Climate Change Impacts in Virginia: from Natural Resources to the National Economy.

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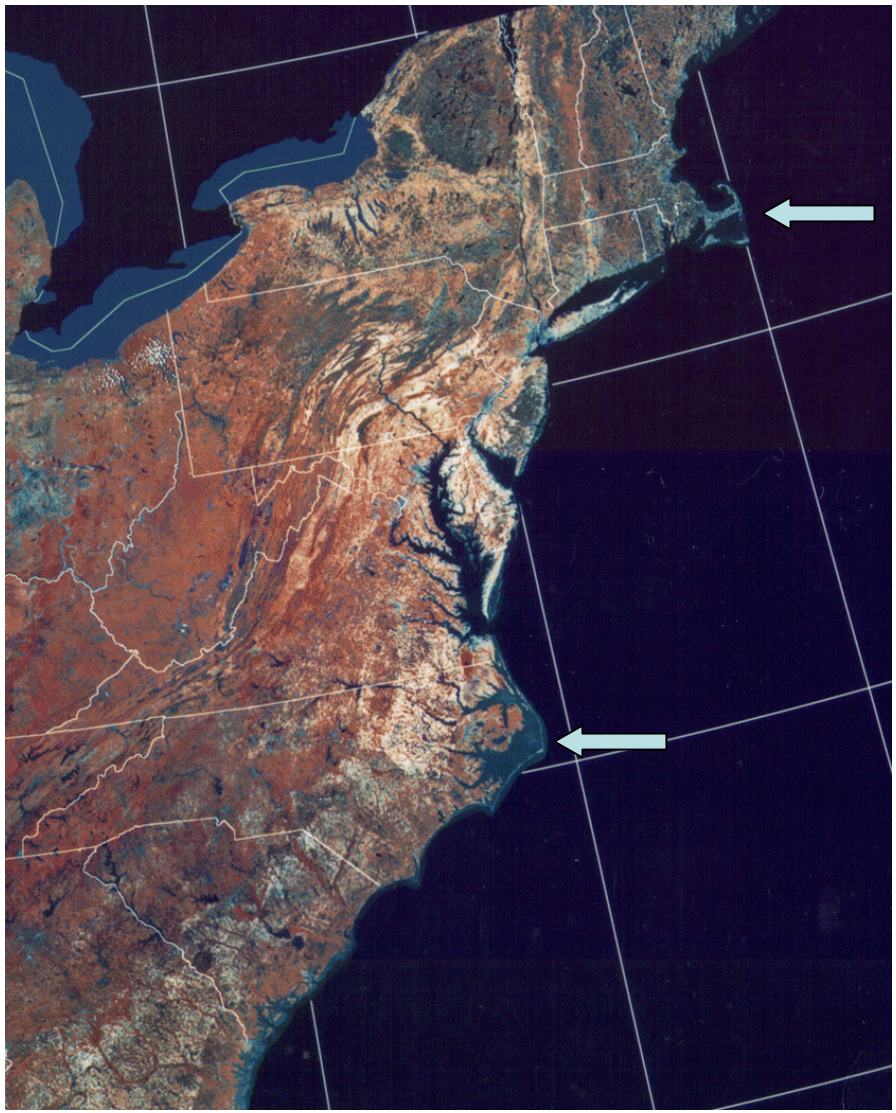
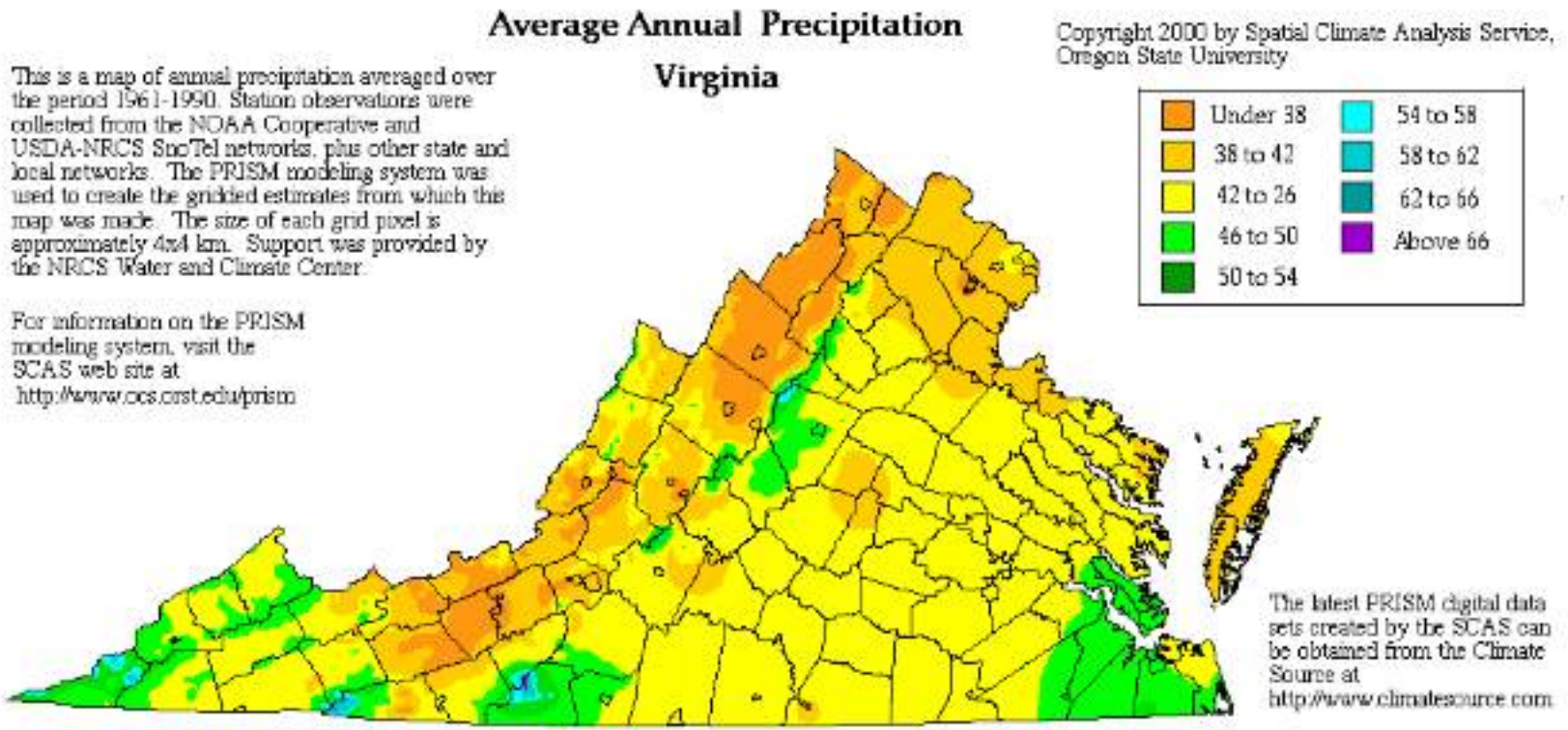
Why here?
Why now?

Virginia is a “state” undergoing climate related change on a variety of temporal and spatial scales. Absent an understanding of both the forces driving these changes and their complex interactions, we lack the ability to forecast, and therefore prepare for the impacts of such change.

Virginia by an assortment of numbers

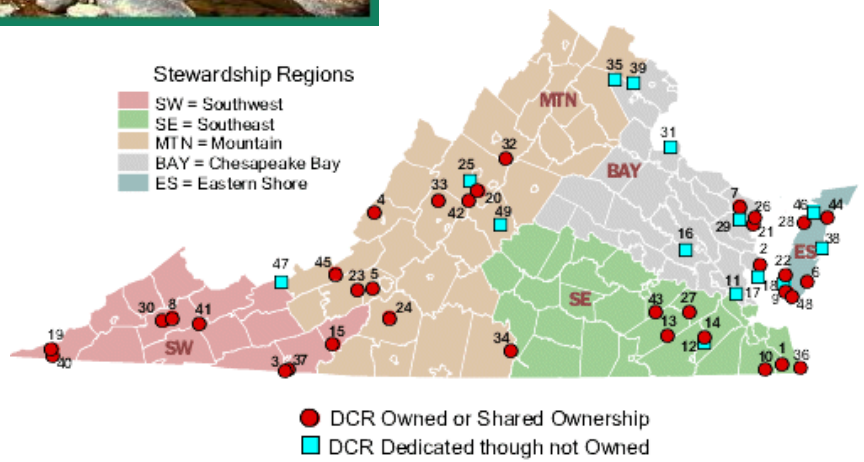


- We are small of footprint - 470 mi west-east by 200 mi north-south, an area of 35,598 sq. mi.
- Geologically ancient through geologically young features.
- population approx. 6.5 million.
- Enormous biological diversity spread along clines of habitat - these are ecologically and economically important.
- 62% is covered by forest.
- 1,000,000 acres wetlands.
- Agriculture as the leading economic contributor.
- Home of the one of the largest ports on the US East Coast and largest Naval Base in the World (Norfolk).



Water - the basis of life (and a very large part of our economy). Virginia is unusual in that effectively all of the fresh water we use in Virginia originates in Virginia. We have the opportunity to manage it wisely.

Virginia, and notably the Chesapeake Bay watershed, enjoys an enormous diversity of native ecosystems - every one subject to climate change impact.



And sea level rise is an acknowledged problem…

HAMPTON

City eyes reinforcing Factory Point

Hampton plans to build it up with 4 feet of sand and 3 breakwaters to protect against storms.

BY MATTHEW STURDEVANT
msturdevant@dailypress.com | 247-7874

HAMPTON — If a major hurricane swirls into Hampton, many people say, the neighborhoods near Back River would be better protected if the Factory Point peninsula is built up with sand.

Factory Point could serve as a barrier, or at least an impediment, to the onslaught of a storm surge, waves and flooding, some say.

The City Council indicated during a recent work session that it was willing to spend more than $3 million to rebuild the peninsula, which has been on maps since the 1600s. Starting about a decade ago, a 3,000-foot-long section of Factory Point has washed away, allowing a wider entrance from the Chesapeake Bay to the Back River.

The council wants to beef up the peninsula with 4 vertical feet of sand and three breakwaters — barriers designed to break up waves — just off its eastern edge. The breakwaters are expected to help sand fill in and widen the beach in that area. The cost is estimated at $1.5 million for the breakwaters and $1.525 million to build up Factory Point with 4 feet of sand.

In a report dated Oct. 29, the City Council was given several options for rebuilding Factory Point. Council members discussed the matter last week, and city employees are expected to come up with a plan for budgeting the improvements by December.

The options for beefing up Factory Point range from a minimalist strategy of adding a 4-foot-high, 200-foot-wide stretch of beach for $1.525 million to paying $10.3 million for 10 vertical feet of sediment and three breakwaters, according to a city document.

All these costs are preliminary, and any project could be more expensive in months or years. The cost to rebuild Factory Point doesn't include annual maintenance.

If a major hurricane — a Category 4 — made a direct hit on Hampton, most of the city would be underwater, according to a recent storm-surge map made by the city's Geographic Information System.

Rebuilding Factory Point is one preventive measure that Mayor Ross A. Kearney II wants to take before a major hurricane hits the city.

Kearney traveled to New Orleans last week for a conference and met city officials to hear

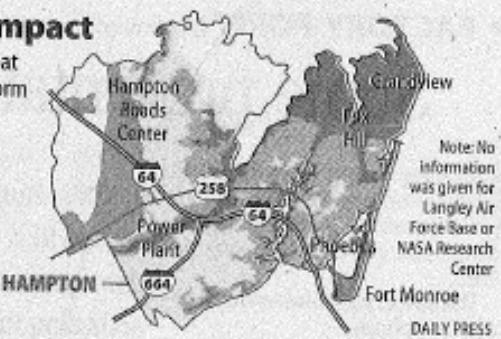
Please see **FACTORY POINT/B2**

Hurricane impact

Areas of Hampton that would be under a storm surge at different hurricane strengths:

- Category 1
- Category 2
- Category 3
- Category 4

Source: City of Hampton

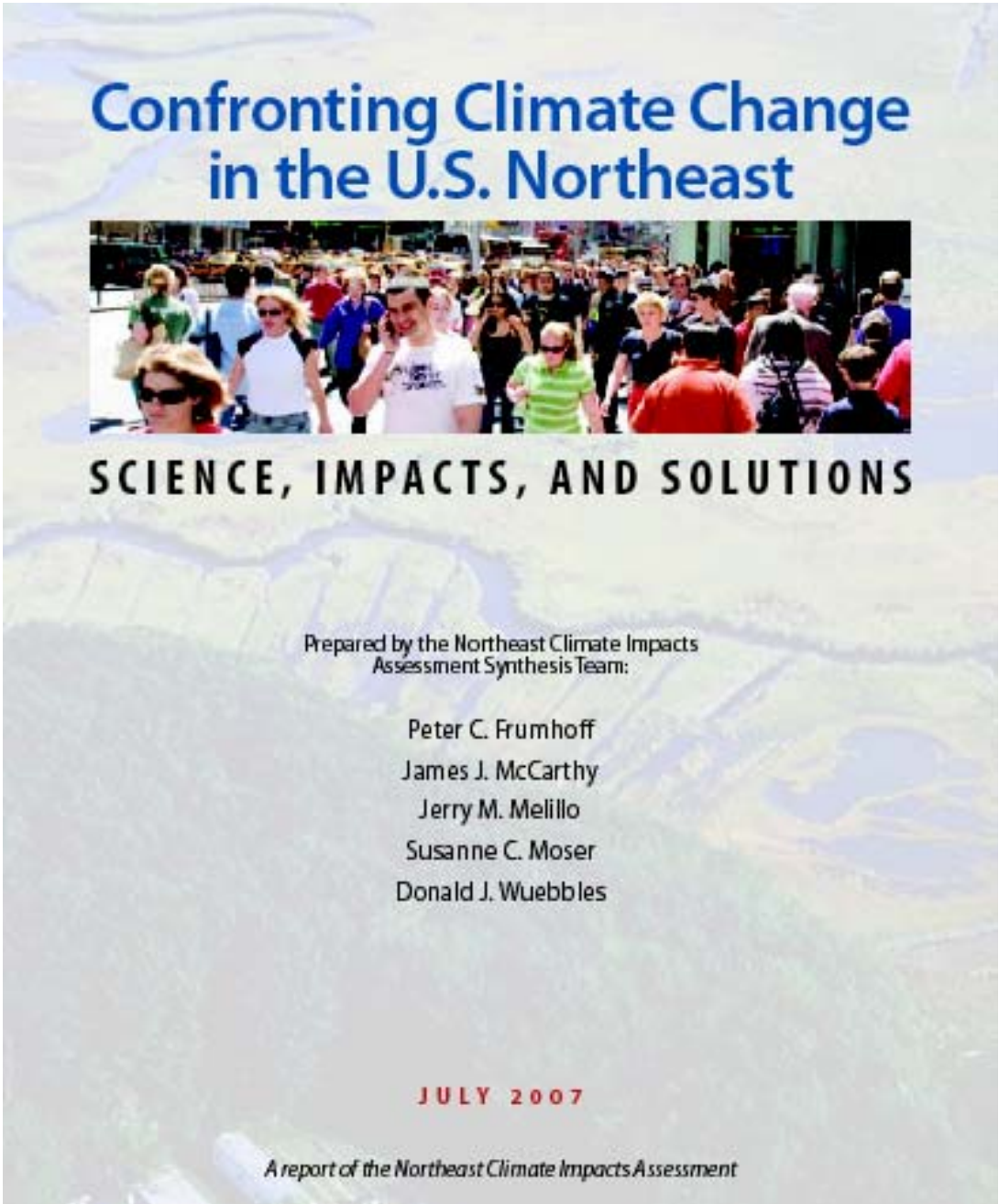


Online extra

Go to dailypress.com/surgemap to see how various categories of hurricanes would flood Hampton.

Impacts of climate change on natural resources - important points to consider.

- Most species have optimal temperature ranges. At the edges of these ranges their responses to change can be large and negative.
- It is not just the absolute temperature - it's the rate of change of temperature.
- What about CO_2, the carbon budget and other greenhouse gases?
- Where does all the water come from and go to?
- Consider rates of change in biological footprints - disturbance and fragmentation result in a domino like chain of events.
- Synchrony and asynchrony in trophic levels - how is this influenced by climate change?
- Disturbance creates opportunities for invasive species.



- We need a coherent assessment of impacts at natural resource and societal levels.
- We do not have one.
- There are templates for such a document, and we should build upon them.

Does the North East document provide indications on what we might expect in Virginia? Yes.

Species move northward.

High emissions result in habitat disappearance.

Diminished habitat at higher elevations create pressures on associated species such as hares, lynx and thrush.

Substantial changes in bird life are expected.

Northward expansion of fatal pests such as hemlock woolly adelgid.

CHAPTER FOUR

Impacts on Forests

KEY FINDINGS

- The character of the Northeast's forests may change dramatically over the coming century as the center of suitable habitat for most of the region's tree species shifts northward—as much as 500 miles by late-century under the higher-emissions scenario, and as much as 350 miles under the lower-emissions scenario.
- Many tree species, including the hardwoods that generate the region's brilliant fall foliage, may be able to persist this century even as their optimal climate zones shift northward. Other species, however, may succumb to climate stress, increased competition, and other pressures.
- If the higher-emissions scenario prevails, productivity of spruce/fir forests is expected to decline and suitable habitat will all but disappear from the Northeast by the end of the century. Major losses are projected even under the lower-emissions scenario. This would greatly exacerbate stresses on the pulp and paper industry in the Northeast, particularly in Maine, where the forest-based manufacturing industry is key to the state's economy.
- Diminished spruce/fir habitat, especially at higher elevations, would increase pressure on associated animal species such as the snowshoe hare, Canada lynx, and Bicknell's thrush, one of the region's prized songbirds. With the late-century summer warming projected under the higher-emissions scenario, suitable habitat for the Bicknell's thrush could be eliminated from the region.
- Substantial changes in bird life are expected across the Northeast due to rising temperatures, shifting distribution of suitable habitat, or declining habitat quality. The greatest changes are projected under the higher-emissions scenario, including declines in the abundance of many migratory songbirds such as the American goldfinch, song sparrow, and Baltimore oriole.
- Winter warming will threaten hemlock stands, not only by reducing suitable habitat for these trees, but also by allowing northward expansion of a fatal pest known as the hemlock woolly adelgid—as far north as Canada by late-century under the higher-emissions scenario.

A walk through Virginia from the mountains to the ocean shore - Virginia's renewable forests and climate change.

(some material source from VA Department of Forestry).

- 15,800,000 acres - 78% hardwood, 22% softwood
- Planted stands make up 12% of total and 54% of softwoods.
- Current forest stock is about 1.2 billion tonnes carbon. It sequesters 6.42 million metric tons of carbon each year - nearly 20% of VA emissions.
- Long generation time with respect to rate of climate change (70 years for managed oak, 35 years for pine) - limited response ability.
- Fragmenting footprint and migratory corridors.
- Disruption of community structure from mammals to birds to insects.
- Leaf litter decomposition rates.
- Soils, stabilization and runoff with downstream watershed impacts.
- Invasive species establishment.

Climate change related impacts on Virginia forests.

Southern pine beetle

- Prospects for insect and pest outbreaks (Asian blight, gypsy moths, southern pine beetles, hemlock woolly adelgid)
- Invasive species displacement and i ^ ` h l c a niche loss.

Q o b b * l c * E b ^ s b k

Canada Thistle

Autumn Olive

Cogon Grass

Chinese Privet

Purple Loosestrife

J f i b * > J f k

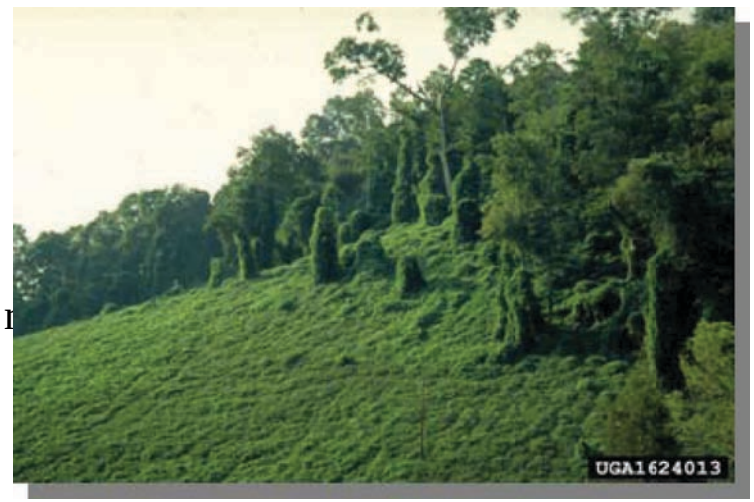
Kudzu

Multiflora Rose

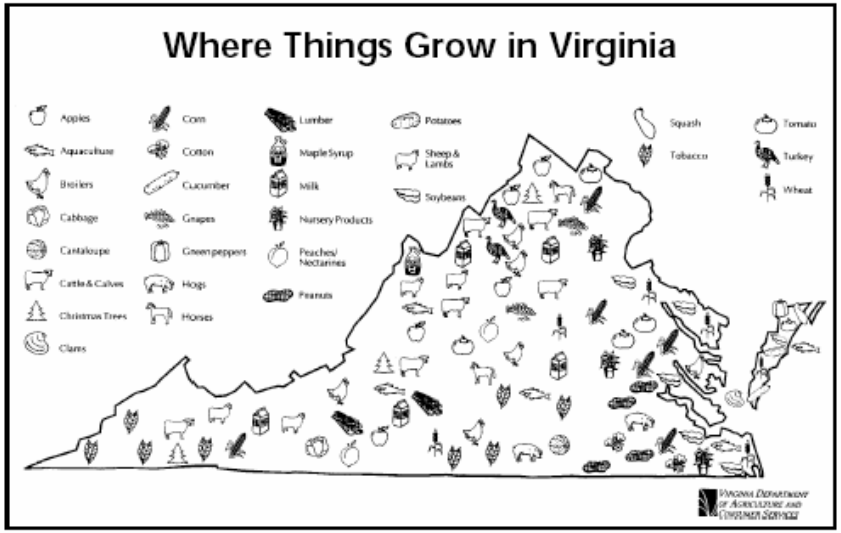
Johnson Grass

Winged Burning Bush

Johnson Grass



Mile-A-Minute



Agriculture in Virginia:
The biggest industry in Virginia (20% of jobs),
8,500,000 acres,
$2.5-3 billion/yr in sales.

- Increased CO_2 will not increase yield.
- Increased temperature will not offer extended growing seasons.
- Increased temperature may damages crop yield - corn is negative at 90^{o}F, badly damaged at 100^{o}F.
- Pest and parasite outbreaks.

- Frequency of droughts, rainstorms increase - water supply rate is critical, to both production and groundwater stability.
- Topsoil integrity and stability of crop production may be compromised.
- Livestock impacts.

We have limited ability to mitigate these impacts.

A wetland along the Chickahominy River in Virginia.

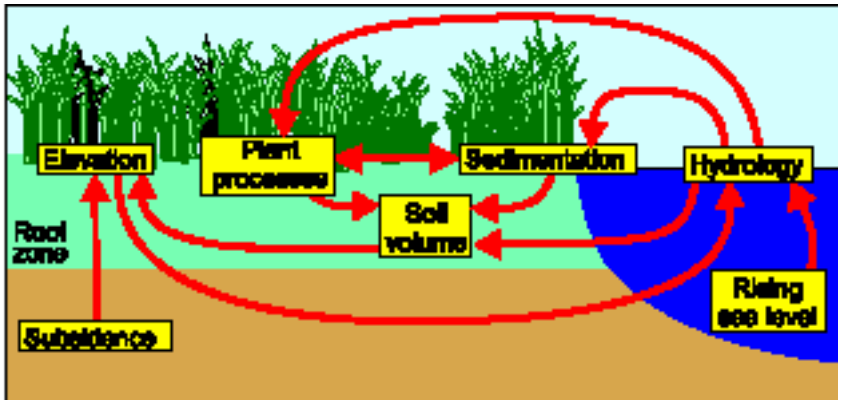
Virginia wetlands.

Definition - Shallow water bodies and high groundwater environments that are characterized by permanent or temporary inundation, soils with hydric properties, and plants and animals that have adapted to life in saturated conditions.

The inventory - 1,000,000 acres in total, 750,000 acres non-tidal, 180,000 acres with no connection to surface water.

- Very sensitive to water level, but they also assist in maintaining base surface water and groundwater flow - especially in times of drought. Water removal for irrigation and municipal use can be problematic.
- Sediment sinks and buffers for flood control.
- Critical habitat, unique communities, wildlife refuges.
- They have nowhere to go - they cannot “migrate”.
- Sources or sinks of greenhouses gases, in particular carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)?

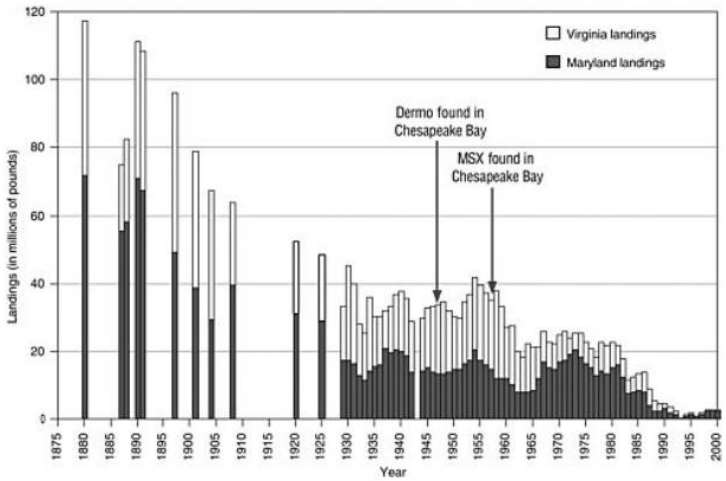
Brackish marshes



- Caught in the squeeze! Land is subsiding on one side and sea level rise causes gradual inundation by salt water on the other.
- Marsh stability is controlled by the balance between accretion (deposition, associated with hydrology), erosion and subsidence.
- Plants and the food chains they support must be more salt tolerant or change will result.
- Add to this possible falling groundwater levels and…. An open hypothesis that perhaps this will exacerbate the already problematic invasion by *Phragmites?*

Graphics: USGS and Bernd Blossey, Cornell University.

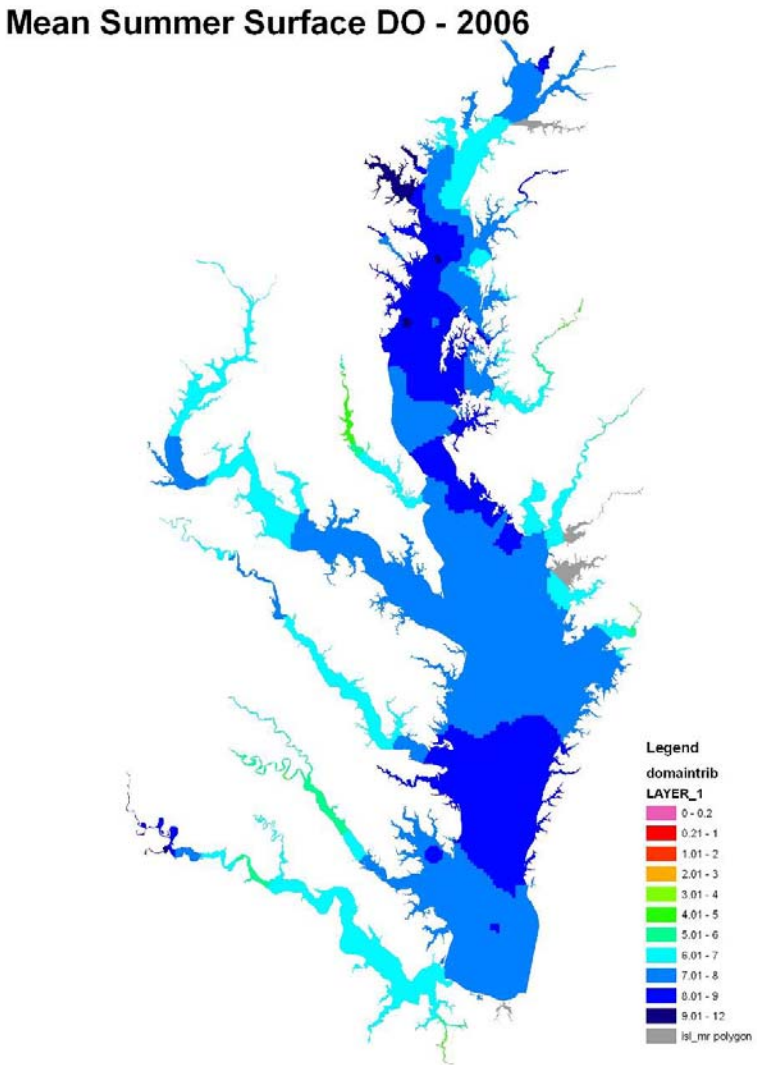
Oysters in Chesapeake Bay (without which no talk can be complete).

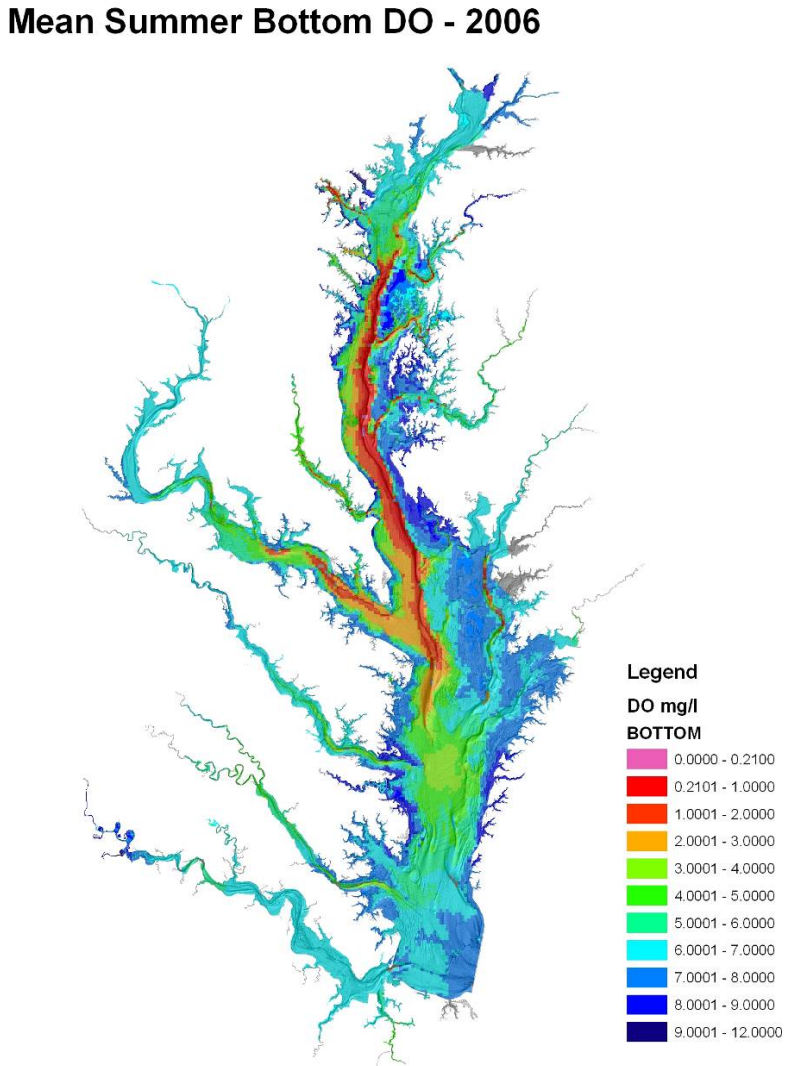


- Long term environmental degradation of a species that creates its own habitat by very small increments - accreting reefs.
- Oysters have been challenged for approximately half a century by two diseases, MSX and Dermo.

- Low salinity depresses disease.
- High salinity enhances disease.
- Warm over winter temperatures accelerate disease in the following year.
- ***Climate change is threatening.***

Climate change and Summer Chesapeake Bay Dissolved Oxygen.

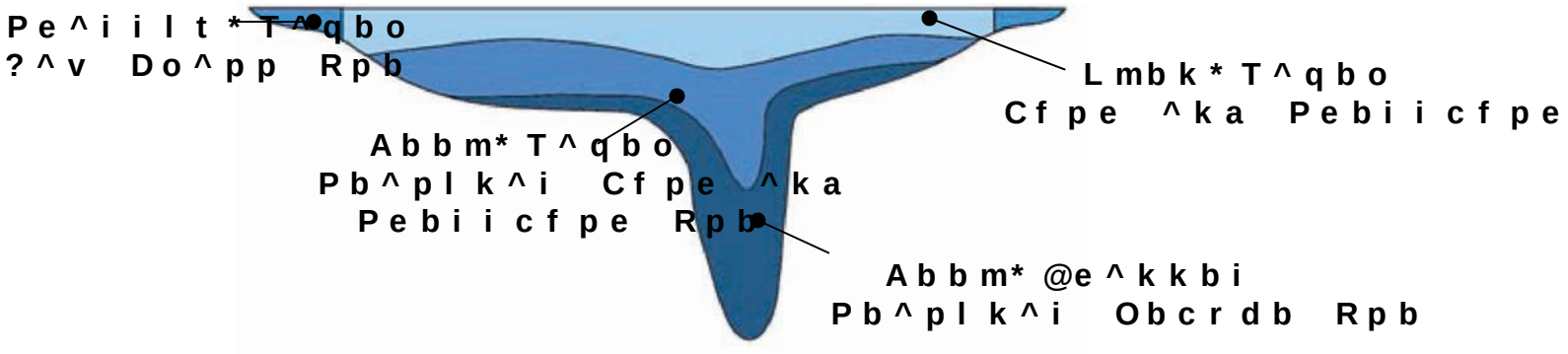




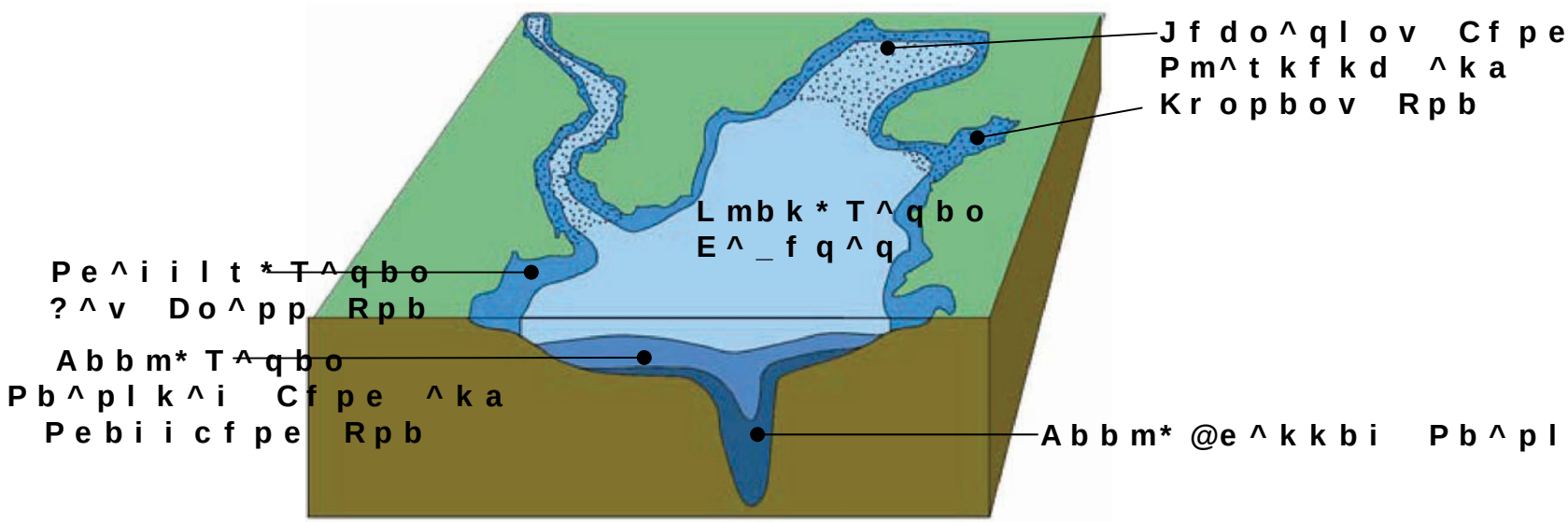
Runoff and temperature patterns influence the size of the low D.O. pool.

E l t a l b p i l t o a l h a b i t a t u s e i n t h e b a y ?

A. Cross Section of Chesapeake Bay or Tidal Tributary



B. Oblique View of the “Chesapeake Bay” and its Tidal Tributaries



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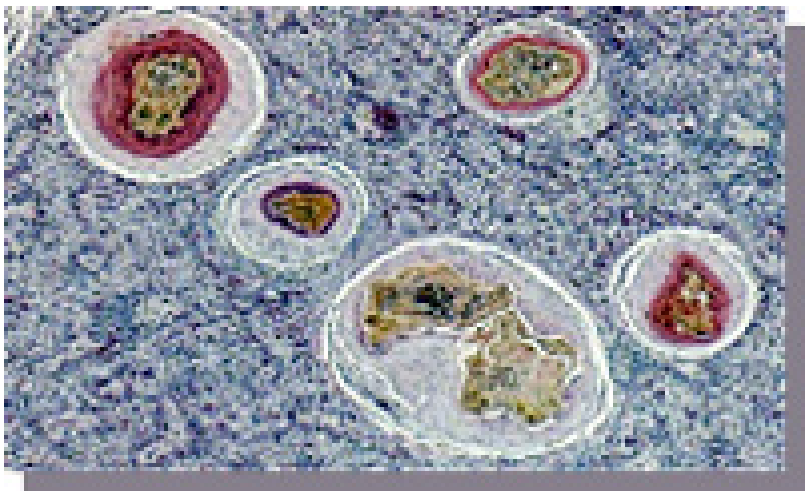
Striped bass in the Chesapeake Bay.



- Large apex predatory fish, managed back to a vibrant stock by strong fishery limitations in the 1980's
- Recently we see *Micobacterium* species as a cause for concern.
- The deep waters were a refuge and a sometime feeding ground) for these large fish, but they are increasingly limited to foraging in higher temperature shallow waters.
- Are they stressed and does this increase their susceptibility to infection?

Images courtesy of Department of Environmental & Aquatic Health - VIMS

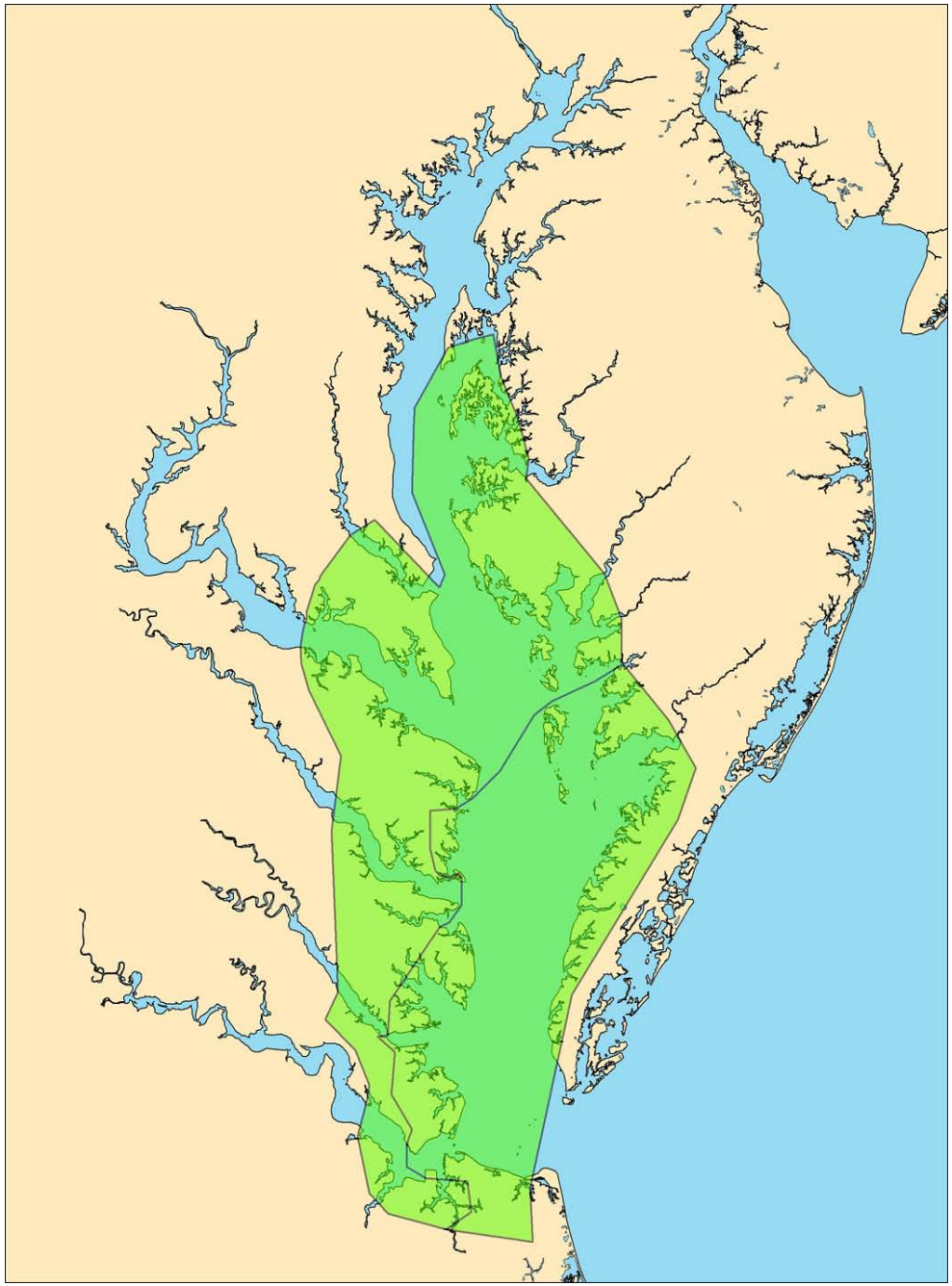
Sea grasses in the Chesapeake Bay -

Critical habitat to early life history stages of many commercially and ecologically important species.

(data and images courtesy of Dr. Robert J. Orth, VIMS)

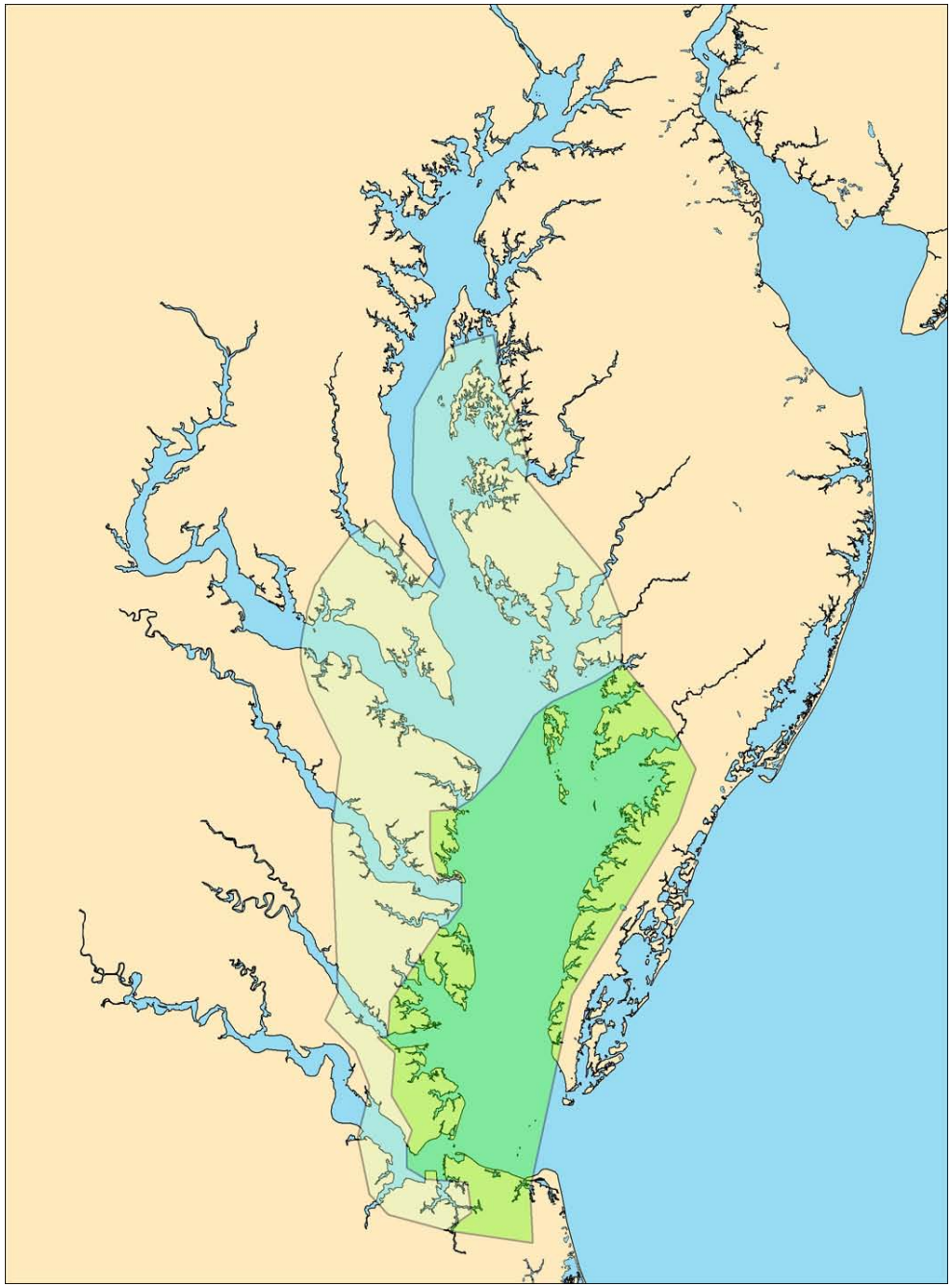
- Eelgrass in the Chesapeake Bay are already at the southern limit of their distribution - so they are sensitized to temperature change.
- Eelgrass has been lost in over half of its distributional range since the 1960s with little or no recovery.
- In the remaining areas, over half of the eelgrass has disappeared since the mid 1990s, with most loss coming from deeper portions of the beds.
- Other stressors contribute to this loss – declining water clarity, hurricanes, biological disturbance such as cow-nose rays.
- If trends continue, concern that eelgrass could be gone from much of the Chesapeake Bay in the not-to-distant future.

Bay wide Distribution Late 1950s/ 1960s

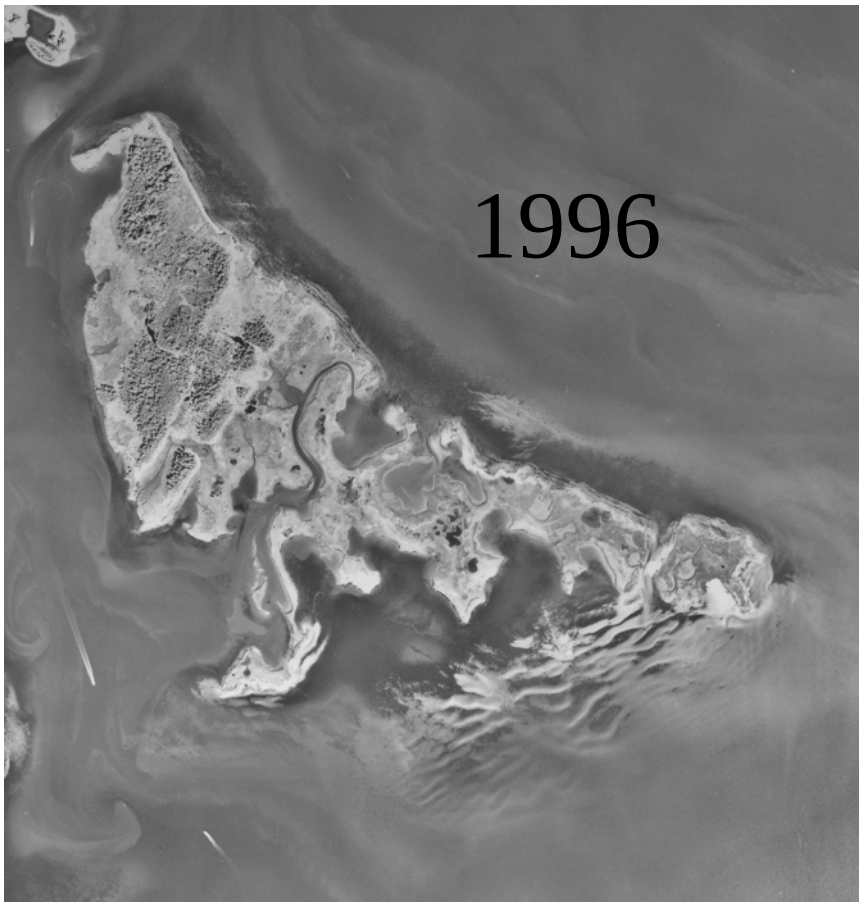


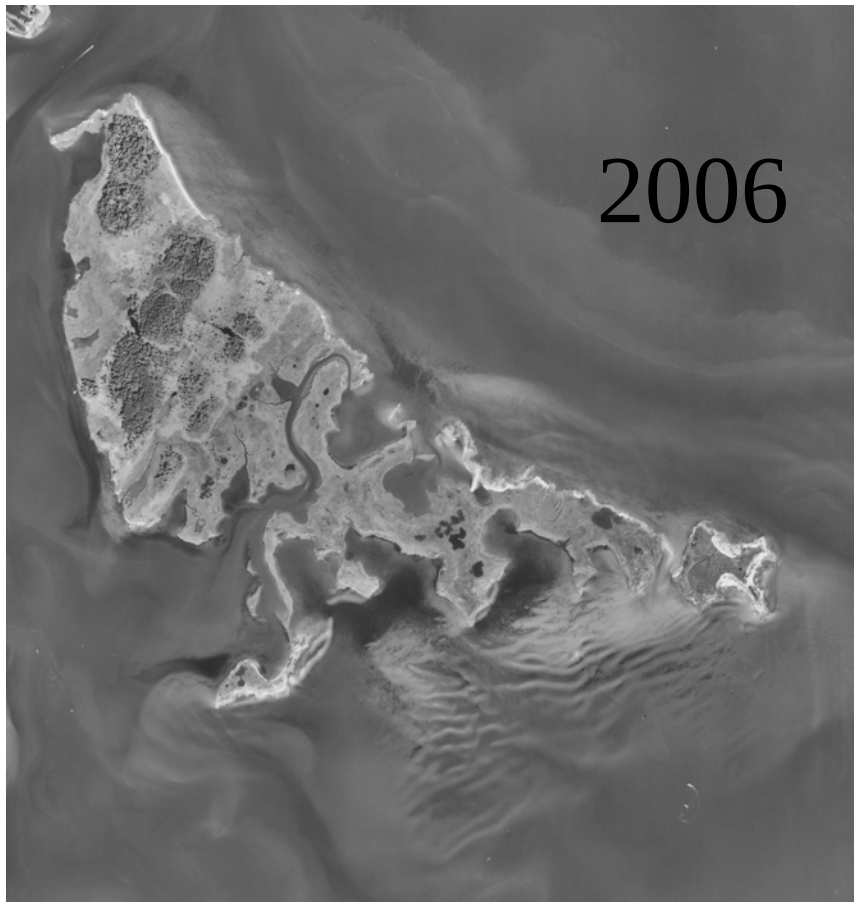
Bay wide Distribution 2007

This major change occurred by mid 1970s (Tropical Storm Agnes)



Goodwin Island – York River





Natural resources: a summary so far….

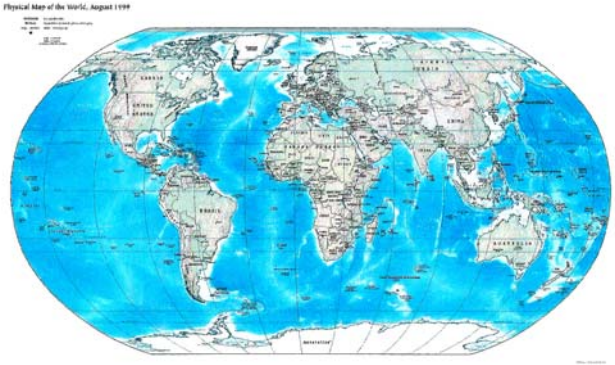
- Each system examined to date and herein is in flux as climate (and more) changes around it.
- The opinions on good versus bad impacts are sometimes mixed, but usually more bad than good.
- We can adapt to some impacts, but not others.
- The rates of change of climate and biology may not always be compatible.
- Disturbance and fragmentation of communities is to be expected with domino like effects that include invasive species.
- In many instances we have a poor understanding of the eventual end points of biological response.
- A large “picture” integrated watershed overview is lacking for Virginia - it is needed.

But if you don’t care that much about the natural resources - after all biologists are smart (are they not?) and they will provide work around answers to these questions…

then consider (to quote Bill Clinton)

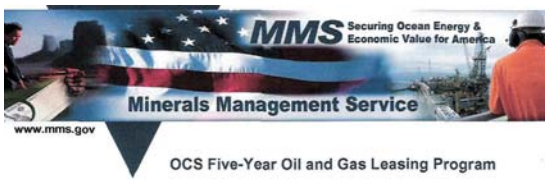
“It’s the economy, stupid!”

Climate change impacts on the Virginia and the national economy can be profound!



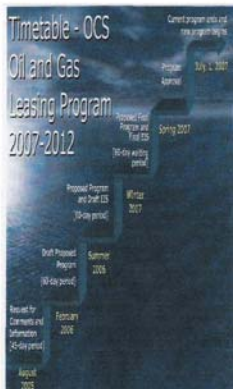
The Ports of Hampton Roads expect a future of explosive growth and importance to the national economy - and with growth comes increased risk.

Outer Continental Shelf Oil and Gas - not so much if as when…



Each and every day, Americans rely on oil and gas from the 1.76 million acres of the Outer Continental Shelf (OCS) to heat our homes, power our automobiles, and more. Those acres are the source of 30 percent of domestic oil production and 21 percent of domestic natural gas production. The Gulf is the most prolific producing offshore region. It provides 27 percent of the *oil* and 20 percent of the natural gas produced domestically.

In an effort that is by and large invisible to the consumer, Minerals Management Service (MMS) energy experts work to organize the myriad aspects of capturing those energy resources and bring them to market. The result of this massive planning process is the OCS Oil and Gas Leasing Program, routinely referred to as the "Five-Year Plan." This document specifies the size, timing, and location of the areas to be considered for Federal offshore leasing during a five year period. This plan is reviewed by Congress and approved by the Secretary of the Interior. The 2002-2007 OCS Oil and Gas Leasing Program will end on June 31, 2007. MMS is *currently working on* the 2007-2012 OCS Oil and Gas Leasing Program, which will take effect on July 1, 2007.



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Chance of drilling off Va. shores is revived
A five-year plan soon to be reviewed by Congress for oil and gas explo-

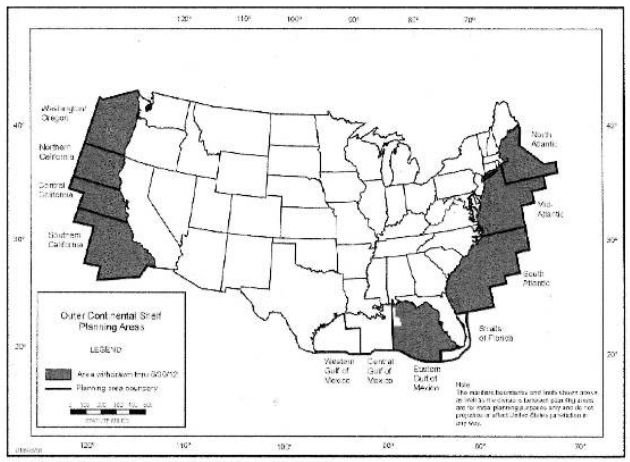
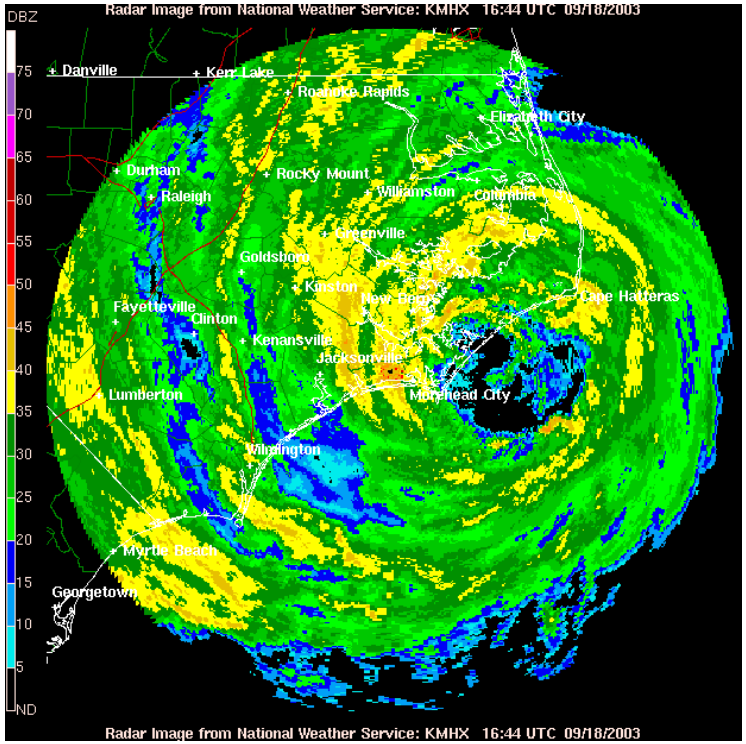


Figure 4. Lower 48 States -- Areas Under Presidential Withdrawal


Radar Image from National Weather Service: KMHX 16:44 UTC 09/18/2003
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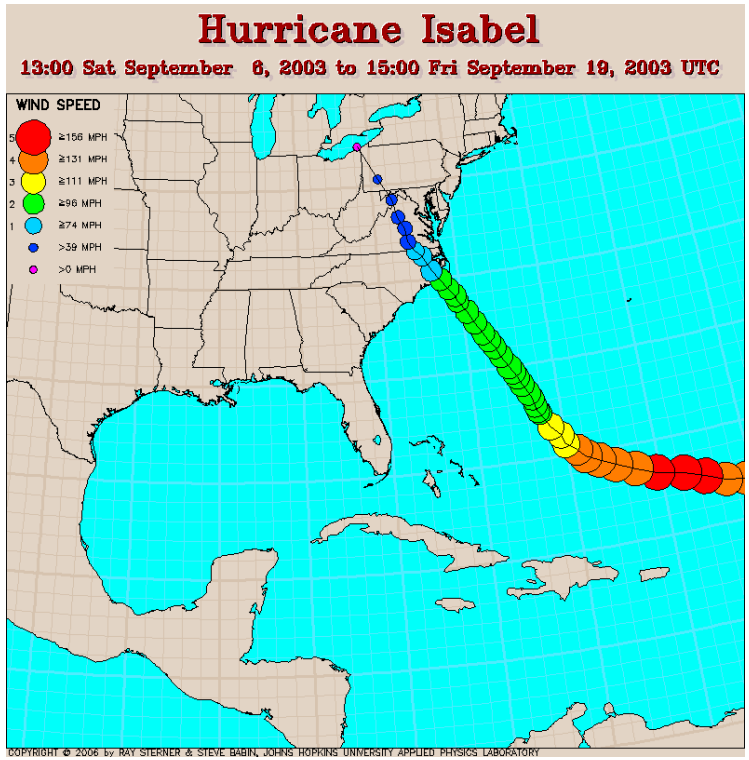
Hurricane Isabel
13:00 Sat September 6, 2003 to 15:00 Fri September 19, 2003 UTC
WIND SPEED
≥156 MPH
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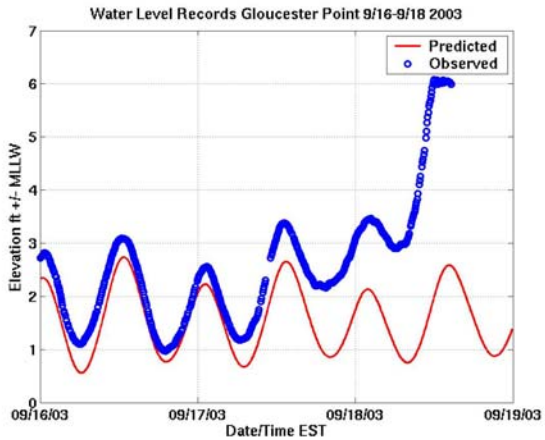
Water Level Records Gloucester Point 9/16-9/18 2003
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Again I ask -
Why here?
Why now?

Again I respond - Absent a thorough understanding of both the forces driving these changes and their complex interactions, we lack the ability to forecast, and therefore prepare for the impacts of such change - both ecologically and economically.