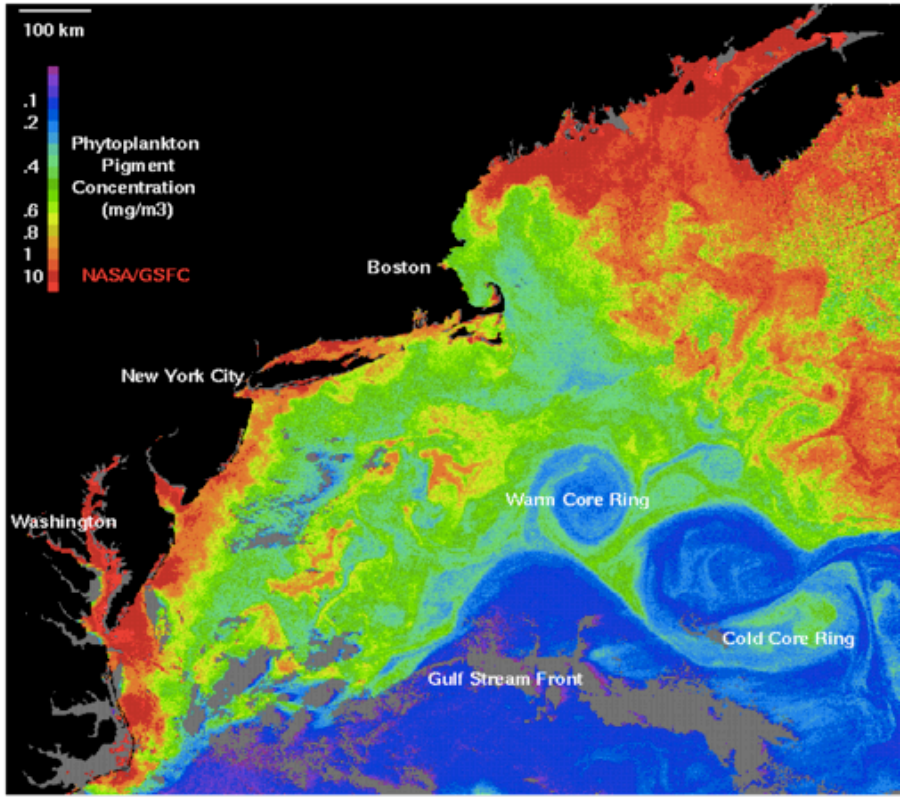
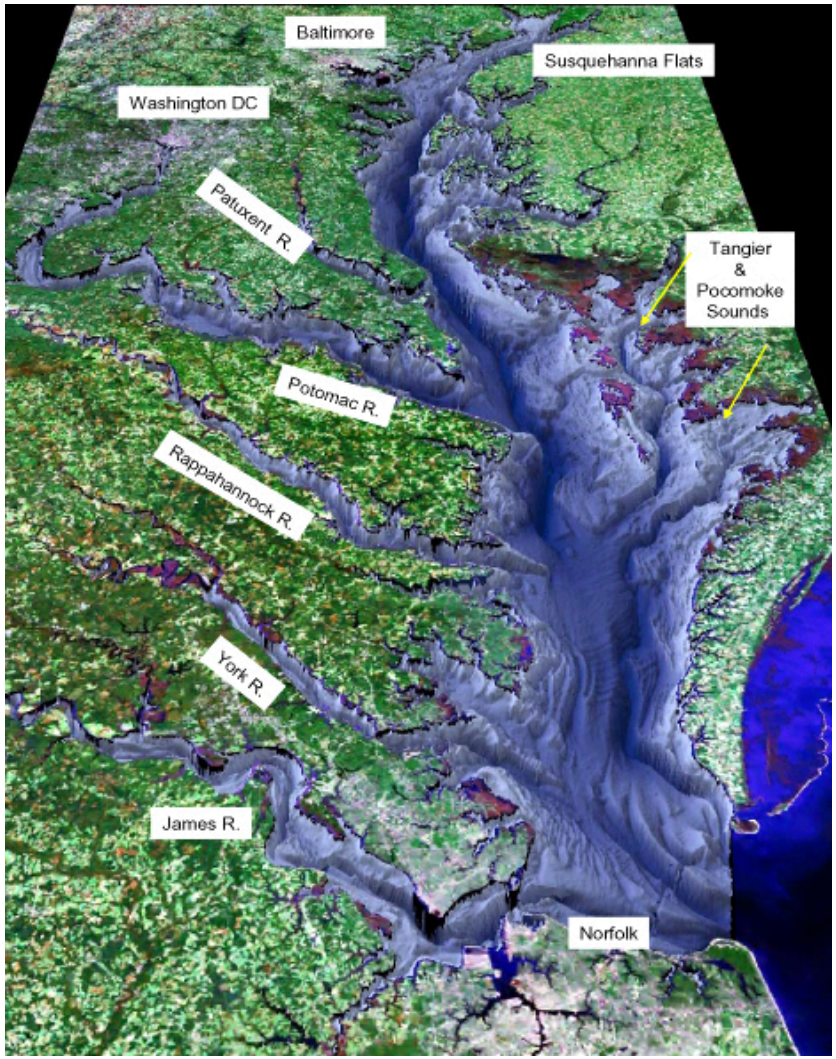
Coastal Ecosystems: Saving Chesapeake Bay





Note the highest pigment concentrations (red) in coastal regions, especially estuaries

Coastal Ecosystems: human impacts

- Humans severely impact the coastal zone through their activities. In this slideshow we discuss the impact that they (you?) have had on Chesapeake Bay, and we show the improvements that have occurred in the Bay as the result of dedicated groups of people in its watershed. You should visit www.chesapeakebay.net and www.eco-check.org for more detailed information and resources. Most of the students in this class of Geosc040 lived in the watershed. Do you?

Chesapeake (a little ditty by Mike Arthur, accompanied by mandolin in Gmin)

Chesapeake your productive waters once drew us to your shores
Ample food for our sons and daughters but we asked for more and more
Now the blue crabs are depleted and your oysters are no more
Yet you are not defeated though your health is rated poor
Chesapeake we cannot let you die

Runoff from a dozen rivers carries a human stain
Pollutants from their graceless givers washed in with every rain
Your waters they are overwhelmed by nutrients and silt
It seems that no one's at the helm of this juggernaut we've built
Chesapeake we cannot let you die

The algae bloom in great profusion blocking out the light
Resulting in the vast exclusion of air for deeper sites
And even all the fish are fleeing from your waters so replete
With nutrients nearly guaranteeing a "dead zone" quite complete
Oh Chesapeake we cannot let you die

What can we do, it breaks our hearts, write checks to "Save the Bay"
Feeling that we've done our parts, we shrug and walk away
But we are all responsible for the flood of N and P
Fixing just what ails the Bay is simply up to you and me
Oh Chesapeake we will not let you die

Gulf of Mexico “Dead Zone”

- Gulf of Mexico, associated with Mississippi River
- “Hypoxia”: large area of oxygen- deficient seawater below ocean surface shown in yellow
- Excess nutrients to blame?

River Source for Nutrients

- Streamflow and dissolved nitrate fluxes to the ocean through the Mississippi River
- Note more than a doubling of N flux since 1950s
- Sources:
  - Fertilizer runoff
  - Sewage treatment
  - Non-point sources

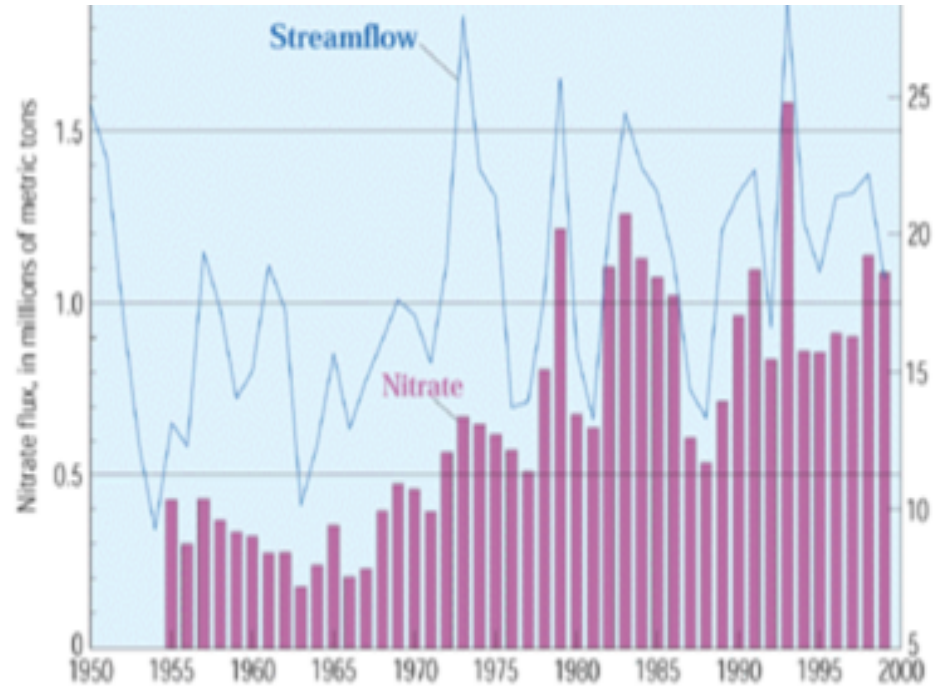


Figure 4. Annual nitrate flux and mean annual streamflow from the Mississippi River Basin to the Gulf of Mexico.

Hypoxia in Long Island Sound

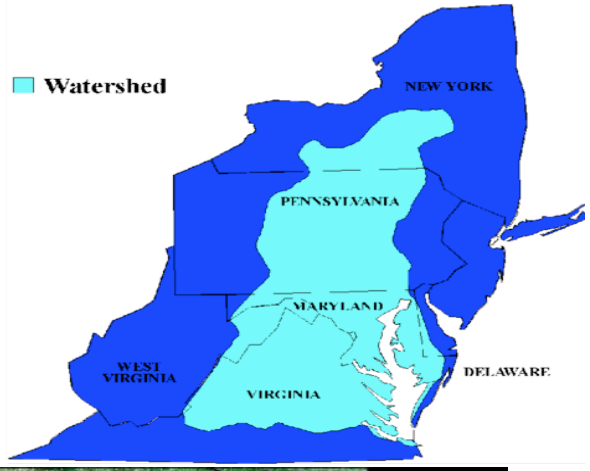
- Decreasing area of habitable seafloor as result of increasing oxygen deficiency
- Factors: poor circulation (restricted exchange with open waters) and eutrophication (excessive nutrient loading) resulting from progressively increasing inputs of nutrients from land. (see next page for definitions)

Key Definitions

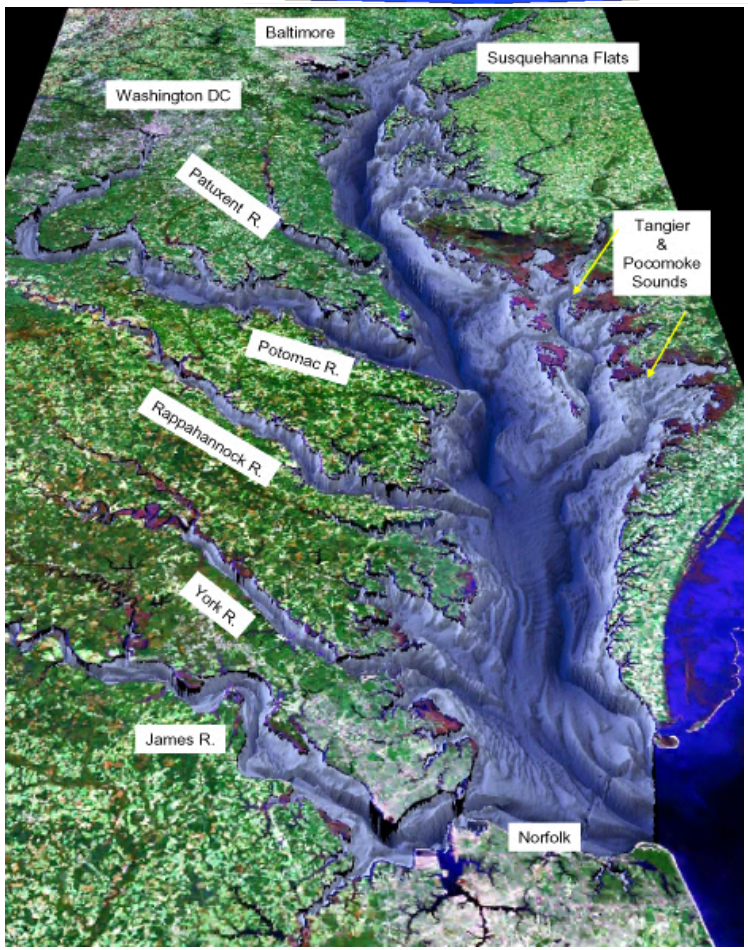
- Hypoxia--
  development of low concentrations of dissolved oxygen near bottom that are deleterious to organisms (different organisms have different tolerances)

- Eutrophication--
  an environmental nutrient excess that stimulates algal production of organic matter in excess of that which can be respired without consuming available dissolved oxygen

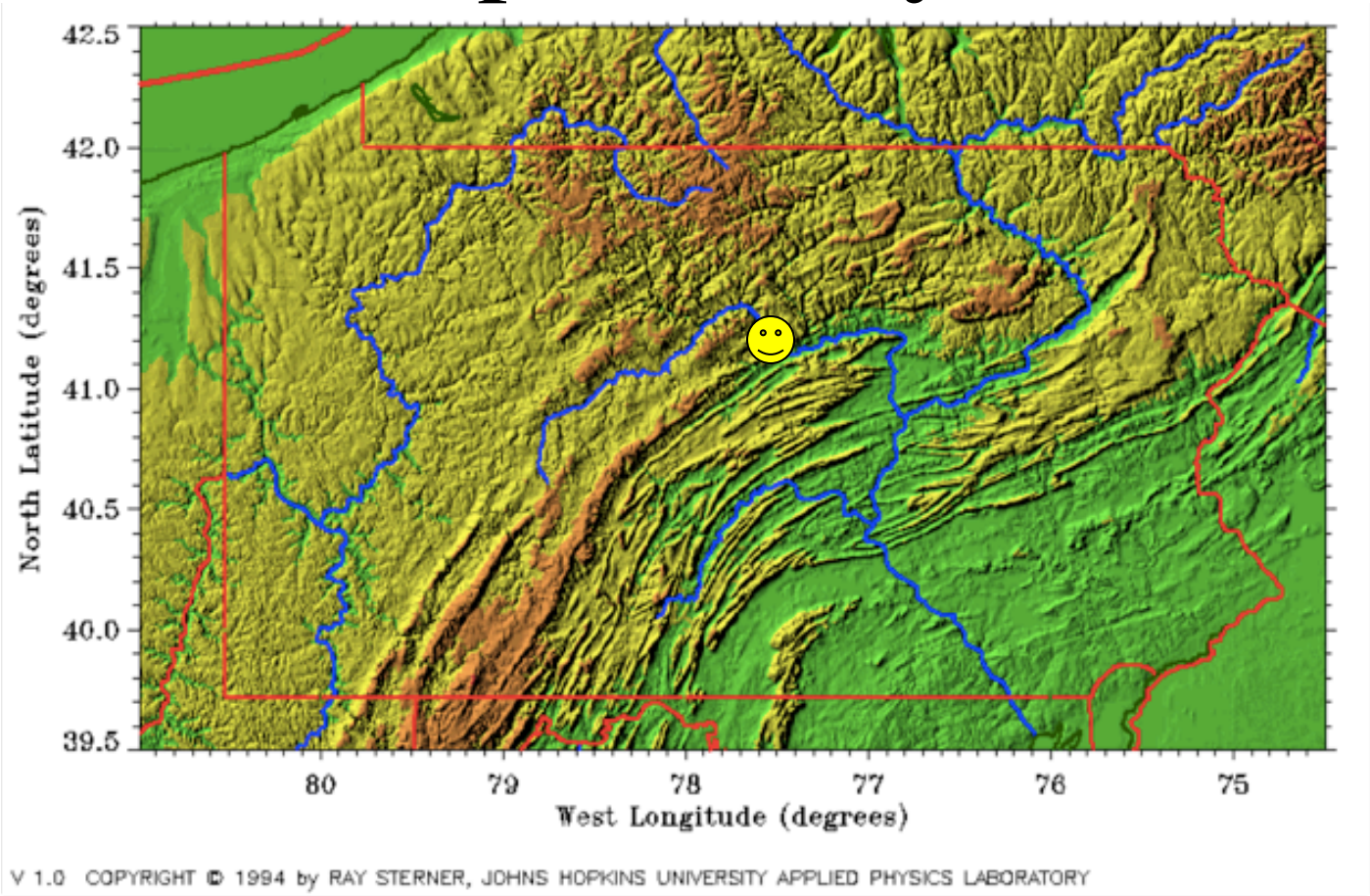
The Chesapeake Bay Watershed



- The Chesapeake Bay watershed includes the Susquehanna River system and the Potomac among other smaller rivers and tributaries. In all, parts of 6 states, including some large cities (e.g. Baltimore, Washington DC, Richmond) and industrial regions as well as extensive agricultural tracts, compose the watershed
- Chesapeake Bay is a drowned estuary, incised by rivers during the last glacial sealevel lowstand and flooded during glacial melting and accompanying sea level rise (by about 6-7kyrs. ago)--but you know this already from Lesson 5, right?



We (at PSU) are in the Chesapeake Bay watershed



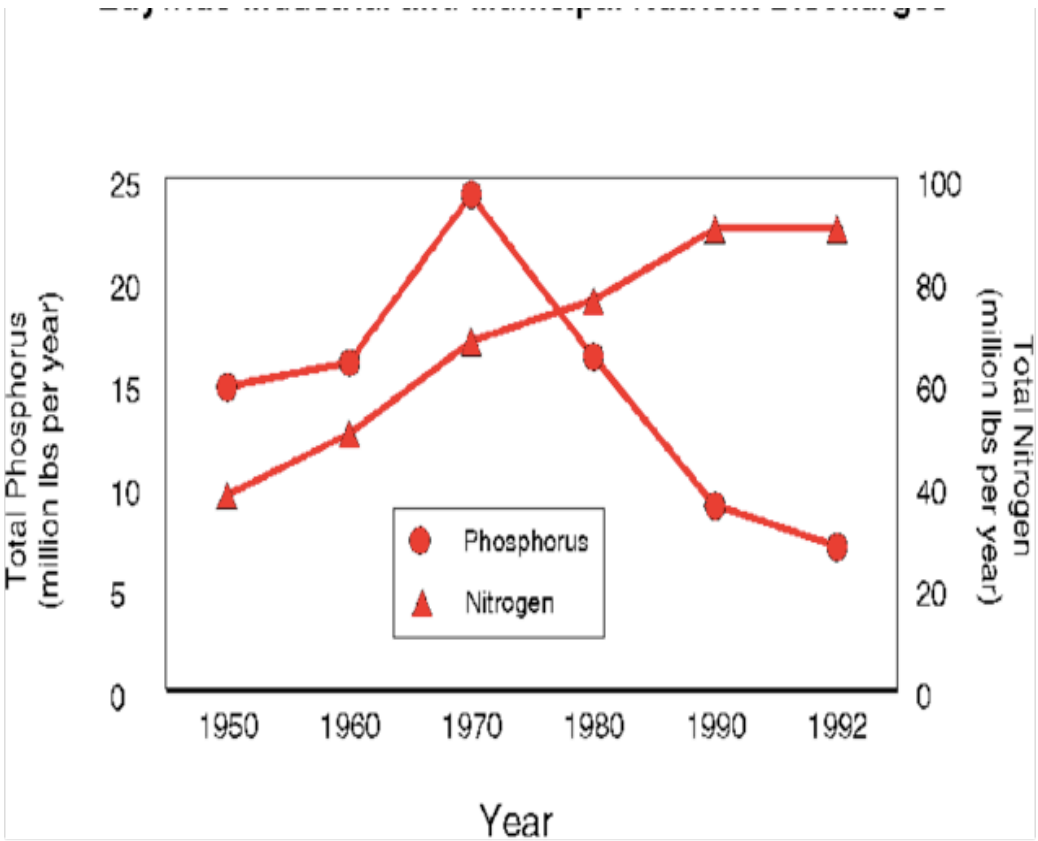
- The Susquehanna River drains into Chesapeake Bay
- PennState practices impact the Bay (you can “act locally”)

A Major Problem: Eutrophication

The viscious cycle:

- Excess nutrients supplied in rivers to the Bay support luxurious growth of phytoplankton (microscopic plants) blooms
- sinking organic matter (sewage sludge has same net effect) is oxidized by bacteria, thereby consuming oxygen
- oxygen deficits occur in bottom waters--these are harmful to benthic organisms, many of which have economic value
- the nutrients released during respiration in deeper waters are cycled back to the surface and produce more blooms and further organic matter loading
- a lack of mixing (stratification) resulting from seasonally strong salinity and temperature gradients (surface to bottom) prohibits oxygenation of bottom waters.

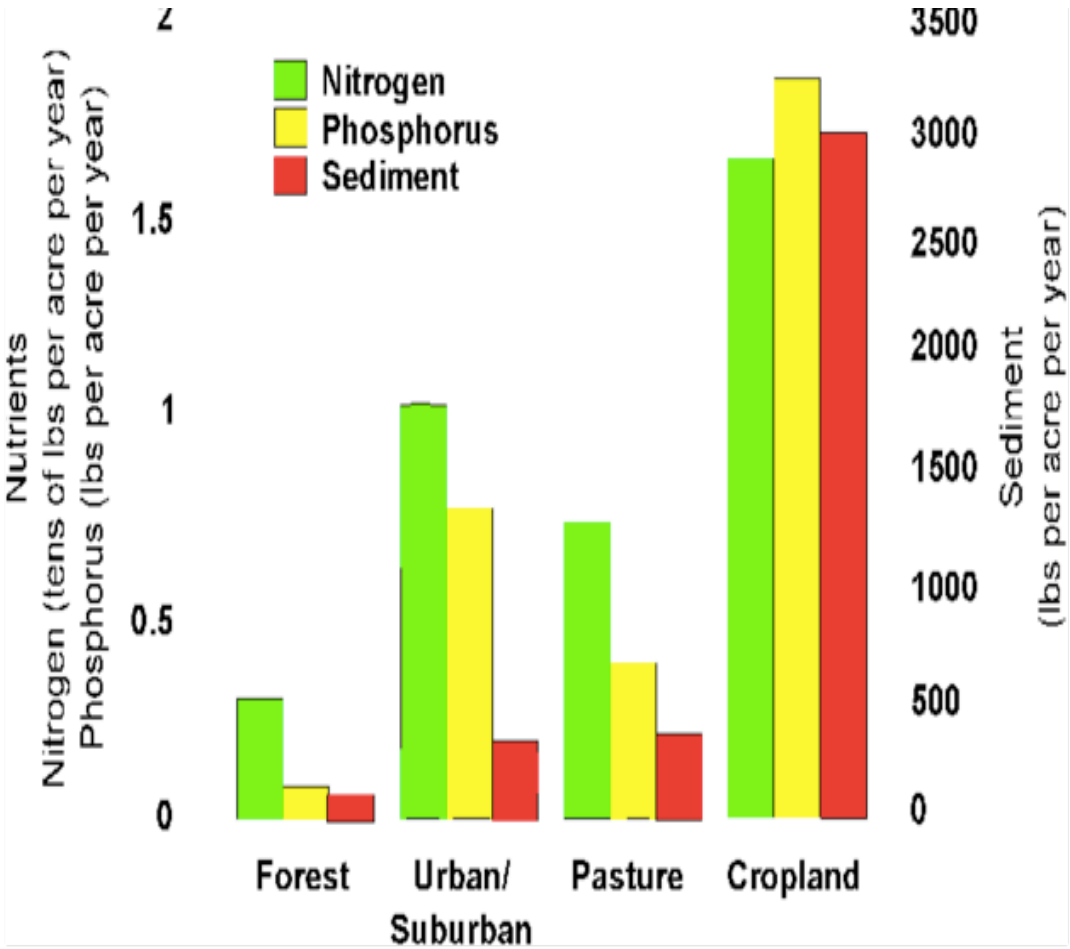
Nutrient Discharges



- Phosphorus discharges were reduced after the early 1970s as result of ban on P in laundry detergents! (see, activism can help!).
- Nitrogen inputs, however, continued to increase and have now levelled off. What are sources of N that could be reduced?

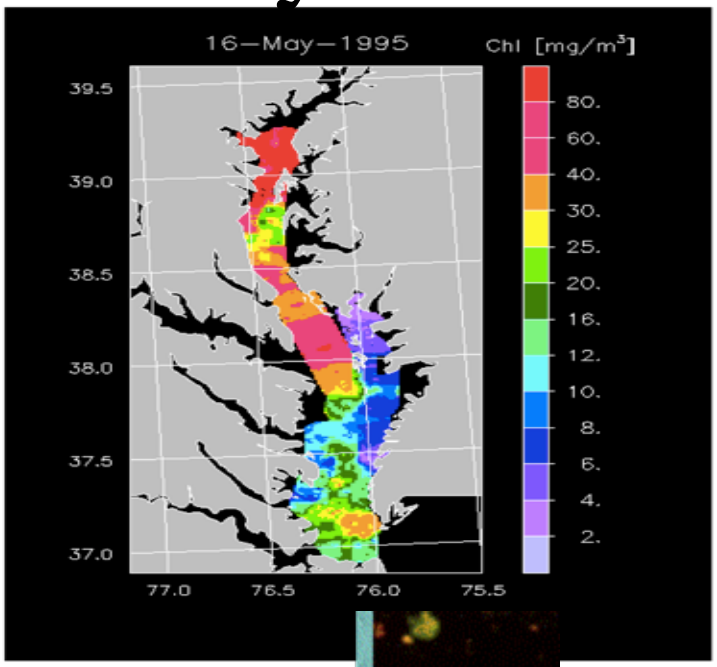
Main Sources of Nutrients and Sediment

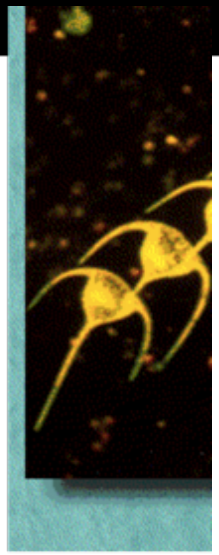
- Clearly, agricultural operations are a major source of nutrients on a per acre basis.
- Widespread adoption of "best practice" methods of tilling and fertilizer application would reduce runoff of nutrients
- Increasing forested regions and/or forest or wetland "buffers" along streams could also help reduce nutrient runoff.



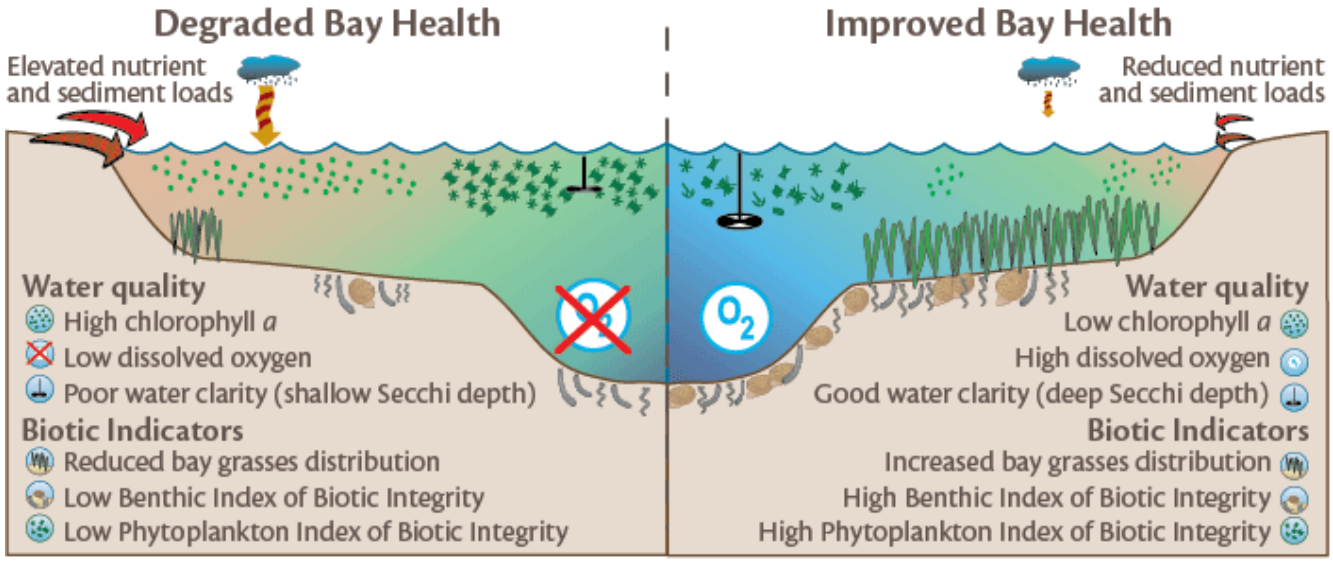
Phytoplankton Blooms in an Eutrophic Estuary

- Top panel--May 16, 1995 (source NOAA) Note gradient of chlorophyll concentrations (mg/liter)with highest values (red) near river mouths
- Eutrophication leads to blooms of nuisance phytoplankton (low food value and/or toxic “red tides” Note *Ceratium* dinoflagellate to right as an example.

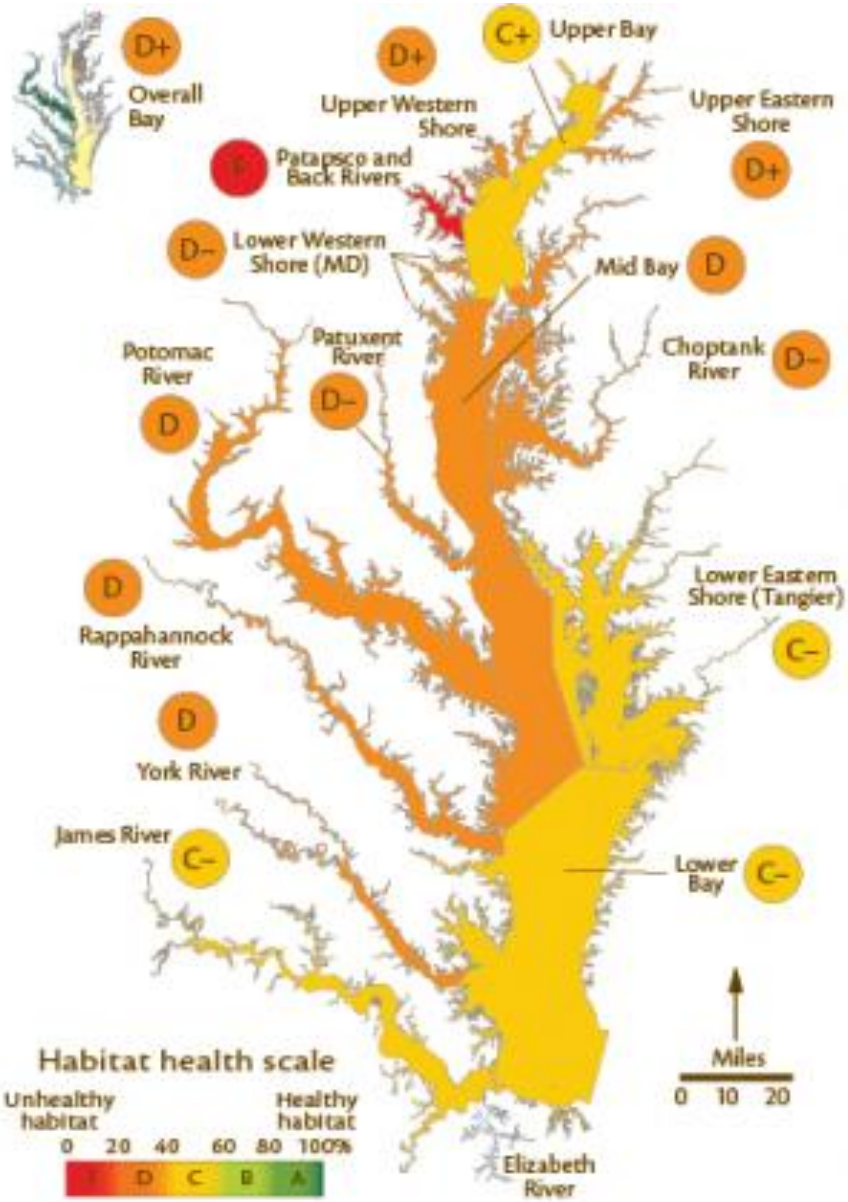




Chesapeake Bay Health Rated Methods



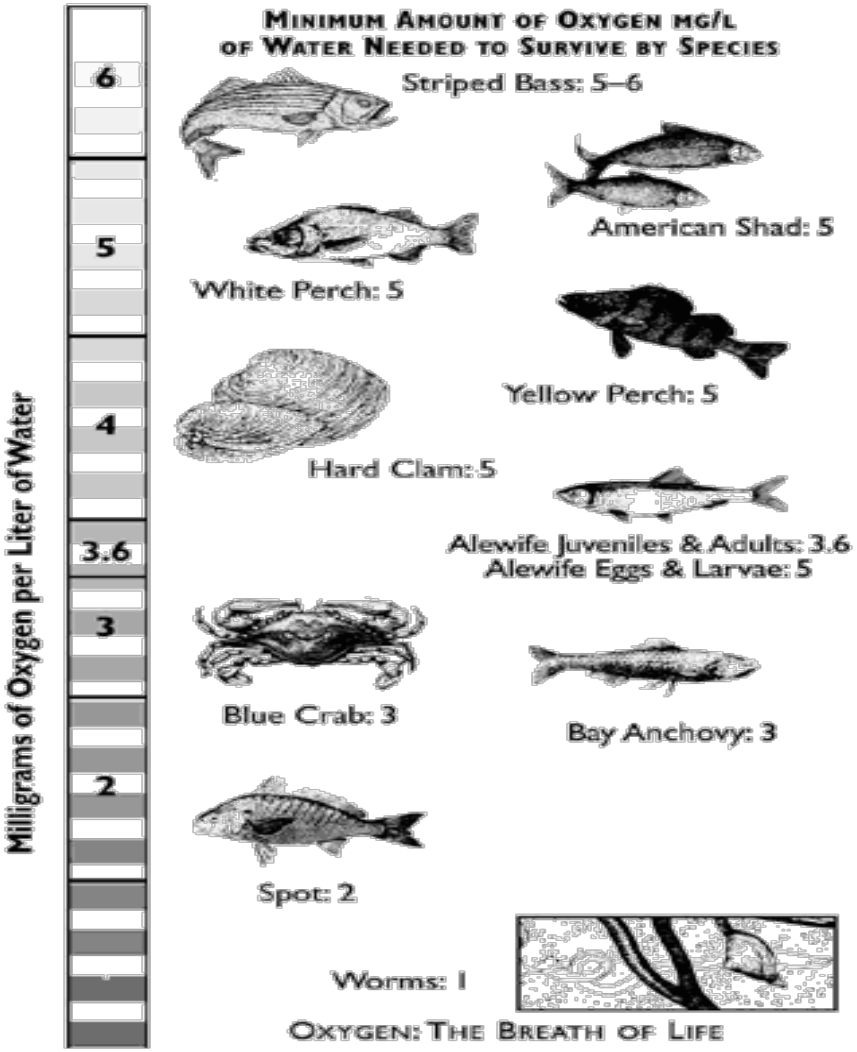
Chesapeake Bay "Report Card"



According to a 2007 analysis.

Response of Organisms to Low Dissolved Oxygen Concentrations

- Prolonged periods of dissolved oxygen below about 2 mg/L eliminate most “seafood” from the affected region
- Each organism has its own tolerance limits
- Values of dissolved oxygen at or above 5 mg/L are considered “healthy”
- During the summer, between 30 -40 % of the volume of the Bay experiences values <5 mg/L



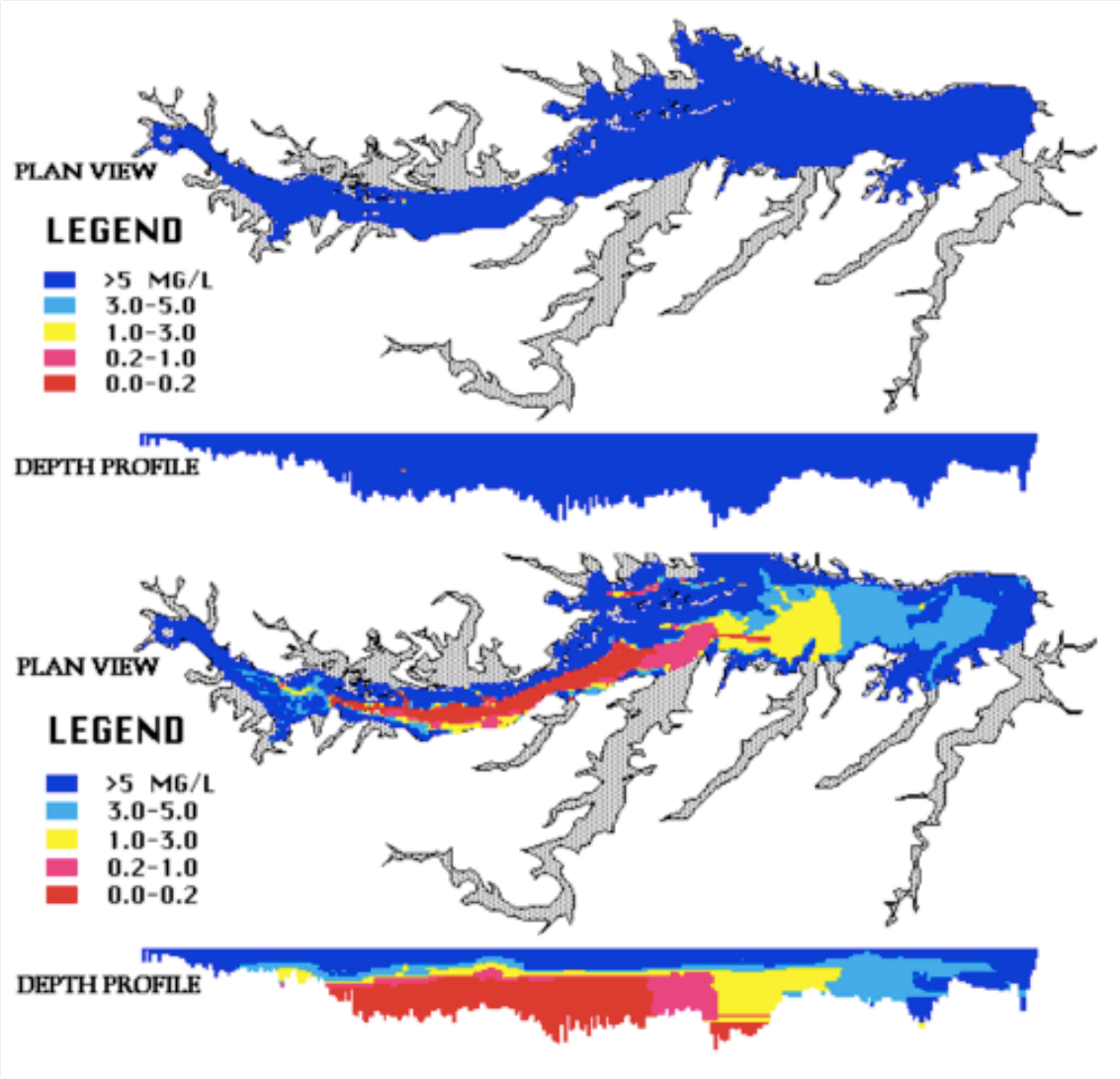
Effects of Climate Change?

POTENTIAL IMPACTS OF GLOBAL WARMING ON CHESAPEAKE BAY FISHERIES

- Potential loss of species altogether in the Chesapeake Bay
- Likely decline in species range or viability in the Chesapeake Bay
- Likely expansion of species range or viability in the Chesapeake Bay

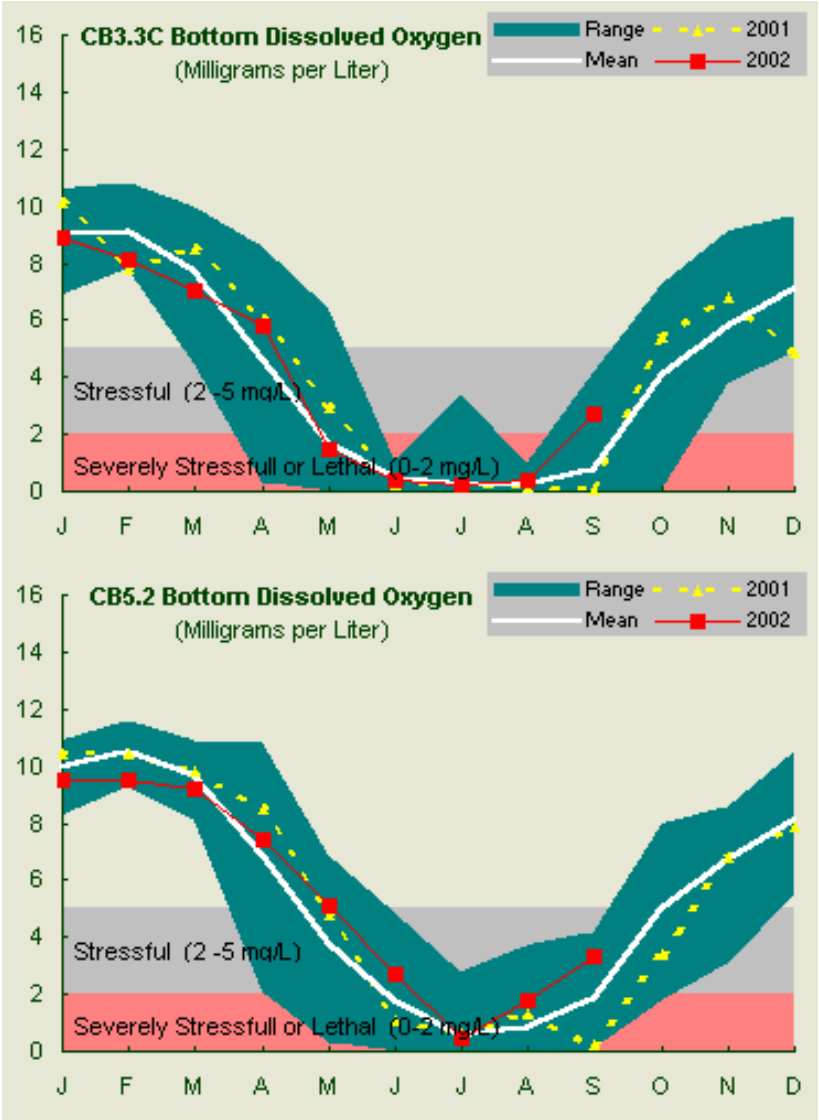
SPECIES	LIKELY TREND	CLIMATE CHANGE IMPACTS IN CHESAPEAKE BAY
Winter flounder		Water temperatures could exceed habitable range.
Soft-shelled clam		Water temperatures could exceed habitable range.
Rockfish		Water temperatures could reach near the upper limit of habitable range and also conducive to outbreaks of mycobacterial infections.
Atlantic sturgeon		Water temperatures could reach near the upper limit of habitable range.
Blue crab		Declining eelgrass habitat with rising sea level and exacerbated eutrophi-cation.
Atlantic menhaden		Warmer water more conducive to mycobacterial infections.
Eastern oyster		Warmer water more conducive to Dermo and MSX.
Brown shrimp		Warmer water more favorable.
Southern flounder		Warmer water more favorable.
Black drum		Warmer water more favorable.
Grouper		Warmer water more favorable.
Spotted seatrout		Warmer water more favorable.

Oxygen Concentrations in Chesapeake Bay



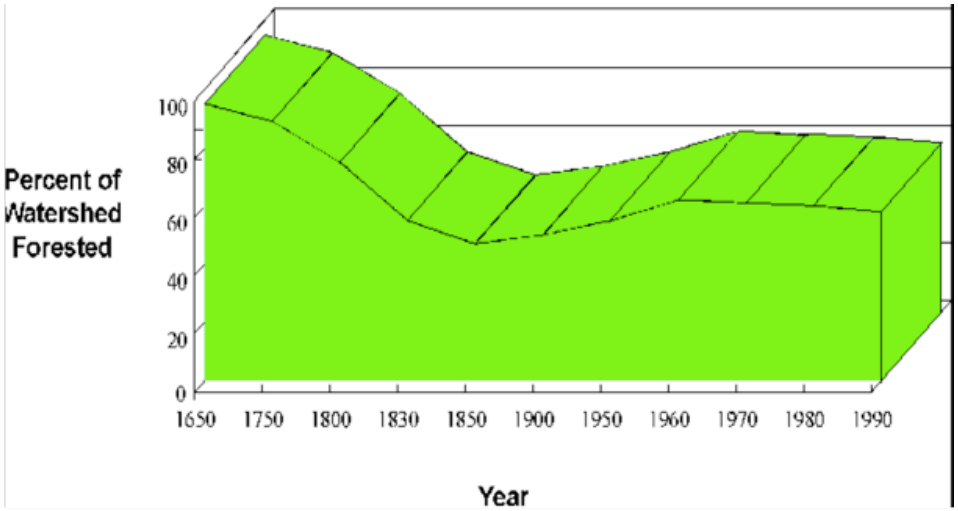
- Plan view and cross sections down the Bay showing seasonal contrasts (top March, bottom July) in dissolved oxygen concentration. Oxygen concentrations drop in July because of thermal stratification (reduced mixing) and increased deep respiration.

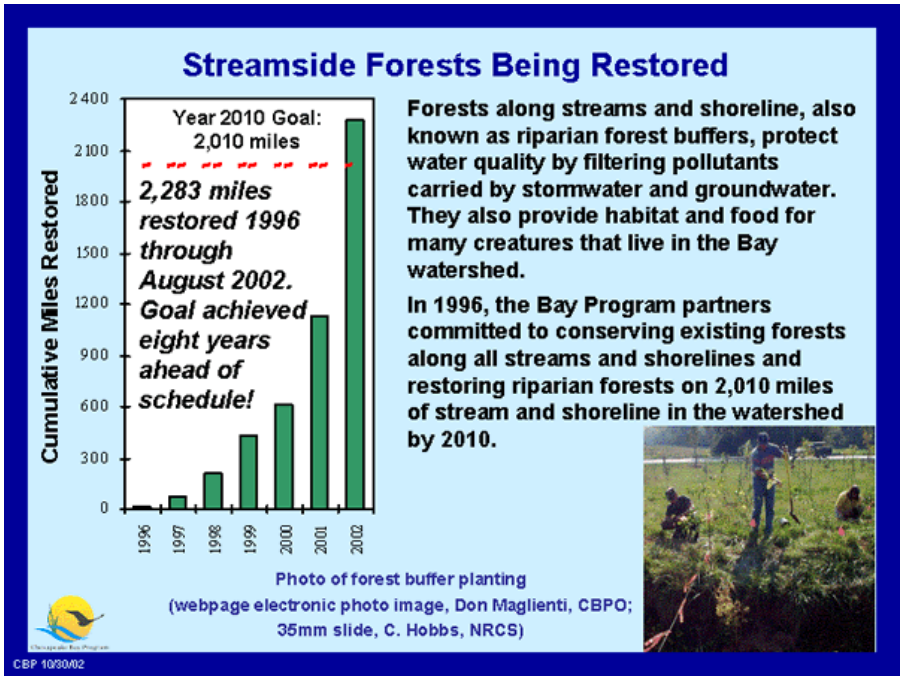
Dissolved Oxygen in Bottom Waters



- Dissolved oxygen at the bottom varies over the seasons and by region in Chesapeake Bay.
- Note that summer warming and stratification can bring stressful to lethal conditions.
- The upper panel provides measurements for 2001-2 at the Bay Bridge, while the bottom panel shows measurements in the Potomac R. sector.
- Generally, oxygen deficiencies are more severe in the upper Bay.

Forests and Forest Buffers

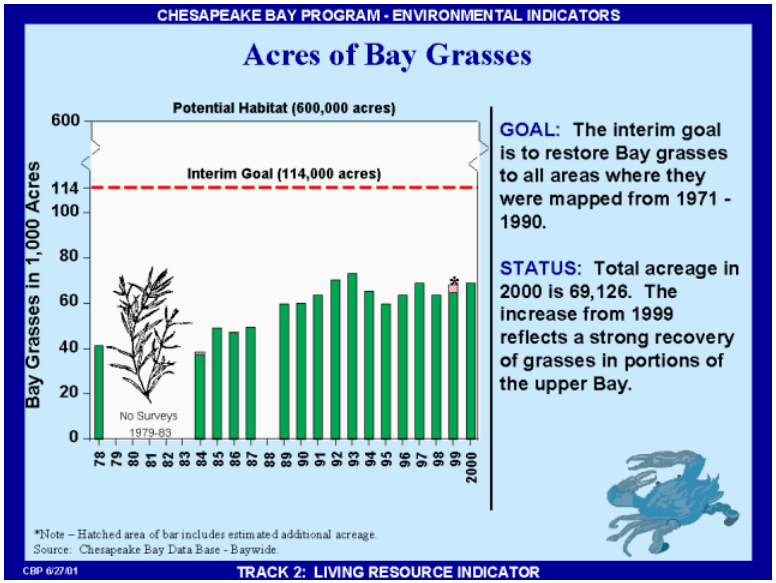




- When colonists first arrived virtually 100 % of the Chesapeake Bay watershed was forested.
- By 1850, about 50% of the forests were gone--to clearing for agriculture, timber harvested for building and for fuel.
- Whole hillsides were stripped of cover and sediment eroded and carried to the Bay in the mid-19th Century.
- Seagrass beds and suitable habitats for Blue Crabs, oysters and other shellfish were destroyed as a result.
- Riparian woodlands are being replanted in new programs.

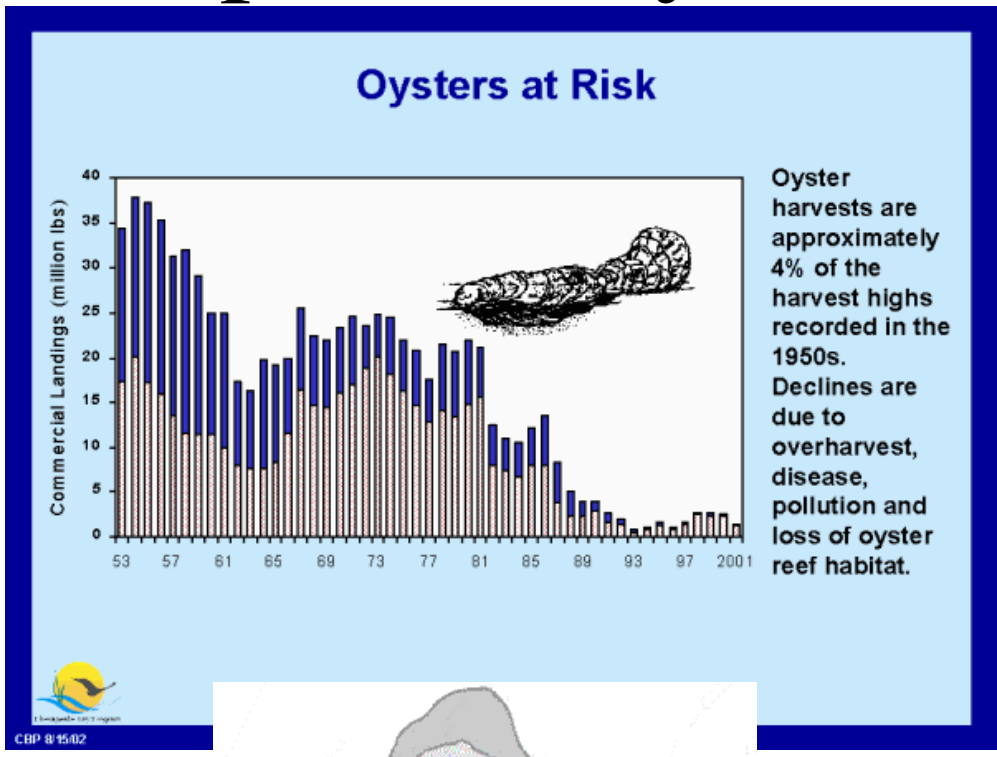
Other Impacts

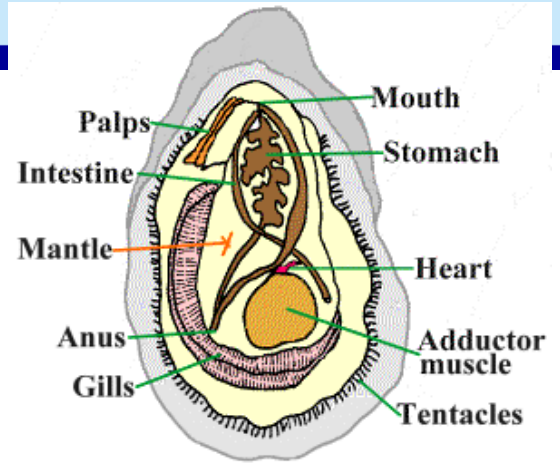
- Sedimentation (particulates carried by rivers) and shading by phytoplankton blooms has contributed to reductions of the area of Bay grasses, which are habitats for many organisms, especially during larval stages.
- Bay grass distribution at present is probably only about 20% of the area once inhabited in the Bay. Some recovery is occurring as the result of efforts to reduce sediment and nutrient flux.



Oysters in Chesapeake Bay

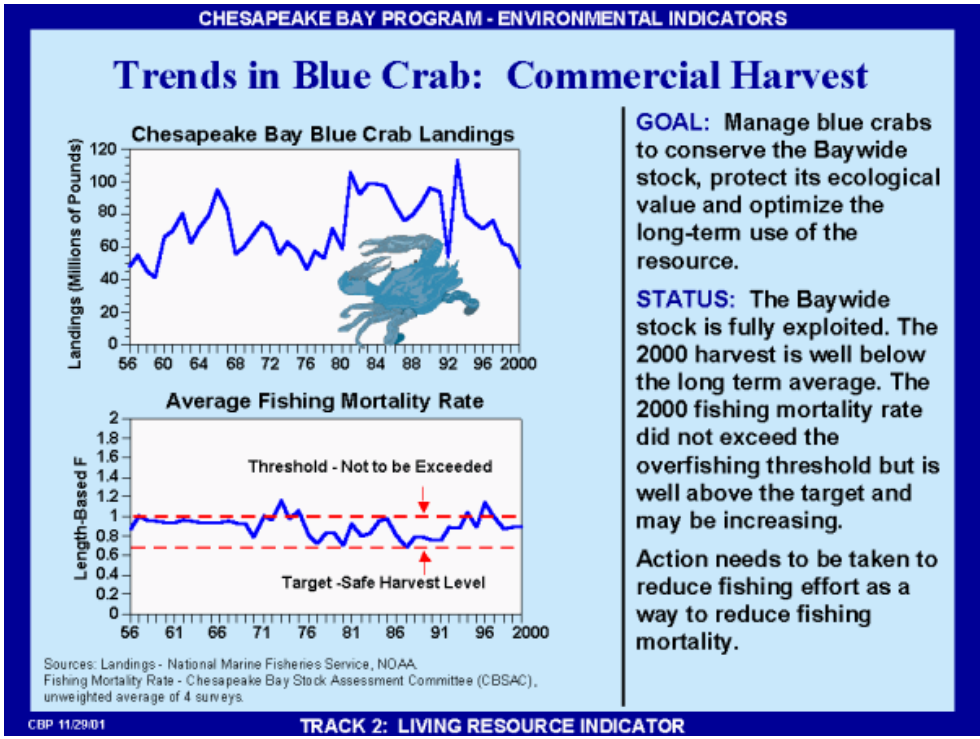
- Once plentiful in banks or reefs in the Bay, oysters have been seriously overharvested and have declined for other reasons as well. Commercial landing plummeted around 1980 and have remained low (gray is MD, blue is VA data)
- Two viral diseases (MSX and Dermo) presently infect Bay oyster populations.
- In addition, bottom conditions have changed significantly over the past several decades (increased sedimentation, low oxygen).





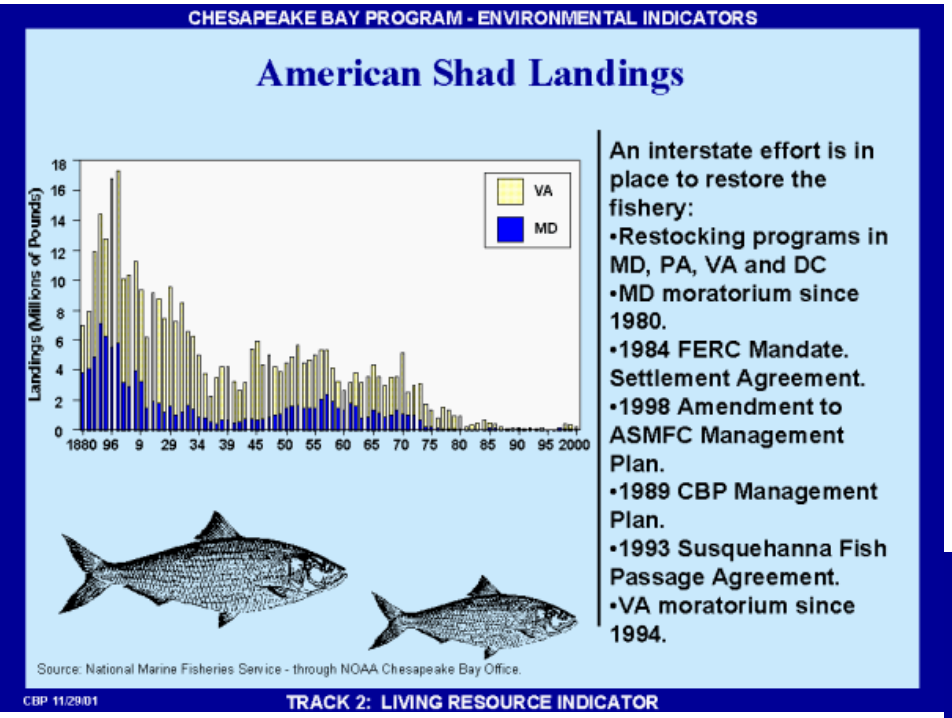
Source: www.assateague.com

Blue Crab Holding Pattern

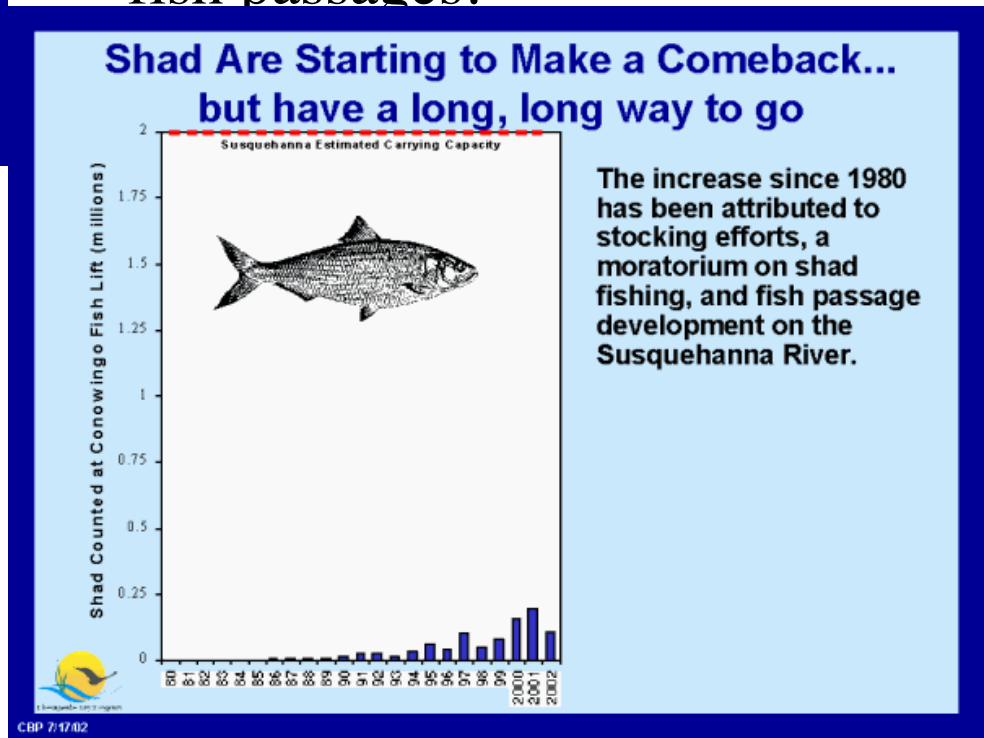


- Blue crab (*Callinectes sapidus*, meaning "beautiful swimmer") stocks are presently on the verge of a potential decline in Chesapeake Bay. Fishing limits have been imposed, but more "management" may be necessary to preserve this resource. Read William Warner's *"Beautiful Swimmers"* for a great treatment of Chesapeake Bay ecology as it existed in the 1970s.

American Shad (a shad tale?)

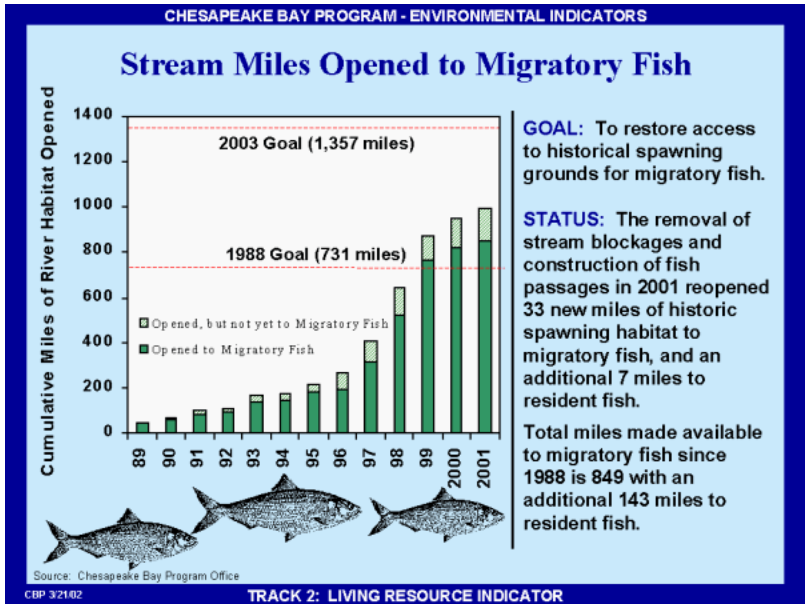


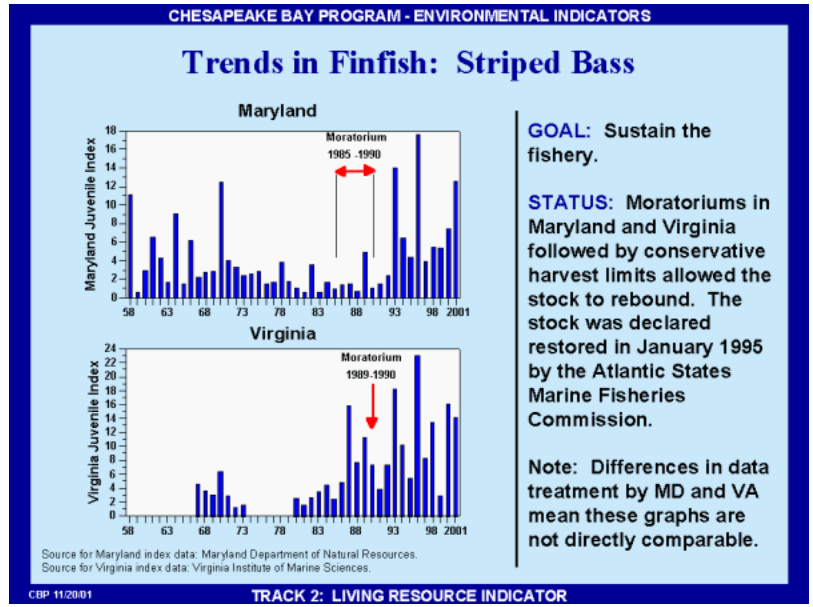
- Once very abundant in mid-Atlantic region rivers, they nearly disappeared. Now making a slow recovery (note: well below carrying capacity) as result of restocking, harvest moratoriums and improved "fish passages."



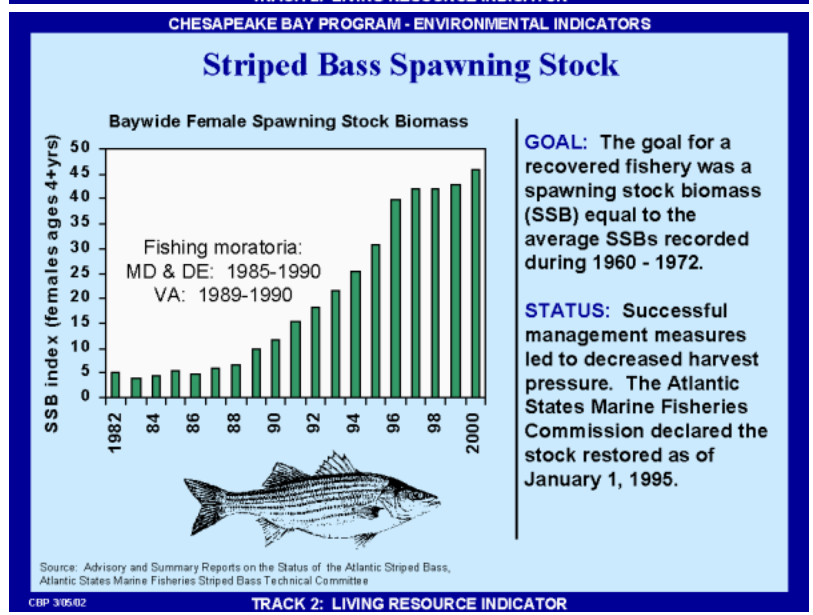
- Shad are very bony fish but dilectable when cooked properly. Shad roe is a delicacy. See 2002 *New Yorker* article by John McPhee for very well written description and shad recipes.

Evidence of Improvement

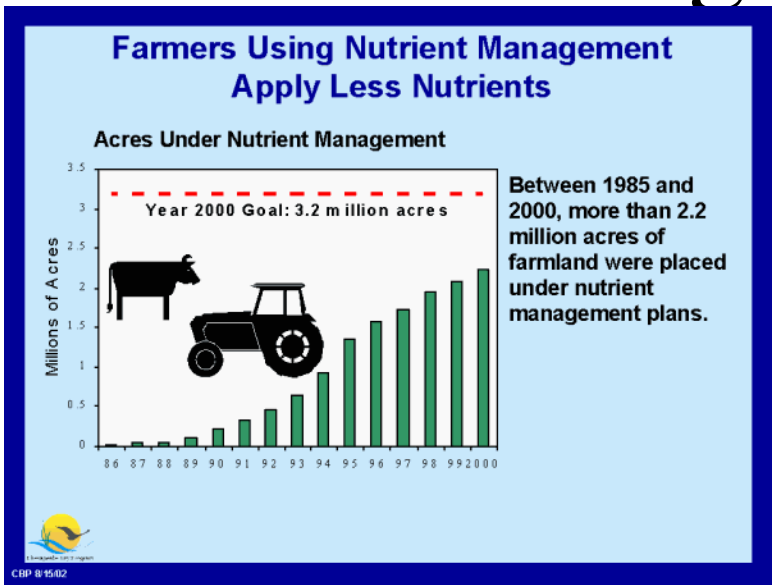


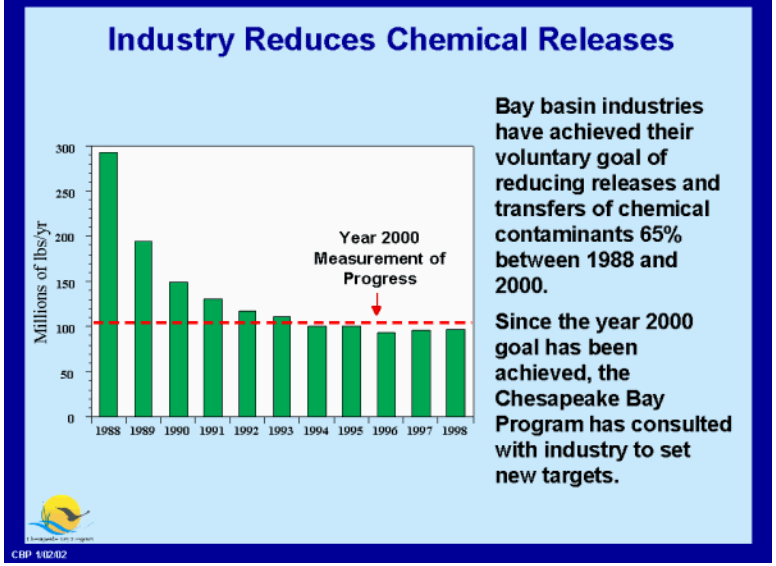


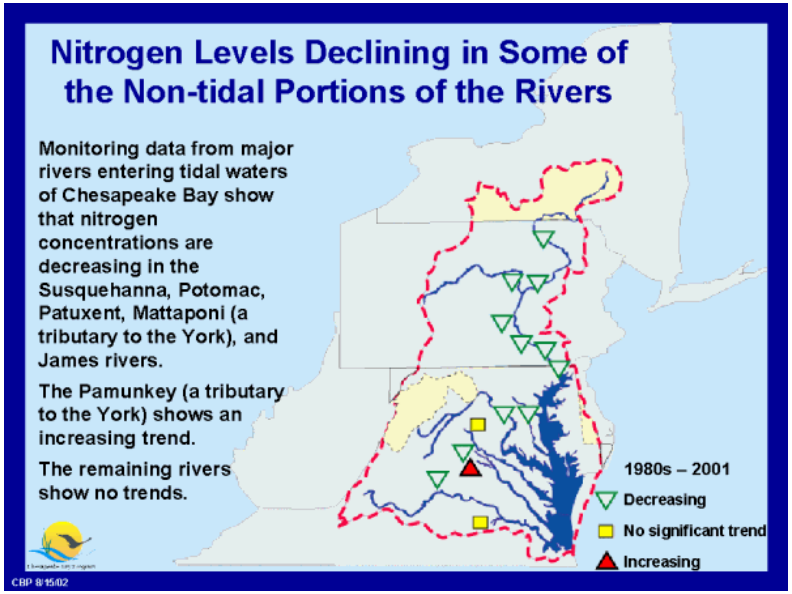
- Increased access to spawning grounds, moratoriums on catches and/or strict limits on harvest have increased striped bass stocks!



The Chesapeake Bay Program Encourages Better Practices

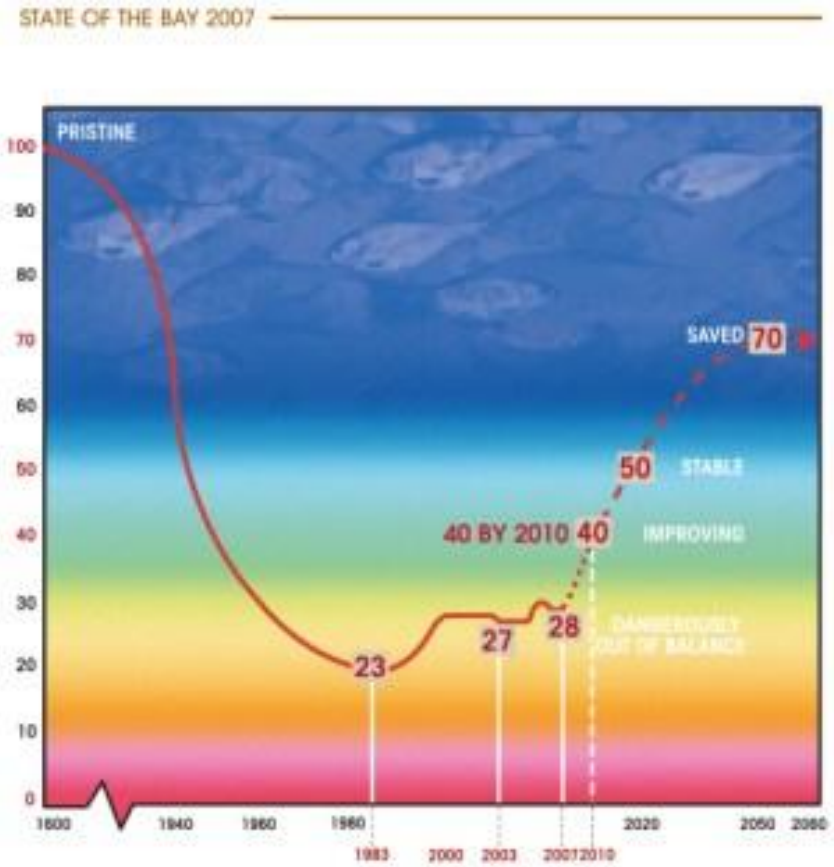






- Voluntary programs of nutrient management appear to have worked to reduce nitrogen levels in many tributaries.
- New targets need to be set to continue the beneficial trend and to eliminate "hot spots."
- Remember, you can make a difference!

The Future?



CHESAPEAKE BAY FOUNDATION
Saving a National Treasure