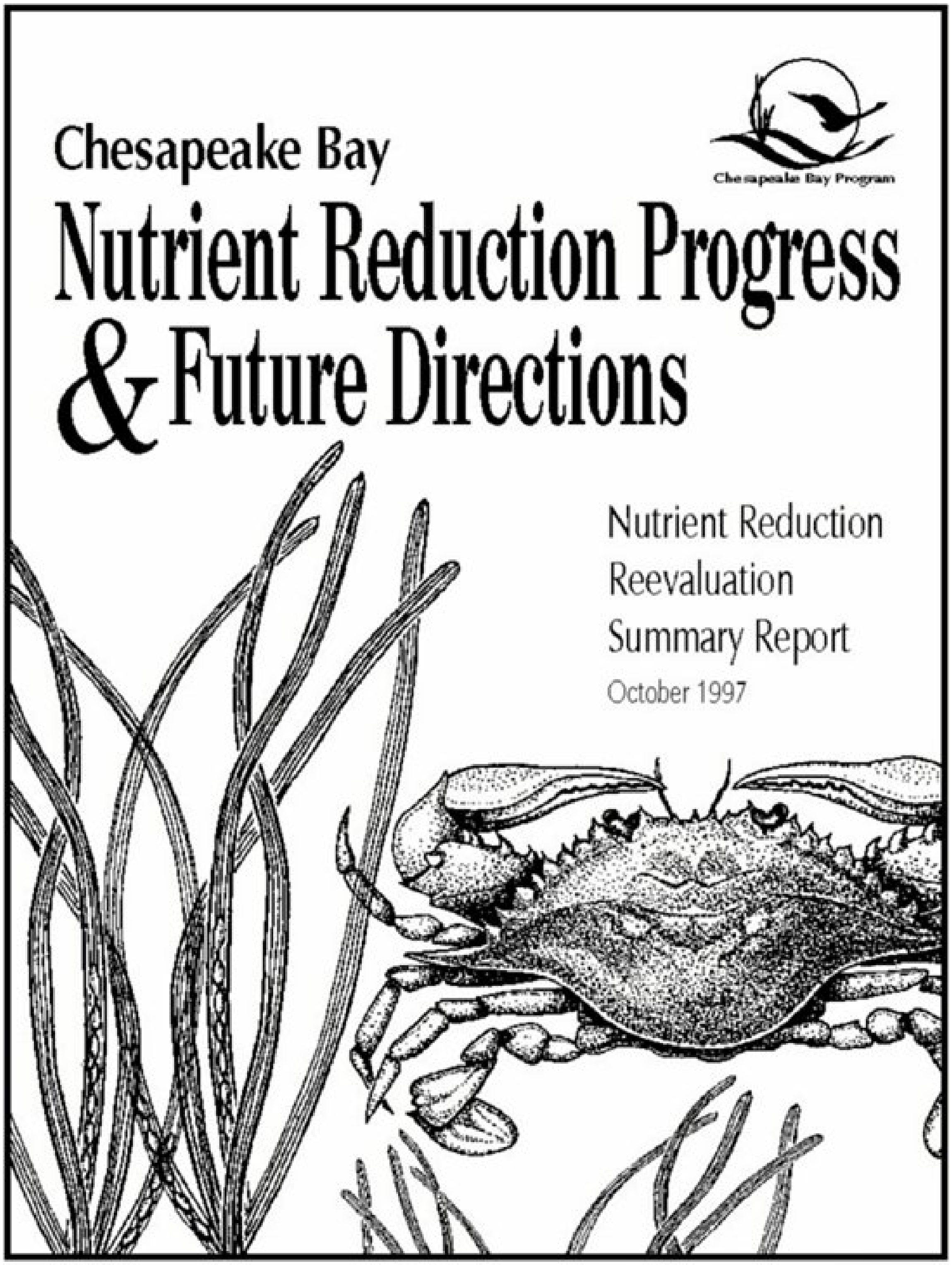
1997 Nutrient Reduction Reevaluation Summary Report



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INTRODUCTION

The Chesapeake Bay is the largest estuary in the United States and one of the most productive in the world. It is also one of this country's premier natural treasures. But its productivity has declined this century due to manmade pollution problems, the overharvesting of its valuable living resources and the forces of Mother Nature.

Since 1983, the Chesapeake Bay Program has been working in cooperation with local governments, industry, farmers, environmentalists, conservation associations, citizen groups and others throughout the Bay region to restore the water quality in the Bay and its rivers by reducing pollution through management efforts. To help guide these efforts and mark progress toward a cleaner, healthier Chesapeake, the Bay Program set a series of challenging goals to achieve its top priority--the restoration of the living resources including finfish, shellfish, underwater grasses and other aquatic life and wildlife. The most important water quality goal set by the Bay Program was the 1987 goal of a 40% reduction of the controllable loads of the nutrients nitrogen and phosphorus entering the Bay between1985 and the year 2000. In 1992 the Bay Program agreed to maintain the reduced nutrient loading levels beyond 2000 a huge challenge in the face of population growth in the region.

As we approach 2000, it's fair to say that the Bay Program has made impressive progress toward the nutrient goals set 10 years ago. Adoption and implementation of tributary strategies has been a key to this progress, along with the strong citizen support. It's also fair to say that the Bay and rivers would be in much worse shape today if no action had been taken. For instance, many of the rivers are running cleaner than they did a decade ago. This is a result of the farmers and others working to control nonpoint source pollution. It also is the result of investments made on the local and regional levels to upgrade sewage treatment plants across the region and to develop better nutrient reduction technology for these plants. The good news is that, in some places, the living resources are beginning to respond, especially in areas where management actions have been concentrated.

However, that good news is tempered by the lack of a water quality response in other areas of the Bay and rivers, and the recent fish kills that are being linked to a Pfiesteria-like organism in some of the Bay's rivers. The lack of an overall living resource response and the challenges we face in trying to deal with Pfiesteria-like toxic dinoflagellates tells us that we need to do more if we want to achieve our living resource and habitat restoration goals and, ultimately, a healthier and more productive Bay system.

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EXECUTIVE SUMMARY

As part of our effort to set and meet challenging goals, the Bay Program periodically measures--or reevaluates--the progress that has been made to date, and measures how close we are to attaining our goals. The following report is a summary of the *1997 Nutrient Reduction Reevaluation* findings. The numbers and findings are preliminary. A more detailed final report will be available in early 1998.

The *1997 Nutrient Reduction Reevaluation* was designed to answer the following questions:

- Will we meet the 40% reductions by 2000?
- Are the nutrient reductions being achieved through the tributary strategies?
- Are we achieving the water quality necessary to support living resources?

In the case of our 40% nutrient goals, we have evaluated our progress and concluded that the Baywide goal for phosphorus reduction will be met by the year 2000. The *1997 Reevaluation* also concluded that unless current efforts are accelerated--and some "gap closers" put in place--the Baywide nitrogen reduction goal will not be met by the year 2000. We are currently exploring our options for closing the gap on the year 2000 goal and for maintaining the reductions after our goals are achieved.

Where we have tributary strategies in place--on the Potomac River and north--we project that we will achieve our nutrient goals when the strategies are fully implemented. However, if we do not speed up implementation of these strategies, some planned improvements will not be completed until after 2000. Where strategies are not yet in place, there is an ongoing process to establish appropriate nutrient reduction goals and to develop final strategies in accordance with statutory deadlines.

While we recognize the need to accelerate our efforts in order to achieve the reduction goals set in 1987 by the Chesapeake Executive Council, meeting these goals may still not be enough to assure the Bay's restoration. A great deal has been learned in the past decade about how storm events, groundwater releases and other natural and manmade challenges affect the pace of recovery for the Bay and its rivers. Throughout the region, the rivers are running cleaner as a result of pollution control measures taken on the land. However, the lack of a water quality response in some areas of the Bay, and recent evidence of possible effects of high loadings of nutrients on living resources and human health, are pointing us in the direction of more area-specific goals as new information becomes available. We also recognize the necessity of having the right programs and institutions in place to maintain the levels of nutrient reduction required into the future.

The findings of the *1997 Reevaluation* also will help us better understand how the Chesapeake system is likely to recover as we accelerate our efforts to reduce nutrient loads. In the next several years, as we apply our refined computer models, we will look at refining our nutrient goals to assure the health of the Bay ecosystem.

The ongoing work to further refine the computer modeling and water quality monitoring programs will be used in 1998 to help set nutrient goals for the Virginia tributaries south of the Potomac. Modeling and monitoring refinements will also be used in 1998 to analyze and prepare a protocol--which will include a public participation component--to determine whether nutrient goals or reduction efforts can further target areas of persistent high loadings, especially where evidence indicates a linkage to critical living resources or human health concerns.

As directed by the Executive Council, the Bay Program will prepare preliminary recommendations, in consultation with local governments and others, by the1999 Executive Meeting for adjustments to nutrient goals to assure the water quality that will support the Bay's living resources. By the Executive Council meeting in 2000, the Bay Program will provide final recommendations for any adjustments to the nutrient goals. By the 2001 meeting, the Bay Program will complete adjustments to the tributary strategies to achieve any revised goals.

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DEFINING THE GOAL

Before we move on to specific results of the *1997 Reevaluation*, it is important to first answer the question, what is the year 2000 goal? Since 1987, as the computer models and water and air quality monitoring have become more sophisticated, the estimates of nutrient loads--controllable and uncontrollable--have been refined.This means that the goal numbers have also been refined.

In 1992, the Bay Program used the Bay Watershed Model to calculate the baseline nutrient loads for each of the 10 major tributary basins in the region. These nutrient loads were further divided into controllable and uncontrollable portions. Uncontrollable loads included natural background load from the forests, air pollution sources and nutrient loads from West Virginia, New York and Delaware--the Bay basin states that are not signatories to the *Bay Agreement*. Then, the 40% goal was applied to this controllable load to calculate a target nutrient loading cap for each tributary. The target cap is the load that remains after the reductions have been achieved. At that point, the jurisdictions began to develop "tributary strategies". These are specific nutrient reduction strategies for the 10 major tributary basins--the Susquehanna, Patuxent, Potomac, Rappahannock, York and James rivers, the Western and Eastern Shore of Maryland and the Western and Eastern Shore of Virginia.

The new 1997 version of the Bay Watershed Model--called the Phase IV Model--refines many of the 1992 numbers, including the baseline nutrient loads for the 10 tributary basins. If the 40% reduction was applied to the new 1997 numbers, the target loads for the tributary basins would change. However, since the 1992 target loads were based on projected water quality and living resource responses in the Bay, the Bay Program decided to maintain these target loads as its goals until more information is available to support goal revisions. So, throughout this document, the goals or targets we refer to are the original 1992 target nutrient loads.

In the near future, the Bay Program will use the latest science, computer modeling and water quality monitoring results to refine our goals to better reflect the nutrient loadings that will result in water quality conditions necessary to restore and sustain the living resources of the Bay and its rivers.

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A LITTLE BAY PROGRAM HISTORY

In the late 1970s the Chesapeake Bay became this nation's first estuary targeted for restoration and protection. Government-sponsored scientific research on the Bay pinpointed four areas requiring immediate attention: an overabundance of the nutrients nitrogen and phosphorus in the water; dwindling underwater Bay grasses; toxic pollution; and the overharvesting of living resources--fish, shellfish and other aquatic creatures and wildlife.

➤ **In 1983**, under the historic *1983 Chesapeake Bay Agreement*, the Chesapeake Bay Program was established as the means to restore this valuable estuary. The six Bay Program partners--signatories to the *Bay Agreement*--are Maryland, Pennsylvania, and Virginia; the District of Columbia; the Chesapeake Bay Commission, a tri-state legislative body; and the U.S. Environmental Protection Agency, representing the federal government. The Bay Program goals and direction are set by the Chesapeake Executive Council. The Executive Council members are the governors of Maryland, Virginia and Pennsylvania, the Mayor of the District of Columbia, the administrator of the Environmental Protection Agency and the chairman of the Chesapeake Bay Commission. Since 1983, the Bay Program's highest priority has been the restoration of the Bay's living resources.

➤ **In 1987**, in the *1987 Chesapeake Bay Agreement* the Chesapeake Bay Program partners set a goal to reduce the nutrients nitrogen and phosphorus entering the Bay by 40% by the year 2000. In setting that goal, the Bay Program partners committed to reduce nitrogen and phosphorus loadings to the Bay from controllable sources within the participating states and use 1985 as the base year. The Bay Program determined that nutrient loads from the non-signatory states of West Virginia, New York and Delaware would not be included since the signatory jurisdictions had no control over them. This goal was selected because the best science at the time suggested a 40% reduction would improve oxygen levels in Bay waters and benefit aquatic life.

➤ **In 1992**, Chesapeake Bay Program partners also agreed to maintain nutrient loadings at the 40% goal level beyond the year 2000 and to attack nutrients at their source--upstream in the Bay's tributaries. With the aid of water quality monitoring data and computer modeling, the amount of controllable nutrients was determined and specific nutrient loading targets were assigned to the 10 major tributary basins. As a result, Pennsylvania, Maryland, Virginia, and the District of Columbia began developing specific nutrient reduction strategies "tributary strategies"--to achieve the nutrient reduction targets. At that point the Chesapeake Executive Council also acknowledged that the goal would challenge the Bay Program partners since, "... achieving a 40% nutrient reduction goal, in at least some cases, challenges the limits of current point and nonpoint source control technologies."

➤ **In 1993**, the Bay Program acknowledged that because each tributary is different in its geography, hydrography, and ecology, each of the tributaries would require different solutions; and that flexibility was needed in allocating nutrient reduction loads to individual tributaries. In Maryland, Pennsylvania, the District of Columbia and northern Virginia, a 40 % reduction in loadings would not only improve water quality in the tributaries, but would improve conditions for living resources in the mainstem of the Bay. In Virginia's Bay tributaries south of the Potomac River, however, nutrient reductions were shown to have little influence on the Bay's mainstem, but would still improve local water quality conditions. For this reason, the Chesapeake Bay Program partners and Virginia undertook enhanced water quality monitoring of these tributaries and initiated development of an enhanced Bay Water Quality Model to determine the level of reduction necessary to improve living resource conditions. In the meantime, Virginia adopted interim 40% reduction goals for these tributary basins.

➤ **1994-1995**, the jurisdictions developed and continued to implement tributary strategies for the river

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basins from the Potomac River north. The Bay Program also continued refining the Bay Watershed Model and developing the enhanced Bay Water Quality Model.

➤ **1996 through 1997**: The Bay Program conducted an extensive reevaluation of its progress toward the 40% goal--the *1997 Nutrient Reduction Reevaluation*.

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THE REEVALUATION QUESTIONS & ANSWERS

The *1987 Chesapeake Bay Agreement* established the goal to attain the water quality necessary to support the living resources of the Bay. As part of that historic agreement, we committed to reduce nitrogen and phosphorus loadings to the Bay from controllable sources by 40% by the year 2000, using 1985 as a base year. In 1992, we reaffirmed this goal and committed to attain it through the use of individual tributary strategies to meet nutrient reduction loading levels established for all major tributary basins. We also committed to maintaining these reduced loading levels beyond 2000.

This year, an extensive reevaluation of our efforts found that we have made impressive progress toward the nutrient goals we set 10 years ago. The reevaluation also tried to gauge the condition of the Bay if we had taken no action, and there is clear evidence that conditions in the Bay and its rivers would have worsened had we not taken the steps we have.

Because it is difficult to evaluate progress on such a broad scale, the *1997 Nutrient Reduction Reevaluation* focused on answering the following questions:

➤ Will we meet the 40% reduction by 2000?

Yes, but we will need to accelerate the current rate of implementation of nutrient reduction measures to do this. The *1997 Reevaluation* has shown that we are on track to meet the Baywide goal for phosphorus by 2000. For nitrogen, where we have tributary strategies in place, we are achieving our Baywide nitrogen goal, although at present levels of implementation some of the planned improvements will occur after 2000. If the rate of implementation remains the same, the nitrogen goal would be attained after 2000.

➤ Are the nutrient reductions being achieved through the tributary strategies?

Yes, for the regions where we have tributary strategies in place--from the Potomac River north--we will achieve the overall reduction goals. However, if we do not speed up implementation of our strategies, some planned improvements will not be in place until after 2000. According to estimates from the *1997 Reevaluation*, the Bay Program partners have installed--through the end of 1996--the nutrient reduction technologies and practices necessary to achieve a reduction of 22 million pounds of nitrogen and three million pounds of phosphorus. This represents nearly half of the 1985-2000 reduction goal for nitrogen and four-fifths of the goal for phosphorus in those parts of Maryland, Virginia, Pennsylvania and the District where tributary strategies are in place. We are optimistic that we will have the momentum, through the continued implementation of the tributary strategies, to accelerate the pace of reductions and make progress more quickly as we close in on 2000.

Where strategies are not yet in place, there are statutory deadlines to complete them and to set appropriate goals. According to estimates from the *1997 Reevaluation*, in the river basins south of the Potomac and on the Eastern Shore of Virginia, where tributary strategies are not yet in place, ongoing federal, state, local and private sector efforts have resulted in the installation of the nutrient reduction technologies and practices necessary to achieve reductions representing about one-quarter of the interim 40% goal established for nitrogen and about fourth-fifths of the interim reduction goal for phosphorus established for the lower Virginia tributaries.

➤ Are we achieving the water quality necessary to support living resources?

In some areas yes, but not Bay-wide yet. Although some river systems are responding, we are not seeing the Baywide response we're looking for. However, there are some bright spots. For instance, in some areas where monitoring shows that water quality is improving, underwater Bay grasses are rebounding and shad, rockfish and crabs are plentiful. But, in other areas, water quality and other conditions are still preventing the restoration of living resources.

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FINDINGS FROM THE 1997 REEVALUATION

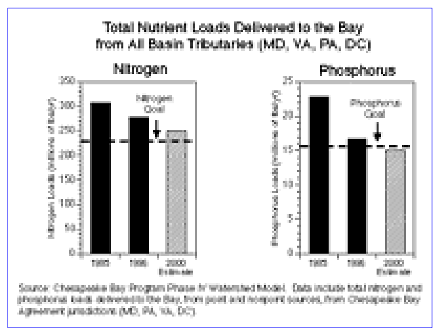
FINDINGS | BAYWIDE PROGRESS

We're Making Progress Toward Our Baywide Nutrient Goal

➤ For phosphorus, the latest computer model estimates--which adjust for flow--show that between 1985 and 1996, loads delivered to the Bay from all its tributaries declined six million pounds per year.

➤ For nitrogen, the latest computer model estimates--which adjust for flow--show that between 1985 and 1996, loads delivered to the Bay from all its tributaries declined 29 million pounds per year.

➤ Maintaining reduced nutrient levels after the year 2000 will be a challenge due to expected population growth in the region.



FINDINGS | PROGRESS ON TRIBUTARY STRATEGIES

In 1992, the Chesapeake Bay Program partners agreed to attack nutrients at their source--upstream in the Bay's tributaries. As a result, Pennsylvania, Maryland, Virginia and the District of Columbia began developing tributary strategies for the 10 major tributary basins to achieve specific nutrient reduction targets. As part of the *1997 Reevaluation* effort, the Bay Program calculated the nutrient reduction progress in areas where tributary strategies are in place from the Potomac River north. Where strategies are not yet in place, there are statutory deadlines to complete them and to set appropriate goals.

➤ For phosphorus, the latest computer model estimates show we will achieve by 2000 the 10 million pound nutrient goal identified by the Chesapeake Bay Program for basins where tributary strategies are in place.

➤ For nitrogen, the latest model estimates show we will be within four million pounds of the 186 million pound goal identified by the Chesapeake

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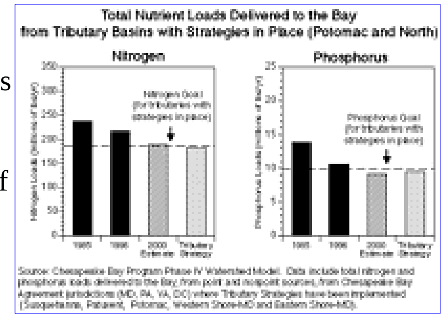
Bay Program for basins where there are tributary strategies in place by 2000. These strategies are projected to achieve the goal when fully implemented. The challenge is to identify opportunities to accelerate our actions to further reduce nitrogen by 2000.

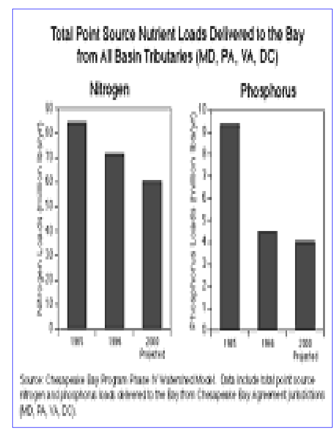


➤ In tributaries south of the Potomac, where the 40% goal is interim, work is underway with local stakeholders to determine methods and approaches to achieve further reductions in these rivers basins and to achieve the nutrient goals once they are established. The setting of refined nutrient goals awaits the completion of computer modeling to evaluate water quality benefits within each of these tributaries. In the meantime, progress also is being made in these river basins, with overall reductions of 10 million pounds of nitrogen and three million pounds of phosphorus anticipated by 2000.

FINDINGS	POINT SOURCE PROGRESS

Nutrient loadings to the Bay and rivers are being reduced through upgrades at sewage treatment plants, including the implementation of biological nutrient removal--BNR--at some facilities. A relatively new technology, BNR has proved to be extremely effective in reducing nutrients. However, BNR has only been implemented at 33 of the 315 major municipal wastewater treatment plants in the Bay region. About 90 facilities are expected to be on line by the year 2000 or shortly thereafter. Among the federal wastewater treatment facilities in the Bay region, only one of the seven major facilities has implemented BNR. By 2000, four additional facilities are expected to have implemented BNR, with another expected to come on line shortly after 2000.

Nutrient Loads from Point Sources Decrease



➤ **Phosphorus Progress to Date**--Between 1985 and 1996, phosphorus point source loads to the Bay from participating states have been reduced by 51%. This five million pound reduction was due to the implementation of phosphate detergent bans that went into effect in each of the states between 1985 and 1990 and the implementation of effluent standards for phosphorus and concurrent wastewater treatment upgrades in each of the jurisdictions.

➤ **Nitrogen Progress to Date**--Between 1985 and 1996, nitrogen loads from point sources in the participating states have been reduced by 15% or 12.6 million pounds. Since 1985, 33 of 315 major municipal wastewater treatment facilities in the watershed have upgraded to BNR technologies. This advanced technology reduced effluent concentrations from 18 milligrams per liter to eight milligrams per liter and kept the municipal loads in check, in spite of an 11% population increase over the last decade. The diversion of industrial effluent to plants with BNR--where it can be treated more effectively--combined with reductions achieved through industrial wastewater treatment upgrades, in-process manufacturing changes and facilities going off-line has played a key role in achieving this level of reduction. In the future, as more municipal plants upgrade, the proportion of reductions from these plants will increase.

➤ **Phosphorus Progress By the Year 2000**--By 2000, point source phosphorus loads are estimated to be 58% lower than 1985 loads delivered to the Bay. The additional reductions beyond those observed through 1996 are due primarily to industrial facilities sending their wastewater for treatment at municipal facilities operating BNR. While phosphorus discharge concentrations from municipal facilities should remain steady in response to specific regulatory discharge limits, increases in flow due to population growth will cause an increase in phosphorus loads from municipal facilities shortly beyond 2000.

➤ **Nitrogen Progress By the Year 2000**--By 2000, a total of 71 major municipal wastewater treatment facilities will be operating BNR, resulting in an estimated 10 million pounds or a 28% reduction in municipal point source nitrogen loads delivered to the Bay since 1985. Upon full implementation of the tributary strategies, an additional 19 municipal facilities will be operating BNR resulting in a further five million pound reduction since 1985. Implementation of BNR at six of the seven major federal facilities

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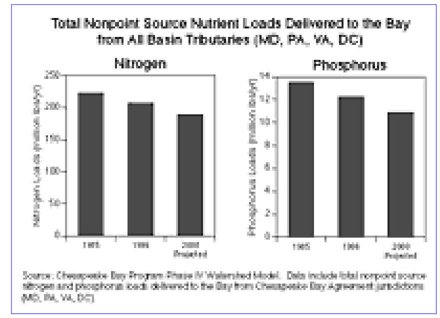
will further decrease loadings by 220,000 pounds. After full tributary strategy implementation, point source nitrogen loads from municipal, industrial and federal facilities will be reduced by 29 million pounds a 34% decrease since 1985.

FINDINGS | NONPOINT SOURCE PROGRESS

Nutrient loadings to the Bay and rivers are also being reduced and prevented through implementation of a range of nonpoint source management practices and control techniques.



Nonpoint Source Management Practices Have Reduced Nutrient Loads

As a result of nutrient reduction management practices put in place through 1996, nitrogen loadings delivered to the Bay from nonpoint sources within the participating states are estimated to have decreased by 16 million pounds, or 7%, and phosphorus loadings are estimated to have decreased more than one million pounds, or 9%, over the past decade. By 2000, nitrogen loadings from nonpoint sources are estimated to be reduced by 34 million pounds or 15%. Phosphorus loadings from nonpoint sources are estimated to be reduced by three million pounds or 19% since 1985.

The majority of the nonpoint source loading reductions for nitrogen 30 million pounds and phosphorus two million pounds anticipated by 2000, will come from those Bay basins with tributary strategies in place (see insert: Highlights on Best Management Practices).

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FINDINGS | WATER QUALITY TRENDS

The question we hear most often about our Baywide nutrient pollution reduction efforts is: "Are the Bay and its rivers getting better?" The complex answer lies in the long-term water quality monitoring data collected since 1985.

The Bay is not just one body of water but rather a large mainstem with many ecologically important tributaries consisting of both tidal and non-tidal regions. A doctor could no more give a single diagnosis of the Bay than to a waiting room full of patients. And, we should remember, while the Bay and its tributaries have clearly been degraded by human activities, they are also subject to many natural processes. These processes can confound our efforts to link the Bay's health to our efforts to restore it. Fortunately, our understanding of the Bay has increased greatly over the past decade and we are in a better position than ever to interpret the complexities we observe--the Bay's vital signs as they relate to nutrients.

For instance, our non-tidal tributary status and trends information is based on flow adjusted data. One of the advances we have made in our understanding of the Bay is the relationship between nutrients in the tributaries and freshwater flows. The quantification of this relationship allows us to remove the effects that both drought and flood have had on the nutrient levels from 1985 to 1996. When we account for these variations in flow, or flow adjust the data, we can more directly see how effective our land-based nutrient reduction efforts have been.

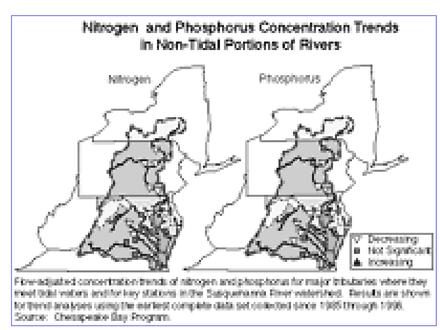
In measuring the response of the Bay and its tidal tributaries, using water quality monitoring data, we also evaluate two key sets of the Bay's vital signs the more recent observed water quality conditions, or status, and the long-term changes, or trends.

Status is a relative measure that allows us to compare current water quality conditions--1994 to1996--on a low to high scale across regions of the Bay with similar salinity levels. It is important to note that when we discuss status, an area with a "low" measurement is considered in good health. An area with a "high" measurement is considered in poor health. Trends in observed water quality are evaluated over a longer period of time. In this case, from 1985 to 1996.

Before we move into the specific status and trends for the Bay and its tributaries, there are two other findings from the *1997 Reevaluation* that are important to understand. They are lag time and high flow (see insert: Factors That Influence Bay and River Response to Reduction Measures).

Non-Tidal Tributaries and Fall Line: Many of Our Rivers are Running Cleaner

Many of our rivers, from the upper reaches of the Susquehanna River across the region to the James River, are running cleaner. These lower concentrations of nutrients and sediment--compared to concentrations observed a decade ago are fully revealed once the effects of variations in river flow are taken into account. Flow adjusted data show that for all major tributaries to the Bay where they meet tidal waters, and for key monitoring stations in the Susquehanna watershed, there are no stations at which concentrations of nutrients are increasing. At most of the non-tidal stations, data show declining concentrations of both nitrogen and phosphorus.



Flow-adjusted concentration trends of nitrogen and phosphorus for major tributaries where they meet tidal waters and/or key stations in the Susquehanna River watershed. Results are shown for trend analyses using the earliest complete data set collected since 1985 through 1996. Source: Chesapeake Bay Program.

The Susquehanna is the largest tributary in the Bay system, providing over 50% of the freshwater to the Bay annually. The nutrient trends in the river are declining, as demonstrated by the following water quality monitoring data.

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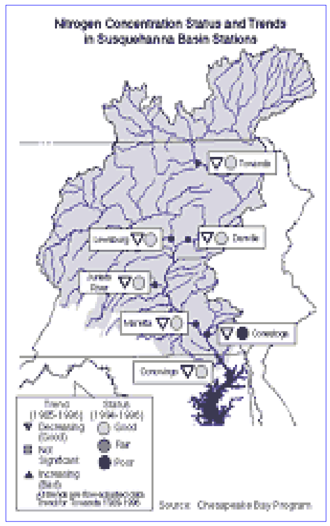
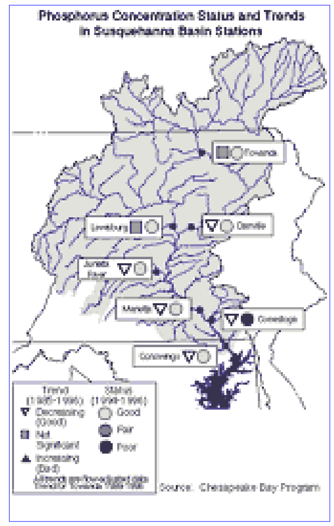
➤ **Phosphorus and Nitrogen Status** Nutrient concentrations at key water quality stations along the Susquehanna River and its major tributaries are among the lowest compared with other non-tidal rivers in the region, indicating good water quality. The exception is the station that measures nutrient loads from the Conestoga watershed, a highly agricultural region where nutrient concentrations still indicate poor water quality conditions.

➤ **Phosphorus Trends 1985-96** Total phosphorus concentrations have decreased at four of the six stations monitored in the Susquehanna River basin. These four stations represent the central and lower parts of the basin and 48% of its 27,000-square-mile drainage area. At the fall line station at Conowingo, where the river flows into the tidal Bay, concentrations of phosphorus decreased 53% since 1985 when adjusted for flow.

➤ **Nitrogen Trends 1985-96** Total nitrogen concentrations have decreased at all key water quality stations monitored along the Susquehanna River and its major non-tidal tributaries. At the fall line station at Conowingo concentrations of nitrogen have decreased 18% since 1985 when adjusted for flow.





The findings from the Bay's major non-tidal rivers have the following implications. First, since the predominant nutrient loading source to most of these monitored sites is nonpoint, they suggest that nonpoint source control measures are beginning to yield results. Second, they suggest that some reductions are due to the drop in phosphorus from point sources, such as wastewater treatment plants. Third, the increasing loadings of nutrients to the Bay due to natural increases in flow would have been far worse if our pollution control measures had not been put into place over the last decade.

Tidal Tributaries: Some Tributaries are Responding to Reduction Measures

In general, the Bay and its tidal tributaries are responding to management actions to varying degrees even in the face of natural delays, including lag times and high flows. Regions with recent significant reductions in point source nutrient loads are showing clear signs of recovery. In contrast, many areas of the Bay and tidal tributaries dominated by nonpoint source loads show fewer signs of improvement and, in some cases, show evidence of increasing nutrient levels.

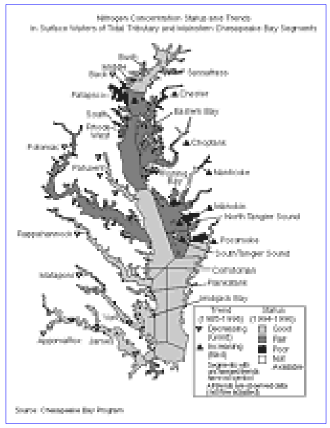
The following status and trends data are not flow adjusted:

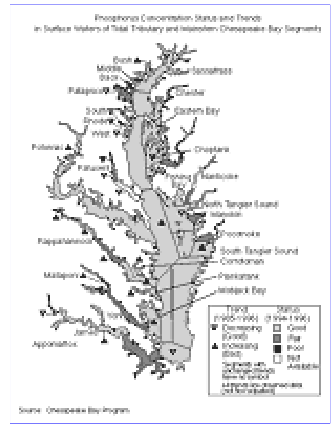
➤ **Phosphorus Status--**Regions of the Patuxent, Rappahannock, York and James Rivers and a few of Maryland's Eastern and Western Shore tributaries have higher phosphorus concentrations than elsewhere.

➤ **Nitrogen Status--**Many of Maryland's smaller Western and Eastern Shore tributaries, the Potomac and portions of the Bay's mainstem in Maryland have higher concentrations of nitrogen than elsewhere.

➤ **Phosphorus Trends 1985-96--**Trends for phosphorus show declines in several of Maryland's Western Shore tributaries including the Patuxent, where significant declines have occurred in phosphorus loadings from wastewater treatment plants. Prior to 1985, similar declines were noted in the Potomac River. In the Virginia tributaries, phosphorus concentrations are increasing in many areas with increases particularly widespread in the Rappahannock, due in part to recent high flow events. Phosphorus concentrations declined in a small area of the upper James River near the Richmond Wastewater Treatment Plant where the phosphorus detergent ban has significantly reduced the phosphorus discharges. Phosphorus concentrations are also declining near the mouth of the Bay. There were no trends in the mainstem York River.

➤ **Nitrogen Trends 1985-96**--Some of the largest decreases in concentration occurred in the Back and Patuxent rivers where historically high contributions of nitrogen from wastewater treatment plants have been substantially reduced in recent years. Nitrogen concentrations throughout the length of the tidal James River have decreased since 1985. Several segments of the Maryland Eastern Shore show increases in concentrations. Since these are nonpoint source dominated regions, at least some of these increases are probably due to recent increases in freshwater flows as explained earlier.

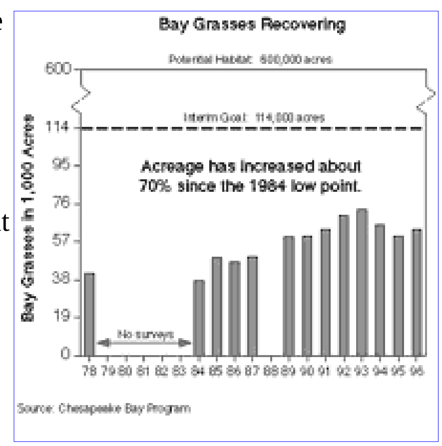




The Living Resource Response

The impacts of nutrient-enriched waters on the growth and survival of underwater Bay grasses, or submerged aquatic vegetation (SAV), are well known. Because of the high amounts of nutrients flowing into the Bay and its tidal tributaries, many of the grasses that used to fringe the shores are now gone. As we have made progress in improving water quality, the Bay grasses have started to rebound.

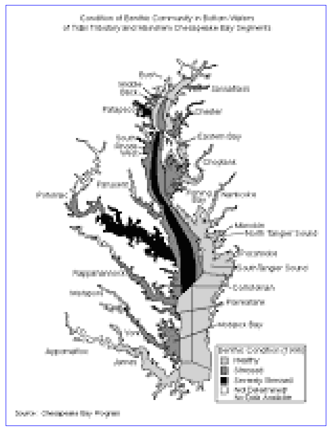
➤ **Bay Grasses** There has been an increase in Bay grass acreage of about 70% between 1984 and 1996. In the recent period of high freshwater flows, however, the pace of the recovery has slowed. In fact, many of the large Bay grass beds in the mid-Bay and in the vicinity of Tangier Sound have been in decline since 1993. These are also areas of the Bay that have experienced some declining water quality trends since 1985. Other areas, while not as significant in terms of areal coverage, are showing some strong upward trends despite the recent high flows. These include Eastern Bay and the outer Choptank embayment on the Eastern Shore and the Gunpowder, Magothy, Severn, upper Patuxent and lower Potomac rivers on the Western Shore. Recently, small grass beds have reestablished in the lower James River in areas that have not been vegetated in decades.

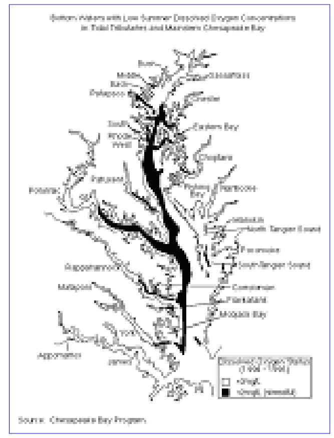


➤ **Plankton Communities**--In rivers like the James where declining trends in nutrient concentrations have been observed, there are signs of improvements in the health and diversity of plankton communities. This has positive implications for the many Bay fish species which feed on these microscopic plants and animals during their early life stages.

➤ **Bottom-Dwelling Organisms**--Another key biological community are those organisms that live on the bottom of the Bay including worms, clams and crustaceans. These organisms are a very important food source for fish and crabs and they can also serve as biological indicators of water quality in a given location since these organisms generally stay in one place. Dissolved oxygen concentration is important in determining whether a region of the Bay can support a healthy bottom-dwelling community. If concentrations drop below five parts per million on a long-term average or below two parts per million periodically, the bottom-dwelling community can be severely impacted. There is a close link between the frequency of low dissolved oxygen events and the health of benthic communities in the Bay. This can be seen when the areas that experience low dissolved oxygen events are compared to the areas where benthic communities are degraded. There are also some areas where habitat conditions other than low oxygen are impacting the benthic community. Overall, since 1985, there has been no clear trend in benthic community condition.

➤ **Bay Bottom Habitat**--Since low oxygen conditions in the Bay are significantly determined by nutrient impacts, the reduction of nutrients is expected to raise oxygen levels and improve habitat for the bottom-dwelling community as well as other organisms which otherwise do not currently use this habitat. Since 1985, there has been no clear trend in oxygen levels. Additional nutrient reductions and a return to more normal flows are expected to raise oxygen levels and lead to improvements in the Bay's bottom-dwelling communities. This improvement also should expand the forage range for several key fish species, including striped bass.





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1997 Nutrient Reduction Reevaluation Summary Report

FRAMEWORK FOR THE FUTURE

Closing the Gap By the Year 2000

The *1997 Reevaluation* taught us a number of new things about how quickly an ecosystem as large and complicated as the Chesapeake responds to actions taken to restore its health. We now know that we must accelerate current efforts and consider additional actions to reduce nitrogen to meet the year 2000 goal.

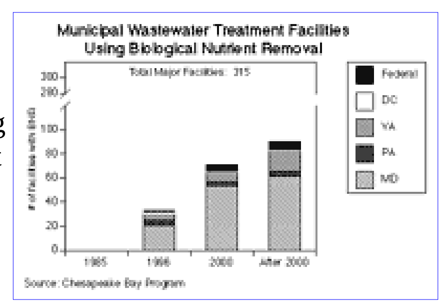
As a result of the reevaluation, we have outlined a number of specific options to "close the gap" on nitrogen and maintain the reductions after 2000. These potential gap closers are the additional actions that the Bay Program partners have agreed are the most feasible, equitable and cost effective means of gaining the extra pound reductions needed to meet the goal. The Bay Program will pursue the gap closers that can be implemented quickly and prove to be the most cost effective. In many cases, further point source reductions must be added to the already substantial progress made by local governments to upgrade wastewater treatment facilities.

Some of the options for closing the gap and maintaining the reduced levels after 2000 are presented in a framework for action signed by the Chesapeake Executive Council as part of the 1997 Executive Council Directive 97-1, *Baywide Nutrient Reduction Progress and Future Directions*. In the pages that follow, the initial framework for these options is fleshed out, beginning with the opportunities to close the gap to meet the year 2000 goal. We also explore the reality of the challenges we face in maintaining the goal levels. Many of the challenges center on the expected increases in population in the Bay region in the coming years which will result in more point source, nonpoint source and airborne nutrients.

Closing the Gap By the Year 2000:
Point Source Reduction Opportunities In Areas Where Tributary Strategies are in Place

➤ **The Executive Council called on the Bay Program in *Directive 97-1*, to build on the substantial progress already made by local governments to upgrade wastewater treatment facilities by accelerating improvements scheduled for after 2000.**

For example, eight facilities identified for treatment upgrades in Maryland's tributary strategies will not have BNR in place by 2000. Almost half of this potential reduction could be achieved through a trading program the Maryland Department of the Environment is considering in partnership with local municipalities between the largest of these eight facilities, Patapsco and Maryland's Back River facility. Rather than operating BNR at Patapsco, which is experiencing technical problems in their BNR pilot studies, additional reductions on the order of 700,000 pounds per year nitrogen delivered to the Bay could occur through methanol addition at Back River which will already be operating a BNR process by 2000.



➤ **The Executive Council called on the Bay Program in *Directive 97-1*, to implement low cost modifications where such accelerated installation is not feasible, in order to obtain short-term partial nutrient reductions.**

For example, 10 facilities in Virginia's Potomac Basin tributary strategy will not have BNR in place by 2000. Implementing BNR at these 10 facilities would result in the removal of four million pounds of nitrogen delivered every year to the Bay. While acceleration of BNR installation may not be feasible at these facilities, certain low cost modifications may be possible while the upgrades are being implemented, thereby achieving some nutrient reductions. Further investigation is warranted into recent recommendations which suggest that two of these facilities could employ low-cost modifications to achieve removals of

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approximately 500,000 pounds per year of nitrogen delivered to the Bay.

➤ **The Executive Council called on the Bay Program in *Directive 97-1*, to encourage voluntary efforts to achieve additional interim reductions from major wastewater treatment plants where nutrient reduction technologies are in place or will be by 2000, but where still higher levels of removal can be obtained from process changes or year-round operation, and support those efforts through innovative federal, state, and local cost sharing arrangements.**

For example, the Blue Plains Sewage Treatment Plant, a regional facility located in the District of Columbia and the largest sewage treatment plant in the Bay region, is exploring the applicability of a three-stage BNR process under a pilot project involving half the flow entering the facility. Following an evaluation of the results of the pilot project, if it is concluded that the process modifications being studied are feasible, full-scale plant modifications will be implemented. The process being tested shows potential for reducing the effluent concentrations of nitrogen below the planned 7.5 milligrams per liter. Other technologies for further reduction of nitrogen also will be tested. However, innovative federal, state and local cost-sharing methods will have to be identified, and issues of permit limit and equity will have to be resolved before the final BNR plan for Blue Plains is developed and implemented.

➤ **The Executive Council called on the Bay Program in *Directive 97-1*, to encourage commitments for additional nutrient reductions from private sector facilities with high loading rates.**

For example, many industrial facilities have already made significant nutrient reductions, largely on a voluntary basis, through in-process changes, end-of-pipe treatment upgrades, or hook-ups to municipalities with BNR. Implementation of nitrogen removal technologies at 15 of the highest nutrient-discharging facilities with no known nutrient removal practices shows the potential for further reducing nitrogen loads to the Bay by at least 1.7 million pounds per year. The Chesapeake Bay Program partners plan to work with these facilities, either through a pollution prevention program, such as *Businesses for the Bay*, or other means to seek additional nutrient reductions.

Closing the Gap By the Year 2000:
Point Source Reduction Opportunities with Non-Signatory States

It is estimated that the other Bay basin states--New York, West Virginia and Delaware--contribute over 12% of the total nitrogen and 9% of the total phosphorus loadings delivered to the Bay. Targeted nutrient reduction actions taken in cooperation with these jurisdictions can result in further reduced nutrient loadings to the Bay.

➤ **The Executive Council called on the Bay Program in *Directive 97-1*, to initiate cooperative efforts with Delaware, New York and West Virginia, with emphasis on New York wastewater treatment plants.**

From a point source perspective, New York-s point source nutrient contributions to the Bay far outweigh those from either Delaware or West Virginia. Current estimates are that reductions on the order of 1.4 million pounds of nitrogen delivered to the Bay annually could be obtained by the implementation of nitrogen removal at New York-s six largest plants discharging into the Bay watershed. The Bay Program partners will be working with New York state and municipal agencies in jointly evaluating nitrogen reduction possibilities from the largest of these, the Binghamton-Johnson City facility--an estimated 600,000 pound nitrogen loading reduction.

Closing the Gap By the Year 2000:
Nonpoint Source Reduction Opportunities in AreasWhere Tributary Strategies Are Already in Place

There are a number of opportunities not identified in the published tributary strategies for further reducing nutrient loadings from nonpoint sources as well. Together these identified actions could further reduce total delivered loads to the Bay by an estimated 1.6 million pounds.

- Reduction of the use of urea as deicer at commercial airports could reduce nitrogen loadings by at least 266,000 pounds by the year 2000; this estimate could increase with concurrent reductions at military facility airfields.
- Implementation of urban nutrient management by homeowners, commercial applicators, and

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building maintenance personnel--adjusting fertilizer application rates to account for available soil nitrogen, plant needs, and timing--could yield nitrogen load reductions on the order of 45,000 pounds through a targeted education program.

- Testing the soil for available nitrogen could reduce the fall fertilizer requirements for small grains, resulting in nitrogen loading reductions up to at least 150,000 pounds.
- Composting of dead poultry into safe and useful products could yield nitrogen reductions on the order of 150,000 pounds.
- Providing for additional marine pumpout stations will provide a yet unquantified additional reduction in nutrient loadings to the Bay.
- Providing for additional reductions due to the new *Conservation Reserve Enhancement Program* recently announced by the U.S. Department of Agriculture and the State of Maryland will provide a yet unquantified additional reduction in nutrient loadings to the Bay.

Closing the Gap By the Year 2000:
Nonpoint Source Reduction Opportunities with Non-Signatory States

➤ **The Executive Council called on the Bay Program in *Directive 97-1*, to initiate cooperative efforts with the other Bay basin states with emphasis on agricultural nonpoint source management in Delaware and West Virginia.**

These efforts could result in even higher nutrient reductions beyond the 700,000- and 100,000-pound reductions in the delivered nitrogen and phosphorus nonpoint source loadings, respectively, anticipated from these states by 2000.

Closing the Gap By the Year 2000:
Reductions Through Innovative Technologies

➤ **The Executive Council called on the Bay Program in *Directive 97-1* to encourage development and use of innovative point source control technologies and new approaches to nonpoint source reductions.**

Innovative technologies to remove nutrients at wastewater treatment plants will continue to be evaluated and demonstrated on a full scale basis where applicable, to provide operators with a full range of economically attractive and technologically feasible options. Studies employing technologies such as algal scrubbers, automatic biological monitors and wetland nutrient uptake should continue to be evaluated.

New technologies currently being developed--for example changes in animal feed and processing manure into commercially available fertilizers--can be utilized for reducing and preventing nonpoint source agricultural nutrient pollution.

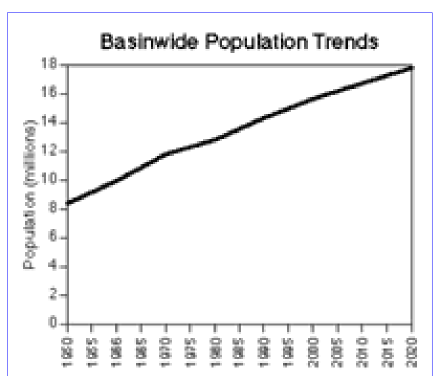
Closing the Gap By the Year 2000:
More Partnerships

The Executive Council called on the Bay Program in another directive *Directive 97-3, the Community Watershed Initiative*--to develop new partnerships at the community level to engage increasing numbers of citizens of the Chesapeake watershed in the clean-up effort.

Challenges: Maintaining the Reductions Will be Challenging

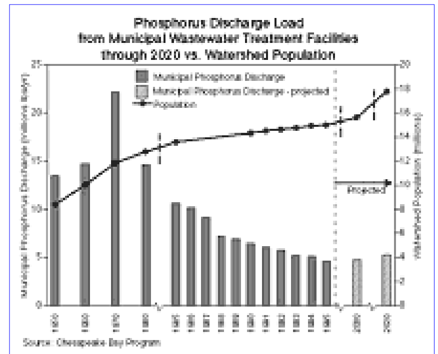
Regardless of our success in speeding up and expanding efforts under our tributary strategies, we face many new challenges to maintain these reduced loading levels into the new century. They include:

➤ **The Region's Population is Growing**--Anticipated population growth and continued urbanization of the watershed will require new pollution prevention and reduction actions just to hold the line on nutrients.



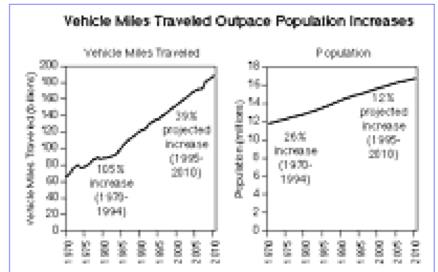
Source: Chesapeake Bay Program

➤ **Population Growth Cuts into Point Source Reductions**--Maintaining reduced phosphorus loadings are particularly challenging because increased population and wastewater flows are already cutting into earlier gains from such actions as the ban on phosphate in detergents.



Source: Chesapeake Bay Program

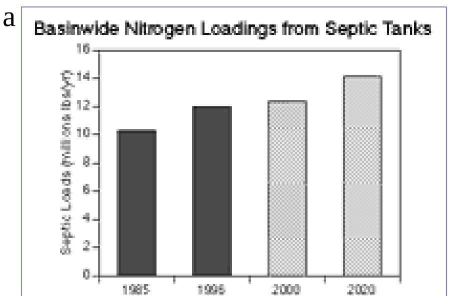
➤ **Vehicle Miles Traveled Increasing**--Between 1995 and 2010, the population is expected to increase 12%, while the vehicle miles traveled is projected to increase 39% in the Bay region. Without technological advances, more miles traveled means more pollution in the air. To date, however, emissions controls on vehicles have buffered the impact of increased travel with nitrogen oxide emissions decreasing 7% from 1985 to 1995, when vehicle miles traveled increased 34%. In the face of sharply increasing vehicle miles traveled trends we may start to lose the ground gained through increased vehicle emission controls. These trends include fleet turnover, changes in fleet composition--such as the popularity of large sport utility vehicles--and the deterioration of emission control equipment over time.



Source: Chesapeake Bay Program

➤ **Number of Septic Systems Increasing**-- Septic systems are a rapidly increasing source of loadings of nutrients in the watershed, and will increase in importance if current trends in land development continue.

➤ **Number of Poultry & Livestock Operations Increasing**--Localized and regional increases in the number and density of poultry and livestock will place pressure on government and agriculture to adopt new management practices to control the potential nutrient loadings from these operations.



Source: Chesapeake Bay Program

Areas of Opportunity Beyond 2000

There are many areas of opportunity to be explored as we seek to meet and maintain our nutrient goals. They include point source opportunities Baywide and further reductions from air.

Areas of opportunity beyond 2000:
Other Point Source Reduction Opportunities

Expanded biological nutrient removal (BNR) and other nutrient reduction technologies can be implemented at a wider range of wastewater treatment facilities due to declining costs, experience with operations, and recognition by facility owners and operators that benefits often include operational cost savings.

Pennsylvania's Tributary Strategy focuses on nitrogen reductions through nonpoint sources because this is the dominant source of nitrogen loadings for this state. However, Pennsylvania's tributary strategy also includes a point source nitrogen reduction component, including studying the feasibility of treatment upgrades at their larger municipal plants and evaluating innovative nutrient removal technologies. The Bay Program partners have assisted in the feasibility study of BNR implementation at 16 Pennsylvania municipal wastewater treatment facilities. Reductions at all 16 Pennsylvania facilities could result in a 2.8 million pound reduction in nitrogen loadings delivered to the Bay. The results of these evaluations--together with recent studies on innovative technologies and the experience Pennsylvania has obtained in the past several years regarding BNR operation at four of their facilities--are currently being evaluated. The Chesapeake Bay Program partners will continue to explore other targeted point source reduction opportunities based on cost effectiveness and feasibility of implementation.

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Areas of opportunity beyond 2000:

Further Reductions from Air

To address this opportunity, the Executive Council called on the Bay Program in Directive 97-1, to work toward additional reductions of airborne nitrogen delivered to the Bay and its watershed from all sources including states outside the watershed, and seek improved understanding of how airborne nitrogen affects the Bay and its tributaries.

- For example, a continuing concern, especially for the northern half of the Bay watershed, New York and Pennsylvania, is the high level of nitrogen oxide emissions from sources in the Ohio Valley and other areas of the Midwest. Atmospheric deposition contributes about 26% of the total nitrogen loadings delivered to the Bay from the Susquehanna watershed. The Bay program partners will continue to work toward reductions of these sources located outside the watershed.
- Over the next 10 years, implementation of the Clean Air Act will result in nitrogen oxide emission reductions from both stationary and mobile sources. Many of these will occur during and after the year 2000.
- By 1996, the coal-fired electric utilities affected by Phase I of the Acid Rain Program under the 1990 Clean Air Act Amendments had reduced their national emissions by 680 million pounds, a 33% reduction from 1990 levels.
- Total national nitrogen oxide emissions from all sources in 1990 were about 46 billion pounds. With implementation of the Clean Air Act Amendments, total emissions of nitrogen oxides in 2007 are projected to decrease by about 10%. However, the electric utility emissions limits are based on burn rate (lbs/MMBtu); there is no national emissions cap for nitrogen oxides as there is for sulfur dioxide emissions.
- Under Title I of the Clean Air Act , the U.S. Environmental Protection Agency is proposing additional nitrogen oxide controls on electric utility, other stationary and mobile sources in the eastern states which if implemented, are projected to decrease total nitrogen oxide emissions by about 35% more. An initial estimate is that implementing these controls and meeting the new ozone and particulate matter standards could reduce the amount of airborne nitrogen impacting the Bay by nearly 17 million pounds a year--or about 23%.
- Other forms of nitrogen which enter the Bay through air deposition are not currently regulated or controlled through the Clean Air Act. Ammonia, for example, is a form of nitrogen that has both natural and anthropogenic sources to atmospheric loadings. Current estimates are that 20% to 40% of the annual atmospheric nitrogen load comes from ammonia-related compounds. The Bay Program is working towards quantifying ammonia emissions and characterizing its deposition in the watershed in advance of determining what options are available to reduce ammonia emissions to the air.

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1997 Nutrient Reduction Reevaluation Summary Report

CONCLUSION

As we approach 2000, it's fair to say that the Bay Program has made impressive progress toward the nutrient goals set 10 years ago. However, we must accelerate our efforts to close the gap on the year 2000 goal, maintain those reduced loading levels into the future and if necessary adjust the nutrient goals to help us achieve the water quality improvements needed to sustain living resources in the Bay. The framework included in Directive 97-1 commits the Bay Program to these efforts.

Since 1983, our highest priority has been the restoration of the Bay's living resources and we are committed to achieving the water quality and other conditions necessary to support and maintain the living resources of the Bay. We believe we must begin planning now to assure we have the structure and capacity in place to take our efforts to restore the Chesapeake into the next century and meet the challenges that population growth will bring to this commitment. We have confidence that our ability to work together, along with our continued reliance on sound science and technology advancement, can make this commitment a reality.

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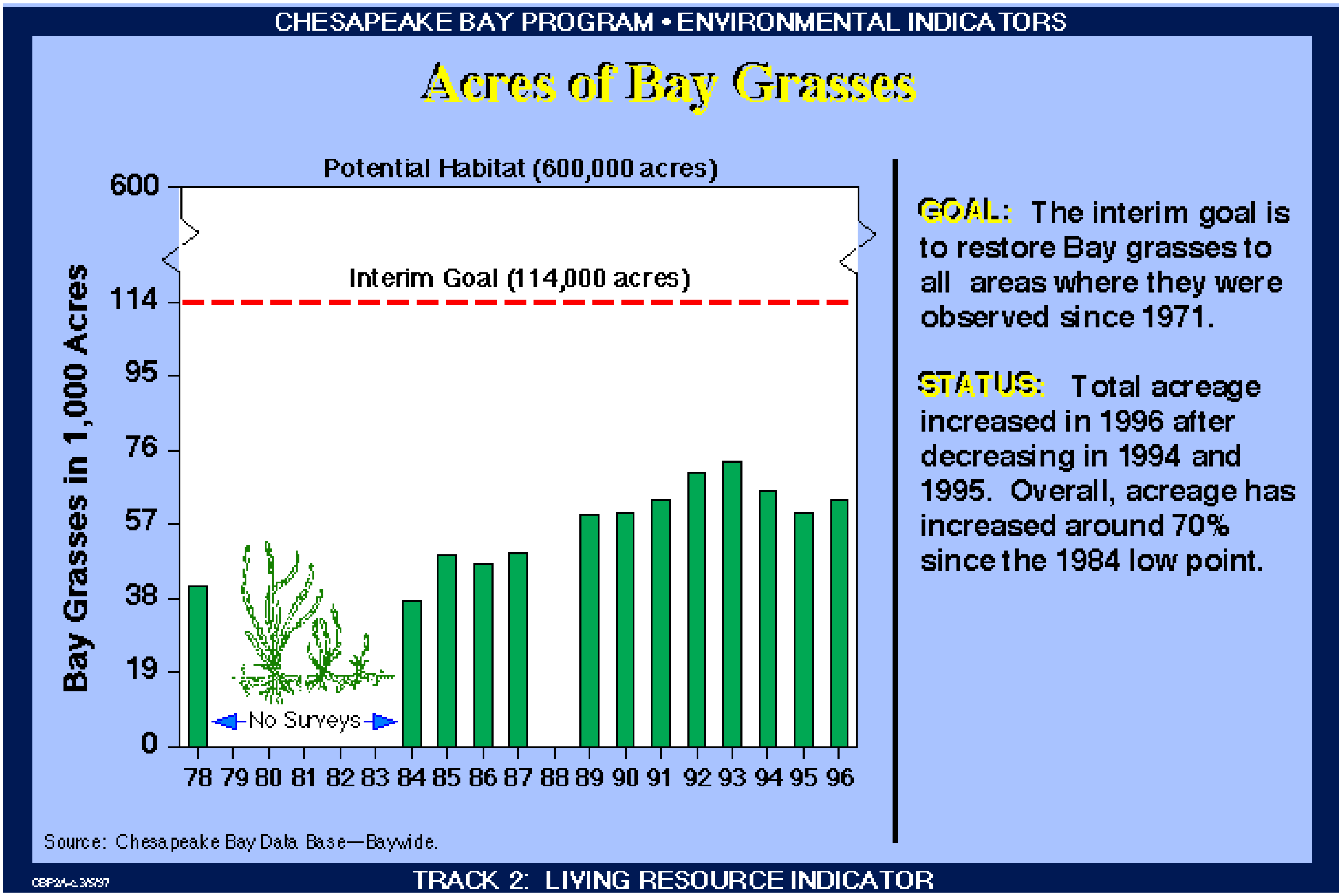
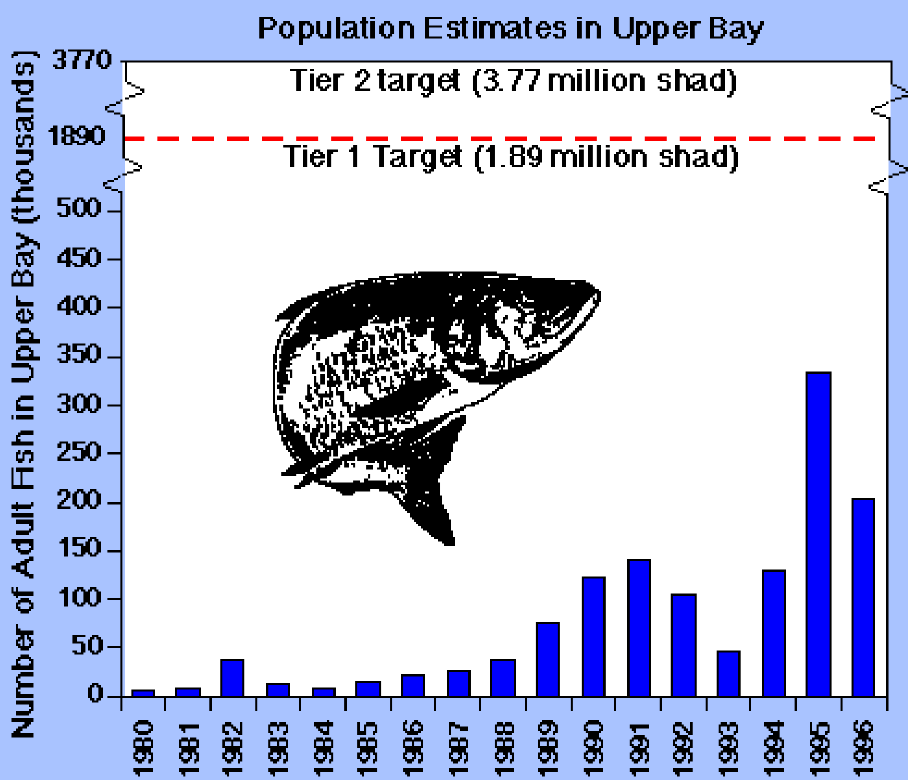

CHESAPEAKE BAY PROGRAM • ENVIRONMENTAL INDICATORS
Acres of Bay Grasses
Potential Habitat (600,000 acres)
Interim Goal (114,000 acres)
Bay Grasses in 1,000 Acres
600
114
95
76
57
38
19
0
No Surveys
78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96
Source: Chesapeake Bay Data Base—Baywide.
GOAL: The interim goal is to restore Bay grasses to all areas where they were observed since 1971.
STATUS: Total acreage increased in 1996 after decreasing in 1994 and 1995. Overall, acreage has increased around 70% since the 1984 low point.
TRACK 2: LIVING RESOURCE INDICATOR

CHESAPEAKE BAY PROGRAM • ENVIRONMENTAL INDICATORS

American Shad: Population Estimates



Source: MD DNR - through NOAA Chesapeake Bay Office.

GOAL: Restore shad populations in the Chesapeake Bay.

STATUS:
Interjurisdictional effort is in place to restore the fishery.

- MD moratorium since 1980
- 1984 FERC Mandate Settlement Agreement
- 2nd Conowingo Dam Fish Lift operational since 1991
- 1993 Susquehanna Fish Passage Agreement

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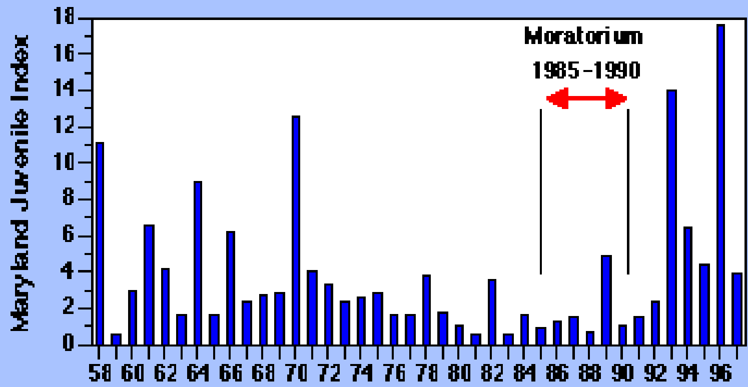
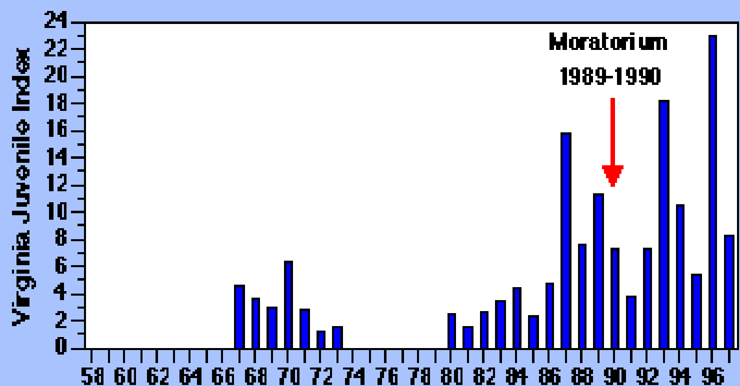
TRACK 2: LIVING RESOURCE INDICATOR

CHESAPEAKE BAY PROGRAM • ENVIRONMENTAL INDICATORS

Trends in Finfish: Striped Bass





Source for Maryland index data: Maryland Department of Natural Resources.
Source for Virginia index data: Virginia Institute of Marine Sciences.

GOAL: Sustain the fishery.

STATUS: Successful management measures first removed, then limited harvest pressure, resulting in a conservatively managed fishery. The stock was declared restored in January 1995 by the Atlantic States Marine Fisheries Commission.

Note: Differences in data treatment by MD and VA mean these graphs are not directly comparable.

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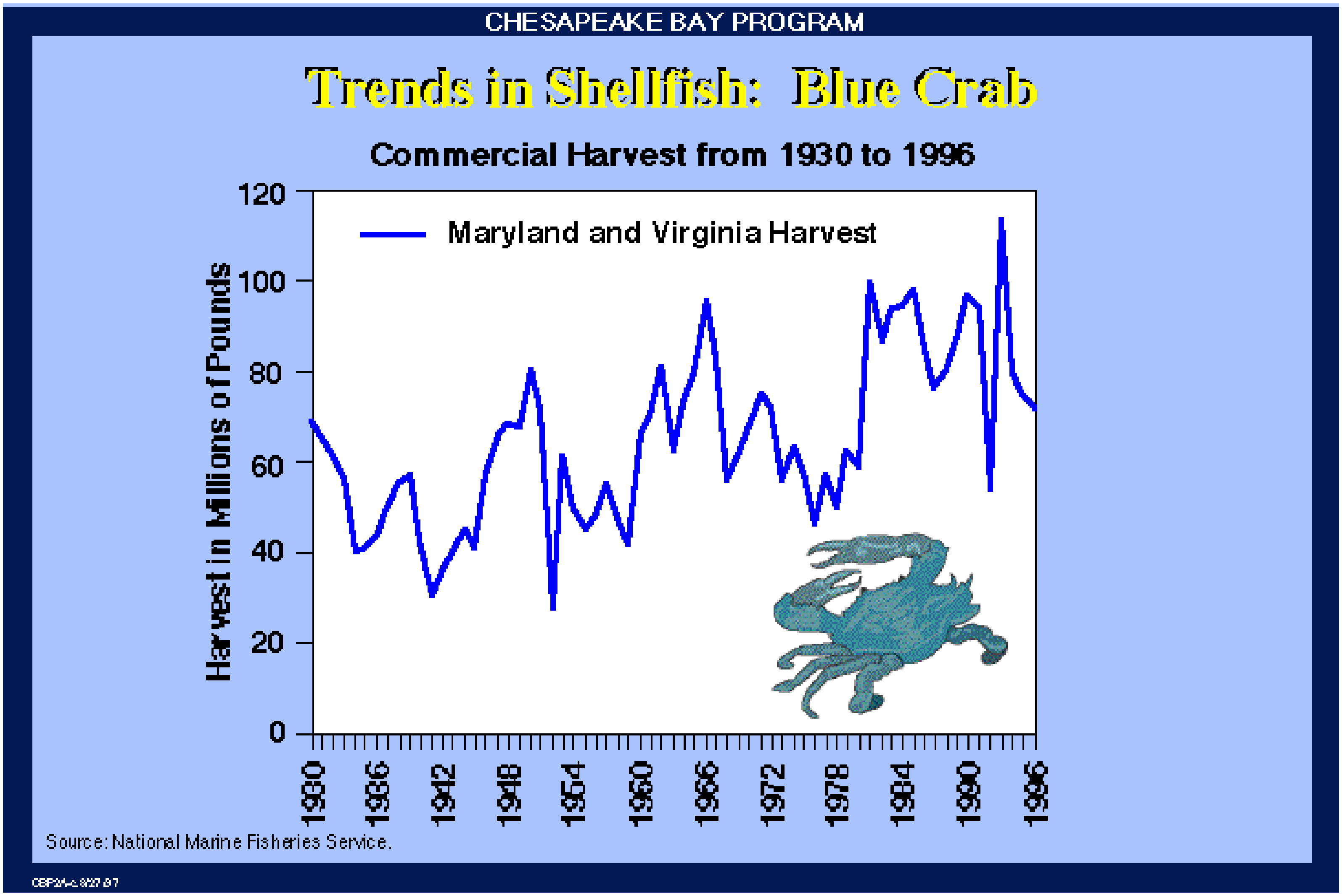
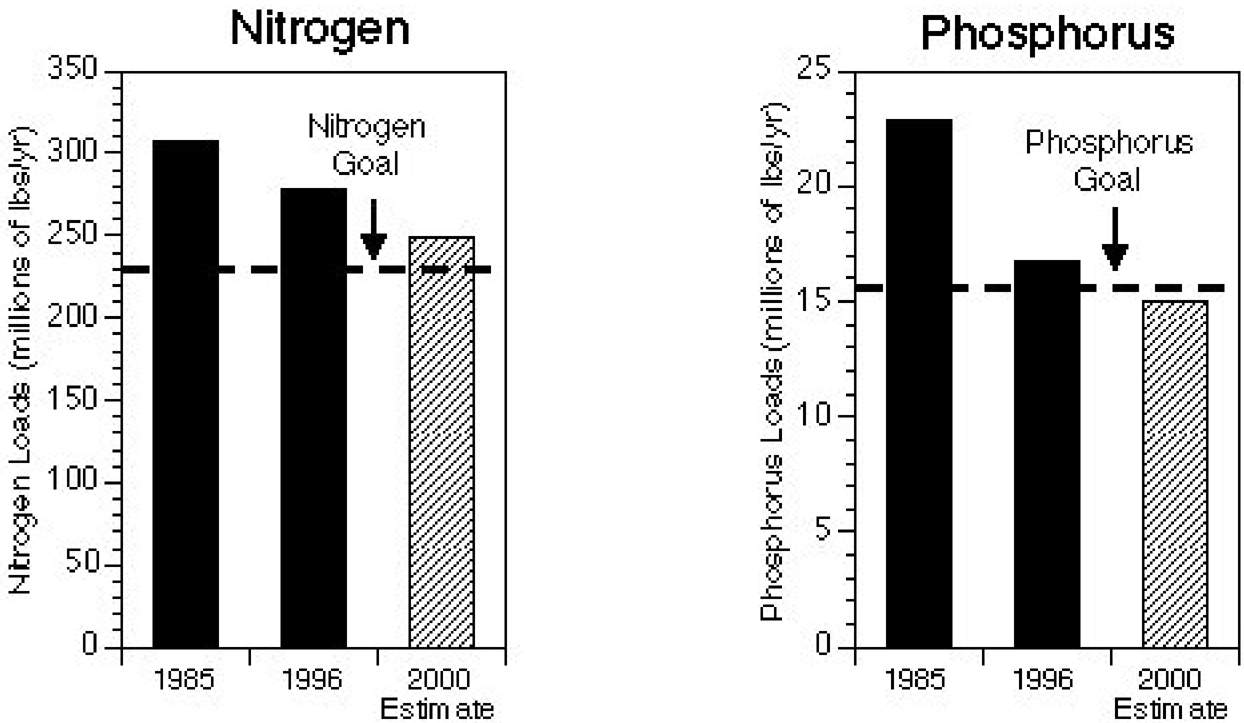
TRACK 2: LIVING RESOURCE INDICATOR


CHESAPEAKE BAY PROGRAM
Trends in Shellfish: Blue Crab
Commercial Harvest from 1930 to 1996
Maryland and Virginia Harvest
Harvest in Millions of Pounds
120
100
80
60
40
20
0
1930
1936
1942
1948
1954
1960
1966
1972
1978
1984
1990
1996
Source: National Marine Fisheries Service.

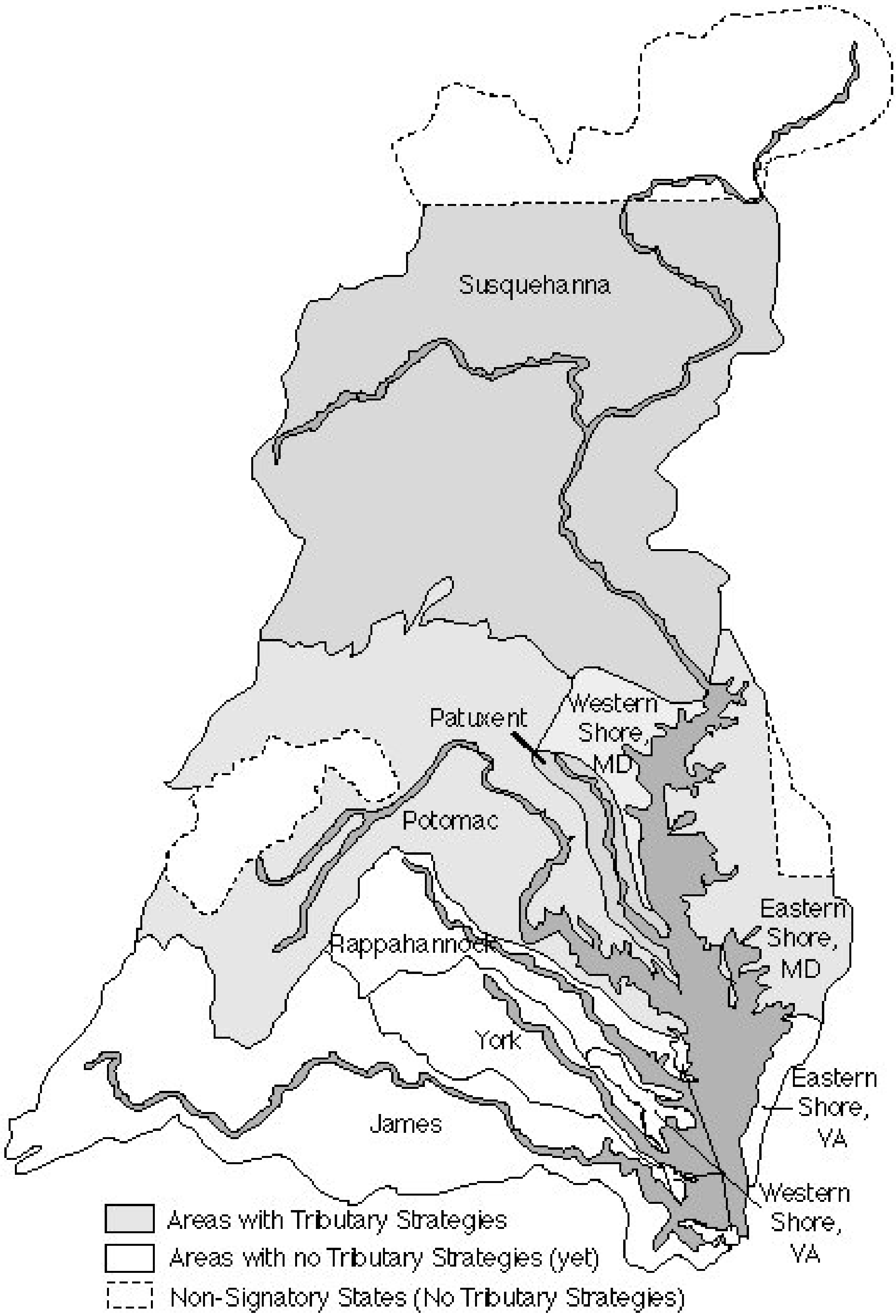
Chesapeake Bay Watershed

Total Nutrient Loads Delivered to the Bay from All Basin Tributaries (MD, VA, PA, DC)

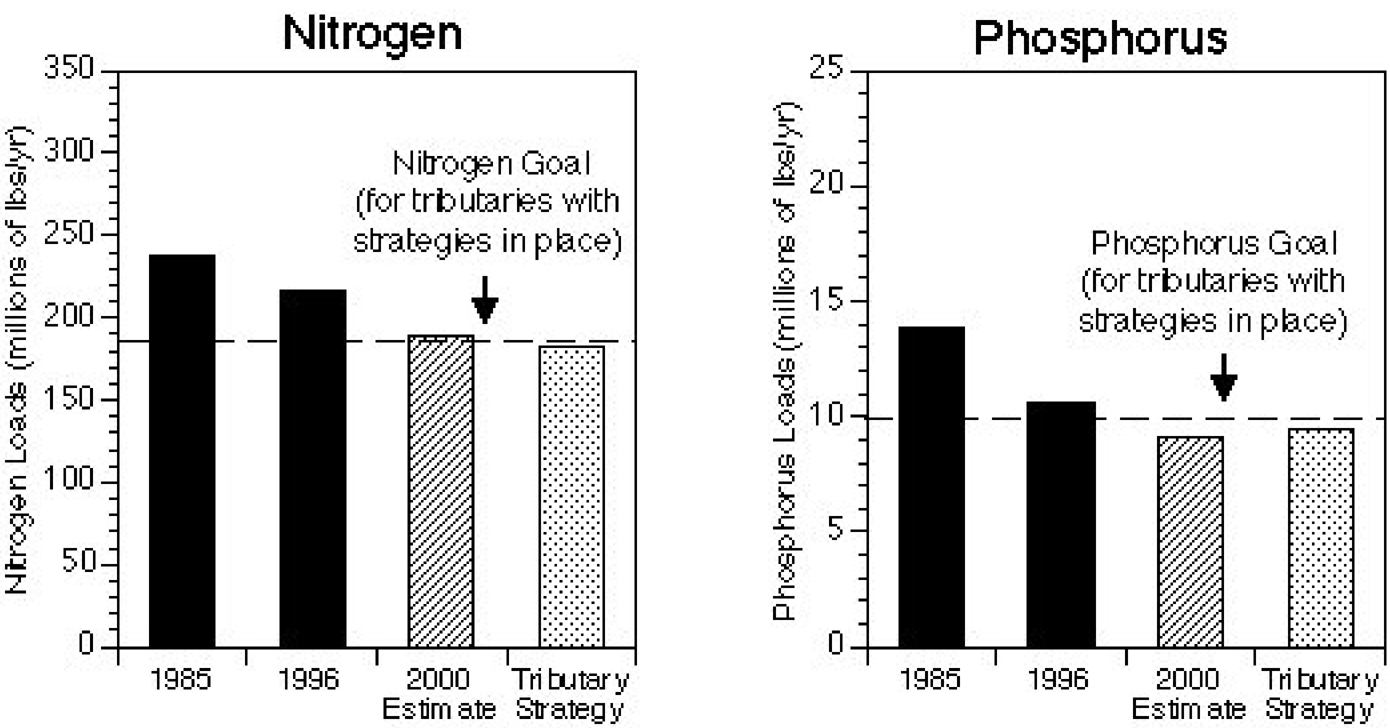


Source: Chesapeake Bay Program Phase IV Watershed Model. Data include total nitrogen and phosphorus loads delivered to the Bay, from point and nonpoint sources, from Chesapeake Bay Agreement jurisdictions (MD, PA, VA, DC).

Chesapeake Bay Watershed: Areas with Tributary Strategies

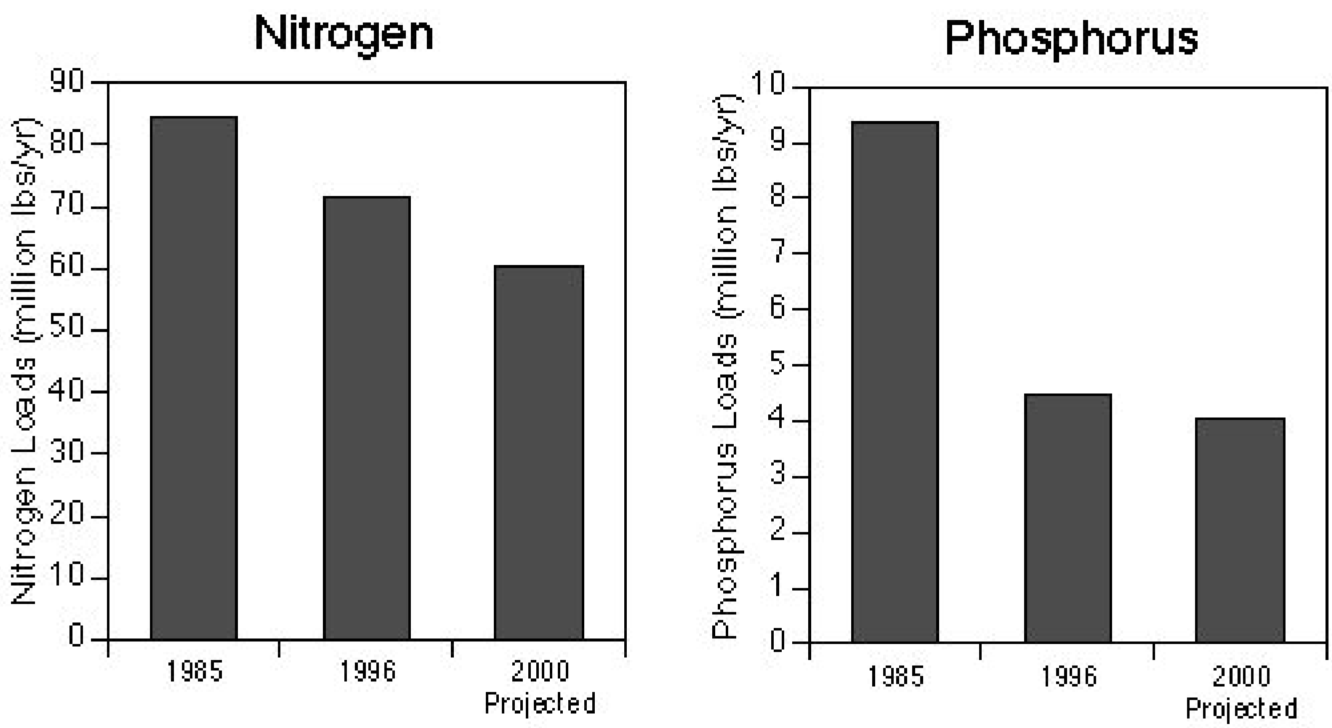


Total Nutrient Loads Delivered to the Bay from Tributary Basins with Strategies in Place (Potomac and North)



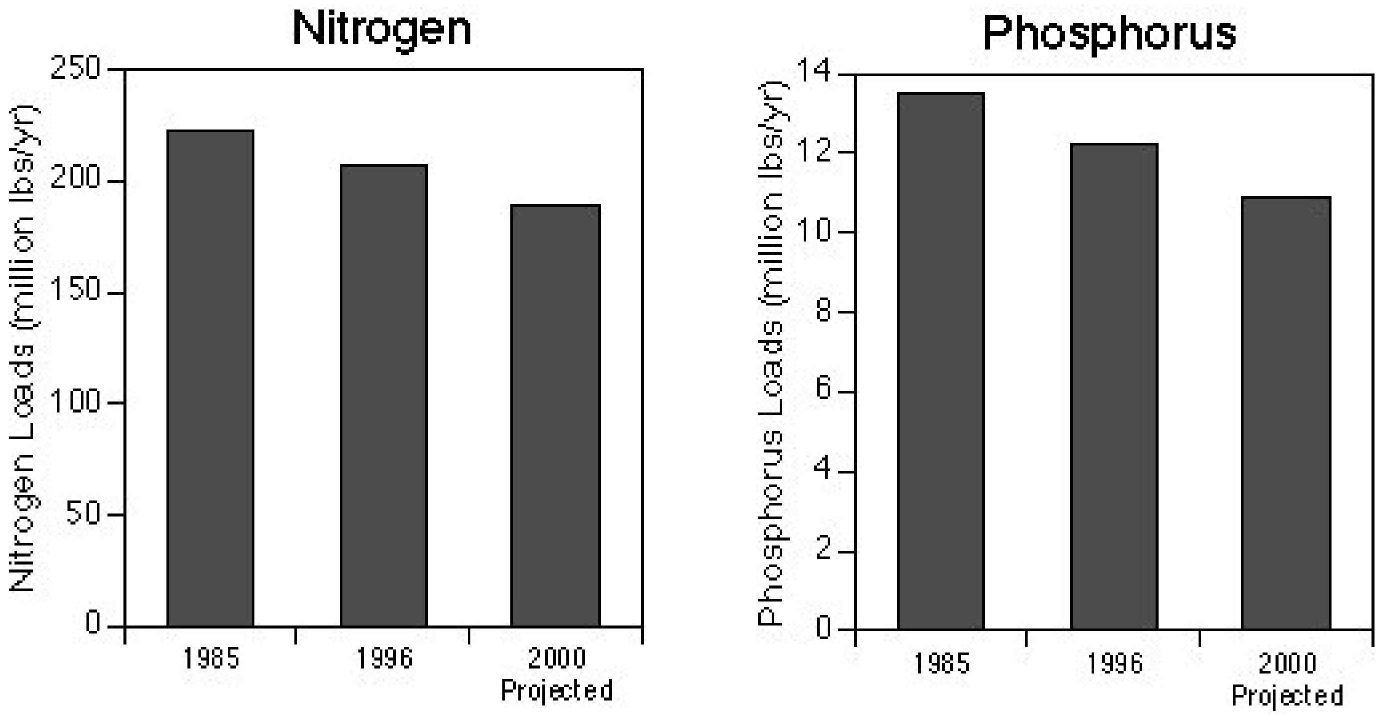
Source: Chesapeake Bay Program Phase IV Watershed Model. Data include total nitrogen and phosphorus loads delivered to the Bay, from point and nonpoint sources, from Chesapeake Bay Agreement jurisdictions (MD, PA, VA, DC) where Tributary Strategies have been implemented (Susquehanna, Patuxent, Potomac, Western Shore-MD and Eastern Shore-MD).

Total Point Source Nutrient Loads Delivered to the Bay from All Basin Tributaries (MD, PA, VA, DC)



Source: Chesapeake Bay Program Phase IV Watershed Model. Data include total point source nitrogen and phosphorus loads delivered to the Bay from Chesapeake Bay Agreement jurisdictions (MD, PA, VA, DC).

Total Nonpoint Source Nutrient Loads Delivered to the Bay from All Basin Tributaries (MD, PA, VA, DC)



Source: Chesapeake Bay Program Phase IV Watershed Model. Data include total nonpoint source nitrogen and phosphorus loads delivered to the Bay from Chesapeake Bay Agreement jurisdictions (MD, PA, VA, DC).

Highlights on Best Management Practices

The tributary strategies each contain specific commitments for implementation of a wide array of best management practices designed to reduce or prevent nonpoint source runoff of nutrients. Several examples of the more widely applied practices are described below.

Agricultural Practices: Substantial progress is forecasted by farmers implementing best management practices (BMPs) contained in farm plans and nutrient management plans. These BMPs include a range of different practices that reduce or eliminate soil loss and provide for the proper application rates of nutrients to cropland. Practices include vegetated buffer strips at the edge of crop fields, conservation tillage, strip cropping, diversion and waterways, nutrient management and stream bank fencing.

Animal Waste Management Practices: Substantial benefits in reductions of nutrients and improved water quality, in both surface and groundwater, can be achieved by 2000 through the adoption of state of the art animal waste management systems, including manure storage structures, runoff controls for barnyards, guttering and nutrient management. These systems address the handling, storage, transport, and utilization of animal waste as fertilizer on cropland.

Riparian Forest Buffers and Other Buffers: Forested and other vegetated buffers serve as a trap for nutrients and sediment from upland sites. Each jurisdiction--including the Federal facilities--is implementing a program to achieve the implementation targets established in their tributary strategies or Riparian Forest Buffer Implementation plans.

Stream Protection Practices: Implementation of stream protection practices, including stream fencing and alterative watering sites, has the potential to provide substantial reductions of sediment loadings in areas where livestock access to the stream is restricted.

Urban Practices: Urban best management practices have the potential to reduce erosion and sediment losses as well as nutrients that are applied in the urban/suburban areas. Practices include storm water management for quality and quantity, erosion and sediment controls on areas under development and storm water controls in developed areas. These practices are applied across a broad spectrum from industrial, commercial and residential facility construction sites to the management of lawns and open spaces.

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Last modified 11/12/97.

FACTORS THAT INFLUENCE BAY AND RIVER RESPONSE TO REDUCTION MEASURES

Understanding Lag Time

Our nutrient reduction progress can be masked or slowed down by natural lag times between actions taken on the land and delivery of resulting reductions to the Bay.

For example, nutrients are transported in the watershed in several ways. Nutrients, dissolved in either water, mostly nitrogen, or attached to sediment, mostly phosphorus, are washed off the land into streams as runoff during rain events. Once in the stream, the nutrients associated with water move along the surface and flow to a nearby stream or river and eventually the Bay.

➤ **Groundwater Lag Time**--Nitrogen-rich runoff also can infiltrate into the ground before reaching a stream, move with groundwater and eventually seep back into streams, rivers and the Bay. But, this can take from 10 to 20 years.

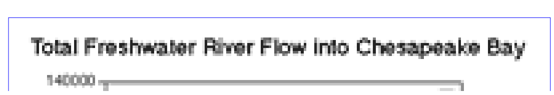
➤ **Sediment Movement Lag Time**--Lag times associated with sediment movement are not well understood but could also be on the order of several decades. What we do know is that a reduction in phosphorus runoff from upper watershed lands may take years to result in improved Bay water quality because the phosphorus attached to sediment remains stored in the local streams and rivers until it is washed downstream to the Bay, usually by major storm events. Large dams in the Bay region can have a similar and, in some cases, more pronounced effect. In the case of the Susquehanna River dams, which have been in place since the 1920s, the dams reduce loadings by literally trapping the sediment behind the dam. Some of this sediment is usually scoured out from behind the dams and flushed downstream during major storm events. In the absence of any major storms, these dams may fill in and lose their sediment-trapping capacity in another 15 to 20 years. This would cause the amount of sediment and phosphorus entering the Bay to increase substantially.

➤ **Living Resource Recovery Lag Time**--There are also lag times in the Bay system associated with the time it takes for living resources to recover once water quality and habitat conditions have improved. For example, once water quality conditions suitable for underwater grasses are attained, it still may be years before enough seeds or vegetative plant material are transported into the restored habitat to support revegetation.

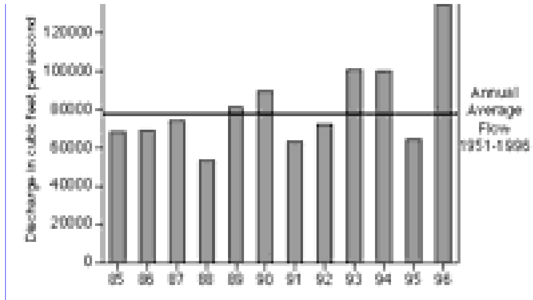
➤ **Internal Nutrient Memory of the Bay**--Not all of the new information on lag times is negative. Scientific studies now show us that the internal nutrient memory of the Bay-the amount of time required to use up excess nutrients contained within the Bay's sediments-is on the order of one to three years. This is compared to a decade as once thought.

Understanding High Flows

Unusually high river flows, caused by storm events



in three of the last four years, resulted in higher loadings of nutrients coming into the Bay from its rivers. These increases, however, were due to the high flows--not increases in pollution. These high flows have masked a stronger Bay water quality response to management actions.



Source: Chesapeake Bay Program.

➤ **Flows Have Been Increasing**--One of the most important influences on the Chesapeake system is rainfall and the resulting freshwater flows that reach the Bay. Records kept since the early 1950s show that total freshwater flows into the Bay during high flow years were over two-and-a-half times greater than low flow years. Since 1985 we have witnessed a trend of increasing flows, with early years (1985-88) tending to be below the long-term average and recent years (1993, 94 and 96) tending to be well above average.

➤ **More Runoff Means More Nutrients**--Higher flows produce more runoff of nutrients from various types of land uses and transports them more efficiently to the tidal waters of the Bay and its tributaries. So, even if we were to hold the line on increases in nutrient concentrations in the rivers through management efforts, the Bay would receive higher amounts of nutrients during high flow years compared to average or low flow years.

➤ **Flow Adjusted Data Helps Reveal Progress**--An examination of the monitoring data collected at the points where the rivers enter the Bay show that nutrient loadings from our rivers have generally increased over the 1985 to 1996 period due to the pattern of increasing freshwater flows--not increased pollution. When these variations in flows are accounted for by flow adjusting data, we see that nutrient reduction management actions taken to date have been effective.

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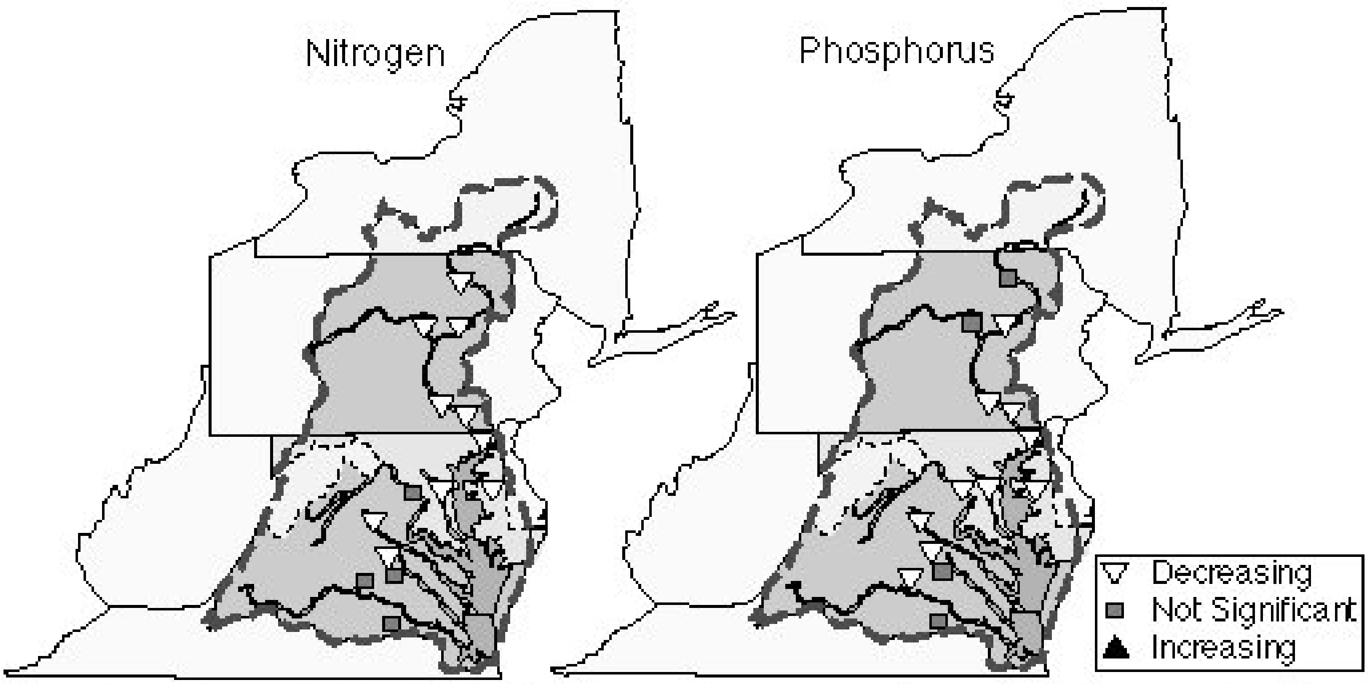
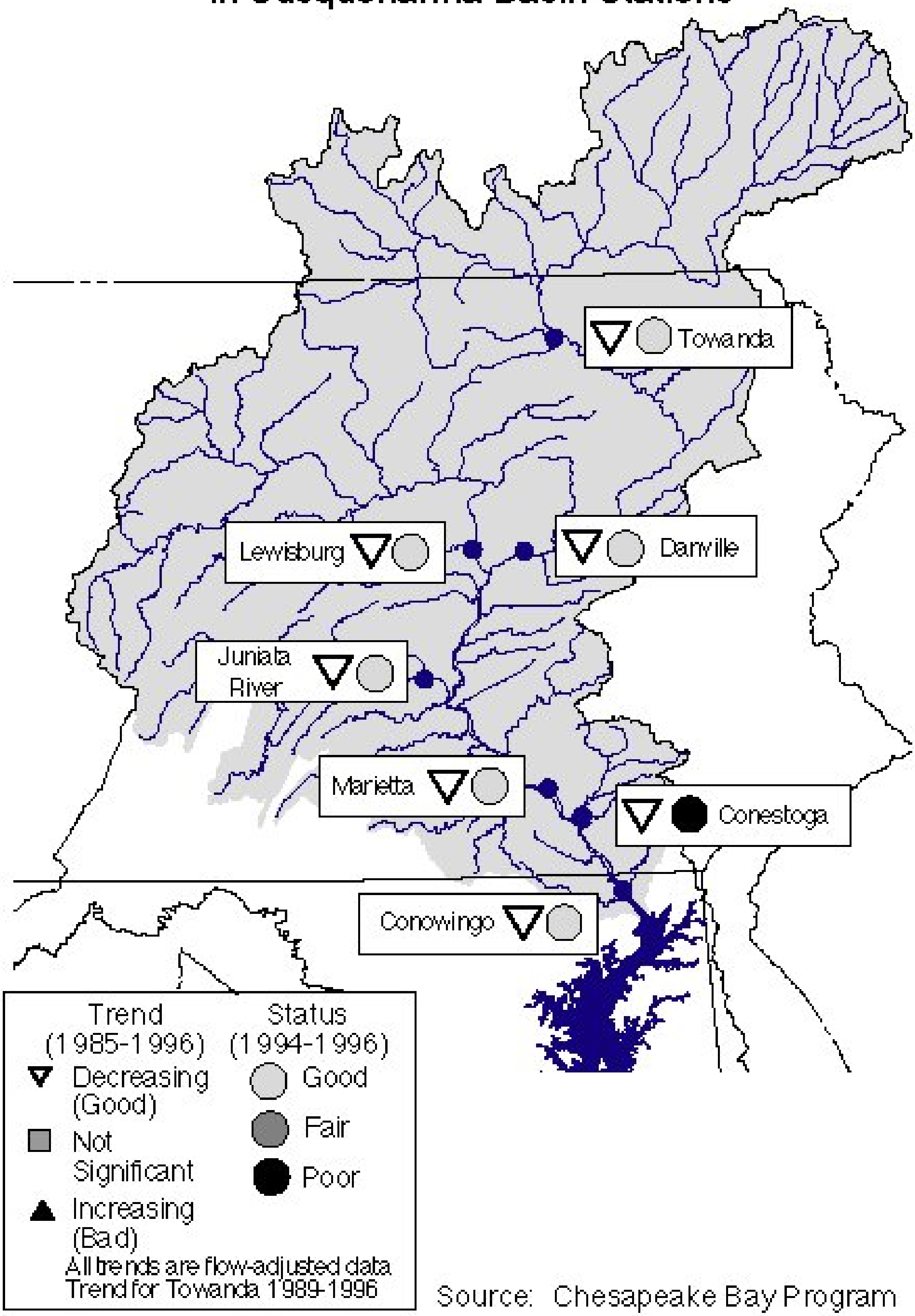
Nitrogen and Phosphorus Concentration Trends in Non-Tidal Portions of Rivers



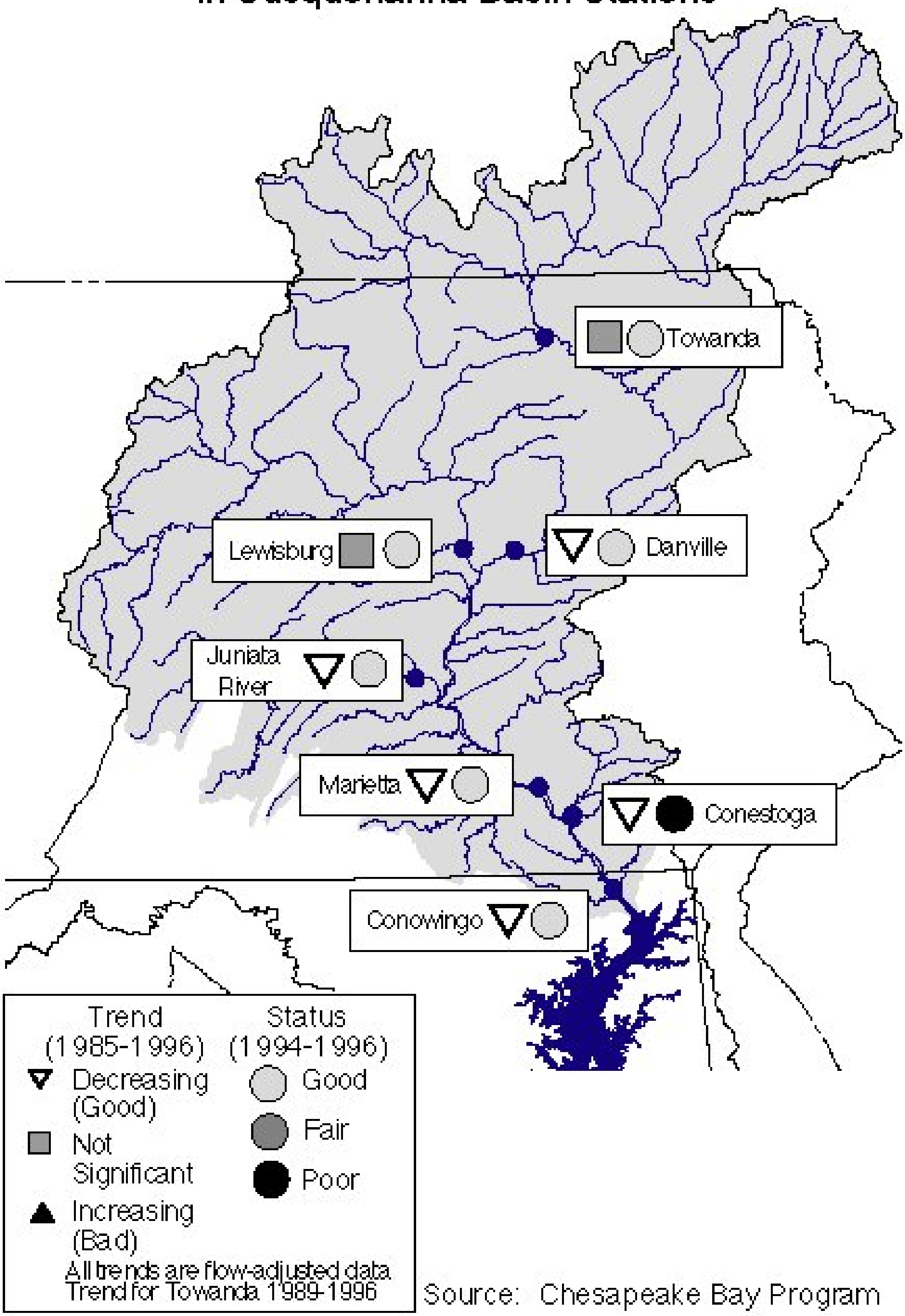
Flow-adjusted concentration trends of nitrogen and phosphorus for major tributaries where they meet tidal waters and for key stations in the Susquehanna River watershed. Results are shown for trend analyses using the earliest complete data set collected since 1985 through 1996.
Source: Chesapeake Bay Program.

Nitrogen Concentration Status and Trends in Susquehanna Basin Stations



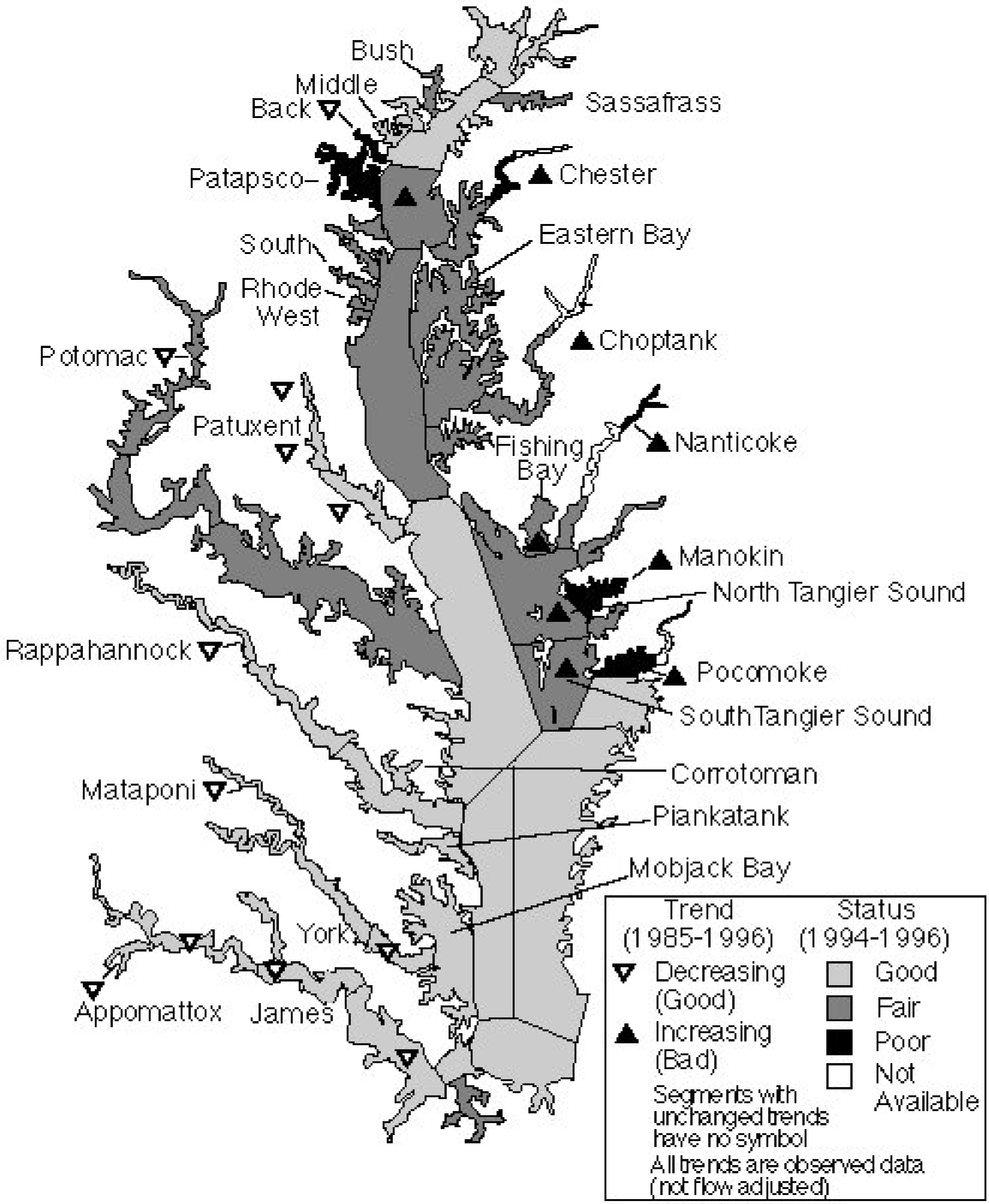
Source: Chesapeake Bay Program

Phosphorus Concentration Status and Trends in Susquehanna Basin Stations



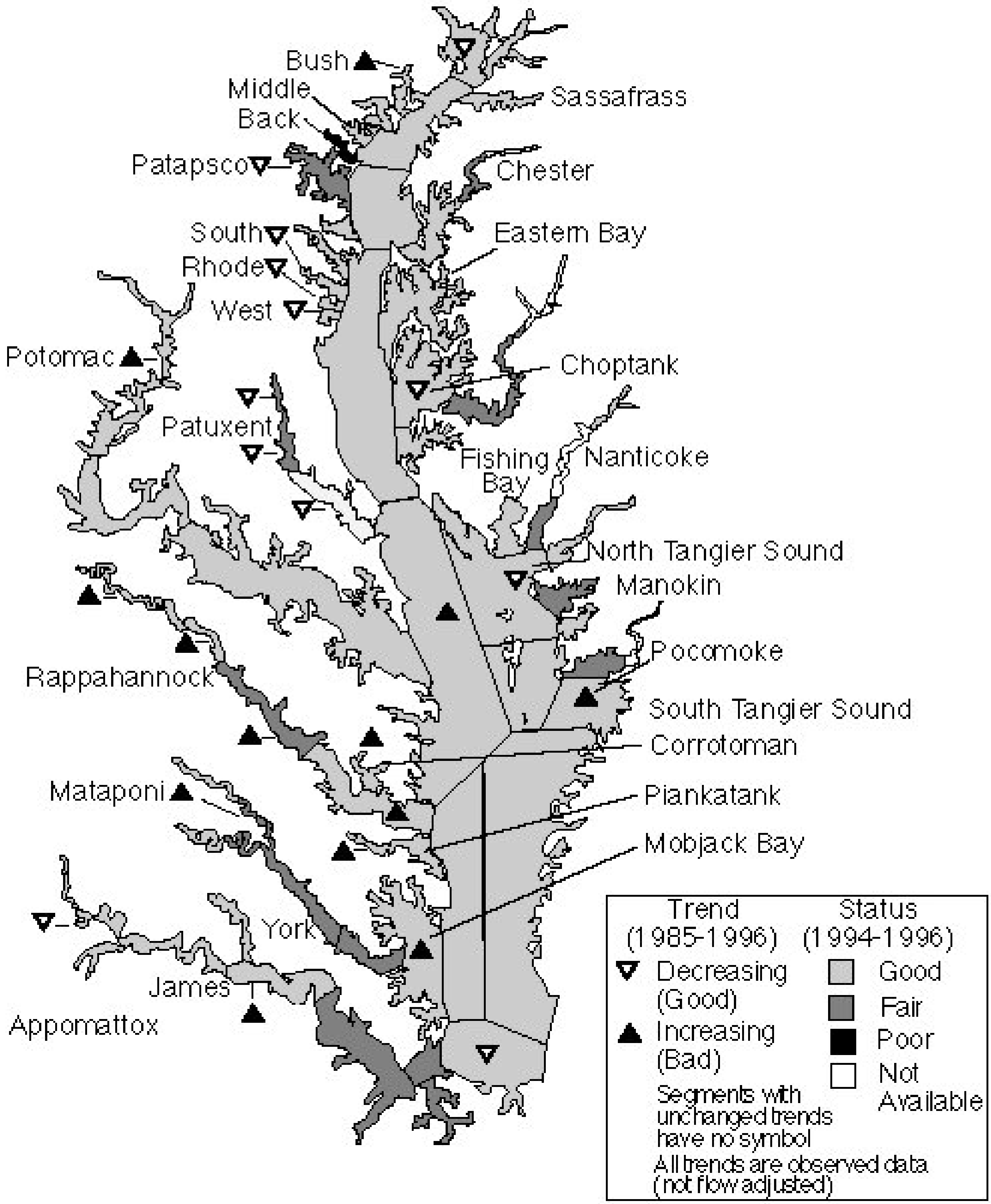
Source: Chesapeake Bay Program

Nitrogen Concentration Status and Trends
in Surface Waters of Tidal Tributary and Mainstem Chesapeake Bay Segments



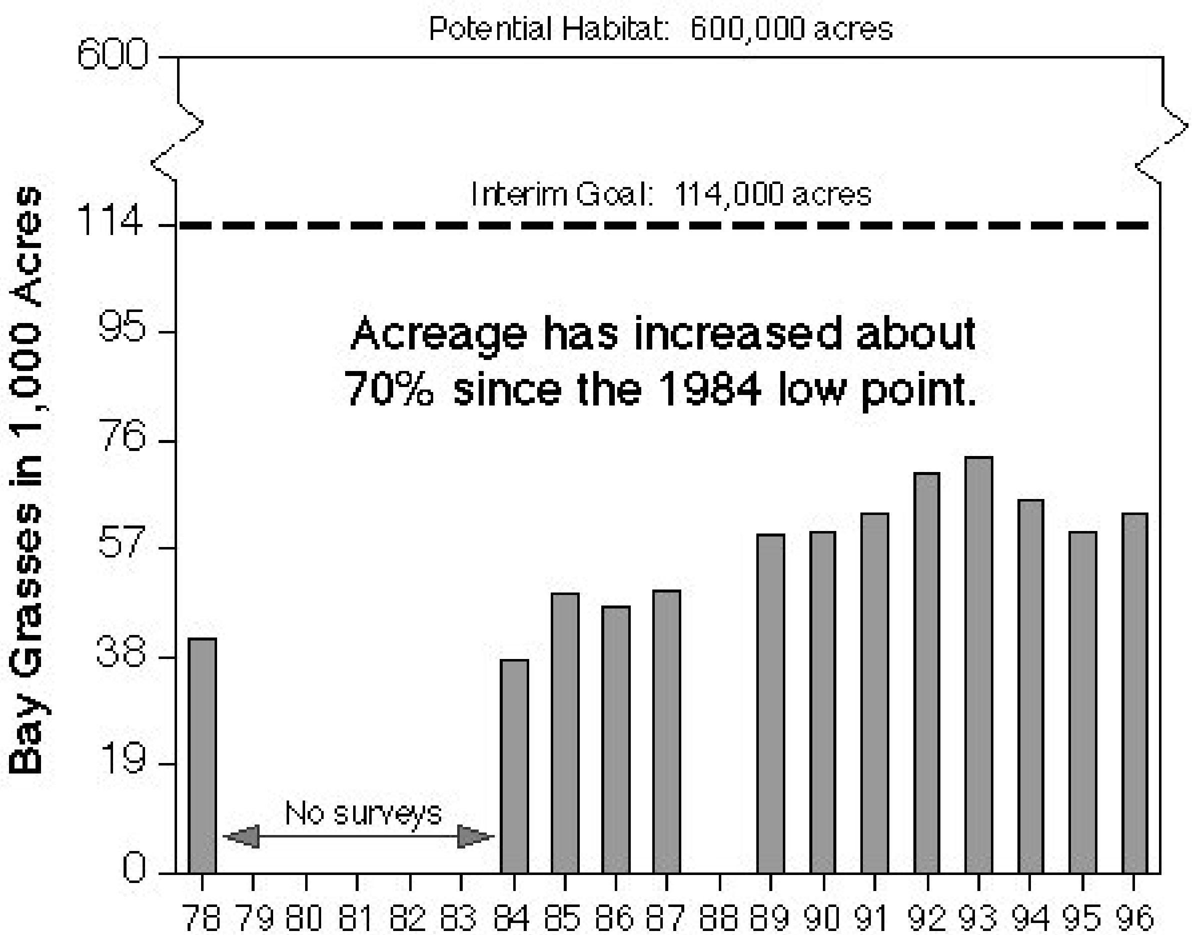
Source: Chesapeake Bay Program

Phosphorus Concentration Status and Trends
in Surface Waters of Tidal Tributary and Mainstem Chesapeake Bay Segments



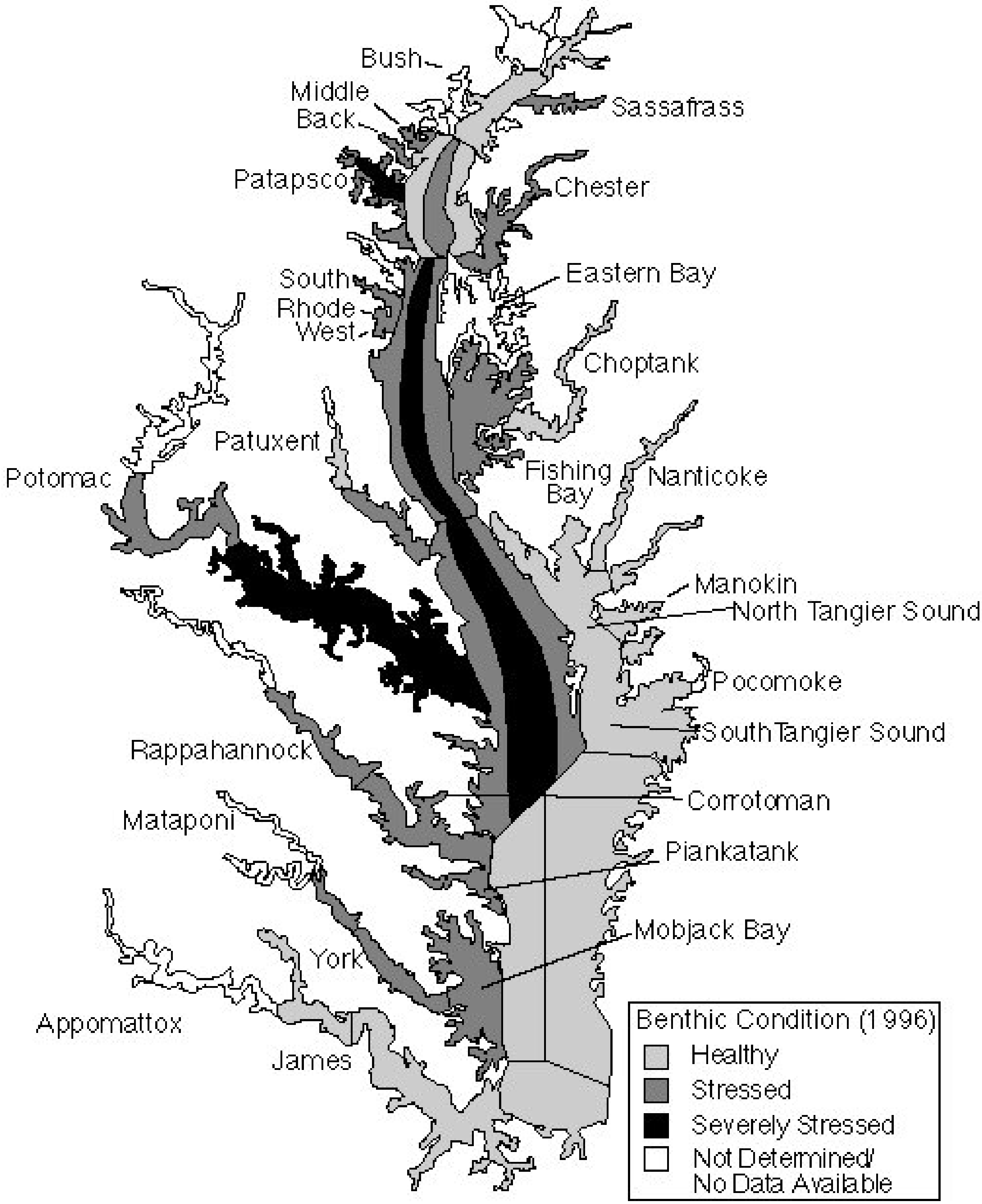
Source: Chesapeake Bay Program

Bay Grasses Recovering



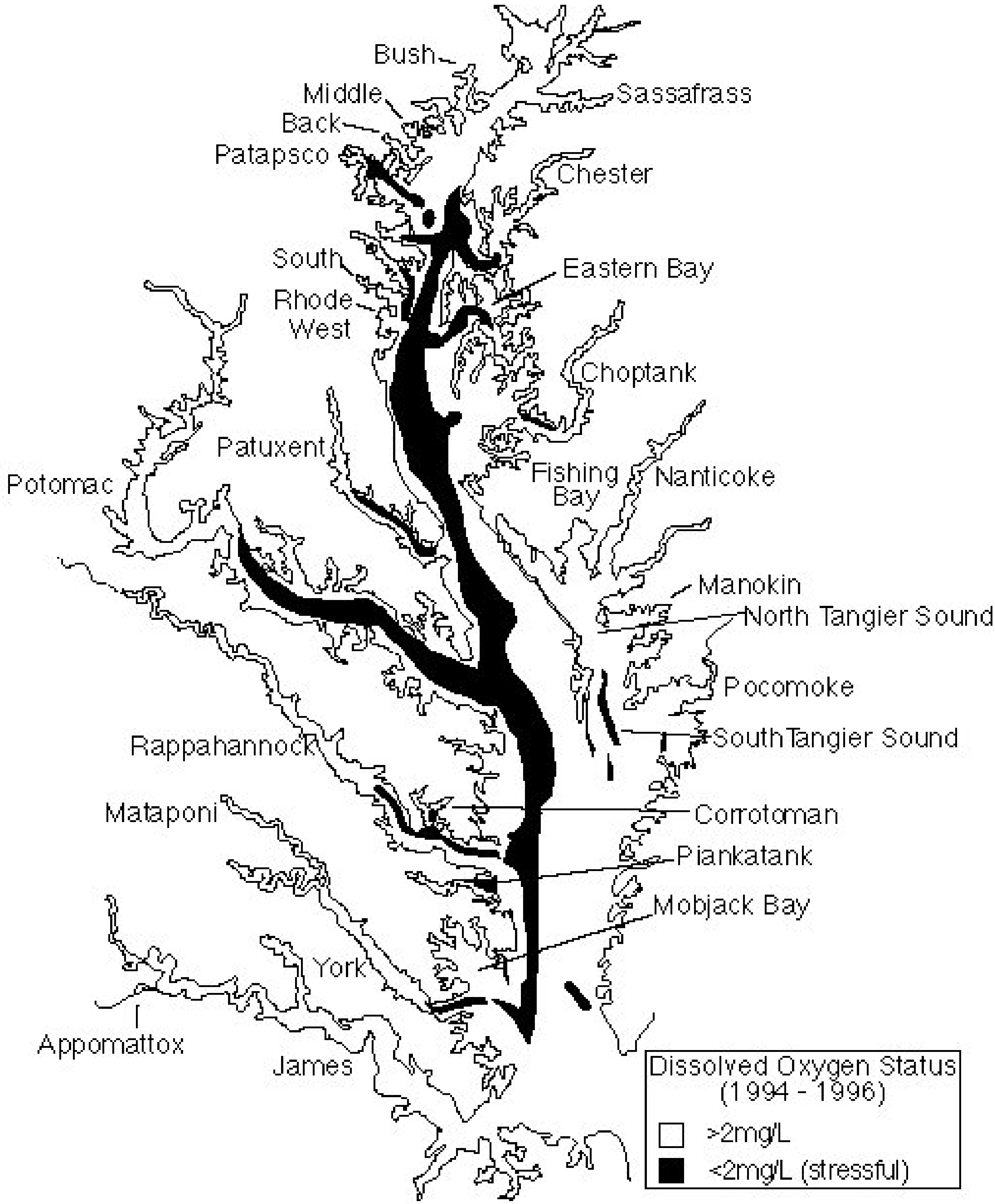
Source: Chesapeake Bay Program

Condition of Benthic Community in Bottom Waters
of Tidal Tributary and Mainstem Chesapeake Bay Segments



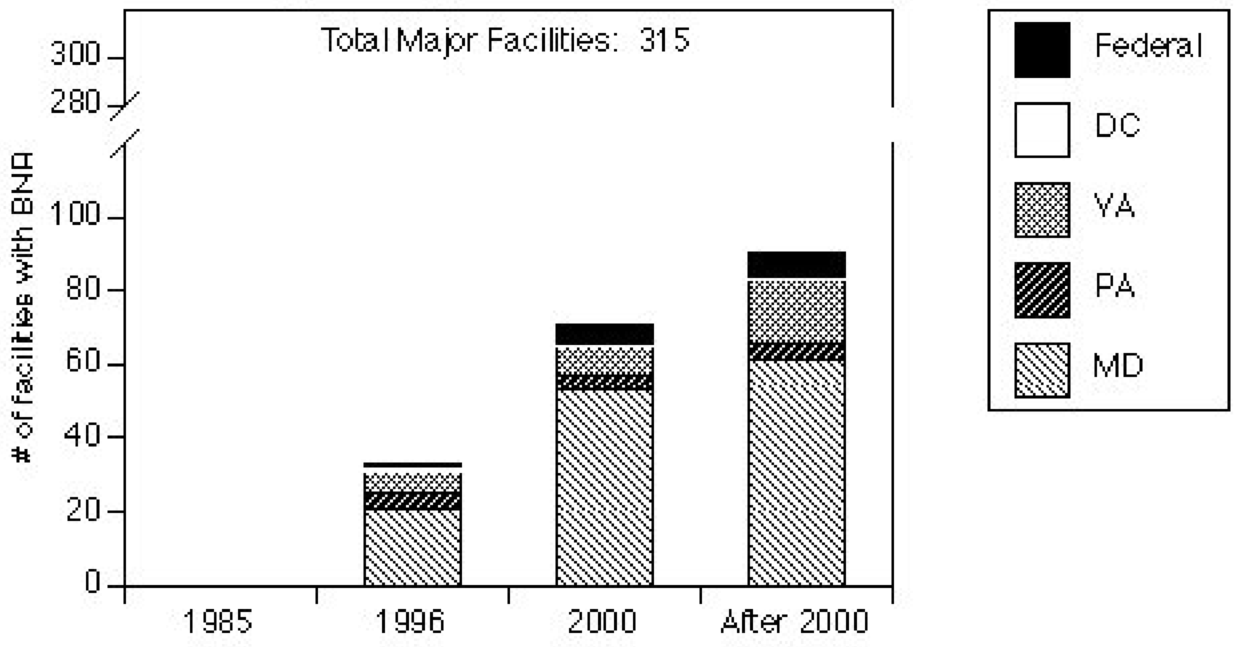
Source: Chesapeake Bay Program

Bottom Waters with Low Summer Dissolved Oxygen Concentrations
in Tidal Tributaries and Mainstem Chesapeake Bay



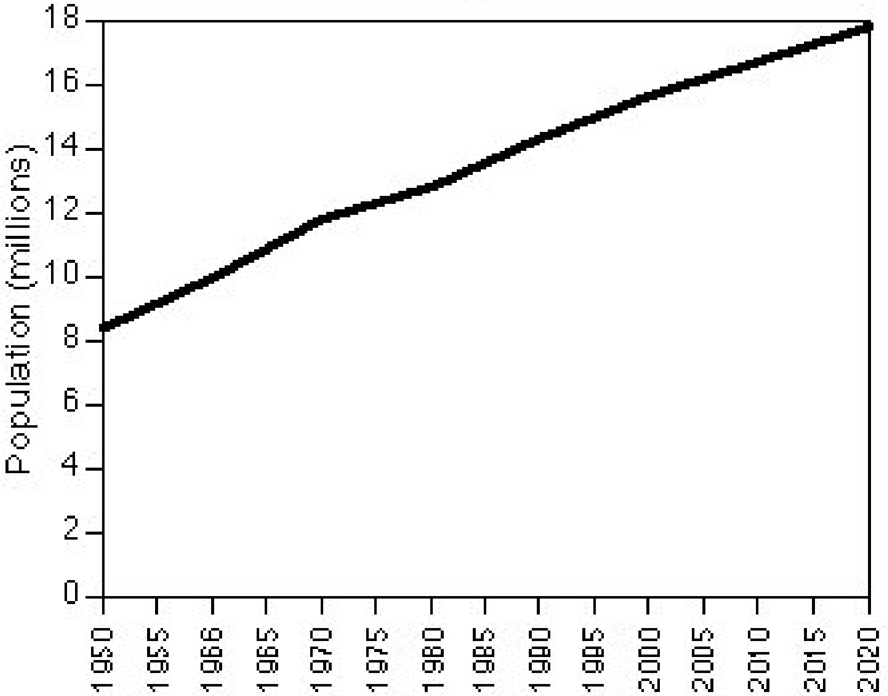
Source: Chesapeake Bay Program.

Municipal Wastewater Treatment Facilities Using Biological Nutrient Removal



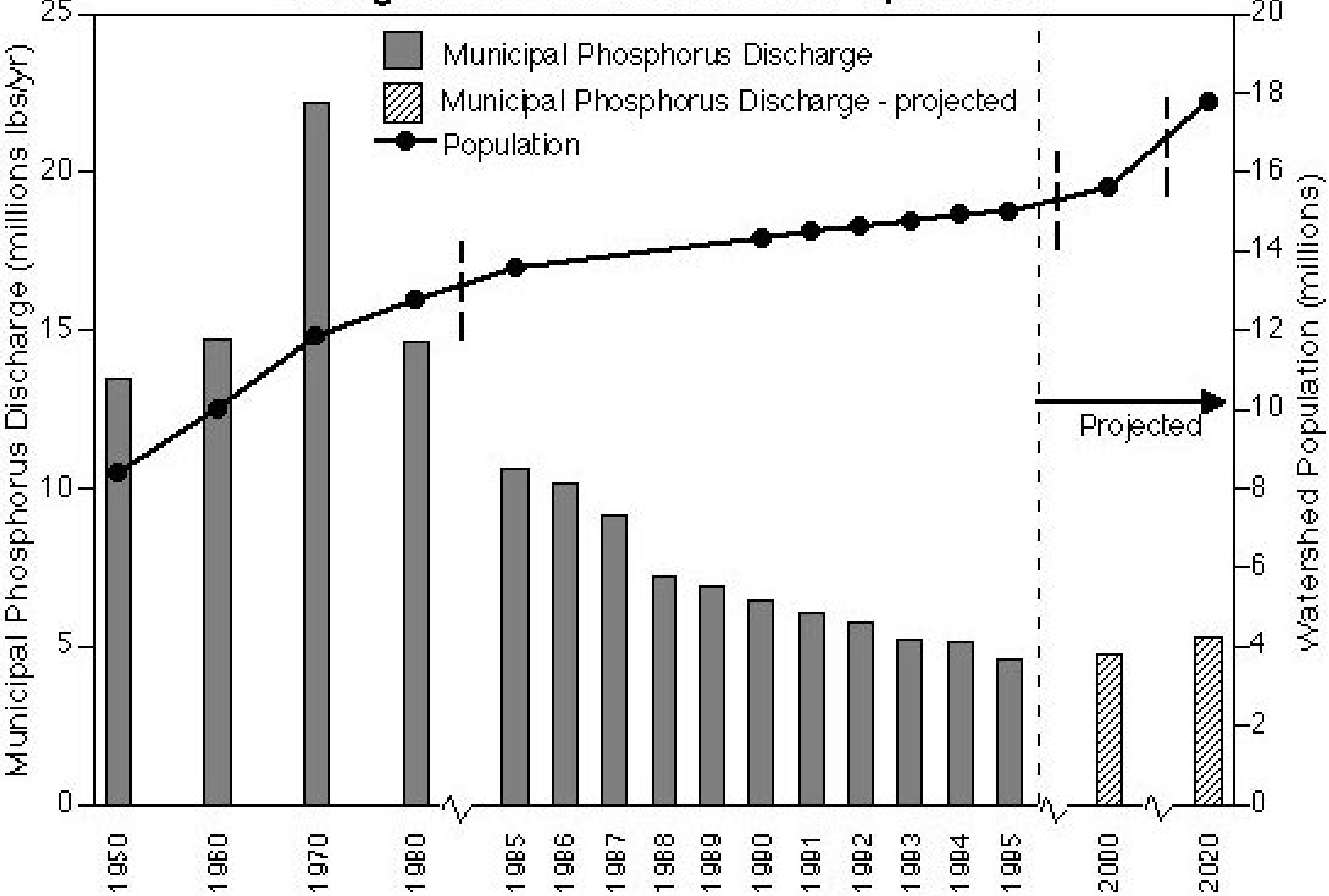
Source: Chesapeake Bay Program

Basinwide Population Trends



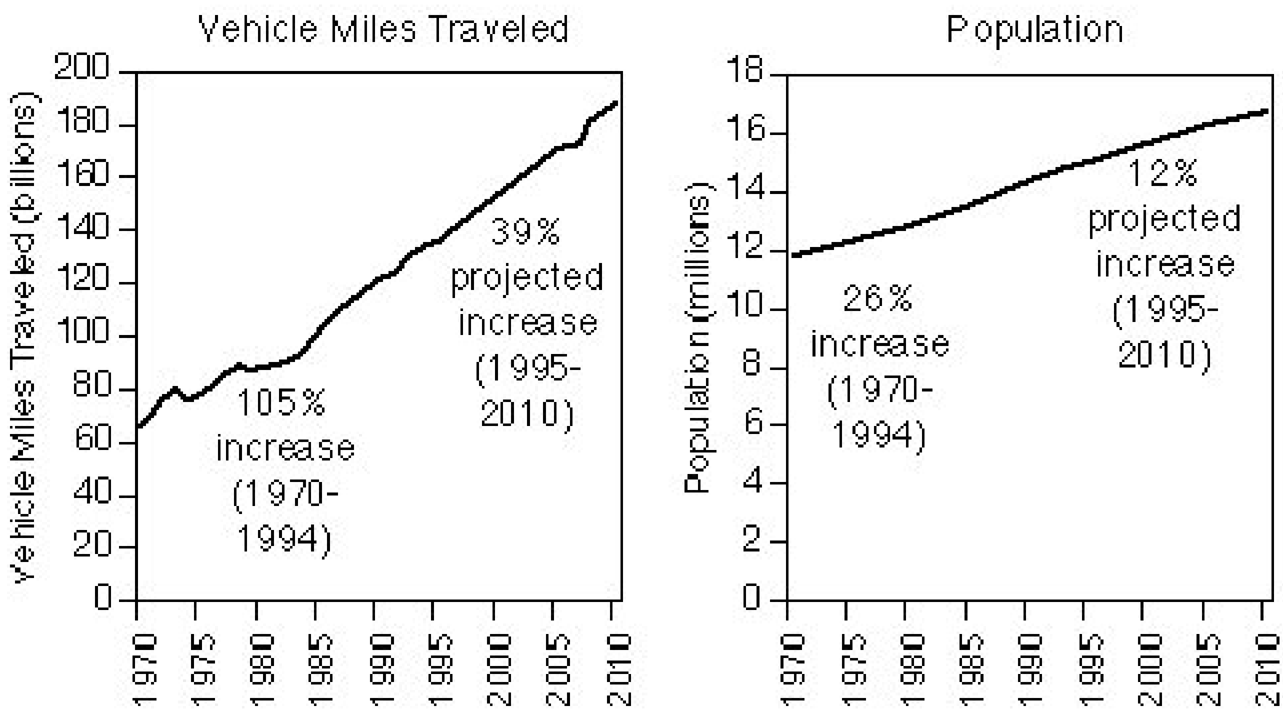
Source: Chesapeake Bay Program

Phosphorus Discharge Load from Municipal Wastewater Treatment Facilities through 2020 vs. Watershed Population



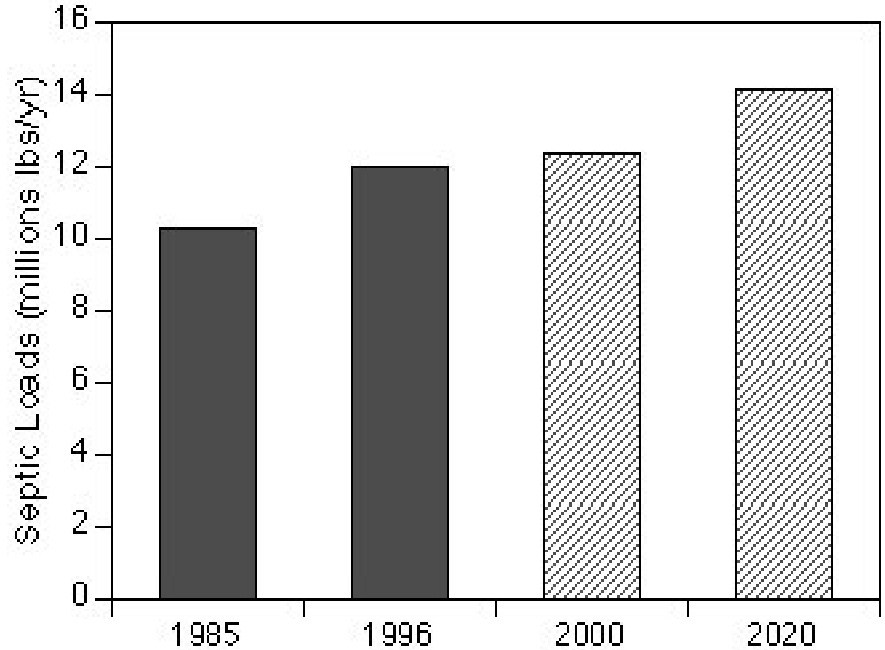
Source: Chesapeake Bay Program

Vehicle Miles Traveled Outpace Population Increases



Source: Chesapeake Bay Program

Basinwide Nitrogen Loadings from Septic Tanks



Source: Chesapeake Bay Program