Climate Change Resilience Index

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BayStat Meeting
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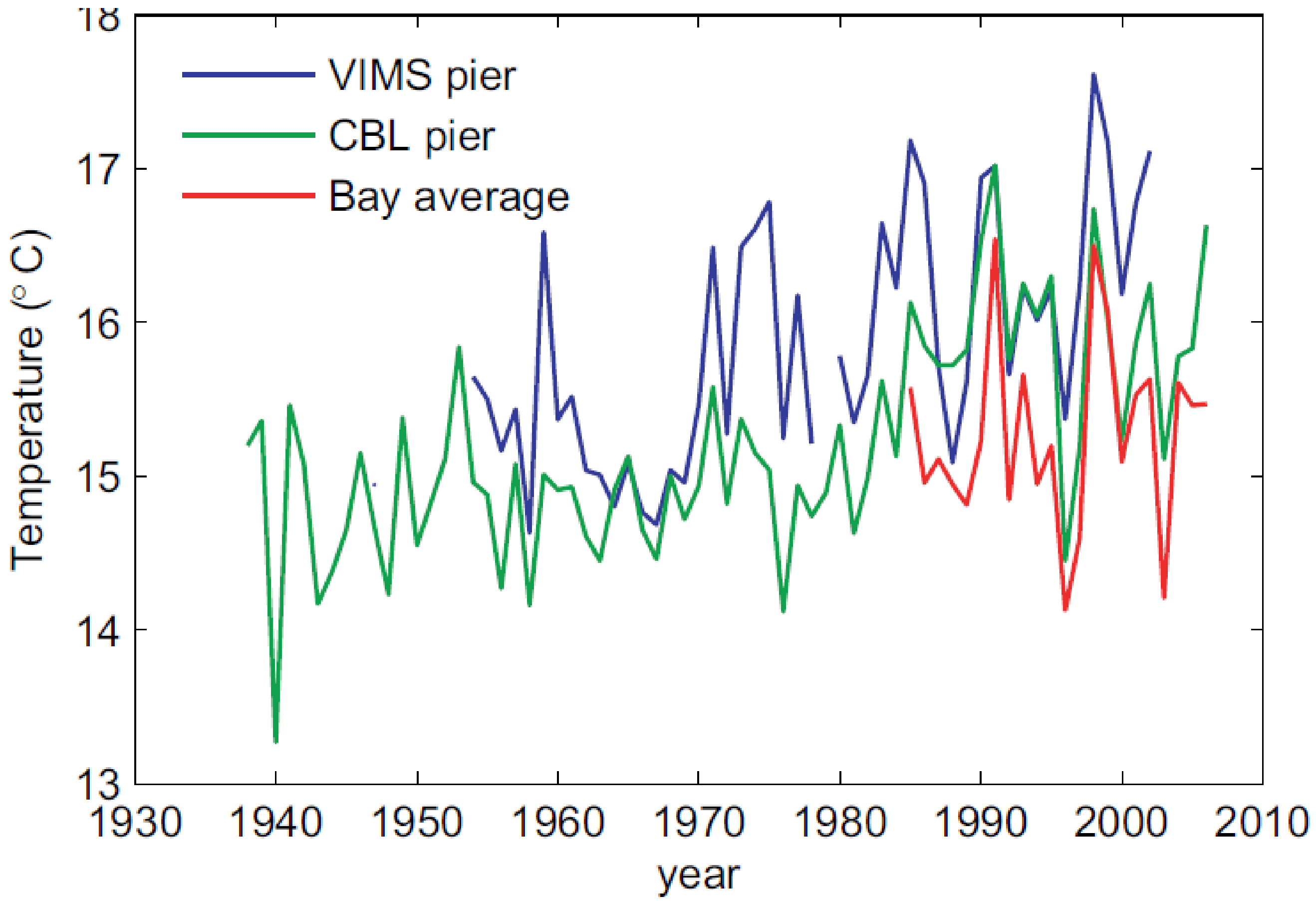
Innovation for a better future
University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE

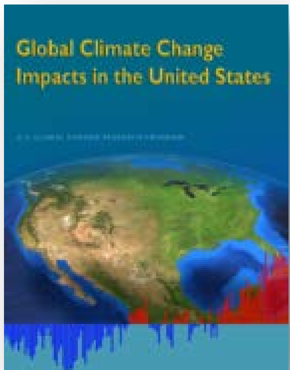
Climate change is already impacting Chesapeake Bay

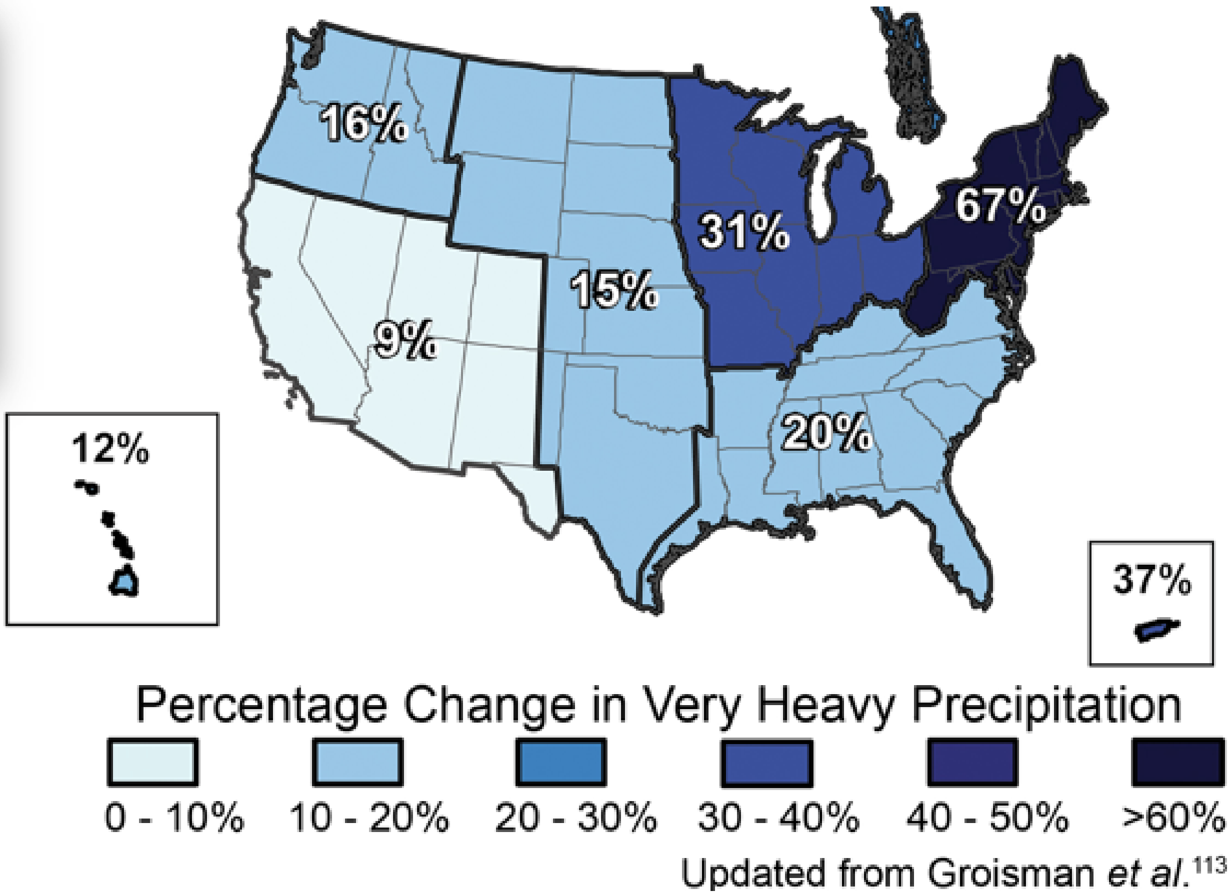
Chesapeake Bay has warmed by more than 2°F



Najjar et al. 2010. *Estuarine, Coastal, Shelf Sci.* 86:1

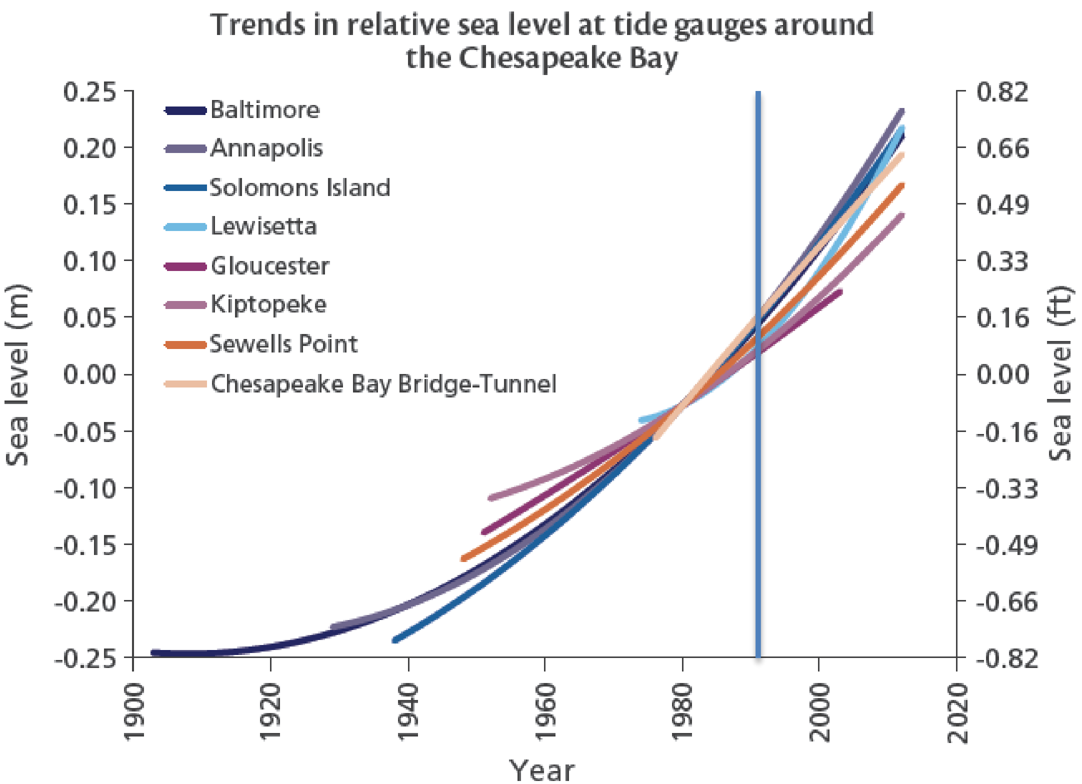
Precipitation is already changing in our region





Global Climate Change impacts in the US from 1958-2007.

Sea level has risen 0.5m since 1900



~17cm of SLR realized since 1992

Ezer, T. and W.B. Corlett. 2012. Is sea level accelerating in the Chesapeake Bay? A demonstration of a novel new approach for analyzing sea level data. *Geophysical Research Letters* 39: L19065, doi:10.1029/2012GL053435.

Winter temperature range increased, summer temperatures decreased slightly

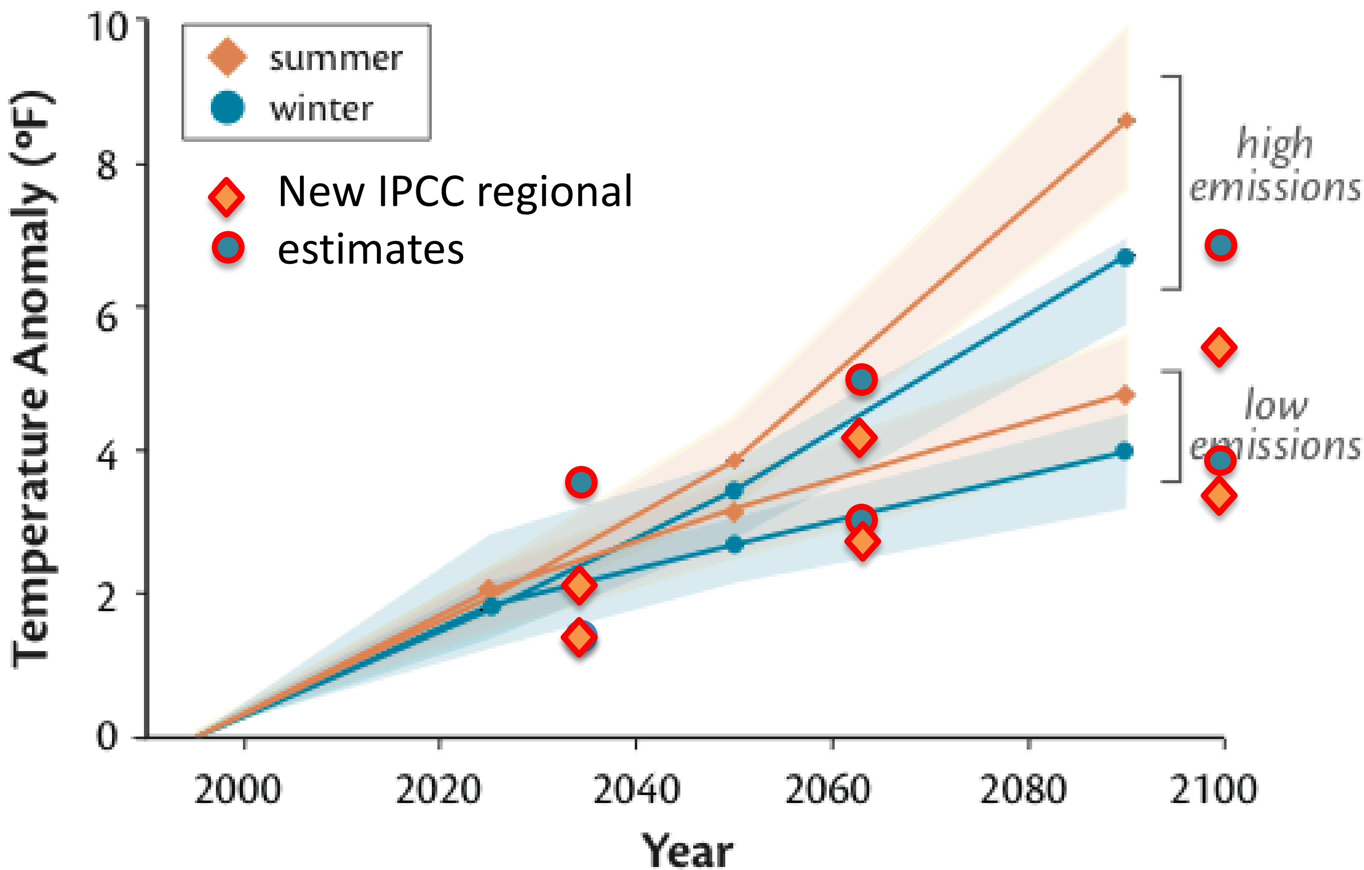


Figure 4.2. Temperature increase (°F) for Maryland from 1990 to the year 2100. The shaded regions depict the 25th-75th percentile spread between all the models.

Winter precipitation range decreased slightly, summer precipitation increased slightly

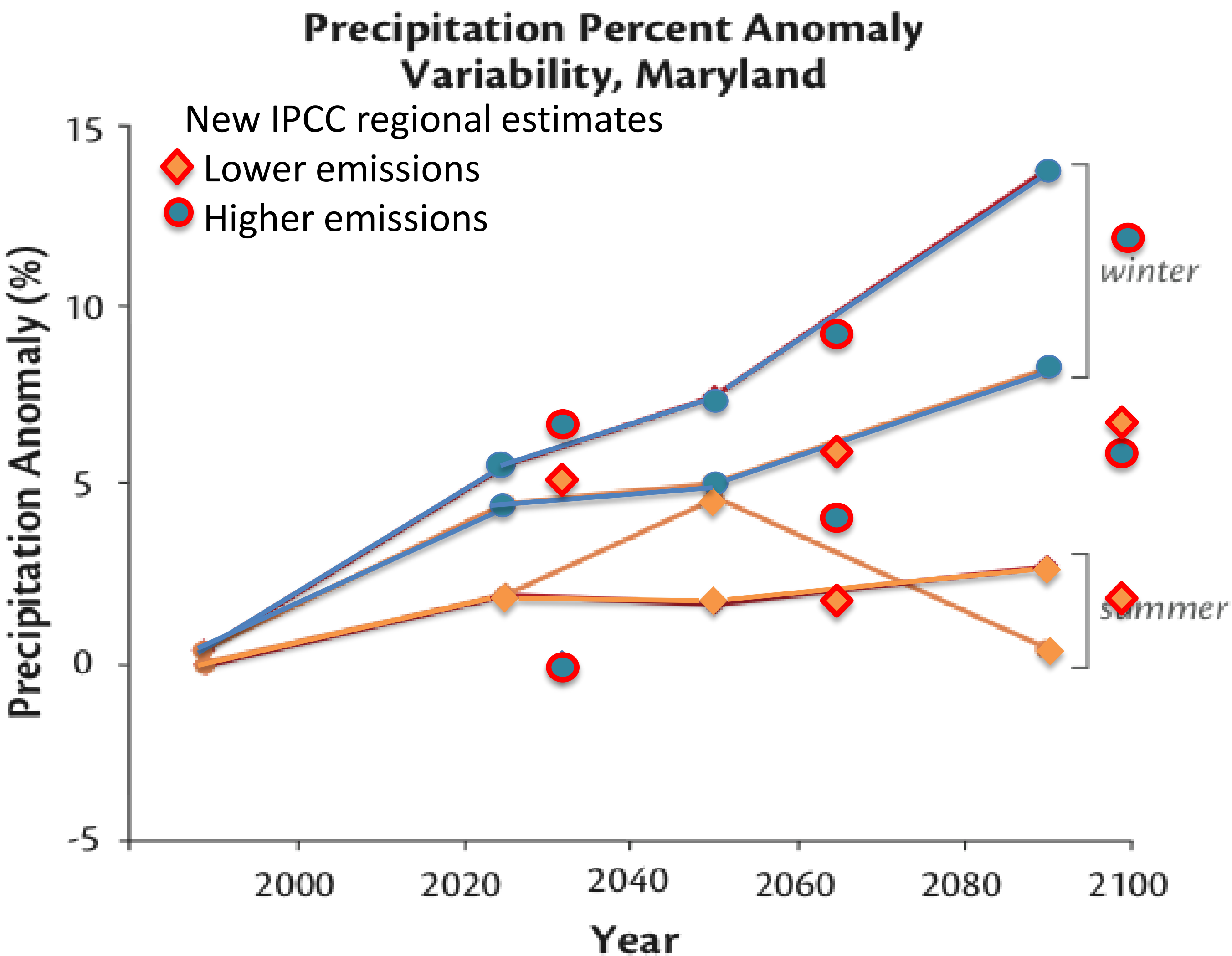


Figure 4.8. Winter and summer percent change in precipitation.

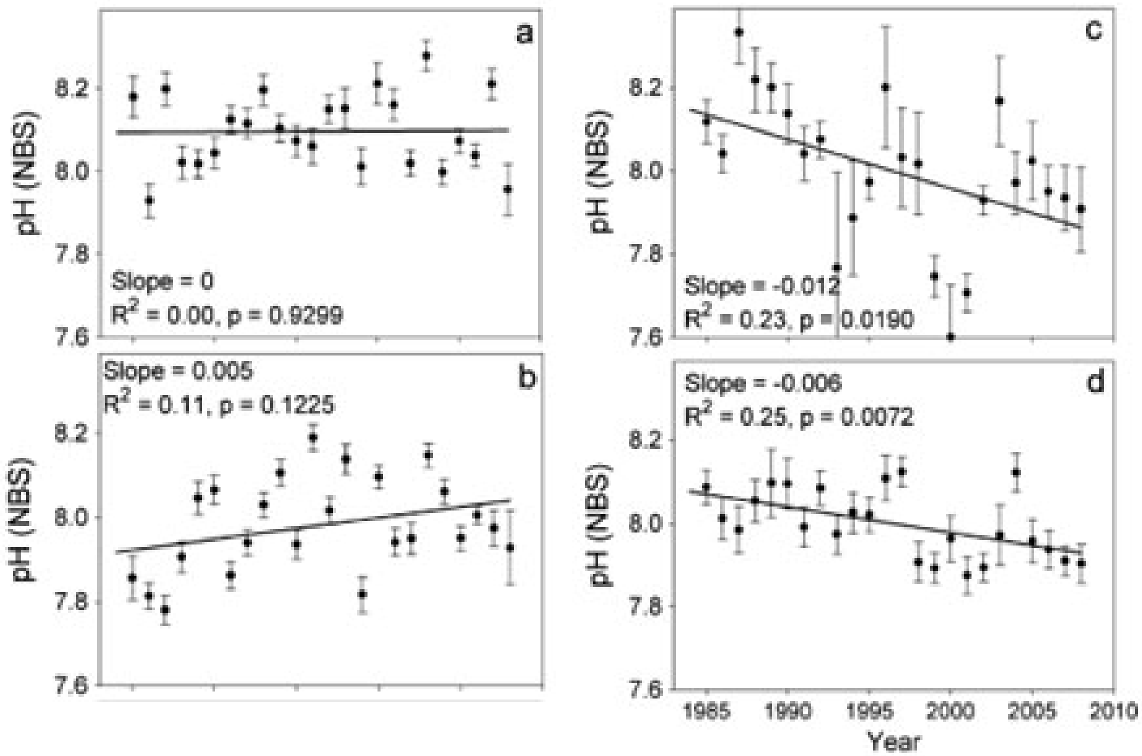
Is acidification occurring in Chesapeake Bay?

Spring-Mesohaline

Spring-Polyhaline

Summer-Mesohaline

Summer-Polyhaline



Waldbusser et al. 2011, Estuaries and Coasts

Fig. 2 Annual trends in Chesapeake Bay surface water pH in the **a** Spring-Mesohaline, **b** Summer-Mesohaline, **c** Spring-Polyhaline, and **d** Summer-Polyhaline. Mesohaline includes salinities of 5–18, and polyhaline are salinities >18. Mean values are based on surface waters of 1 m or less, averaged over season. Spring is defined as April, May, June, and summer June, July, August, September, corresponding to important growth periods for adults and juvenile oysters, respectively. *Error bars* are the 95% confidence interval for the mean values. Data originally obtained from Chesapeake Bay Program Water Quality Database (1985-2008)

Focus on impacts to and resilience of key resources

- Four focus areas
  - Salt marsh and Submerged Aquatic Vegetation
  - Bacteria and Pathogens
  - Oyster and fish recruitment
- Expect various impacts from sea level rise, temperature, storm frequency, precipitation, and salinity changes

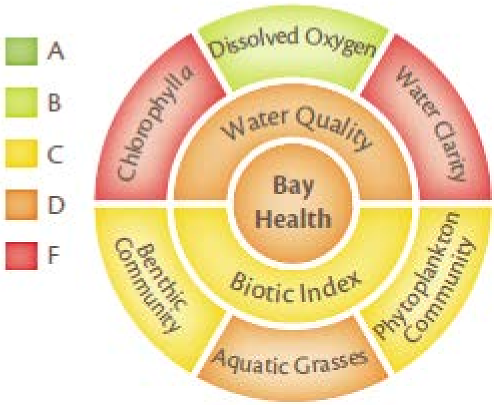
Resource	Impact: SLR	Impact: Temperature	Impact: Storm Frequency	Impact: Salinity	Impact: Precipitation
Salt Marsh	x	x	x		
SAV	x	x	x		
Bacteria and Pathogens	x	x	x	x	x
Water Quality	x	x	x		x
Oysters		x		x	
Fish recruitment				x	x

Outcomes of January webinar

- Define communities – not just salt marsh, but woods/wetlands
- Interactions of climate change factors on water quality, which then affects SAV and salt marsh, which are being directly by climate change as well. How will we address this?
- Add pH/ocean acidification to list of climate change impacts
- Salinity – how it affects submerged aquatic vegetation
- Measuring oysters is not a strong point in the Bay right now, so will have to think about a resilience indicator, cannot just be basic abundance
  - Maybe resiliency of oysters to storm frequency, possible use shellfish bed closures as proxy?
- Create a new Bay scenario with current IPCC report results
  - Integrate the effects of warm and wet (it's not just going to be wet and cool, or dry and warm)
  - Use Tropical Storm Lee as example of what Chesapeake Bay will see in future
- How does adding climate change to the report card jive with the Chesapeake Agreement, since the agreement currently doesn't address climate change?
  - Having Governor O'Malley as chair of the Executive Council will hopefully change the language of the Agreement

Outcomes of January Data Meeting

- Approach
  - Resources, ecosystem services/functions, socioeconomic impacts
- How do we measure resilience?
  - Current bay versus future bay
- How do we incorporate the resilience index into a report card?
  - Four focus areas
    - Salt marsh and SAV
    - Water quality
    - Bacteria and pathogens
    - Oyster and fish recruitment

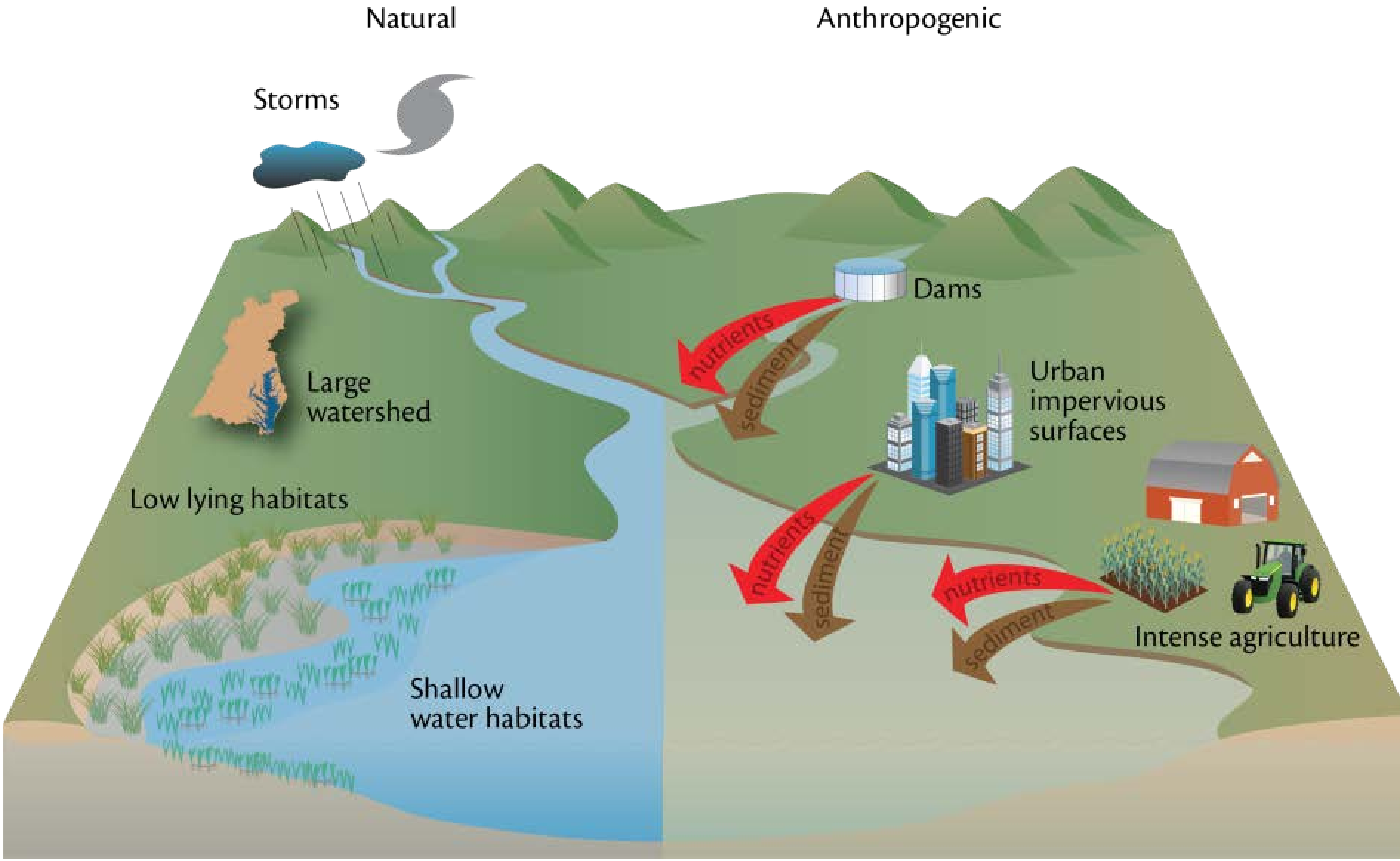


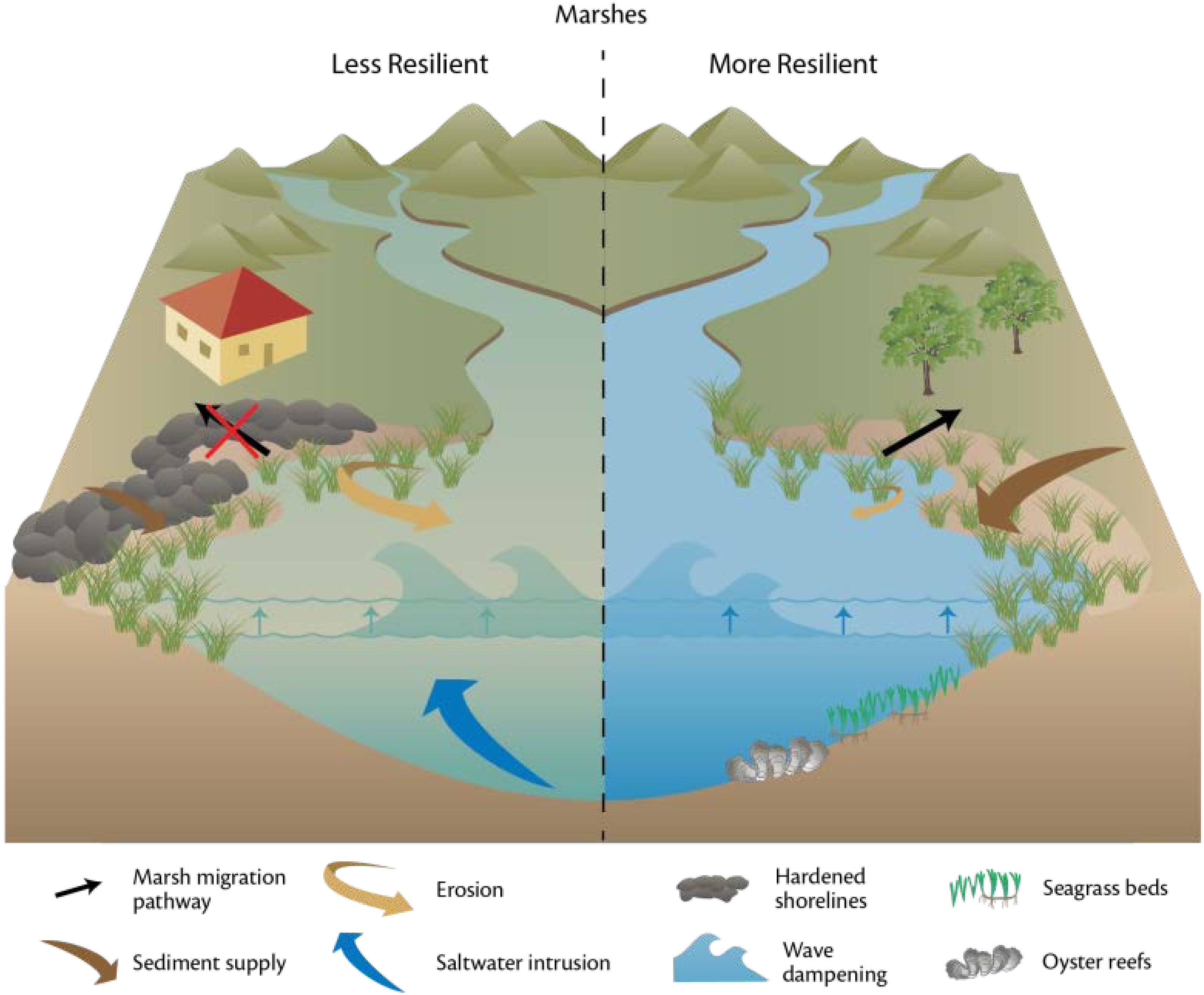
- Why are HABs not considered?
- Instead of saltmarsh, use wetlands or just marsh

Outcomes of April Communication Meeting

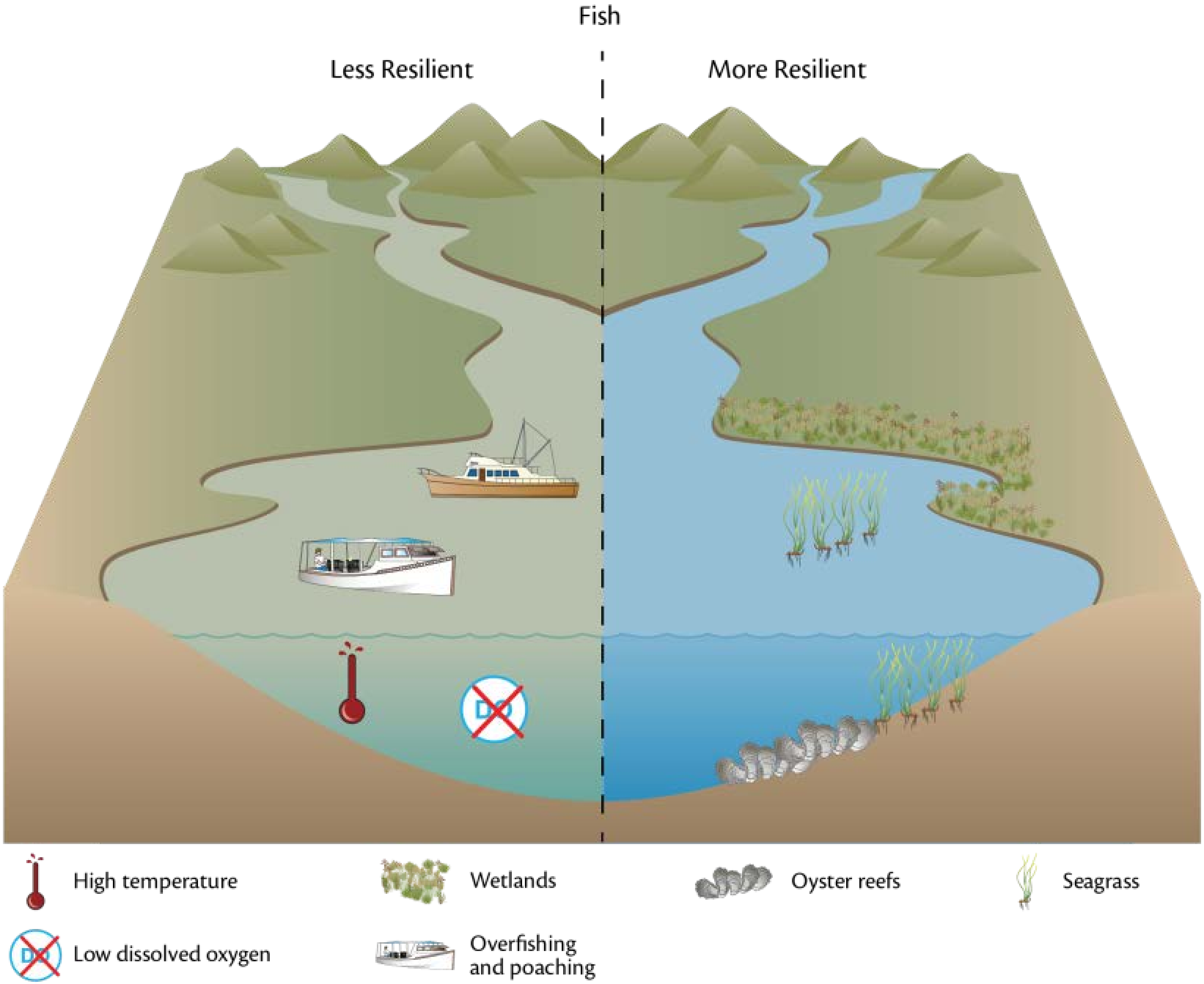
- How do we communicate this information?
  - Display data over time
  - Spatial data can be included on maps
- What is the vision for this report/product? What is the actual product?
  - There will be a printed component
- Will this be included within the report card, or as a separate piece?
- Since the CCRI is so detailed and needs a lot of explanation, should it be separate? Maybe a 2-page or 4-page document.
- There will also be a component of this included on the website.
- Having an initial status of the index in the watershed, what are the initial values, and then also have a retrospective analysis as well as a projection of data using scenarios (2015, 2020, 2050).
  - We can conceptualize scenarios, but probably not run actual models as a part of this project.

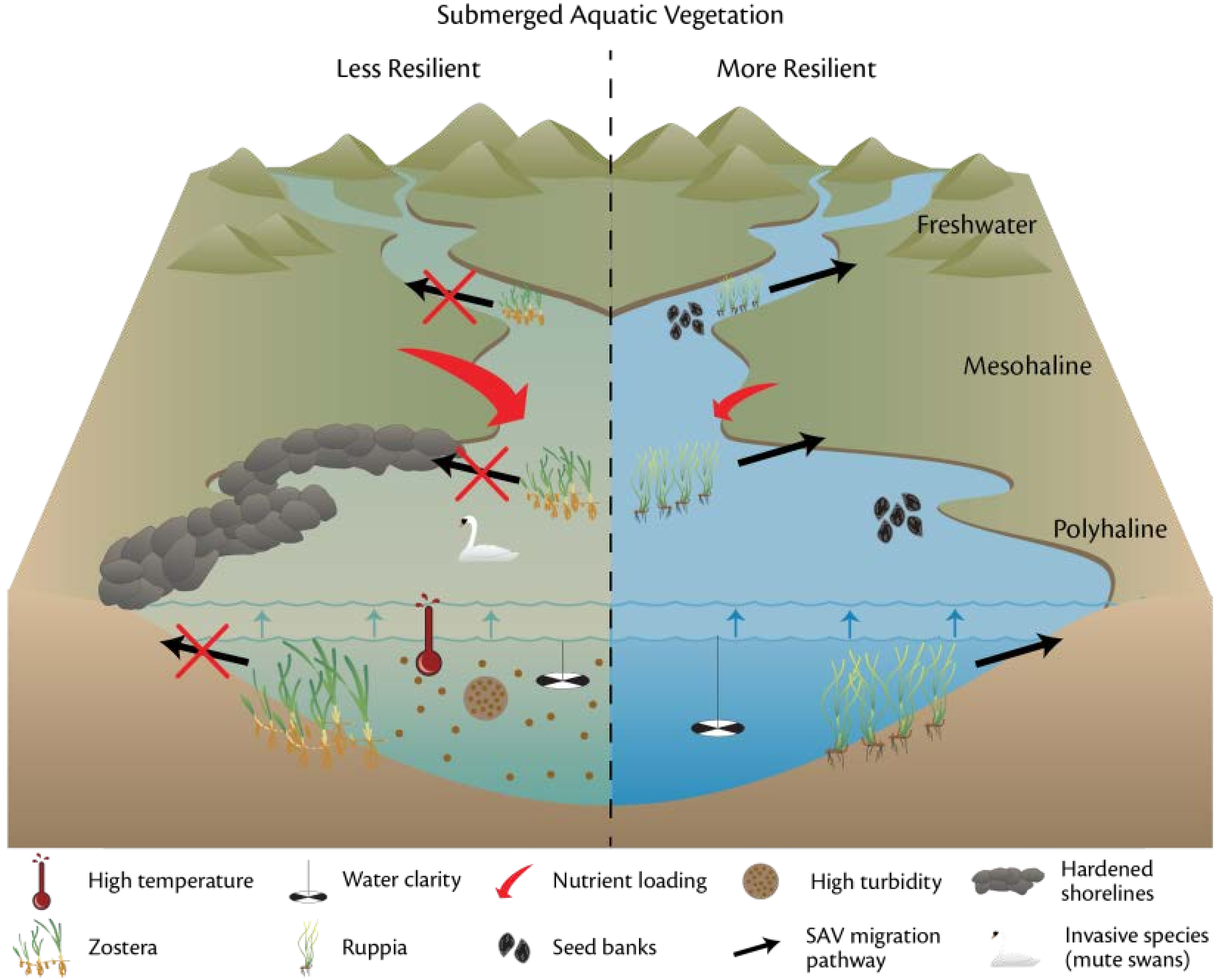
Chesapeake Bay Climate Change Vulnerability

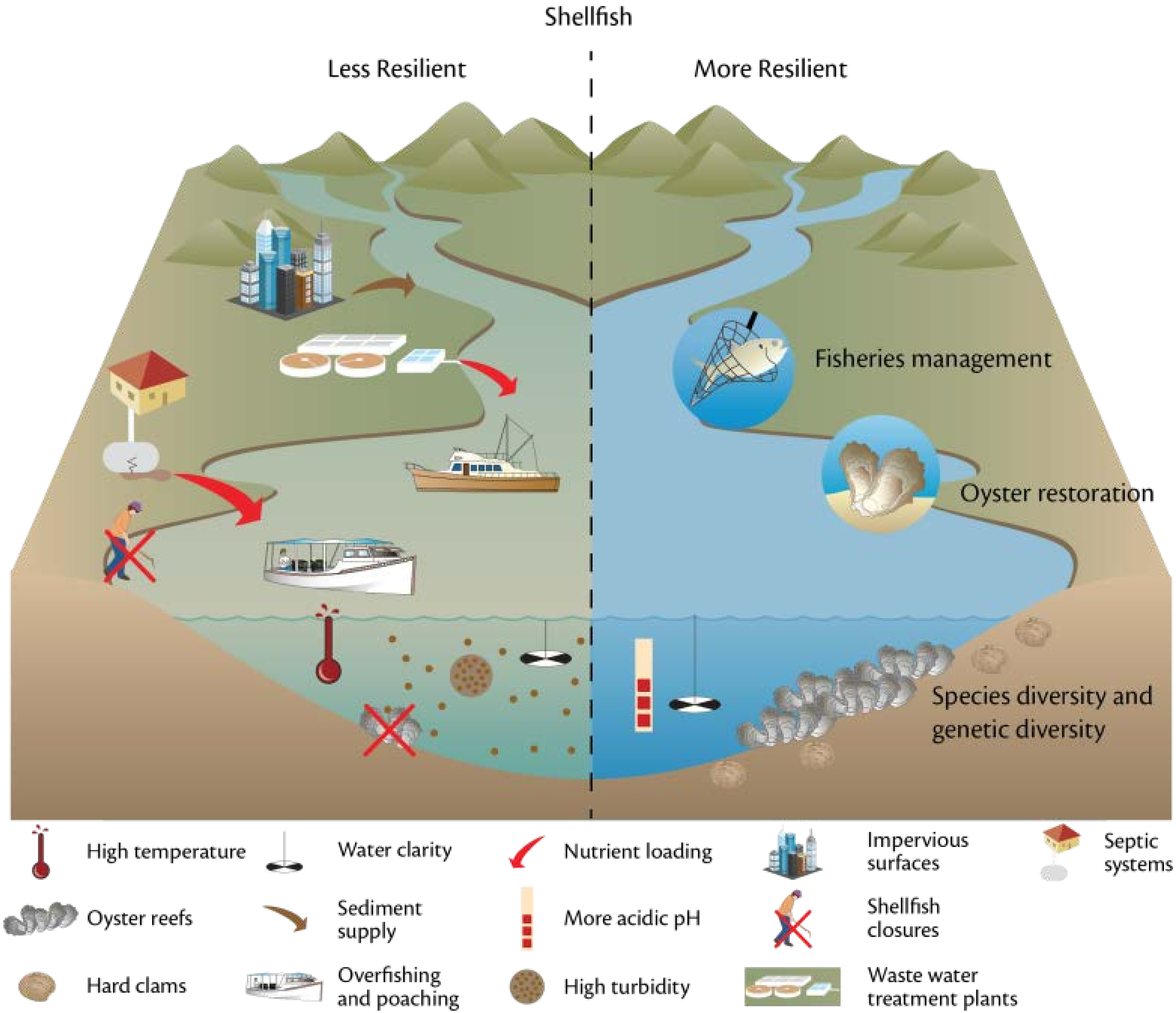


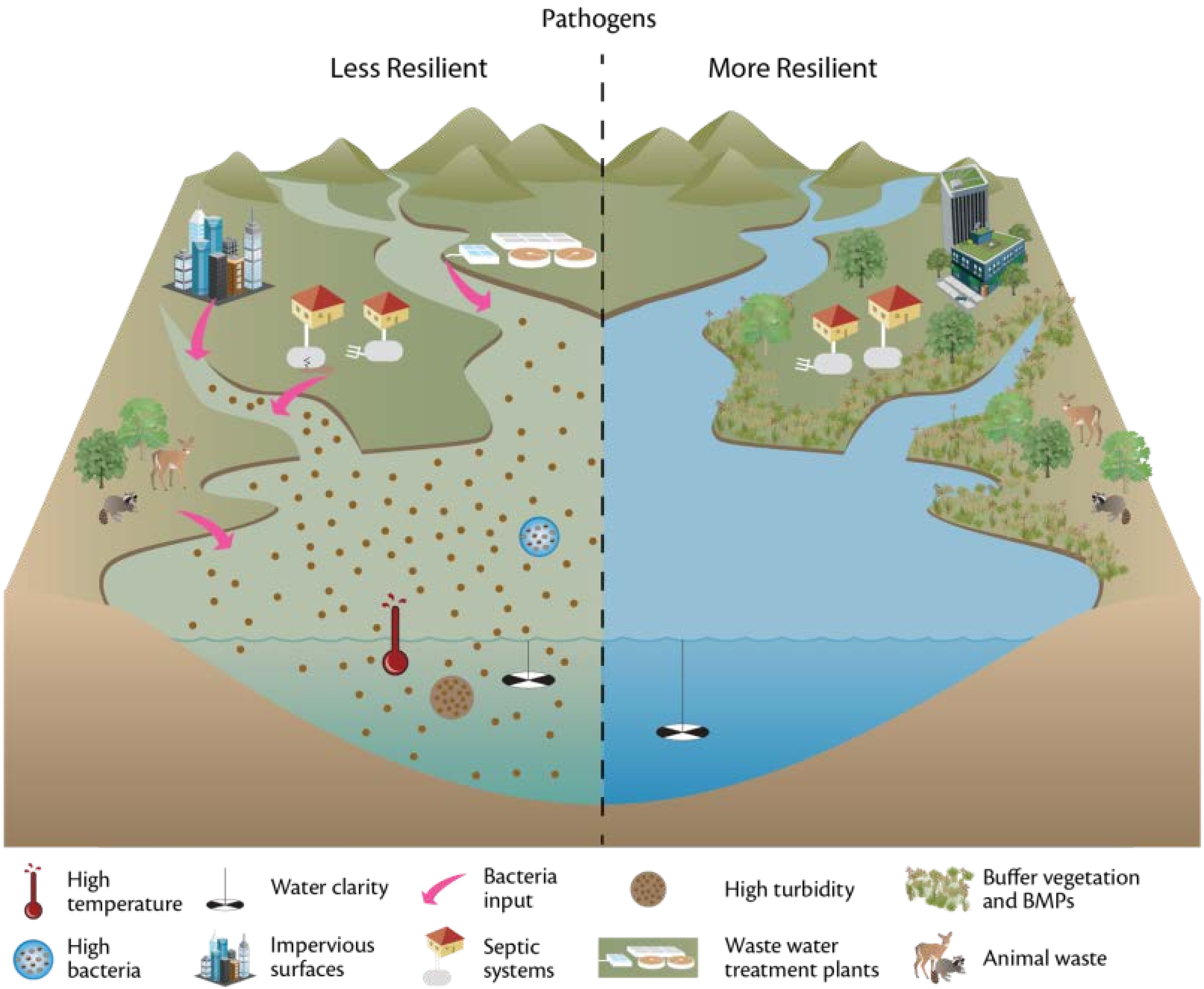


Marshes
Less Resilient
More Resilient
Marsh migration pathway
Erosion
Hardened shorelines
Seagrass beds
Sediment supply
Saltwater intrusion
Wave dampening
Oyster reefs

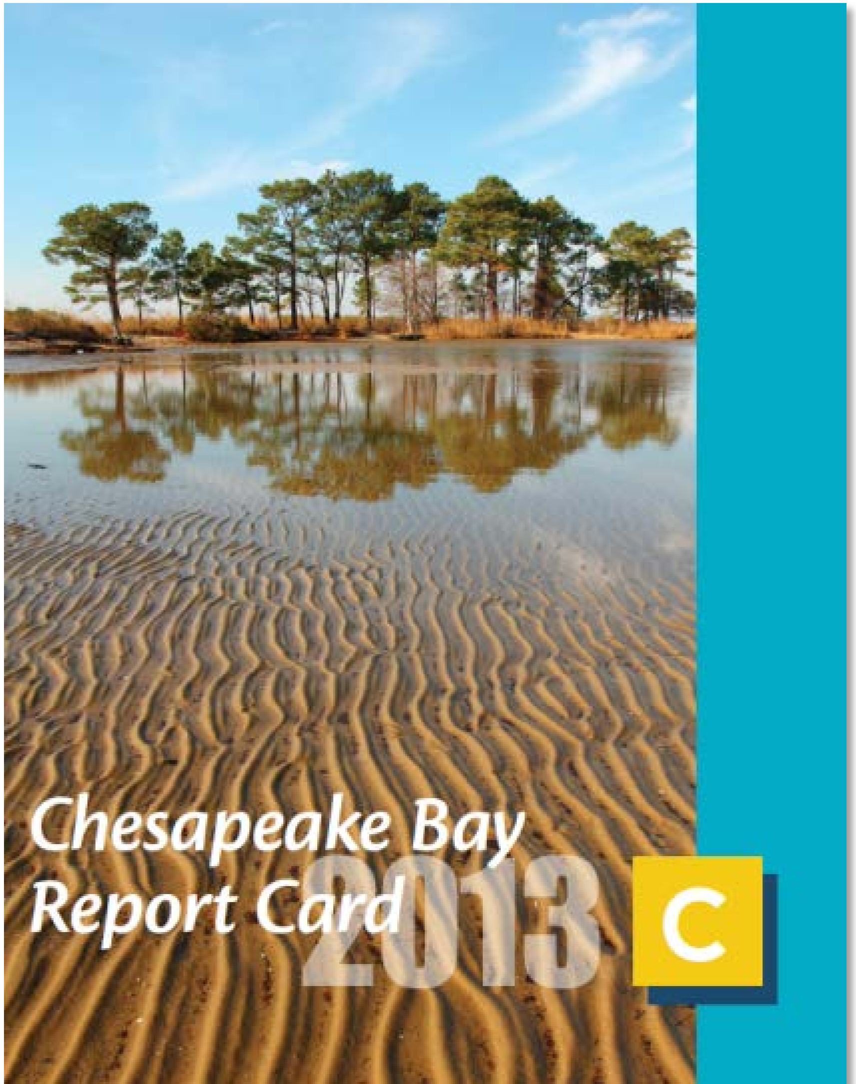

Fish
Less Resilient
More Resilient
High temperature
Wetlands
Oyster reefs
Seagrass
Low dissolved oxygen
Overfishing
and poaching


Submerged Aquatic Vegetation
Less Resilient
More Resilient
Freshwater
Mesohaline
Polyhaline
High temperature
Water clarity
Nutrient loading
High turbidity
Hardened shorelines
Zostera
Ruppia
Seed banks
SAV migration pathway
Invasive species (mute swans)


Shellfish
Less Resilient
More Resilient
Fisheries management
Oyster restoration
Species diversity and genetic diversity
High temperature
Water clarity
Nutrient loading
Impervious surfaces
Septic systems
Oyster reefs
Sediment supply
More acidic pH
Shellfish closures
Hard clams
Overfishing and poaching
High turbidity
Waste water treatment plants


Pathogens
Less Resilient
More Resilient
High temperature
Water clarity
Bacteria input
High turbidity
Buffer vegetation and BMPs
High bacteria
Impervious surfaces
Septic systems
Waste water treatment plants
Animal waste

Chesapeake Bay Report Card 2013



Climate change impacts

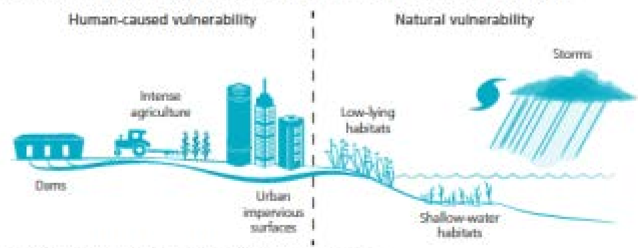
- Sea level rise
- Temperature
- Precipitation
- Storms
- Salinity
- pH

Climate change indicators

- Coastal wetlands
- Submerged aquatic vegetation
- Fish
- Shellfish
- Pathogens

How will Chesapeake Bay respond to climate change?

Protection and restoration of the Chesapeake Bay must account for climate change impacts that we are experiencing now. These impacts include sea level rise, increasing water temperatures and rainfall, increasing storm frequency and intensity, changes in salinity, and ocean acidification (pH). We are currently developing a suite of indicators that will measure resilience of Chesapeake Bay to climate change. These indicators are coastal wetlands, submerged aquatic vegetation, fish, shellfish, and pathogens.



The new Climate Change Resilience Index addresses both human-caused and natural vulnerabilities of Chesapeake Bay to climate impacts.

How can we measure resilience to climate change?

We are creating the Climate Change Resilience Index using a 5-step process:

1. **Conceptualize:** illustrate the ways that climate change may affect resources from sea level rise, increased temperature, precipitation, and storm frequency and intensity, and ocean acidification.
2. **Choose Indicators:** choose indicators that reflect the processes from the conceptualization.
3. **Define Thresholds:** determine the desired condition for each one of the indicators.
4. **Calculate Scores:** compare data to the desired conditions, and combine into an index for climate resilience.
5. **Communicate Results:** the index will be incorporated into the Chesapeake Bay Report Card, and will be highlighted in newsletters and other reports.

A conceptual diagram shows that coastal wetlands that are protected from erosion have adequate sediment supply to build upwards, and have access to landward migration pathways, will likely be more resilient to climate change effects.

As an example, Conceptualization shows that coastal wetlands are likely to be affected by their ability to migrate landward or grow upwards as sea levels rise, and will be protected by underwater grasses and oyster habitat, which reduce wave action and erosion during storms. Indicators that can be used to measure wetland resilience include migration pathways that will allow the wetlands to migrate landward, and sediment supply, which allows wetlands to grow upward as sea levels rise.

Chesapeake Bay Report Card 2013

Climate change impacts

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- Temperature
- Precipitation
- Storms
- Salinity
- pH

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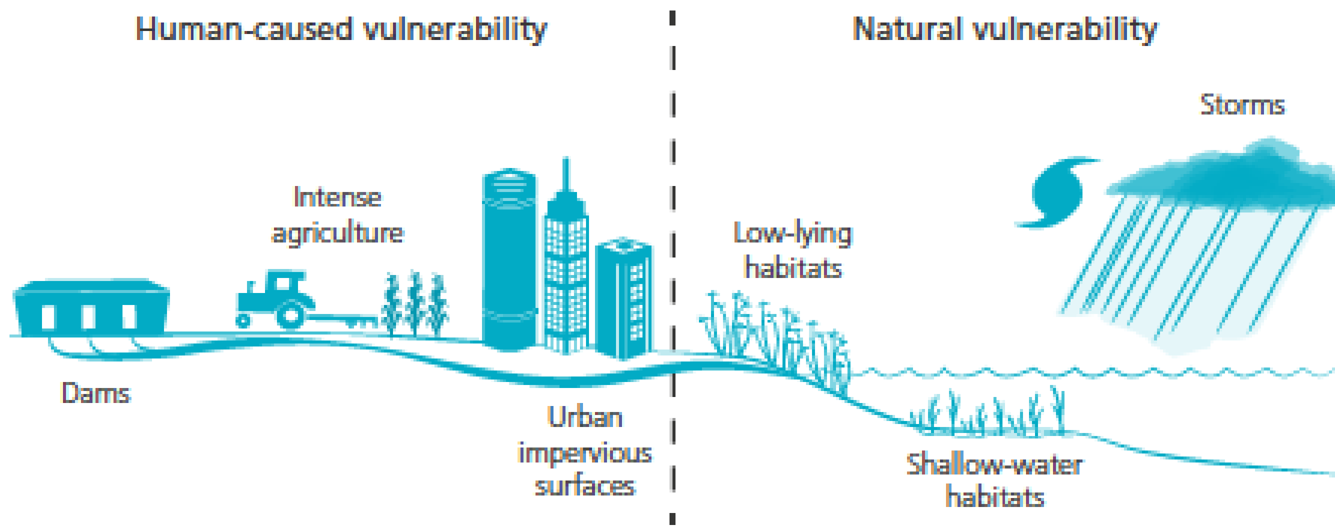

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Chesapeake Bay Report Card 2013

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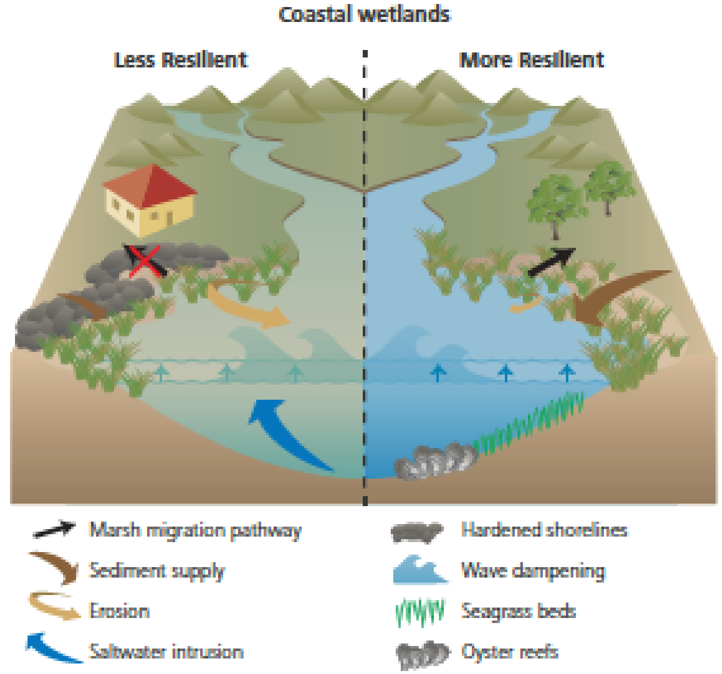

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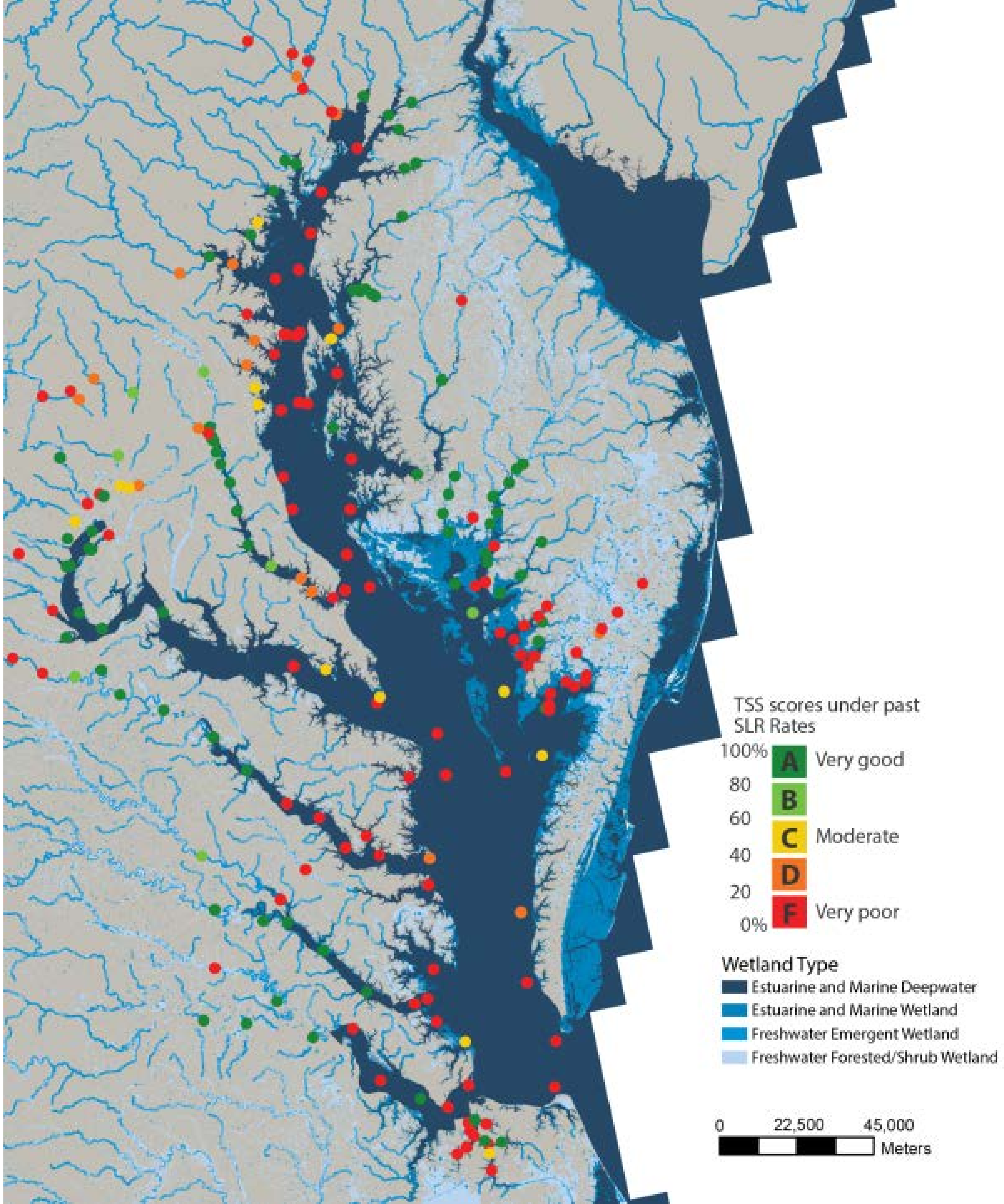
Wetlands

- Total Suspended Solids
  - From Kirwan et al. paper
  - Data from Chesapeake Bay Program’s database
  - Paper outlines thresholds
- Past, Current, and Future SLR Rates used
  - Past: 4mm/yr SLR = 9mg/l TSS
  - Current: 6mm/yr SLR = 15.5mg/l TSS
  - Future: 12mm/yr SLR = 35.5mg/l TSS

TSS Scores based on Past SLR Rates



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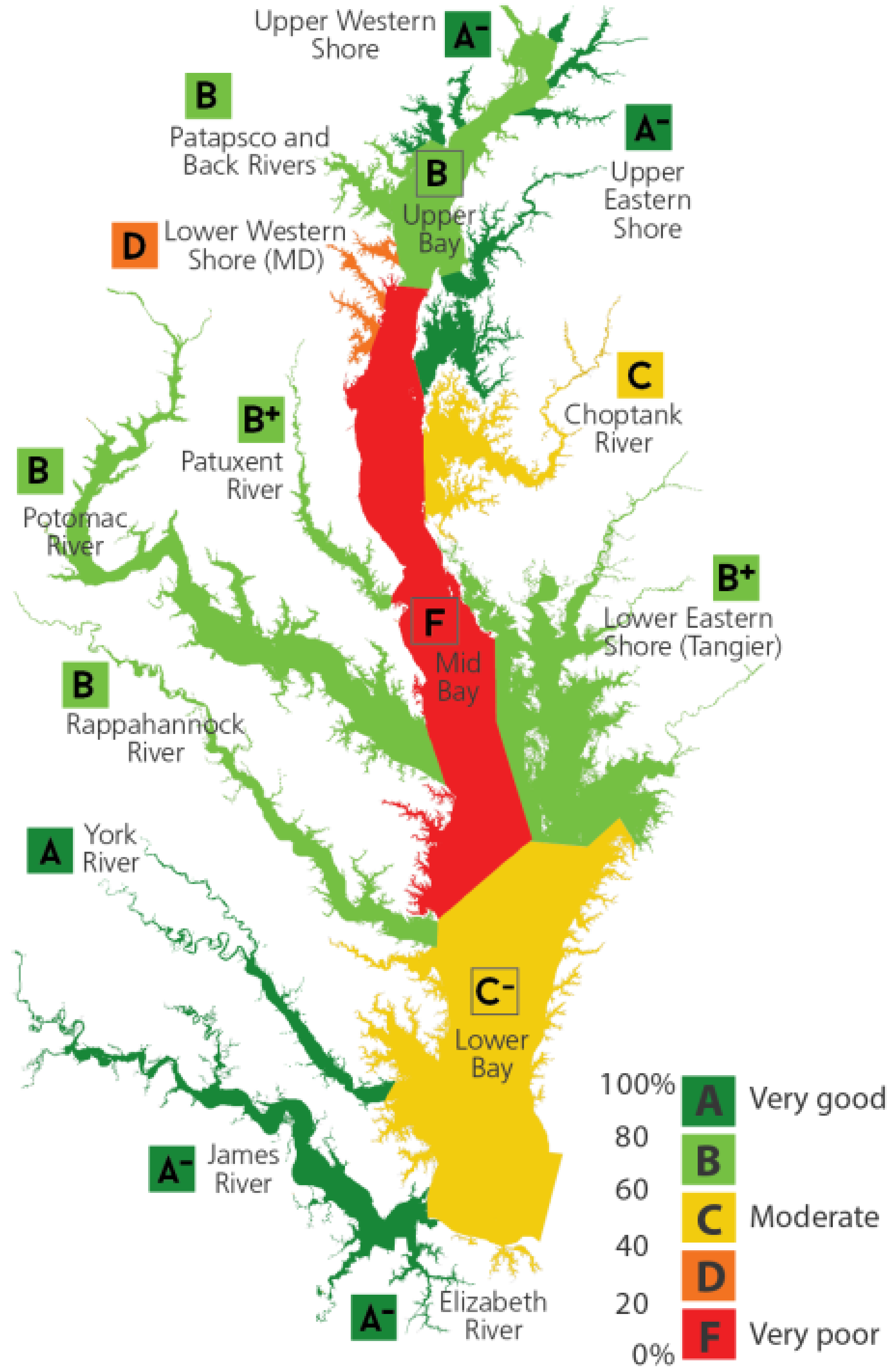
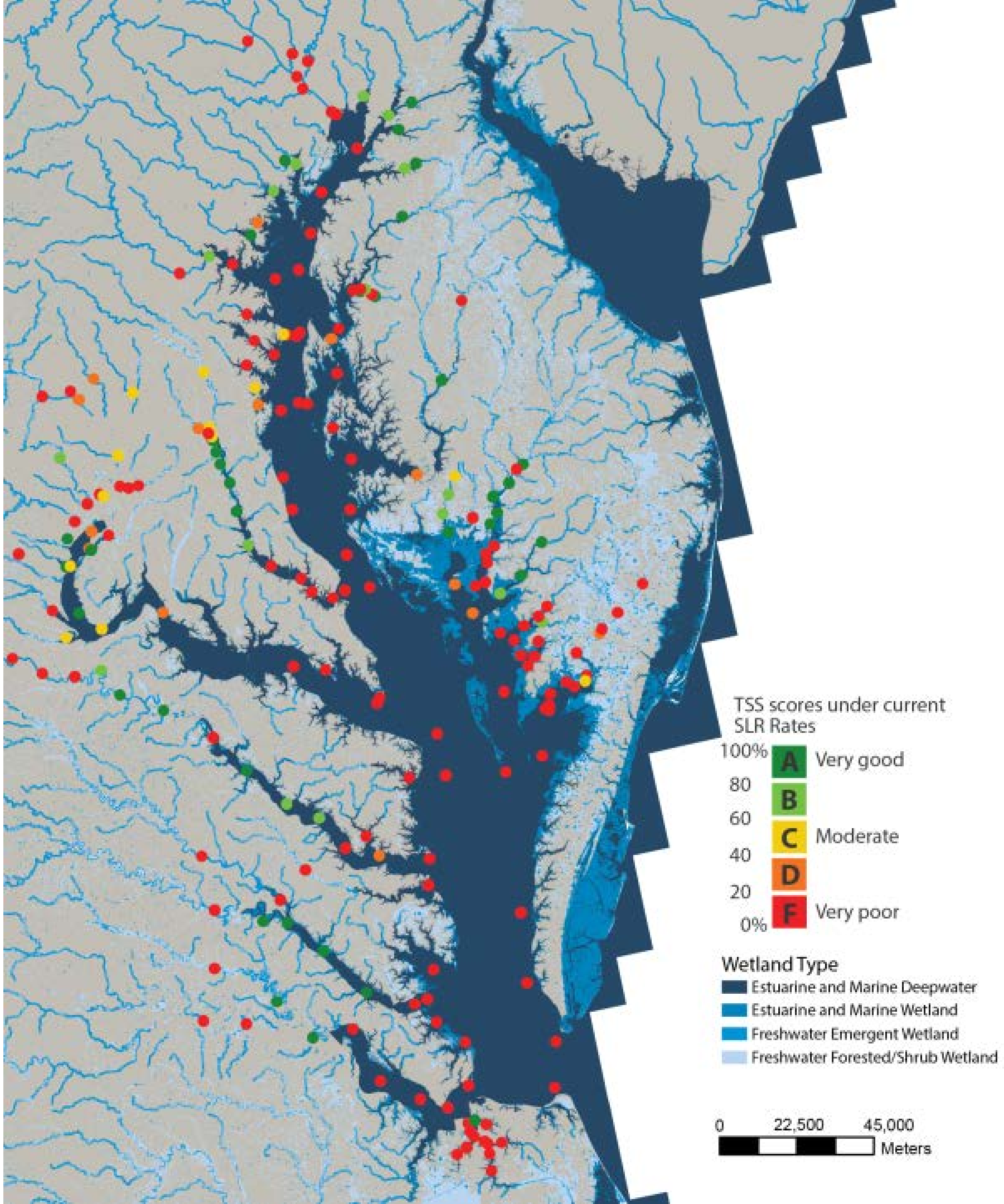
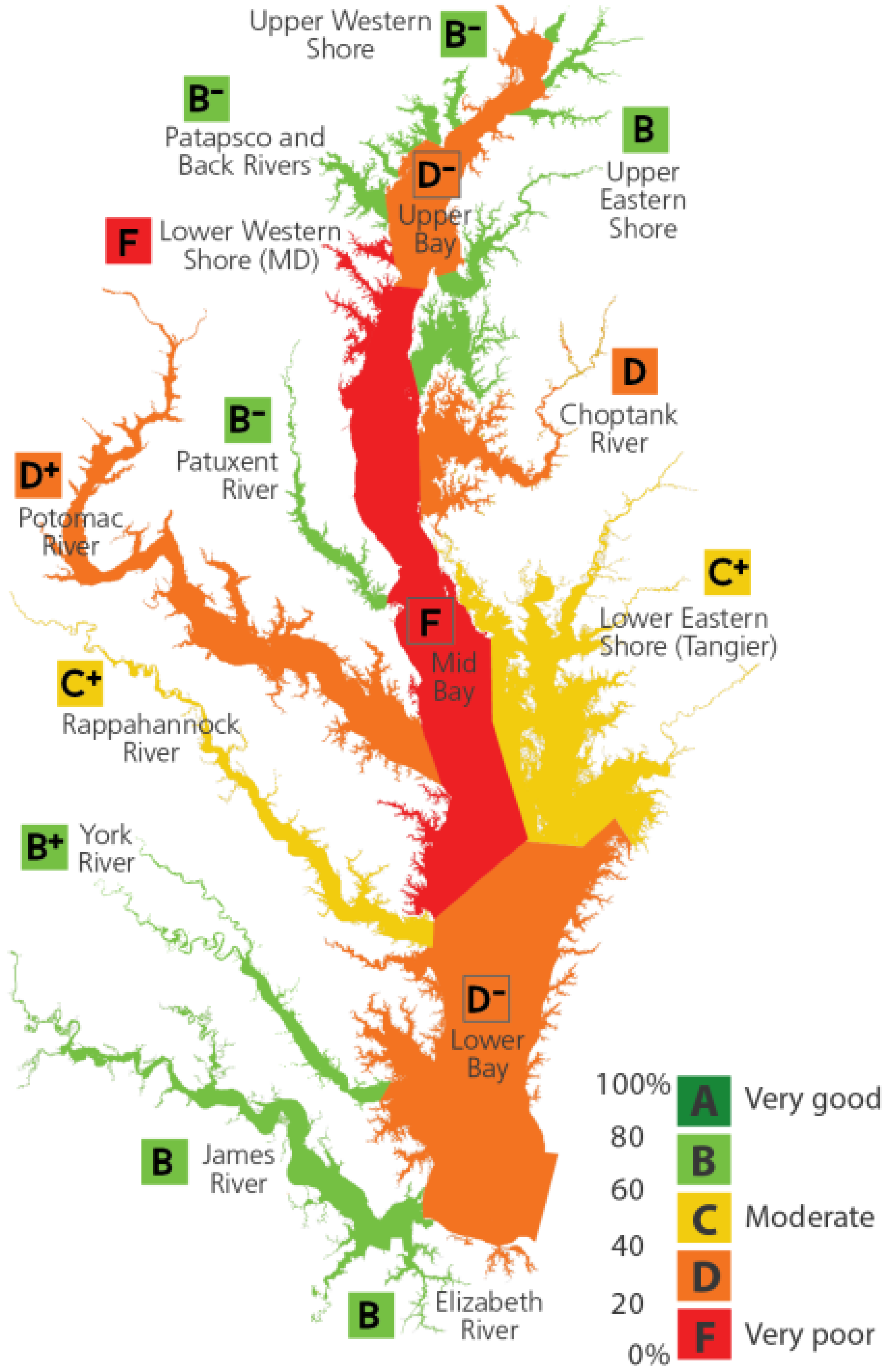


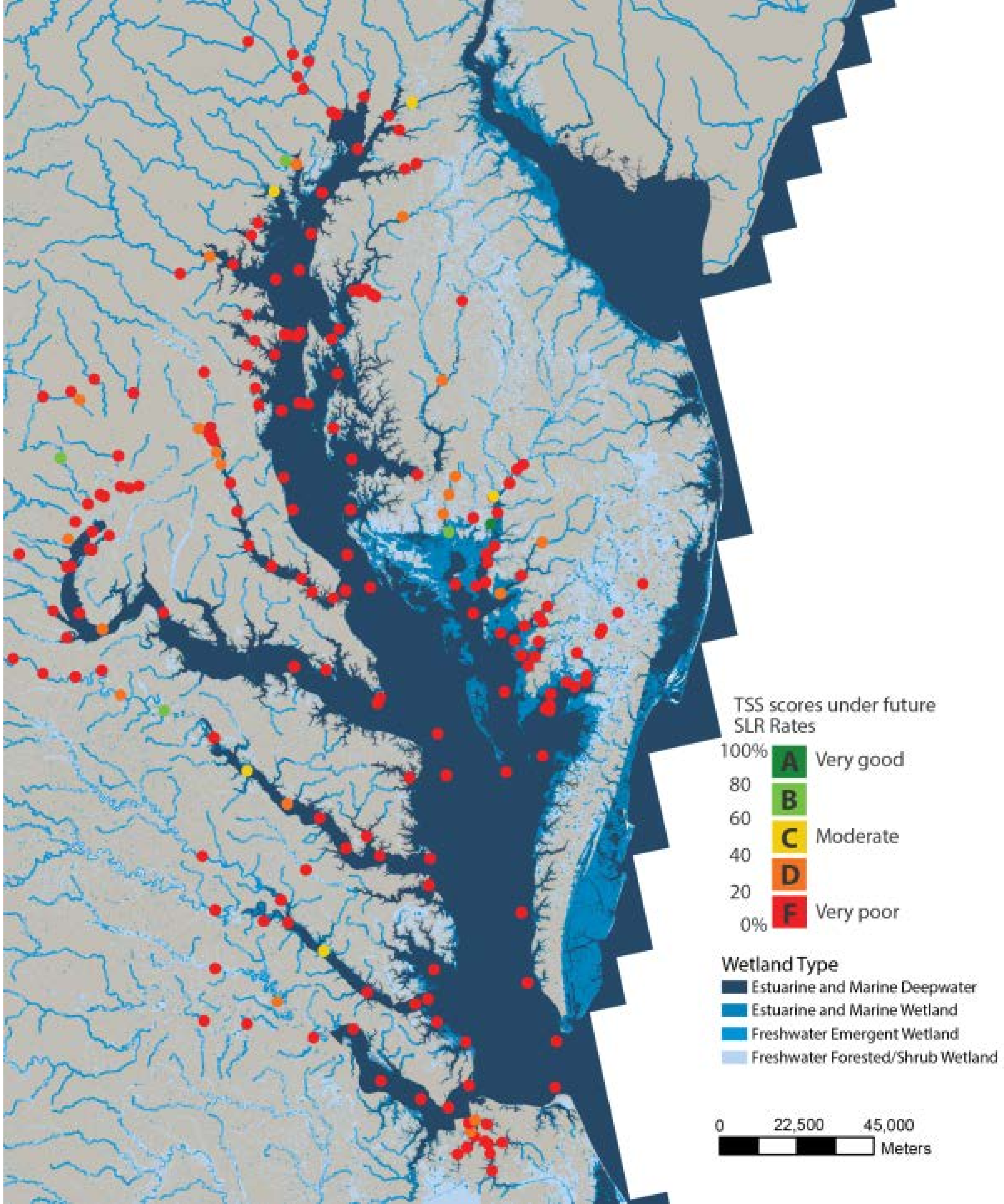
TSS Scores based on Current SLR Rates



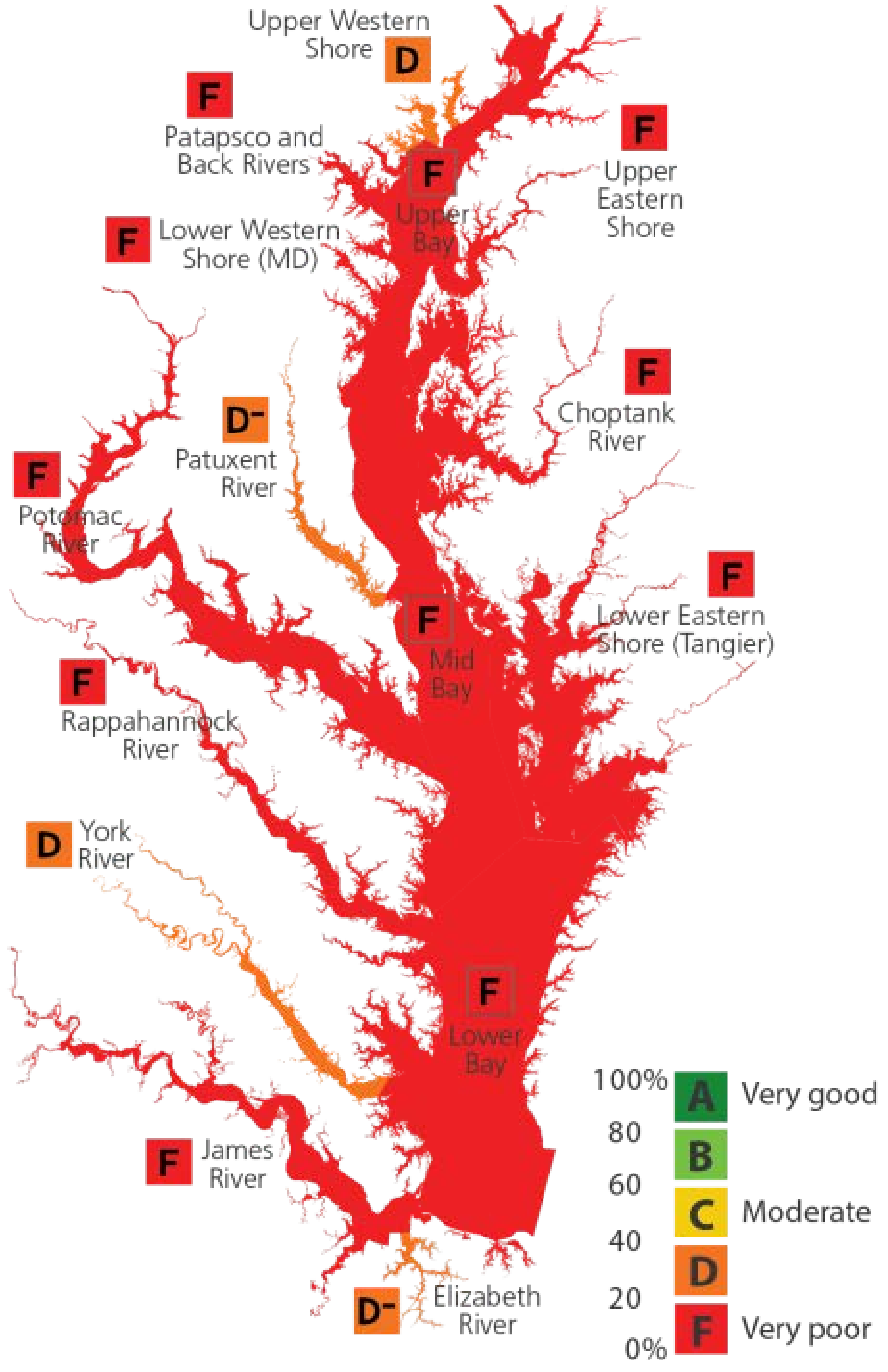
TSS Scores based on Current SLR Rates



TSS Scores based on Future SLR Rates



TSS Scores based on Future SLR Rates



Chesapeake Bay Fisheries

- National Fish and Wildlife Foundation's "The Chesapeake Bay and Global Warming" (2007)
- Have data on some of these species
- Look for trends

TABLE 2. 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 eutrophication.
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.

Note: These probable effects were identified based on available information, but significant changes in key parameters such as temperature and salinity are likely to have wide-ranging unpredictable effects on life cycles and food webs.

Submerged aquatic vegetation

- Gurbisz and Kemp 2014
- Working with Gurbisz on resilience indicator
- Resilience = [measure of SAV]/[disturbance]
- Example = % loss/# of days with low water clarity

Other indicators

- Beach closures – no trend, nothing to show
- Oysters – no raw data to even look at
- Pathogens – want to link to impervious surface