2008 report.[3] In May 2009, President Obama expressed his concern about the health of the Chesapeake Bay in an Executive Order to the Environmental Protection Agency. In this Executive Order, President Obama established a Federal Leadership Committee for the Chesapeake Bay to coordinate protection and restoration efforts for the Bay. The President also asked the EPA to publish guidance for federal

stormwater management and other tools to reduce water pollution in the Bay.[4]

Health and Economic Threats Stemming from Pollution

Pollution into the Chesapeake Bay has been linked to increases in parasites, viruses, and bacteria that make recreational swimming and eating shellfish from the Bay dangerous. Maryland and Virginia both test for *Enterococci* bacteria at Chesapeake Bay beaches, but tests are often not frequent enough and results are not available soon enough to sufficiently alert the public of unsafe conditions. Algal blooms have been linked to health concerns as well as low oxygen conditions that suffocate fish. Stressed fish populations, poor water quality, and eyesores that decrease tourism to the Chesapeake Bay threaten the estimated one trillion dollar value of the Chesapeake Bay.

Figure 1: Chesapeake Bay Watershed



Data source: Chesapeake Bay Program. For more information visit www.chesapeakebay.net. Created by EA 1/24/08.

Recommendations for Protecting the Chesapeake Bay Watershed

It is a critical time to implement changes in federal and state policies that affect the Chesapeake Bay. President Obama has asked for progress in the clean up and restoration of the Bay's health, and there are multiple active pieces of legislation that can make this happen. By supporting legislation to create an enforceable nutrient cap and trade program for the Bay, a national climate change bill and approving additional financing for stormwater infrastructure and beach water quality testing, the government will be taking a step forward to ensure a healthier future for the Chesapeake Bay.

CHAPTER 1

Sources of Pollution in the Chesapeake Watershed

From human sewage, to stormwater, and runoff from agriculture, highways, and urban areas, the Chesapeake Bay is the dumping ground for many types of pollution. Unfortunately, climate change will only increase the flow of pollution from many of these sources. The contaminants flowing into the Bay are harmful not only to aquatic life, but also to the people who visit Bay beaches.

Flushing Pollution Into the Bay

The Chesapeake Bay watershed has more than 250 major wastewater treatment plants (those with a capacity above 500,000 gallons/day) that treat industrial, commercial, and household wastewater. Unfortunately, not all pollutants are removed by the treatment processes these plants employ. Nutrients like nitrogen and phosphorus, and parasites like *Giardia* and *Cryptosporidium*, can be found in water even after it is treated.[1] Also, during storms, combined sewer systems, which treat a combination of stormwater runoff and sanitary sewage (including human, commercial, and industrial waste) may discharge untreated or partially treated sewage directly into the waters of the Chesapeake Bay.

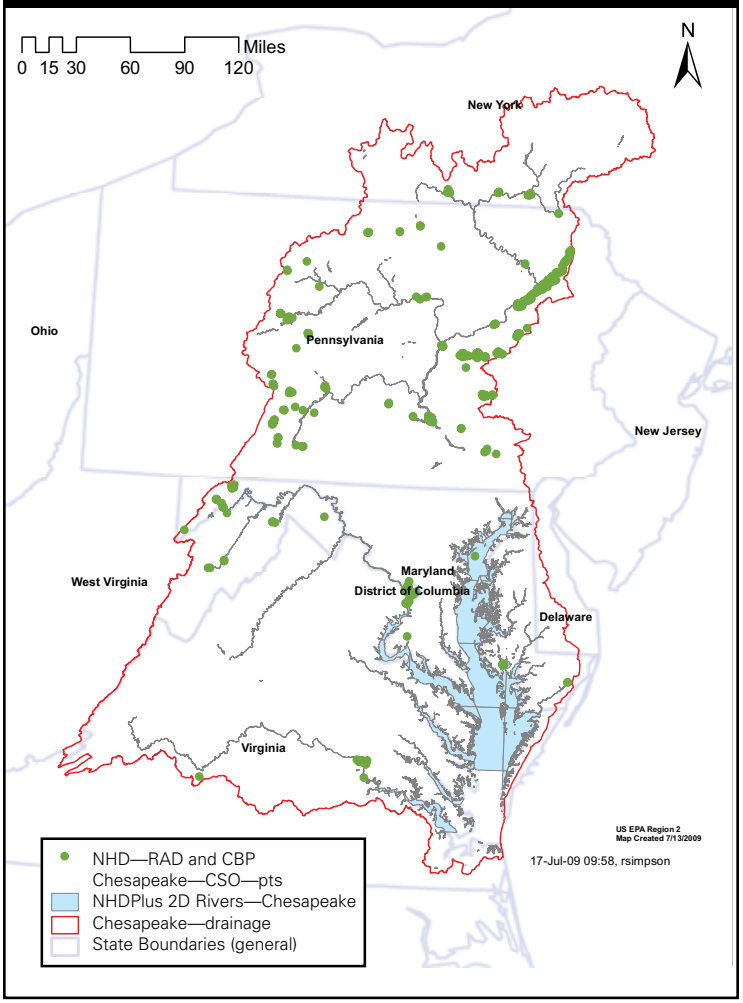
The Blue Plains Treatment Plant, which is the largest advanced sewage treatment plant of its type in the country, treats wastewater from Washington, D.C., Maryland, and Virginia, processing up to 370 million gallons of water per day on average, and as much as 1.076 billion gallons per day during wet weather.[2] Blue Plains is considered an advanced wastewater treatment plant because of its nitrogen/denitrification and filtration process, but it still releases nutrients into the Bay. The sewer systems that feed into Blue Plains have combined sewage and stormwater pipes in approximately one-third of the District of Columbia and separate stormwater and sanitary sewer systems in the rest of the District and its suburbs. When it rains as little as one tenth of an inch in the neighborhoods with combined sewers (e.g., Georgetown in Washington, D.C.), the pipes exceed capacity and a combined-sewer overflow (CSO) event occurs, releasing sewage directly into the Anacostia and Potomac Rivers and Rock Creek, all of which flow into the Chesapeake Bay.[3]

CSOs are not the only source of sewage pollution in the watershed. Sanitary sewer overflows (SSOs) from pipes that do not convey stormwater also occur, and sewage is discharged into the Bay because of inadequate or decaying infrastructure, power failures, blockages, and line breaks.[4] Many of the sewer pipes in the Chesapeake Bay watershed are more than one hundred years old and are in need of repair to ensure that sewage makes it to a plant for treatment. Hundreds of combined and separate sewer systems have the potential to discharge raw sewage into the Chesapeake Bay watershed, especially when rainfall overwhelms treatment capacity (see Figure 2).

Another important source of sewage entering the Bay is leaking septic tanks. There are more than 2 million septic systems in the Chesapeake Bay watershed and an estimated 40,000 failing septic systems in Maryland alone.[5,6] Untreated sewage contains trash, pathogens that can make people sick, and nutrients that lead to algal growth and depleted oxygen levels in the Bay.

In January 2005, Maryland added a "flush tax" to water bills of property owners using municipal sewer systems or septic systems. These funds are placed in the Chesapeake Bay Restoration Fund, which subsidizes upgrades for sewage treatment plants and septic systems. This initiative, one of the more significant initiatives for the Bay in the past 20 years, is expected to raise approximately $60 million per year to repair leaky sewage pipes, to upgrade septic systems and sewage treatment plants, and to support the Maryland Department of Agriculture's cover crop cost share program, which encourages farmers to plant cover crops for harvest as well as for soil erosion protection.[7] Virginia and Washington, D.C. have begun to explore the possibility of a flush tax similar to the one in place in Maryland.

Figure 2: CSO Outfalls in the Chesapeake Bay Watershed



Chesapeake drainage extent with CSO points and major rivers (1:100K) Multiple CSO outfalls may be within the same CSO community. (Data represent Combined Sewer Overflow Points within the National Hydrographic Dataset Reach Address Database and EPA Region III's Permit Tracking System. Shared with permission of the Chesapeake Bay Program Office.

Producing Polluted Runoff on the Farm

Both agricultural crop production and concentrated animal feeding operations (CAFOs) threaten the Chesapeake Bay by adding nutrient and pathogen pollution to the Bay. With 22 percent of the watershed in agricultural production, agriculture is the single largest source of pollution into the Chesapeake Bay.[8]

Traditional row crop production generally requires a large amount of fertilizer and often results in high levels of sedimentation due to plowing techniques that expose bare soil. Areas in southwestern Pennsylvania and along the southern Virginia coastal region rank in the upper 10 percent of watersheds nationally in the use of nitrogen fertilizer.[9] Fertilizers can run off into local water bodies rather than absorb into the ground if fertilizer is applied before a heavy rainstorm or in volumes greater than needed for a given area. Some simple ways to decrease the impact of agriculture on the Chesapeake Bay include planting cover crops that trap nitrogen to be used by the following year's crops and creating nutrient management plans to determine the appropriate application rate for nutrients to maintain an optimum crop yield and decrease nutrient loss. Using no-till farming techniques and conservation tillage practices can also help to reduce erosion and runoff.[10]

Farmers across the country, including those in the Chesapeake Bay watershed, have experienced increased pressure and incentive to produce greater crop volumes for use as fuel. The Energy Independence and Security Act of 2007 requires that 36 billion gallons of renewable fuels—15 billion gallons to be derived from corn—are incorporated into the nation's gasoline supply by 2022.[11] According to a 2007 report by the USDA Agricultural Research Service, increased corn production in the Chesapeake Bay watershed could result in an additional 8 to 16 million pounds of nitrogen pollution and 0.8 to 1.5 million pounds of phosphorus pollution into the Bay annually.[12] The

use of other grains for fossil fuel, such as hulless barley and switch grass, would have less impact on the Bay than row crops that are dependant on large volumes of fertilizer for high harvest yields.

At CAFOs located along Maryland's eastern shoreline, poultry manure is produced in large volumes. Large chicken farms in the area now number more than 800, house approximately 570 million chickens, and produce 650 million pounds of manure each year.[13] A bloom of the harmful algae *Pfiesteria* in 1997 on the Pocomoke River in Maryland may have been a result of nutrient enrichment from manure discharged into the Bay. This bloom was linked to human neurological problems in those exposed to the *Pfiesteria* toxins in the water. The bloom also resulted in a loss of sales volumes in the commercial fishing, tourism, recreation and subsistence harvests.[14]

Urban and highway runoff both threaten the health of the Chesapeake Bay by adding nutrients, waste, and sediment to the Bay.

Manure from CAFOs is rich in nutrients as well as bacteria and other pathogens that if not treated properly can run off into streams and waterbodies. In 2008, the United States Environmental Protection Agency (EPA) finalized a rule that requires all CAFOs to include a manure management plan as part of their Clean Water Act permit applications. However, the rule continues to exempt many large CAFOs.[15] Data supplied to NRDC by the EPA based on the first quarter of 2009 (after the compliance deadline had passed) showed that not a single CAFO had obtained a permit in Virginia, and only 14 percent of Maryland CAFOs had permits.[16] Although the EPA has not yet updated that information, the Environmental Working Group reports that 80 percent of livestock animals (dairy, beef, and swine) are under Clean Water Act permits and that 80 percent of poultry animals are expected to receive permits.[17]

Transporting Contaminants from Roads and Cities

Urban and highway runoff both threaten the health of the Chesapeake Bay by adding nutrients, waste, and sediment to the Bay. Increased urban and suburban development in the watershed results in forest and open space being replaced with more impervious surfaces (e.g., roads, parking lots, and rooftops) across which stormwater flows instead of infiltrating into the ground. A one-acre parking lot produces about 16 times the volume of runoff when compared to a one-acre meadow.[18] Stormwater that flows across impervious surfaces picks up waste, such as pet waste, oil, metals, gasoline, floatable trash, and nutrients from lawn fertilization and carries the water and waste into storm drains, most of which drain directly into the Bay and its tributaries. Urban stormwater, which routinely causes exceedances of bacterial water quality standards, is associated with the closure of streams, beaches, and shellfish harvesting areas after significant rain events within the Chesapeake Bay watershed.[19]

The increase in sediment loads and nutrients into the Bay is also due to the high speed of the stormwater as it travels over impervious surfaces. This change in hydrology alters creeks, streams, and rivers by scouring their bottoms and banks, carrying large amounts of nutrients and sediment to the Bay.[20] The contribution of nutrient load to the Chesapeake Bay from urban land increased from less than 5 percent in 1985 to 19 percent of the total nitrogen load and 30 percent of the total phosphorus load into the Bay in 2005, making urban nutrient loads the fastest growing source of nutrients in the Bay.[21] Urban stormwater runoff also contributes 9 percent of sediment loads to the Bay.[22]

Each year, highway surfaces discharge an estimated 4 million pounds of nitrogen, 820,000 pounds of phosphorus, and 150,000 tons of sediment to the Chesapeake Bay watershed.[23] There are almost 100,000 miles of federally funded highways in the states discharging this nutrient- and sediment-rich stormwater to the Chesapeake Bay and its tributaries.[24] These highways, as well as state and local roads, do not have sufficient controls to reduce polluted runoff, which can make people sick if it reaches the beach. Nitrogen pollution in the Bay can also be attributed to emissions of nitrogen-containing air pollutants from vehicles on these highways. A study by researchers at Cornell University shows that air deposition of nitrogen gas from cars and power plants is a significant source of nutrient pollution in the Chesapeake Bay and other wet climates.[25]

In October 2007, Maryland passed the Stormwater Management Act of 2007. This act requires that environmental site design practices be implemented to the "maximum extent practicable" to reduce stormwater pollution. Virginia also has a Stormwater Management Law and management regulations that specify which development

activities require permits, including nonresidential development sites more than one acre in size.[26] In May 2009, Maryland updated its stormwater management regulations to incorporate the design practices from the Stormwater Management Act for new development and redevelopment projects, which requires control of sediment and stormwater as close to the source as possible to decrease the effects on downstream environments.[27] By taking these initiatives to address stormwater runoff, Maryland and Virginia are beginning to stem the tide of pollution affecting the Chesapeake Bay and its beaches.

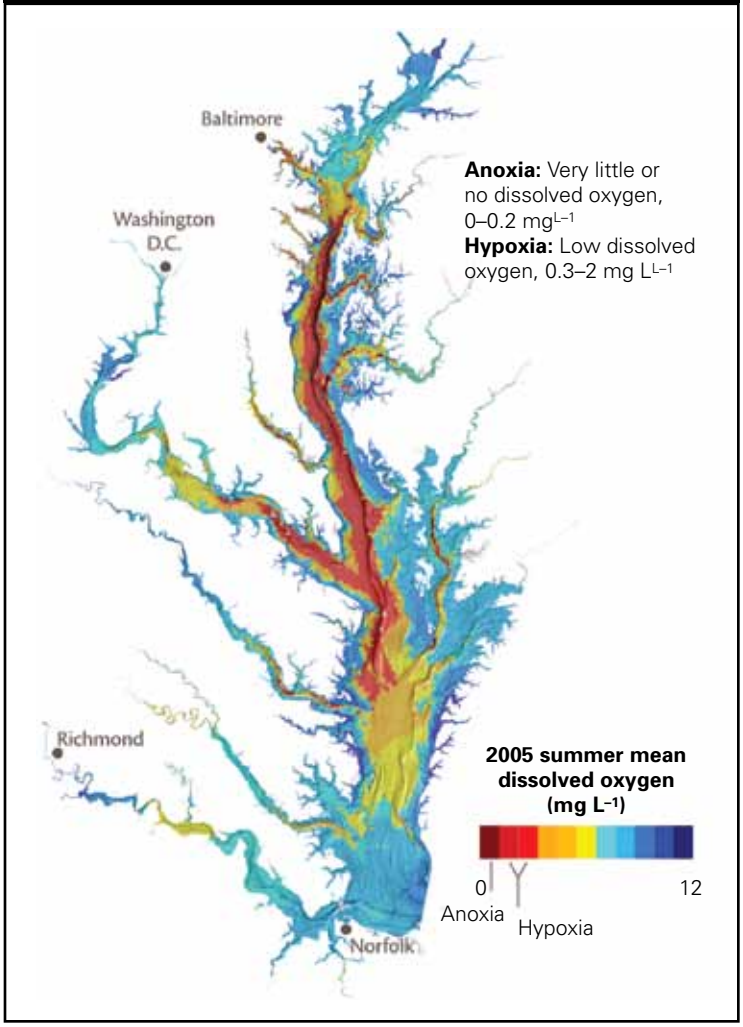
Trash, which is carried into waterways from streets and parking lots by stormwater, is a nuisance and a serious environmental problem. Washington, D.C. has recently passed legislation focused on decreasing the volume of shopping bags that end up as trash in the Anacostia River. The Anacostia River, which drains portions of Washington, D.C. and Montgomery and Prince George's County in Maryland, has been identified as one of the most polluted urban rivers in the country. The Anacostia has been cited as a national example of urban watershed problems, notably in the form of 20,000 tons of trash flowing into the river each year.[28] Currently, more than 50 percent of the approximately 17,000 tons of plastic products in the river are plastic bags.[29] Many of these bags get caught on low hanging trees in the Anacostia River, but sometimes they sink to the bottom of the river or flow out to the Chesapeake Bay. The recently enacted Anacostia River Cleanup and Protection Act of 2009 places a five cent fee on disposable, recyclable plastic bags and paper carryout bags from vendors in Washington, D.C. A majority of this fee (four cents) will be used to fund an Anacostia River Cleanup and Protection Fund to protect and restore of the Anacostia.[30] This local initiative to curb the flow of trash into the Anacostia will result in less trash in the Potomac River and ultimately less trash in the Chesapeake Bay.[31]

Climate Change: Exacerbating the Pollution Problem

The earth's climate is changing and many local environmental threats are emerging. According to the Intergovernmental Panel on Climate Change (IPCC), from 2000 to 2009 the average warming of Virginia and adjoining areas is projected to be 3.1°C with an increase in annual precipitation of 11 percent.[32] The extreme weather events such as floods and hurricanes that are associated with climate change will have adverse impacts on people through injuries, drowning, an increase in illnesses, and property losses.

Weather changes expected as a result of climate change can have detrimental effects on the coastal waters of the Chesapeake Bay. Figure 3 shows a representation of low

Figure 3: Map of Low Dissolved Oxygen Zones (Dead Zones) in the Chesapeake Bay



This map of bottom dissolved oxygen illustrates areas that are off limits to Bay organisms due to low dissolved oxygen. Based on 2005 summer mean dissolved oxygen data. Image and captions from Chesapeake Bay Program, May 2007 EcoCheck: Breath of Life: Dissolved Oxygen in Chesapeake Bay, available at: http://www.eco-check.org/pdfs/do_letter.pdf.

dissolved oxygen areas in the Bay. Increases in precipitation will increase runoff, exacerbating the flow of nutrients, pollutants, and sediments into the Chesapeake Bay. Dead zones (oxygen depleted areas where fish and other aquatic organisms cannot survive) are likely to continue to increase in size and intensity in the Chesapeake Bay as a result of rising water temperatures and added nutrient runoff. Warmer surface water temperatures combined with reduced salinity from expected increases in freshwater runoff prevents oxygen replacement in deeper waters because of an increased difference between surface and bottom water density.[33] Added nutrients stimulate the growth of algal blooms, which decrease oxygen levels as they decompose, creating hypoxic conditions.

Climate change is also expected to increase incidents of harmful algal blooms (HABs) as blooms may begin earlier and new species of algae may move into the Bay.[34] Scientists have expressed concern that harmful algal blooms are a "significant and expanding threat to aquatic life, human health, and regional economies."[35] As a public health concern, HABs can cause liver disease, skin rashes, nausea, and vomiting upon human exposure.[36]

There are also concerns that increased water temperatures may lead to increases in jellyfish populations that can sting beachgoers. A review of climate variations and the abundance of some species of jellyfish showed that most species of jellyfish in temperate waters seemed to respond positively to warm waters. Also, species that cannot tolerate higher temperatures in tropical waters may start migrating to more temperate, cooler waters.[37]

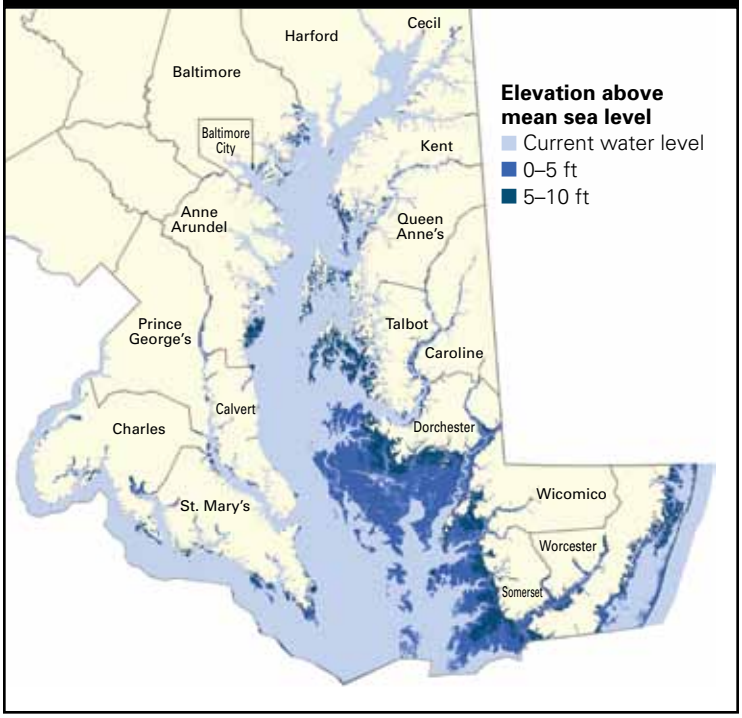
An increase in stratification of salt and fresh water related to warming might also favorably affect jellyfish populations, as well as eutrophication. Several studies indicate that higher nitrogen ratios can lead to eutrophic conditions that change the size of microplankton thereby favoring jellyfish feeding patterns over the feeding patterns of other fish, thus leading to jellyfish blooms.[38]

Sea level rise is another effect of warming temperatures and more extreme storm events that is a concern for coastal communities. According to the Governor's Commission report for Virginia, the Virginia Beach-Norfolk Metropolitan Statistical area at the mouth of the Chesapeake Bay region is the tenth largest coastal city in the world "in terms of assets exposed to increased flooding from sea level rise."[39] The 7,000-mile Maryland coastline will also be directly affected by climate change in the Chesapeake Bay. Maryland is one of the ten states most vulnerable to sea level rise, with 6.1 percent of the state's land below 1.5 meters in elevation.[40]

Increases in waterborne and food borne illnesses are expected as a result of extreme weather. For example, *Vibrio*, a family of bacteria that can cause life-threatening skin and blood infections, thrive on eating the algal blooms found in warm, nutrient-impaired waterways. Incidence of *vibrio* infections, while still small, have increased steadily in both Maryland and Virginia over the past decade, leading to 22 deaths in Maryland and nine in Virginia.[41] Vector-borne diseases, such as West Nile Virus, are expected to increase in incidence with rising waters and to emerge in areas where they were previously limited or not existent.[42]

Through changing rates of precipitation, erosion, changing temperatures and sea level

Figure 4: Land That Would Be Inundated by Sea Level Rise of 2–10 Feet



Note: LIDAR elevation data were not available for Baltimore City, Harford County, and Prince George's County, therefore, vulnerability data do not exist for those areas and cannot be shown on this map. (Image and legend from Maryland Department of Environmental Protection as featured in the Maryland Commission on Climate Change August 2008 Report)

rise, climate change can physically change the landscape of the Chesapeake Bay. If global sea level rises two feet in Chesapeake Bay by 2100 (an estimate based on greenhouse gas emissions increasing at the same rate as in 2008) there will be drastic changes to the Bay coastline.[43] Approximately 190,000 acres of diverse brackish marshes and swamps would be inundated and replaced with less diverse salt marshes and open water. More than 160,000 acres of dry land would be at risk of being converted to salt marsh as well. This loss of land would include a loss of 58 to 69 percent of the region's beaches, and up to 79 percent of the beaches at Norfolk and Virginia Beach at the mouth of the Chesapeake Bay.[44] Figure 4 shows the land in Maryland that would be inundated by a rise in sea level by 5 to 10 feet. Shoreline armoring and development in the region will exacerbate these problems by disrupting the natural wave action that replenishes beach sediment. Regional development is also a threat because development limits the inland migration of marshes and beach habitats as sea level rises and increases stormwater and sediment pollution.[45]

If global sea level rises two feet in Chesapeake Bay by 2100 . . . [loss of land would include] 58 to 69 percent of the region's beaches and up to 79 percent of the beaches at Norfolk and Virginia Beach at the mouth of the Chesapeake Bay.

CHAPTER 2

Measuring the Health of Chesapeake Bay Beaches

This year, for the first time, NRDC conducted an analysis of water quality at the beaches along the shoreline of the Chesapeake Bay using publicly available monitoring data. Out of 30 coastal states nationwide, Maryland and Virginia ranked 8th and 3rd respectively in beachwater quality. The rating was based upon exceedances of the daily maximum bacterial standard (104 enterococcus colony-forming units per 100ml of water) measured as required by the Beaches Environmental Assessment and Coastal Health (BEACH) Act. Exceedances of this standard indicate that there is human or animal waste in the water that could make swimmers sick.

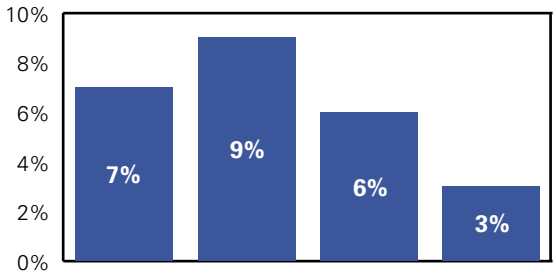
Majority of Polluted Beachwater Occurs on the Chesapeake Bay

In both Maryland and Virginia, the majority of coastal water quality samples that exceeded the BEACH Act standard were at beaches on the Chesapeake Bay. Only one Maryland and three Virginia beaches on the Atlantic Ocean had exceedances during the 2008 swimming season. Because there is more circulation and mixing at ocean beaches, it is generally safer to swim at ocean beaches than the Chesapeake Bay beaches in Maryland and Virginia. The Chesapeake Bay, though an immense water body, is enclosed on all sides by sources of pollutants, and is reliant on currents, winds, and tidal cycles to flush nutrients and pollutants from the water. Ocean front beaches are impacted by pollutants from land on only one side and have more wave action to quickly dissipate any polluted runoff.[1]

In 2008, 3 percent of monitoring samples at Chesapeake Bay beaches exceeded the BEACH Act's daily maximum enterococcus standard (based on 2,783 samples at 83 beaches). However, in order to make a meaningful comparison from year to year, NRDC includes only those beaches consistently reporting monitoring data results each year between 2005 and 2008. Based on the results of this set of 68 Chesapeake Bay beaches, exceedances decreased to 3 percent in 2008 from 6 percent in 2007 (see Figure 5).

The 3 percent exceedances for all Chesapeake Bay samples are below the nationwide average of 7 percent for 2008. Maryland had a slightly greater percentage of

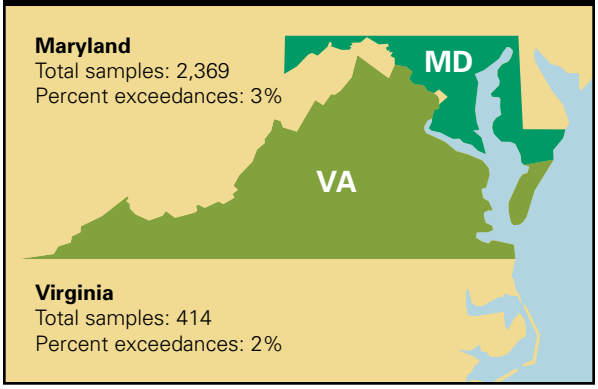
Figure 5: Percent Exceedances for All Chesapeake Bay Beaches Combined



Based on 68 beaches reporting monitoring data each year.

exceedances in 2008 than Virginia (see Table 1). Fairview Beach in King George County, Virginia, was the only beach in the Chesapeake Bay to have more than 25 percent of samples (8 of 25 samples, or 32 percent) exceed the national daily standard in 2008. Fairview Beach was also the only beach in the Bay, and one of only two dozen beaches in the nation, with more than 25 percent of samples exceeding the daily national standards for the past four beach seasons (2005-2008).[2] Local officials in Fairview Beach, which is located on the Potomac River, have fixed problems with failing septic systems and leaky sewage pipes, but problems continue after heavy rains. Researchers from Virginia Tech are continuing to investigate potential sources of contamination.[3]

Figure 6: Rank of States with Chesapeake Bay Beaches by Percent of Samples Exceeding the National Daily Standard in 2008



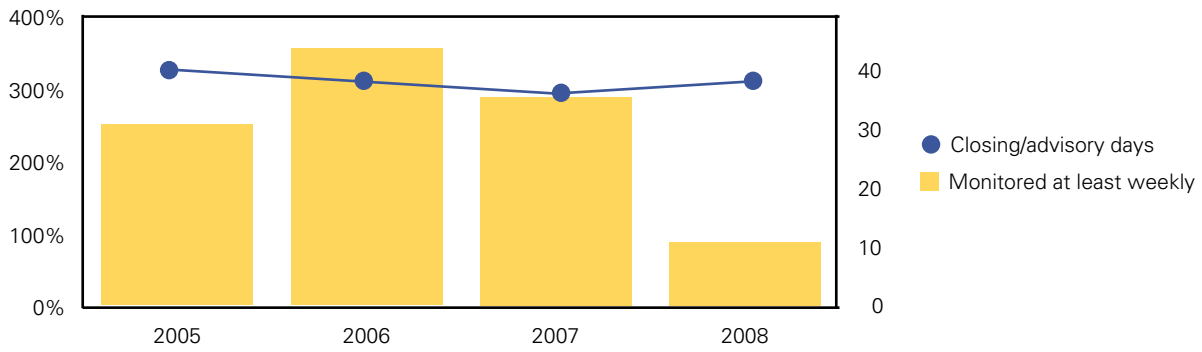
The top dozen Chesapeake Bay beaches in 2008 with the highest percentage of exceedances were Fairview Beach in King George County (32%), Kurtz Beach in Anne Arundel County (18%), Red Point Beach in Cecil County (17%), YMCA Camp Tockwogh (Youth Camp) in Kent County (15%), Elk Neck State Park North East River in Cecil County (14%), Bay Country Campground and Beach in Kent County (11%), Grove Point Camp in Cecil County (11%), Tolchester Estates Beach in Kent County (10%), Elm's Beach-Public Beach in St Mary's County (8%), Cedarhurst in Anne Arundel County (8%), Boy Scout Beach (Eliason) in Kent County (7%), and Franklin Manor in Anne Arundel County (7%). Although Virginia leads the way with a beach with the most exceedances for the Bay, all 11 of the other beaches in the top dozen are in Maryland.

Twelve beaches in Maryland and Virginia were rated as part of NRDC's 200 Popular Beach rating. As summarized in the 2009 Testing the Waters Report, the ocean beaches in Maryland and Virginia received more stars in the five star ratings than most Chesapeake Bay beaches. Ocean City at Beach 6 received a five star rating for water quality, frequency of testing and policies for immediate notification for closings and advisories. Four Virginia Beach beaches, Little Island Beach North, Little Island Beach South, Virginia Beach at 15th Street and Virginia Beach at 28th each received four stars, missing a five star rating because they are only monitored once per week. Hilton Beach on the Bay also received four stars and would have received five stars if water quality tests were taken more than once a week. Anderson Beach and Huntington Beach in Newport News VA, Sandy Point State Park East and South Beaches and Point Lookout State Park in Maryland all received three stars for water quality in 2008, but did not rank as high for water quality over the past three years, and also did not test more than once a week. King/Lincoln Beach in Newport News Virginia received the least stars

Explaining the Standards for Testing Beachwater Safety

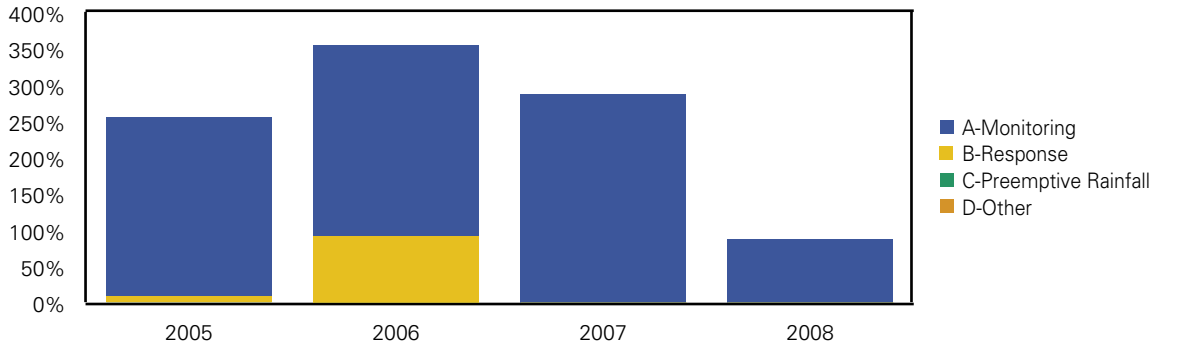
- Both Maryland and Virginia use the BEACH Act single-sample maximum standard to inform beach closing/advisory decisions. This standard is 104 cfu/100 ml for enterococcus at all beaches in Virginia and Tier 1 and Tier 2 beaches in Maryland. Tier 3 beaches in Maryland have a 158 cfu/100 ml standard. Maryland calculates the mean of three simultaneous samples before comparing to the single sample standards.
- Maryland also applies a geometric mean standard for at least five samples collected during a 30-day period of *enterococcus* of 35 cfu/100 ml.
- Neither Maryland nor Virginia uses predictive models to determine beach closures at any of their beaches, though Maryland's Department of Environmental Protection is developing a predictive model for Sandy Point State Park, a high use beach near the Chesapeake Bay Bridge. Predictive models allow real-time estimates of the likelihood that water quality standards will be exceeded based on easily measured physical parameters such as wind direction and water temperature. These models allow for real-time beach closing/advisory determinations, which are more protective of public health.

Figure 7: Total Closing/Advisory Days at Chesapeake Bay Beaches, 2005–2008 (excluding extended and permanent)



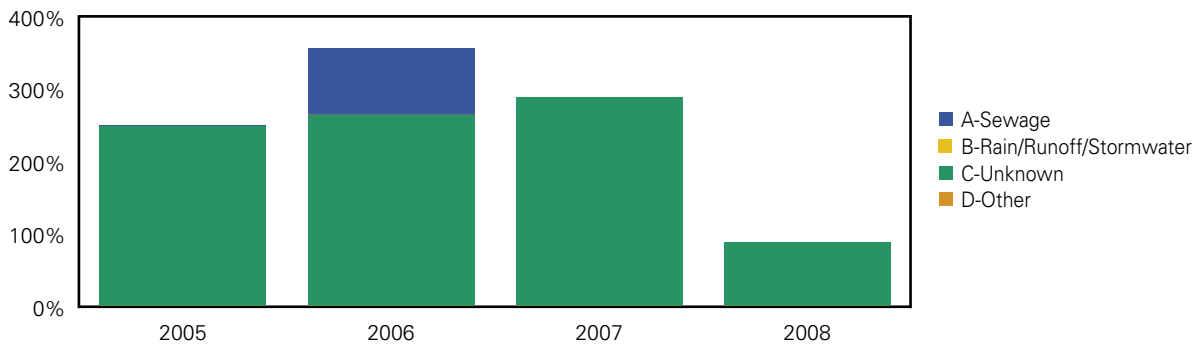
Note: Because of inconsistencies in monitoring and closing/advisory practices among states and the different levels of data submission over time, it is difficult to make comparisons between states or to assess trends based on the closing/advisory data.

Figure 8: Reported Reasons for Closings/Advisories at Chesapeake Bay Beaches, 2005–2008



Key: (A) Based on monitoring that detected bacteria levels exceeding standards. (B) In response to known pollution event without relying on monitoring. (C) Preemptive due to rain known to carry pollution to swimming waters. (D) Other reason.

Figure 9: Sources of Pollution that Caused Closings/Advisories at Chesapeake Bay Beaches, 2005–2008



Key: (A) Sewage spills and overflows. (B) Polluted runoff, stormwater, or preemptive due to rain. (C) Unknown. (D) Other reasons, including those with no source information provided.

of a beach in the Bay with two stars for immediate notification policies, but did not receive stars for water quality due to six percent water quality exceedances in 2008.

Breaking Down Chesapeake Bay Beach Closings, Advisories, and Pollution Sources

During 2008, Chesapeake Bay beaches had 87 days of closings and advisories. There were no extended (more than six weeks but less than 13 consecutive weeks) or permanent closings or advisories (more than 13 consecutive weeks). The number of beach closing and advisory days decreased 70 percent between 2007 and 2008 (287 vs. 87 days) (see Figure 7). Relatively dry weather, with less frequent stormwater overflows, may have contributed to this decrease.[4]

All beach closings and advisories in 2008 were based on monitoring that detected bacteria levels exceeding beachwater quality standards from unknown sources of contamination (see Figures 8 and 9).

CHAPTER 3

Health and Economic Threats Stemming from Pollution

Algal blooms and low fish yields have become expected occurrences on the Chesapeake Bay. Pollutants, overfishing and climate changes are stresses associated with an increase in parasites and bacteria in the Bay and decreases in the economic value of resources from the waters of the Chesapeake Bay. Restoration of the Chesapeake Bay is now an important focus for the region to bring back the economy of a Bay that once flourished.

Identifying the Pathogens Contaminating the Bay

There are public health risks associated with recreational activities in waters that are contaminated with sewer overflows, urban stormwater runoff, and agricultural pollution, such as the Chesapeake Bay. When swimmers and boaters recreating on the Chesapeake Bay ingest or come in contact with water through the eyes, ears, nose, cuts, and abrasions, there is an opportunity for pathogens to be taken in and cause health problems. Suburban and urban development and agricultural activities in the Chesapeake Bay watershed exacerbate runoff and increase pollution discharges and their related health effects. The eastern shore of Maryland is also located in the main flyway for migratory Canada geese and other waterfowl, which are known to carry high loads of *Cryptosporidium* in their waste.[1] The oocysts of the *Cryptosporidium* can be found in the geese droppings left on agriculture fields, which then run off into the Bay when it rains.

The Virginia Department of Health and the Maryland Department of the Environment, agencies responsible for beach water quality testing at bathing beaches on the Chesapeake Bay, are not required to test directly for the pathogens in the water that can make people sick while swimming at the beach. Both departments test for *Enterococci* bacteria, which are present in the intestines of many animals and are an indicator of fecal contamination and the potential presence of pathogens. Dr. Gracyk of the Center for Water and Health at the Johns Hopkins Bloomberg School conducted tests for *Cryptosporidium*, a parasite that can cause gastrointestinal ailments, at an inland beach at Gunpowder Falls State Park and in 2007 showed that 32 percent of 60 samples and 70 percent of weekend samples had *Cryptosporidium* at levels that could cause infection.[2] Virginia and Maryland monitor their beaches at most once a week and do not test for *Cryptosporidum*. This level and type of monitoring may not be sufficient to detect all pathogens of concern, especially during the heaviest visitation times.

Eating and handling fish and shellfish exposed to fecally contaminated water can also expose humans to harmful pollutants. In a study of seven commercial oyster reefs in the Chesapeake Bay, Fayer et al (1999) found that all seven sites contained oysters with *Cryptosporidium parvum* oocysts, spore phases of the pathogen that can survive outside the *Cryptosporidium*. If this shellfish is ingested raw, it can make you sick, so it is recommended that all shellfish from the Chesapeake Bay be cooked before eating to kill pathogens.[3]

A view of the Chesapeake Bay Bridge from Sandy Point Beach State Park, Maryland.

Managing the Rise in Harmful Algal Blooms

Nutrient over-enrichment in the Chesapeake Bay has led to harmful algal blooms (HABs) of a variety of species. These algal blooms cause biological, economic, aesthetic, and human health concerns for the Chesapeake Bay. *Pfiesteria*, a microscopic organism that does not change the color of the water, has also been associated with fish kills in the Pocomoke River in Maryland and Virginia. Health symptoms associated with contact with *Pfiesteria* in watermen and recreational water users are thought to include skin, digestive, respiratory, and memory problems. Because scientific studies are still ongoing to better define a connection between *Pfiesteria* and the health affects mentioned above, these effects are being referred to as "Estuary-Associated Syndrome" by medical scientists.[4]

Blooms of blue-green algae (*Microcystis aeruginosa*) have resulted in temporary beach closures, as well as closures in shellfisheries in the Bay. These blooms, if ingested by humans, can lead to abdominal stress and can have more serious consequences if ingested by dogs and farm animals. Though blue green algal blooms are less prevalent than they used to be due to improved wastewater treatment processes, these blooms still appear in the Bay, including during September 2009.[5]

The Maryland Department of Natural Resources and a variety of groups in Virginia, including the Virginia Department of Health, the Virginia Department of Environmental Quality, the Virginia Institute of Marine Sciences, and Old Dominion University, test regularly for algal blooms along the coastline of the Chesapeake Bay. In May 2009, two algal blooms were reported in Maryland for two species of algae: *Karlodinium veneficum* and *Prorocentrum minimum*. These two species, both referred to as "mahogany tide" for their deep reddish brown color, are often found in higher concentrations in wet springs when there is a high volume of runoff. These algal blooms have also been associated with anoxia and fish kills in the Bay.[6] Dead fish floating on the water's surface are not only a sign of waters that are unhealthy for wildlife, but also can be unsafe for recreational beach users and for fish and shellfish consumption.[7]

Adding Up the Economic Cost of Pollution in the Bay

From fisheries, to agriculture, to prime waterfront real estate, and recreation and tourism dollars, the Chesapeake Bay is a hub of the local economy. A University of Maryland Study completed in 1989 attempted to determine the value of the Chesapeake Bay and estimated the Bay was worth $678 billion. With inflation today, this value is estimated at more than 1 trillion dollars.[8] Water pollution that results in poor water quality can negatively impact

most of the economies that contribute to this estimate of the value of the Bay. The catch has decreased for most species in the Bay, some drastically, and poor water quality can make real estate along the coasts less attractive. A study of the St. Mary's River watershed (an area between the Potomac and Patuxent Rivers on the western shore of Maryland that has seen a recent rise in population and development) analyzed housing values in correlation to water quality samples in the watershed. The study found that a 1 milligram per liter increase in total suspended solids has a negative impact on average housing prices within the watershed of $1,086. The study also found that a 1 milligram per liter change in dissolved inorganic nitrogen also has a negative impact on average housing prices in the watershed of $17,642.[9]

According to the 2006 National Survey of Fishing, Hunting and Wildlife-Associated Recreation, conducted thorough the Census Bureau and sponsored by the U.S. Fish and Wildlife Service, there are more than 1.5 million anglers that spend more than 16 million days fishing in Maryland and Virginia each year. These activities, which account for local and visiting fisherman, bring in more than $1.2 billion, from trip related costs to equipment. According to the same source, more than 3.5 million wildlife watching participants contribute more than $1.5 billion to the local economy in Maryland and Virginia as well.[10] Tourism provides work for many individuals in Maryland and Virginia. According to the U.S. Department of Labor, Maryland and Virginia provided more than 580,000 jobs in the leisure and hospitality industry across the states in May 2009.[11] Though these numbers reflect jobs and money brought into the entire states of Maryland and Virginia, the Chesapeake Bay has been a focal point of fishing, wildlife viewing, and tourism and contributes significantly to these totals.

The Chesapeake Bay Program's Living Resources Subcommittee notes that blue crab, menhaden, and striped bass are the marine resources of greatest economic value to the Chesapeake Bay.[12] In 2008, the blue crab harvest was 48.6 million pounds, below the 74 million pound long term (1968-2005) average, but 11 percent higher than the record low 2007 harvest.[13] About 8 percent of total harvest is assumed to be recreational harvest, yet blue crabs still bring in more than $50 million a year.[14] Menhaden is an important species of fish because it forms a link between the upper and lower food webs of the Chesapeake Bay. More pounds of menhaden are landed each year than any other fish in the Bay. In 2006, 376 million pounds of menhaden were caught in Maryland and Virginia waters valued at about $22.8 million.[15] The striped bass population has been increasing in the Bay after moratoriums in the 1980's to help the population rebound from more than fishing. The fishery is again sustainable, with a focus on research about disease and lack of predation affecting the fish.[16] These fishery resources are of great value to the Chesapeake Bay and clean water is important to sustain and increase the population of these fish in the Bay.

The Chesapeake Bay supports local economies through the many restoration activities occurring in the Bay as well. With further water quality improvements in the Chesapeake Bay, the boating, fishing, and swimming benefits could range from $357.9 million to $1.8 billion.[17] Habitat restoration in the Bay employs restoration scientists and field staff and also is a way to share the non market value of the Bay with the Chesapeake Bay community. Not only does a healthy Chesapeake Bay provide valuable resources, but it also is aesthetically valuable for residents and visitors. Studies have shown that residents in the Chesapeake Bay watershed are willing to pay to help improve the watershed and Bay. A poll of Virginia voters conducted by the Chesapeake Bay Foundation in 2004 found that 63 percent of those polled would support a $50 user fee on their water bills to improve local rivers and Bays. Similarly, a Maryland public opinion poll found 72 percent support for a $30 septic fee.[18] A flush tax is now in effect in Maryland and citizens are contributing through taxes to an improved Bay. The many sources of restoration funding for the Bay, including this citizen supported tax in Maryland, shows that there is interest and concern for improving the Bay.

CHAPTER 4

Recommendations for Protecting the Chesapeake Bay Watershed

The health and economic prosperity of the Chesapeake Bay are threatened by the pollutants associated with agriculture, development and climate change. Without actions to change the way we treat the bay, beaches and other bay habitats will continue to decline. NRDC offers the following recommendations for protecting the Chesapeake Bay and the health of all who enjoy its waters:

• Pass the Chesapeake Bay Ecosystem Resoration Act. This legislation recently announced by Senator Cardin would reauthorize section 117 of the Clean Water Act to include a nutrient cap and banking program in the Chesapeake Bay. Pollutant loading limits have already been set for tributaries in the Bay watershed, but those loading limits need to be aggregated into Bay-wide pollution limits that are capped and then implemented through a trading strategy that allows pollution reductions to be made in the most cost-effective manner.

• Expand permitting and set regulatory standards under the new Executive Order for the Bay for controlling stormwater pollution. The goals should be to control all major sources of stormwater pollution, set standards based on use of low-impact development, and address stormwater volume as well as pollutant loadings to prevent erosion and protect the hydrology of the watershed. The EPA's draft report under the Executive Order commits to undertake a rulemaking addressing these issues, which is critical since stormwater is the fastest growing source of water pollution in the Bay.[1]

• Revise the federal CAFO rule so that all large CAFOs are required to obtain permits and create manure management plans. CAFOs have been polluting the Bay for decades without effective regulation. It is time to close the loopholes that allow them to discharge undocumented volumes of animal waste into the watershed without treatment. The EPA has also committed to taking action to address this undercontrolled source of pollution.[2]

• Pass a comprehensive climate change bill in the Senate this year. The U.S. House of Representatives passed the American Clean Energy and Security Act of 2009 (H.R. 2454) on June 26, 2009. Passage of the House bill was an important step toward an energy plan that will decrease global warming greenhouse gas emissions and limit adverse impacts of global warming on coastal waters. The House-passed bill also included funding to help states minimize impacts to water and other environmental resources through adaptation and to help farmers reduce greenhouse gas emissions generated by fertilizer use and animal waste operations. Passage of the Clean Energy Jobs and American Power Act (S. 1733) in the Senate would move Congress toward a full vote and would show America's commitment to addressing global warming and climate change through a national energy plan.

• Move through the Senate several Clean Water Act bills that have passed the House, including the Clean Coastal Environment and Public Health Act (H.R. 2093/S. 878) to reauthorize and improve the BEACH Act of 2000. The BEACH Act has allowed for federal funding to be distributed to all coastal states to fund water quality testing at coastal beaches. This legislation would reauthorize the BEACH Act and build on its ability to protect public health at the beach through increased federal grants and improved coordination between beachwater managers and environmental officials. The Senate Bill includes a requirement that rapid test methods that take four hours or less to measure bacteria concentrations be used so that the public is notified in a timelier manner than the current 24 hour period it takes to determine test results. The reauthorization of the BEACH Act will benefit Chesapeake Bay beachgoers with quicker notification of polluted waters that are unsafe for swimming.

• Pass the Water Infrastructure Financing Act (S. 1005), which would provide increased federal funding for water and wastewater infrastructure needs, including incentives for green infrastructure, and includes the provisions of the Sewage Overflow Community Right-to-Know Act (H.R. 753/S. 937). The latter bill would direct owners and operators of publicly-owned treatment works to improve their policies for notifying the public about sanitary sewer overflows. The bill asks for an alert system for sanitary sewer overflows, public notification within 24 hours of these overflows where human health is potentially affected, and immediate notification to public health authorities, like beachwater managers. With greater communication about sanitary sewer overflows on the beaches in the Chesapeake Bay, beachgoers will know earlier when their beaches are polluted.

• Include highway runoff controls when the Federal Surface Transportation Reauthorization Act moves forward. Highway runoff controls to capture stormwater before it flows into combined-sewer treatment plants or surface waters are important for decreasing the volume of sediment, nutrients, and other polllutants flowing into the Bay. Highways and mobile sources contribute nitrogen to the region's air and water. This runoff can be captured in vegetated buffers along highways where the nutrients in the water can settle out and be taken up by the vegetation rather than running off into the Chesapeake Bay. Highway runoff controls would decrease the volume of nutrients flowing into water bodies throughout the 64,000 square mile Chesapeake Bay drainage area and can greatly decrease the nutrients reaching the Bay.

• Encourage Virginia and the District of Columbia to develop state and local funding sources for Bay restoration to complement federal dollars. One example is a "flush tax" for sewage treatment and stormwater utilities to fund green infrastructure and other enhanced stormwater management. Less stormwater and sewage pollution will mean safer swimming at the beach.

Endnotes

EXECUTIVE SUMMARY

1 Chesapeake Bay Program, A Watershed Partnership. Development. Available at: http://www.chesapeakebay.net/developmentpressure.aspx?menuitem=19514
2 NOAA and University of Maryland Center for Environmental Science: 2008 Chesapeake Bay Report Card. Available at: http://www.eco-check.org/reportcard/chesapeake/2008/
3 Chesapeake Bay Foundation. 2008 State of the Bay Report.
4 White House Office of Press Secretary. May 12, 2009. Executive Order: Chesapeake Bay Protection and Restoration. Available at: http://www.whitehouse.gov/the_press_office/Executive-Order-Chesapeake-Bay-Protection-and-Restoration/

CHAPTER 1

1 EPA. Report to Congress: Impacts and Controls of CSOs and SSOs. August 2004 (EPA 833-R-04-001). Available at: http://cfpub.epa.gov/npdes/cso/cpolicy_report2004.cfm.
2 D.C. Water and Sewer Authority. Facilities. Available at: http://www.dcwasa.com/about/facilities.cfm
3 Potomac Conservancy. State of the Nation's River 2008 Potomac Stormwater Runoff.
4 EPA. August 2004.
5 U.S. EPA, "The Next Generation of Tools and Actions to Restore Water Quality in the Chesapeake Bay," Sept. 9, 2009.
6 Sheets, Connor Adams. : "Flush Tax' money is Beginning to Find Its Way to the Bay." Washington Post: March 12, 2006. Available at: http://www.washingtonpost.com/wp-dyn/content/article/2006/03/10/AR2006031002524.html
7 Sheets, Connor Adams. 2006.
8 Chesapeake Bay Program. Landuse website. Available at: http://www.chesapeakebay.net/landuse.aspx
9 Chesapeake Bay Watershed Blue Ribbon Finance Panel. 2004. Saving a National Treasure: Financing the Cleanup of the Chesapeake Bay. p.12.
10 EPA Office of Inspector General and DOA Office of Inspector General. November 20, 2006. Evaluation Report: Saving the Chesapeake Bay Watershed Requires Better Coordination of Environmental and Agricultural Resources. Available at: http://www.epa.gov/oig/reports/2007/20061120-2007-P-00004.pdf.
11 Chesapeake Bay Commission and Commonwealth of Pennsylvania September 4, 2008. Chesapeake Bay Next Generation Biofuels Summit Presentation.
12 USGS-ARS. 2007. Biofuels and Water Quality: Meeting the Challenge and Protecting the Environment. 2007. Available at: http://www.screwworm.ars.usda.gov/research/publications/publications.htm?SEQ_NO_115=216012
13 Urbina, Ian. 2008. In Maryland, Focus on Poultry Industry Pollution. New York Times. Available at: http://www.nytimes.com/2008/11/29/us/29poultry.html?_r=1.
14 Maryland DNR. 2009. Harmful Algal Blooms In Maryland. Available at: http://www.dnr.state.md.us/Bay/hab/#2.
15 Environmental Protection Agency. November 8, 2008. Revised National Pollutant Discharge Elimination System Permit Regulation and Effluent Limitations Guidelines for Concentrated Animal Feeding Operations in Response to the Waterkeeper Decisions. Federal Registry Vol. 73, No. 225
16 Data supplied to NRDC on July 7, 2009.
17 Perez, M., "Facing Facts in the Chesapeake Bay," Environmental Working Group (Sept. 2009).
18 Chesapeake Bay Watershed Blue Ribbon Finance Panel. 2004.
19 Schueler, Tom. Chesapeake Stormwater Network. 2008. Final. Bay-Wide Stormwater Action Strategy Recommendations for Moving Forward in the Chesapeake Bay. p.7
20 Chesapeake Bay Watershed Blue Ribbon Finance Panel. 2004.
21 Schueler, Tom. Chesapeake Stormwater Network. 2008. p.6
22 Chesapeake Bay Program: Stormwater. Available at: http://www.chesapeakebay.net/stormwater.htm.
23 Chesapeake Bay Foundation. Federal-Aid Highway Runoff Pollution Management Program: Stakeholder Talking Points Draft. Fact sheet prepared by Joshua Saks, Federal Affairs Associate.
24 Blankenship, Karl, Editor. 2009. 6 Bay governors unite in drive to put runoff controls in highway bill. Available at: http://www.bayjournal.com/article.cfm?article=3624.
25 Cornell University Chronicle. 2005. Climate change and growing vehicle traffic are increasing nitrogen pollution in nation's coastal waters, Cornell-led study finds. Available at: http://www.news.cornell.edu/releases/Feb05/AAAS.Chesapeake.ssl.html.
26 Virginia Department of Conservation & Recreation. Virginia Storm Water Management Program. Available at: http://www.dcr.virginia.gov/soil_and_water/stormwat.shtml#overview.
27 Maryland Department of the Environment. Maryland's Stormwater Management Act of 2007. Available at: http://www.mde.state.md.us/Programs/WaterPrograms/SedimentandStormwater/swm2007.asp.
28 NOAA, Anacostia Watershed Society and Metropolitan Washington Council of Governments. May 2005. Anacostia Watershed Project: Marine Debris Cleanup and

Prevention. Available at: http://www.darrp.noaa.gov/partner/anacostia/pdf/marine_debris_proposal_revised_final_web.pdf
29 Anacostia Watershed Society. 2009. Support the Anacostia River Cleanup & Protection Act of 2009. Available at: http://www.anacostiaws.org/Programs/Restoration/TrashCleanup/DCPlasticBags.html
30 Anacostia Watershed Society. 2009.
31 NOAA 2005.
32 Virginia Governor's Commission on Climate Change. Final Report: A Climate Change Action Plan. December 15, 2008. pg. 5,8. Available at: http://www.deq.state.va.us/info/climatechange.html
33 Maryland Commission on Climate Change. January 14, 2008. Climate Action Plan Interim Report to the Governor and the Maryland General Assembly. Published by the Maryland Department of the Environment. Available at: http://www.mdclimatechange.us/ewebeditpro/items/O40F14798.pdf.
34 Cheapeake Bay Foundation. July 2009. Bad Water 2009: The Impact on Human Health in the Chesapeake Bay Region. Available at: http://www.cbf.org/Document.Doc?id=328.
35 Chesapeake Bay Foundation. July 2009.
36 Chesapeake Bay Foundation. July 2009.
37 Jennifer E. Purcell 2005. Climate effects on formation of jellyfish and ctenophore blooms: a review. Journal of the Marine Biological Association of the United Kingdom. Volume 85 pp.461-476.
38 Jennifer E. Purcell, et al. 2007. Anthropogenic causes of jellyfish blooms and their direct consequences for humans: a review. Marine Ecology Progress Series. Volume 350 pp.153–174.
39 Virginia Governor's Commission on Climate Change. 2008.
40 Maryland Commission on Climate Change. 2008.
41 Chesapeake Bay Foundation 2009. p.5.
42 Virginia Governor's Commission on Climate Change. 2008.
43 Maryland Commission on Climate Change. 2008.
44 National Wildlife Federation 2008. Sea-level Rise and Coastal Habitats of the Chesapeake Bay: A Summary. Available at: http://www.nwf.org/sealevelrise/pdfs/NWF_ChesapeakeReportFINAL.pdf.
45 National Wildlife Federation 2008.

CHAPTER 2

1 Heal The Bay. Last updated October 2007. "Swimming in the Bay" Available at: http://www.healthebay.org/stayhealthy/swimming/.
2 Current beachwater monitoring data for Fairview Beach is available at http://www.beachwaterquality.org/beach.php?state=VA&county=King%20George%20County&beachsolo=Fairview%20Beach.
3 Dennen, Rusty. June 12, 2009. Agency: Swim at your own Risk. Fredericksburg.com available at: http://fredericksburg.com/News/FLS/2009/062009/06122009/472527.
4 Virginia rainfall 85% of normal for summer 2008. USGS. Water Resources of Virginia. Available at: http://va.water.usgs.gov/; Rainfall in Eastern and Central Maryland below normal in summer 2008. State of Maryland Department of the Environment. Precipitation Indicators for Maryland Drought Regions. Available at: http://textonly.mde.state.md.us/Programs/WaterPrograms/Water_Conservation/Previous_Conditions/rainfall-31aug2008.asp.

CHAPTER 3

1 Thaddeus K. Graczyk et al. 2000. Susceptibility of the Chesapeake Bay to Environmental Contamination with *Cryptosporidium parvum*. Environmental Research Section A. Volume82 pp.106–112.
2 Chesapeake Bay Foundation 2009. Pg 10.
3 Fayer et al. 1999. *Cryptosporidium parvum* in Oysters from Commercial Harvesting Sites in the Chesapeake Bay. Emerging Infectious Diseases Vol 5 No 5.
4 Virginia Department of Health. May 2009. *Pfiesteria*: What you should know about *Pfiesteria* and Virginia's Waters. Available at: http://www.vdh.virginia.gov/epidemiology/DEE/HABS/Pfiesteria/index.htm
5 Maryland DNR. 2009. Harmful Algal Blooms In Maryland: What are harmful algae? Available at: http://www.dnr.state.md.us/Bay/hab/#1.
6 Maryland DNR. 2009.
7 Virginia Department of Health May 2009.
8 Chesapeake Bay Watershed Blue Ribbon Finance Panel. 2004.
9 P. Joan Poor, et al. 2007. Exploring the hedonic value of ambient water quality: A local watershed-based study. *Ecological Economics* Volume 60, No. 4 pp.797–806.
10 U.S. Department of the Interior, Fish and Wildlife Service, and U.S. Department of Commerce, U.S. Census Bureau.2006 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation.Virgina and Maryland Reports.
11 U.S. Department of Labor, Bureau of Labor Statistics. Available at: http://www.bls.gov/eag/
12 Alliance for the Chesapeake Bay. Ask the Bay Experts. Available at: http://www.alliancechesbay.org/asktheexpert.cfm?question_id=88.
13 Chesapeake Bay Stock Committee. June 22, 2009. Chesapeake Bay Blue Crab Advisory Report Approved by the Fisheries Steering Committee. Available at: http://chesapeakebay.noaa.gov/docs/BlueCrabAdvisoryReport2009.pdf.
14 Chesapeake Bay Program. Blue Crab Harvest. Available at: http://www.chesapeakebay.net/crabs.aspx?menuitem=14700
15 Chesapeake Bay Program. Atlantic Menhaden Harvest. Available at: http://www.chesapeakebay.net/atlanticmenhadenharvest.aspx?menuitem=14702.
16 Chesapeake Bay Program. Striped Bass Harvest. Available at: http://www.chesapeakebay.net/stripedbassharvest.aspx?menuitem=15316.
17 Cynthia Morgan and Nicole Owens. 2001. Analysis: Benefits of water quality policies: The Chesapeake Bay. Ecological Economics Volume 39 pp.271-284.
18 P. Joan Poor, et al. 2007. Exploring the hedonic value of ambient water quality: A local watershed-based study. Ecological Economics Volume 60, No. 4, pp.797-806.

CHAPTER 4

1 EPA. Next Generation of Tools, p.3.
2 EPA. Next Generation of Tools, p.3.

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