United States Environmental Protection Agency

Climate Indicators and Progress for the Chesapeake Bay

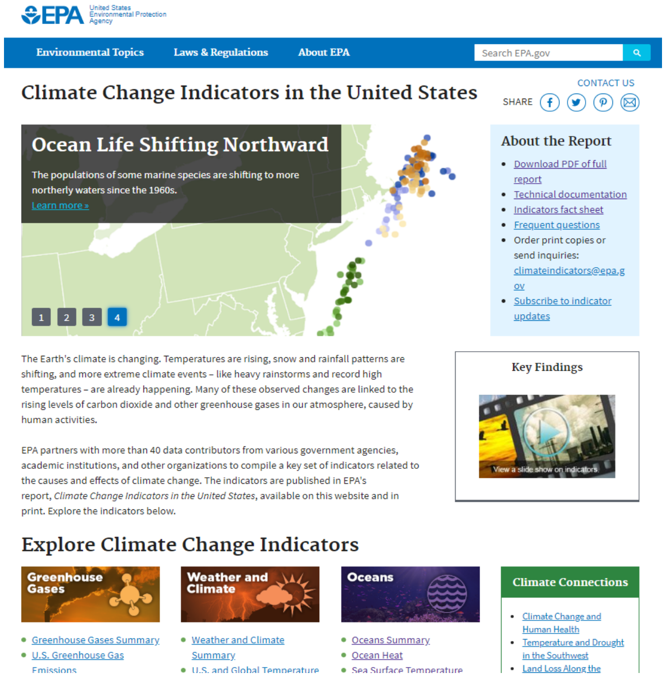
Climate Resilience Workgroup Meeting
March 16, 2020

Mike Kolian, US EPA, Office of Atmospheric Programs (OAP)
Climate Change Division

EPA's Climate Change Indicators

EPA's Climate Indicators Project

- Primary goal is to communicate the causes and effects of climate change
- Observations only (no projections)
- Highlights federal government data and analyses
- A collaboration of over 40 agencies and organizations
- Indicators and reports undergo an independent peer review
- Captures a growing body of scientific evidence
- Continuing to update existing indicators and develop new ones



2010 2012 2014 2016

U.S. Environmental Protection Agency. 2016. Climate change indicators in the United States, 2016. Fourth Edition. EPA 430-R-16-004. www.epa.gov/climate-indicators.

EPA's Climate Change Indicators

Greenhouse Gases

- U.S. Greenhouse Gas Emissions
- **Residential Energy Use (Summer)**
- Global Greenhouse Gas Emissions
- Atmospheric Concentrations of Greenhouse Gases *
- Climate Forcing *

Weather and Climate

- U.S. and Global Temperature *
- High and Low Temperatures *
- **Heat Waves (U.S. Cities) ***
- **Winter (Seasonal) Temperatures ***
- U.S. and Global Precipitation *
- Heavy Precipitation *
- River Flooding
- Drought *
  - **Standardized Precipitation Evapotranspiration Index**
- Tropical Cyclone Activity

Oceans

- **Ocean Heat ***
- Sea Surface Temperature
- **Marine Heat Waves**
- Sea Level *
- Coastal Flooding *
- Ocean Acidity

Health and Society

- Heating and Cooling Degree Days *
- Heat-Related Deaths
- **Cold-Related Deaths**
- Heat-Related Illnesses
- Lyme Disease *
- West Nile Virus *
- Length of Growing Season *
- Ragweed Pollen Season
- **Growing Degree Days (pollen)**

Snow and Ice

- Arctic Sea Ice *
- Antarctic Sea Ice *
- **Ice Sheets**
- **Glaciers ***
  - **Arctic Glaciers**
- **Permafrost**
- Lake Ice
- Snowfall
- Snow Cover
- Snowpack *
  - **Peak Snowpack**

Ecosystems

- Wildfires *
  - **Wildfire Season Length**
  - **Wildland Urban Interface**
- Streamflow *
- Stream Temperature
- **Ground Water Levels**
- Great Lakes Water Levels
- **Great Lakes Ice Cover**
- **Lake Temperature**
- Bird Wintering Ranges
- Marine Species Distribution *
- Leaf and Bloom Dates *
- **Frost Free Season**

Features

- ***Community Connection: Ice Breakup in Two Alaskan Rivers ****
- *A Closer Look: Land Loss Along the Atlantic Coast*
- *A Closer Look: Temperature and Drought in the Southwest **
- ***A Closer Look: Glaciers in Glacier National Park***
- ***A Closer Look: Black Guillemots of Cooper Island ****
- *Tribal Connection: Water Temperature in the Snake River **
- *Community Connection: Cherry Blossom Bloom Dates in Washington, D.C *.*
- *Connections Between Climate Change and Human Health*

New Content Themes and Frameworks

- ***Vulnerability: Wildfire: WUI, Floodplain, Urban Heat Islands***
- ***Population exposure (census data)***
- ***Changing Seasonality***
- ***Social Science***

Legend

Red = new since 2016
Orange = new dataset(s)
* = updated data since 2016

EPA's Basic Methodology

- Evaluate, assess data quality and select indicators (use criteria below)
- Develop technical documentation (13 elements for each indicator)
- Expert technical review
- Independent ‘peer review’
- Make publicly available (website, reports, etc.)
- Routinely update indicator based on data availability (e.g., annually)

Criteria used to evaluate and select indicators:

- Trends over time
- Based on observed data
- Broad geographic coverage
- Published or peer-reviewed data
- Usefulness
- Relevance to climate change
- Feasible to construct
- Transparency, reproducibility, and objectivity
- Ability to communicate to the public

Chesapeake Bay Program's Basic Methodology

- Climate Monitoring and Assessment
- Climate Resiliency
- Influencing Factor

- Evaluate data quality and select indicators
- Develop technical documentation (37 elements for each indicator)
- Expert technical review
- Independent 'peer review' (CRWG approves?)
- Make publicly available (website, reports, etc.)
- Routinely update indicator based on data availability (e.g., annually)

Categories used to document the indicators:

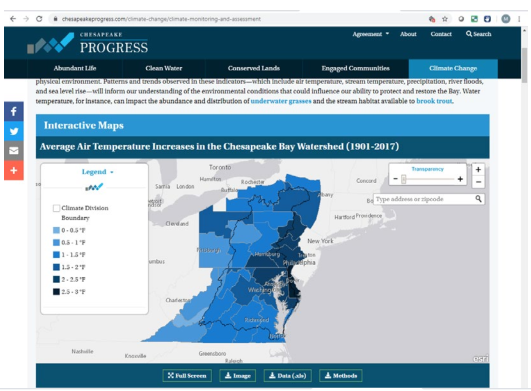
- Data set and source
- Temporal considerations
- Spatial considerations
- Communicating the data
- Adaptive managment
- Analysis and interpretation
- Quality
- Additional information

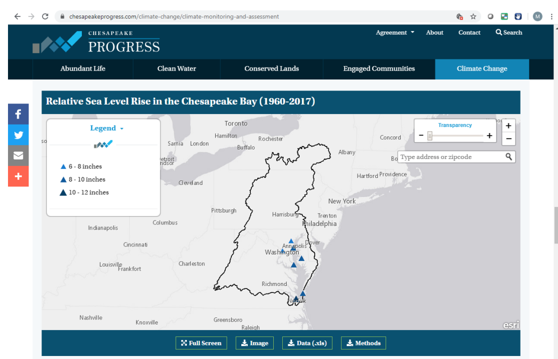
Chesapeake Progress // Update Summary

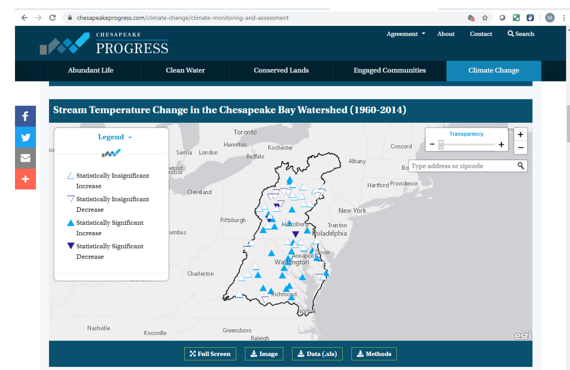
- **Average Air Temperature** – updated thru 2018.
- **High Temperature Extremes** – updated thru 2018.
- **Precipitation** – updated thru 2018.
- **Relative Sea Level** – updated thru 2018.
- **The frequency of tidal flooding in four coastal cites** – ‘High Tide Flooding’
  - Newly created indicator thru 2018 - ready for review.
- ***River Flooding Magnitude and Frequency*** *– no change.*
- ***Stream Temperature*** *– no change.*

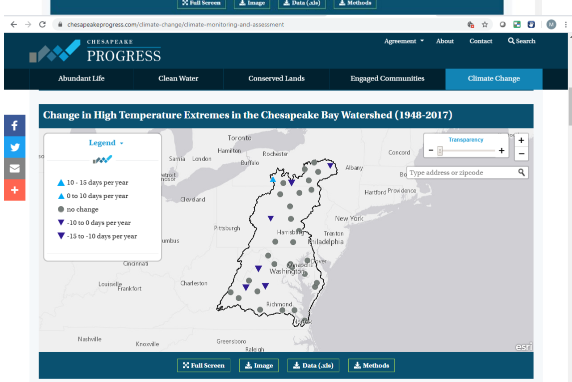
4 pieces

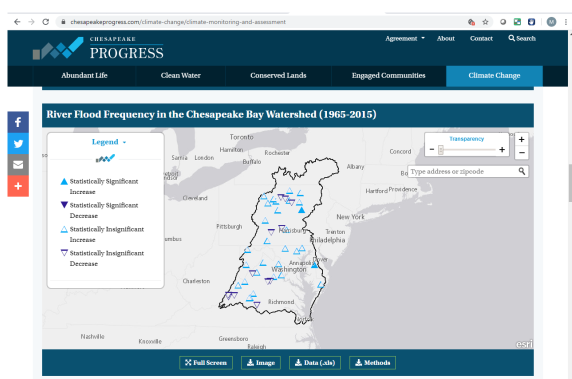
- Text Summary
- Analysis & Methods
- Data file
- Geodatabase files

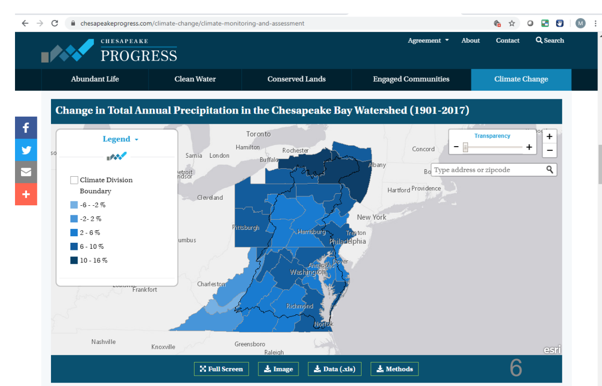












EPA United States Environmental Protection Agency

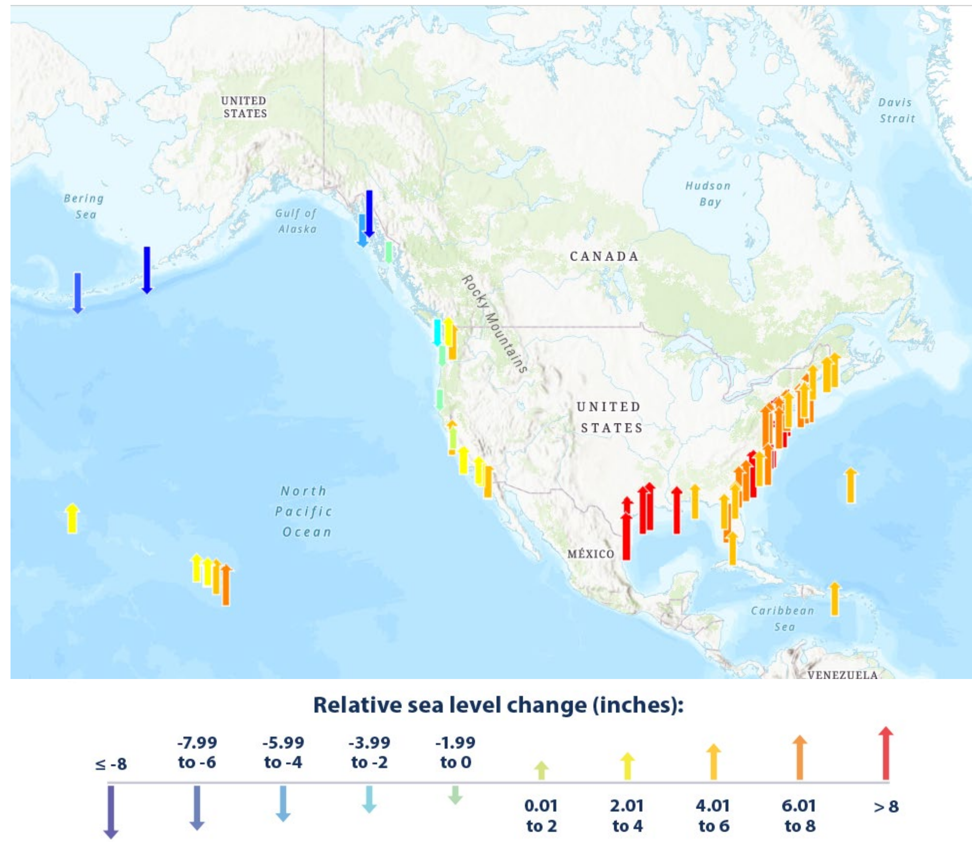
Sea Level

This indicator shows how sea level has changed over time. Relative sea level reflects changes in sea level as well as land elevation.

- Relative sea level rose along much of the U.S. coastline between 1960 and 2018, particularly the Mid-Atlantic coast and parts of the Gulf coast, where some stations registered increases of more than 8 inches. Meanwhile, relative sea level fell at some locations in Alaska and the Pacific Northwest.
- Relative sea level also has not risen uniformly because of regional and local changes in land movement and long-term changes in coastal circulation patterns.

Data Source: NOAA's National Ocean Service, National Water Level Observation Network (NWLON).

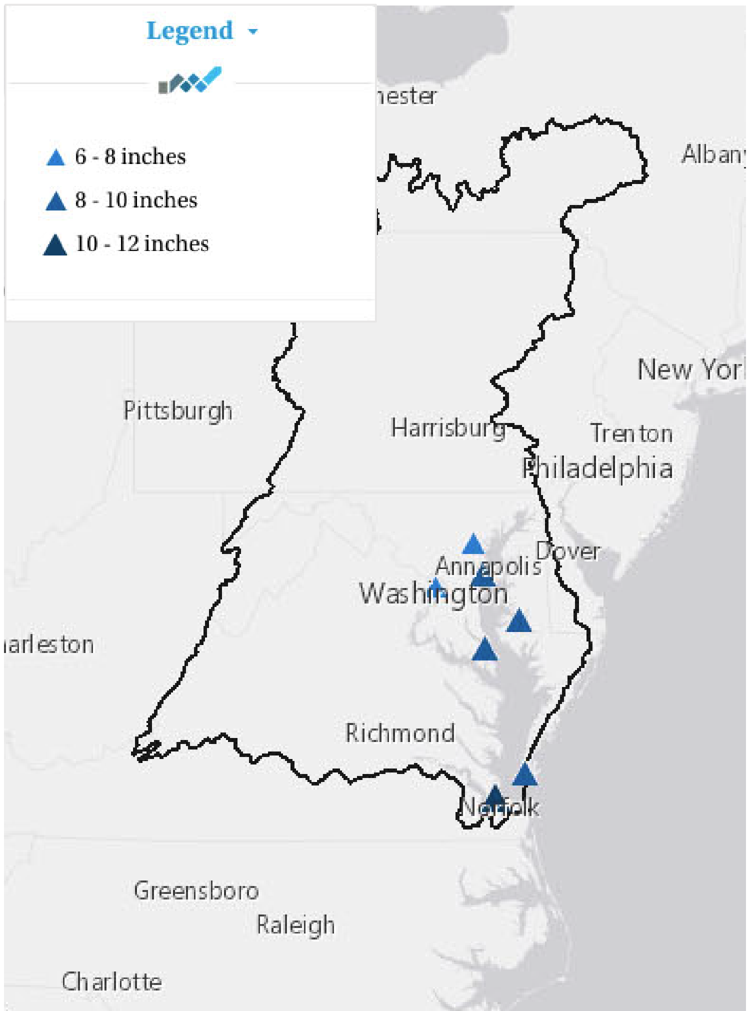
Relative Sea Level Change Along U.S. Coasts, 1960-2018



This map shows cumulative changes in relative sea level from 1960 to 2018 at tide gauge stations along U.S. coasts. Relative sea level reflects changes in sea level as well as land elevation.

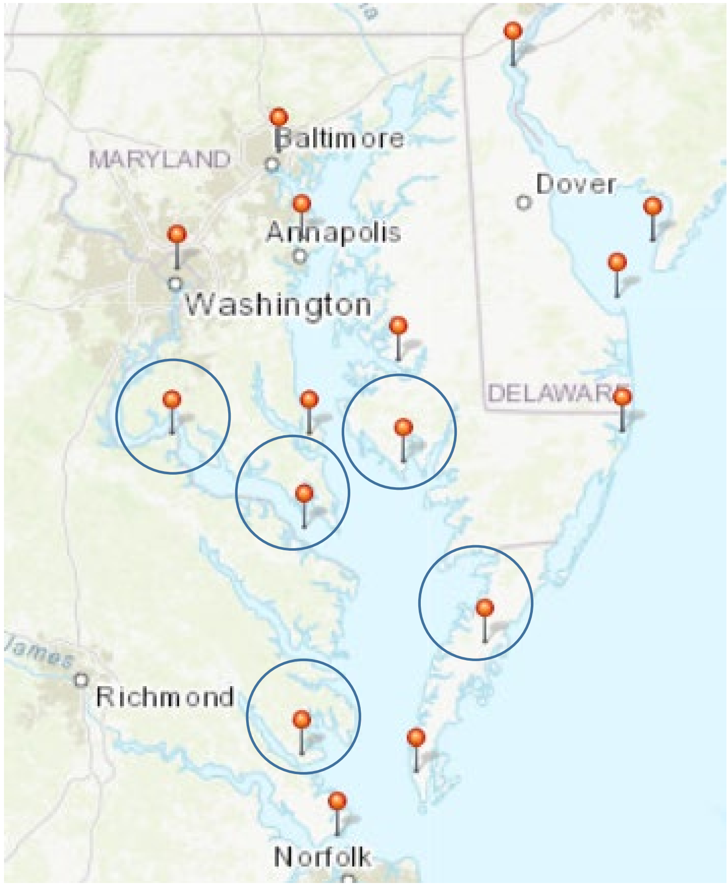
Sea Level Rise

Relative Sea Level Change Along U.S. Coasts, 1960-2017



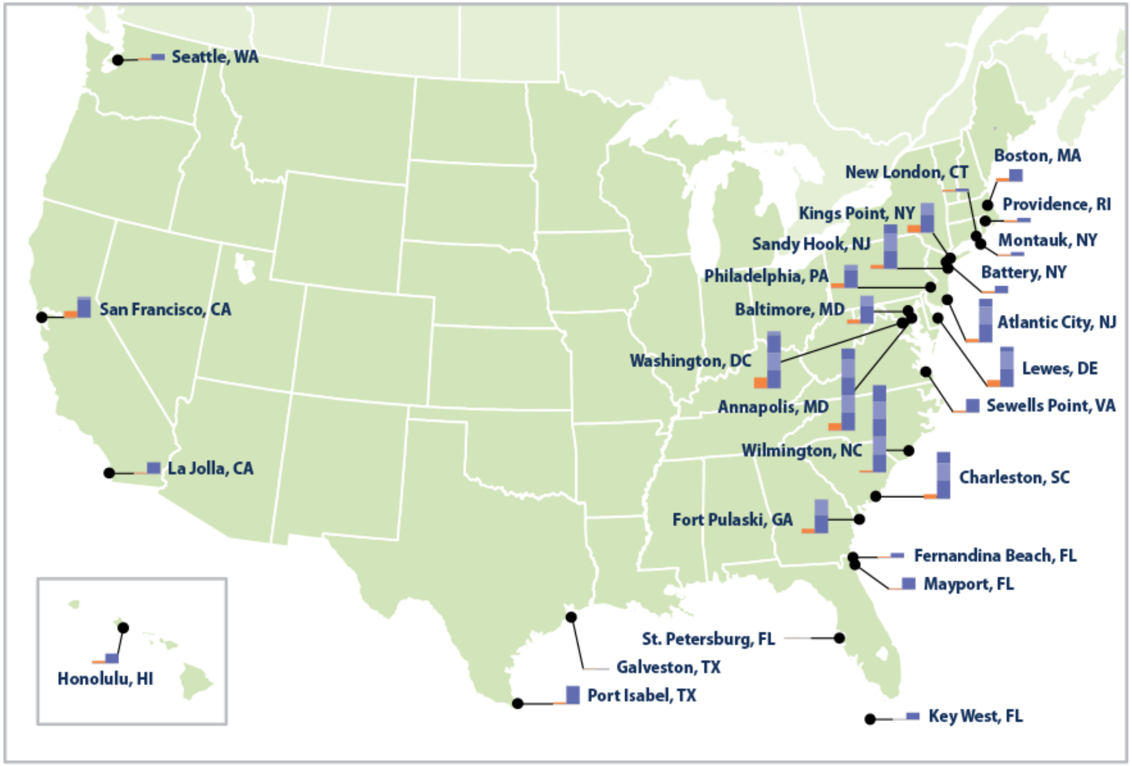
This map shows cumulative changes in relative sea level from 1960 to 2017 at tide gauge stations along U.S. coasts. Relative sea level reflects changes in sea level as well as land elevation.

Is it useful to add more sites?
Would mean using a shorter time period.



Coastal Flooding

Frequency of Flooding Along U.S. Coasts, 2010-2015 Versus 1950-1959



Average number of flood days per year:

Data source: NOAA, National Ocean Service

EPA developed this indicator in partnership with NOAA and focuses on 27 long-term tide gauge locations in the U.S. from 1950-2015.

This indicator shows how the frequency of coastal flooding has changed over time.

- Tidal flooding is becoming more frequent along the U.S. coastline. Nearly every site measured has experienced an increase in tidal flooding since the 1950s. The rate is accelerating in many locations along the East and Gulf Coasts.
- The Mid-Atlantic region suffers the highest number of tidal flood days and has also experienced the largest increases in flooding.

Health Connection:
Recurrent coastal flooding can increase the risk that drinking water, wastewater, and drainage infrastructure will fail, putting people at risk of being exposed to pathogens, disease vectors, and harmful chemicals.

Coastal 'High Tide' Flooding – *NEW*

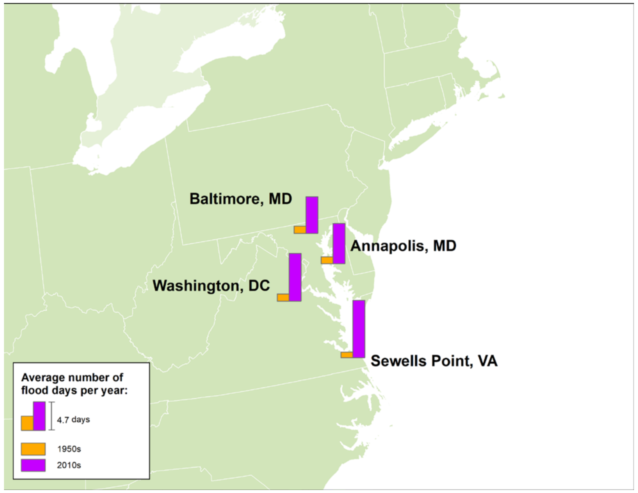
The frequency of tidal flooding in four coastal cities

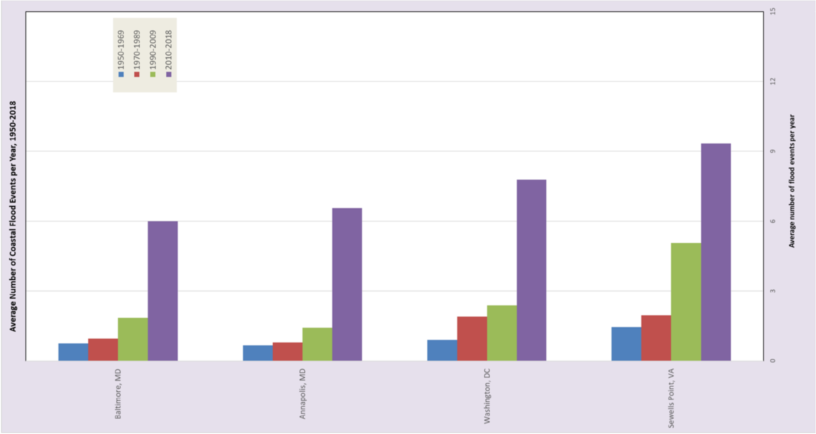
- Tidal flooding is occurring more frequently along the Chesapeake Bay and its tributaries, the rate of increase appears to be accelerating.
- Four locations along the shore have been measured consistently for many years and all four experienced an increase in the average number of flood days per year since the 1950s.
- The average number of flood days per year during the most recent decade ranged from six in Baltimore to about nine in Norfolk (Sewell's Point).
- Tidal flooding happens five times more often than it did in the 1950s in Baltimore, six times more often in Annapolis and Washington, and 10 times more often at Norfolk.

Data Sources and References:

- EPA's Coastal Flooding Indicator
- https://tidesandcurrents.noaa.gov/publications/techrpt86_PaP_of_HTFlooding.pdf
- https://tidesandcurrents.noaa.gov/HighTideFlooding_AnnualOutlook.html

Frequency of Flooding Along U.S. Coasts, 2010-2018 Versus 1950-1959

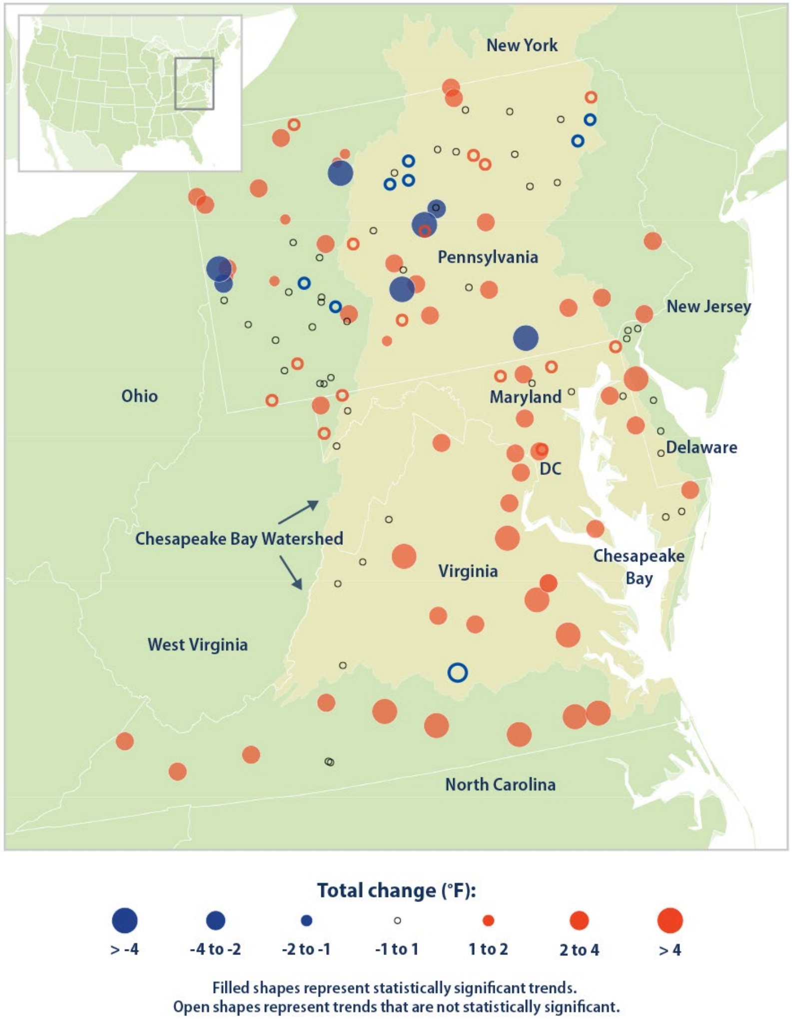




Data source: NOAA, National Ocean Service, 2019

Stream Temperature

Changes in Stream Temperatures in the Chesapeake Bay Region, 1960–2014



Data source: USGS; Jastram and Rice 2015

This indicator shows changes in stream temperature across the Chesapeake Bay region.

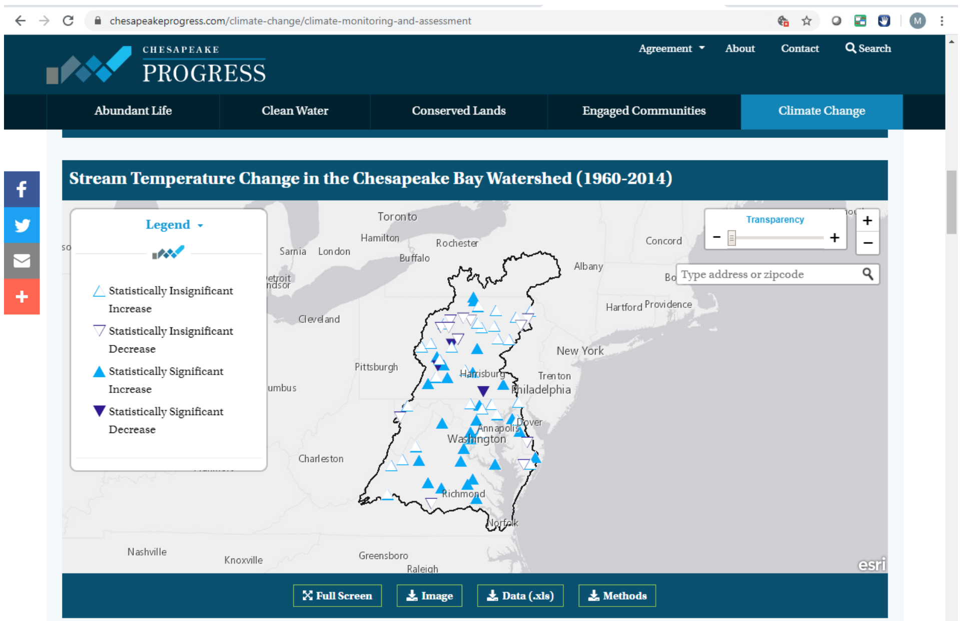
- Stream temperatures have risen throughout the Chesapeake Bay region. From 1960 through 2014, water temperature increased at 79 percent of stream sites in the region.
- Temperature has risen by an average of 1.2°F across all sites and 2.2°F at the sites where trends were statistically significant.

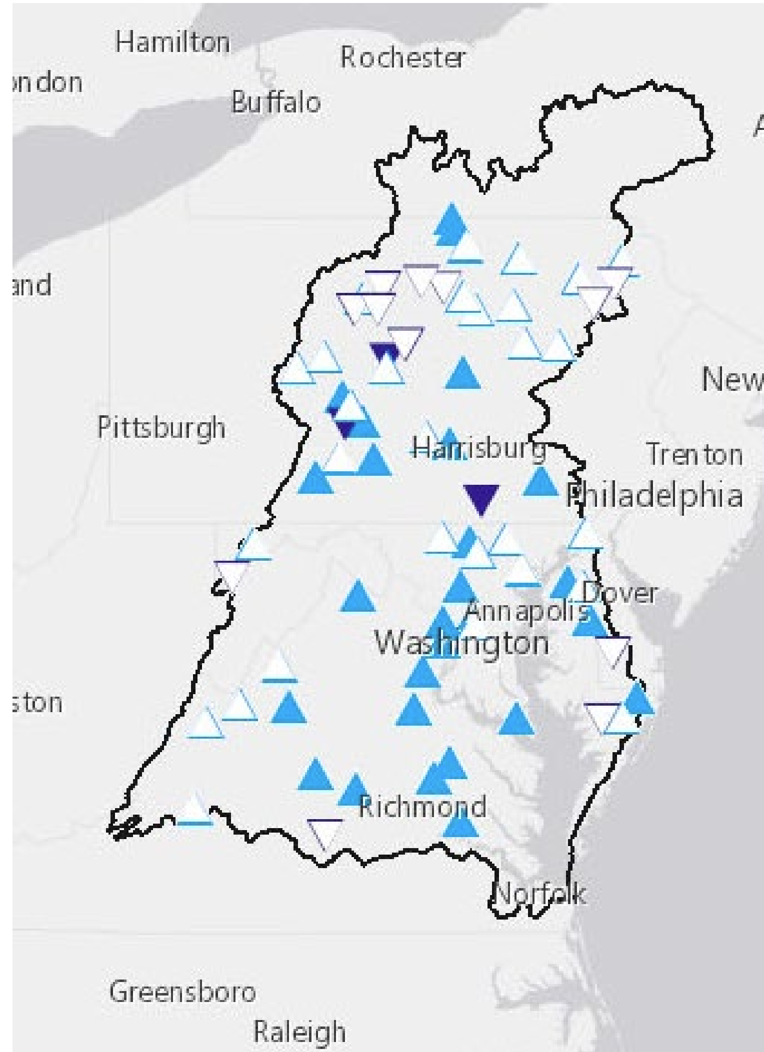
EPA developed this indicator in partnership with USGS and is based on an analysis of water temperature data from about 130 stream gauges across the Chesapeake Bay region.

EPA United States Environmental Protection Agency

Stream Temperature

Changes in Stream Temperatures in the Chesapeake Bay Region, 1960–2014





In 2020, a large database of QA’d stream water temperature data from the USGS will be released —much of which has heretofore not been available to the public. Daily mean data for close to 10,000 sites.

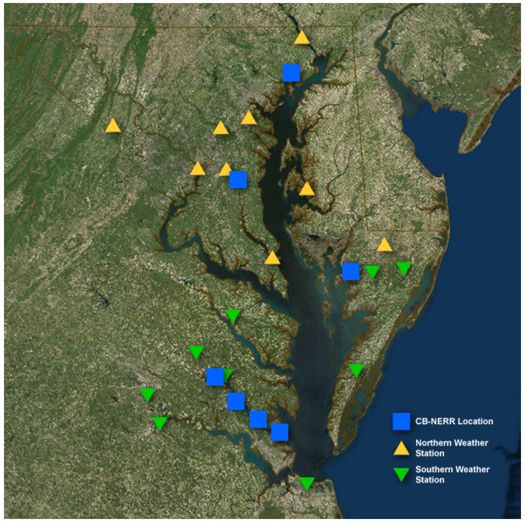
Implications – Increased Water Temperature

- Temperature is currently a leading cause of impairment in the U.S. – an increasing challenge in future (**TMDLs**)
- Decreased dissolved oxygen and assimilative capacity of receiving waters below point source discharges, e.g., effects biochemical oxygen demand (**NPDES**)
- Urban storm water events on hot days causing episodic, local scale increases in water temperature (**Stormwater**)
- Fish and other aquatic animals sensitivity; require a certain temperature range to survive and reproduce; reduce suitable habitat for cold and cool water organisms (**Bioassessment, TMDLs**)
- Expansion of aquatic invasive species such as zebra mussel, or thermal stress on aquatic vegetation - SAVs (**above 30°C for prolonged periods of time)**

United States Environmental Protection Agency

Water Temperature

[Detecting Climate change in Chesapeake Bay]



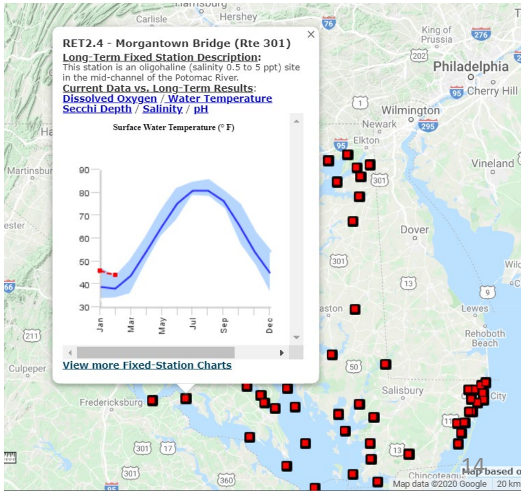
- Water temperature – several endpoints and purposes (e.g., water quality high spatial/temporal variability, requires different types of thresholds physical water quality and biological - SAVs)

- Many geographic areas are under-represented with monitoring; also most managers want local/fine scale information

- Use layers of information and leverage other sources of climate relevant indicator information.

- High level, 1st order assessment might be to demonstrate changes from long-term monitoring sites that have min, max, and long-term means.

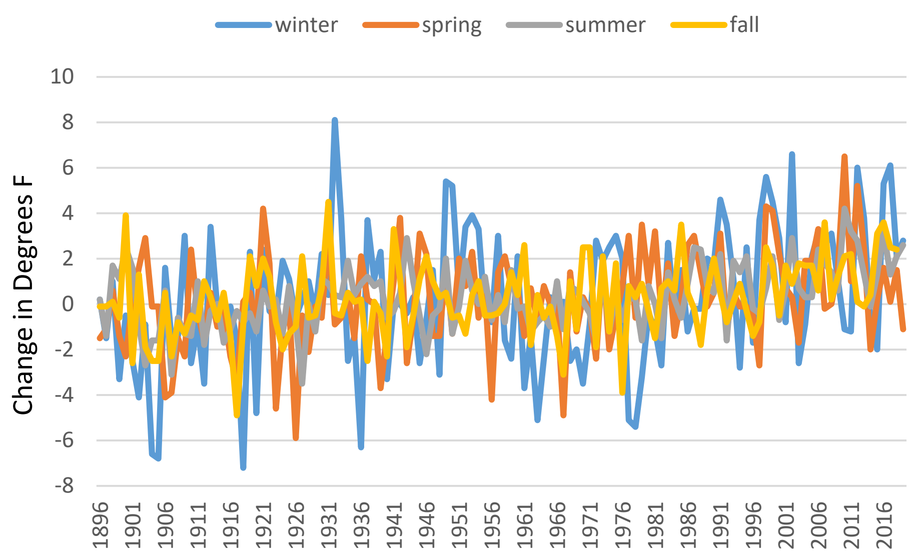
[Eyes on the Bay]



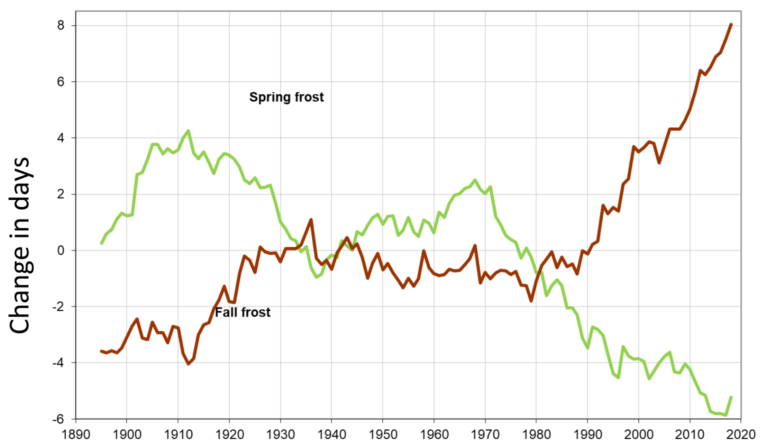
Seasonal Changes

- **Changes in Seasonal air temperature**
- **Growing Season Length**
- **Growing Degree Days**
- **Changes in Phenology (e.g., leaf, bloom)**

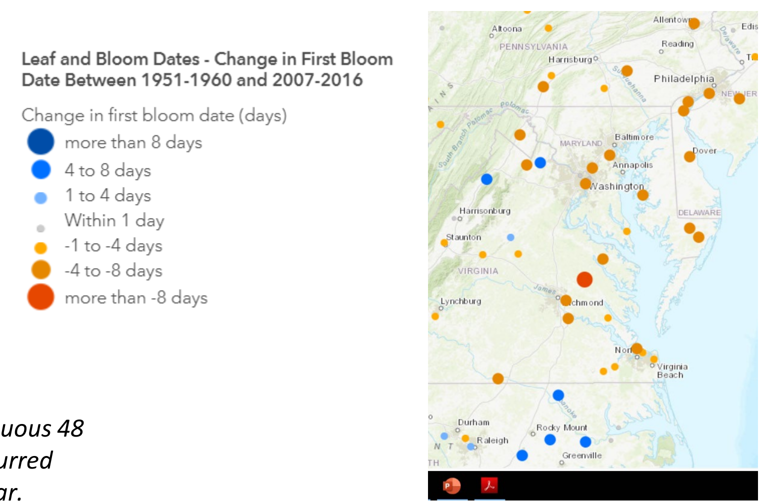
Seasonal Temperatures, 1986-2018: **Maryland**



Timing of Last Spring Frost and First Fall Frost, 1895-2018 (contiguous 48 states)



This figure shows the timing of the last spring frost and the first fall frost in the contiguous 48 states compared with a long-term average. Positive values indicate that the frost occurred later in the year, and negative values indicate that the frost occurred earlier in the year.



Opportunities and Possible Next Steps

Some possible near-term areas of focus or investigation:

- Additional water temperature information
- Heavy precip. variability; more in large events, longer dry spells between events;
  - High Streamflow, moving toward effects from run-off, erosion
  - Other inland, coastal river flooding metrics
- Expand or modify some of the existing indicators to make them more comprehensive.
- Seasonal changes (temperature, phenological – terrestrial and aquatic)
- Marine Species Distribution
- Sea level rise, salt water intrusion

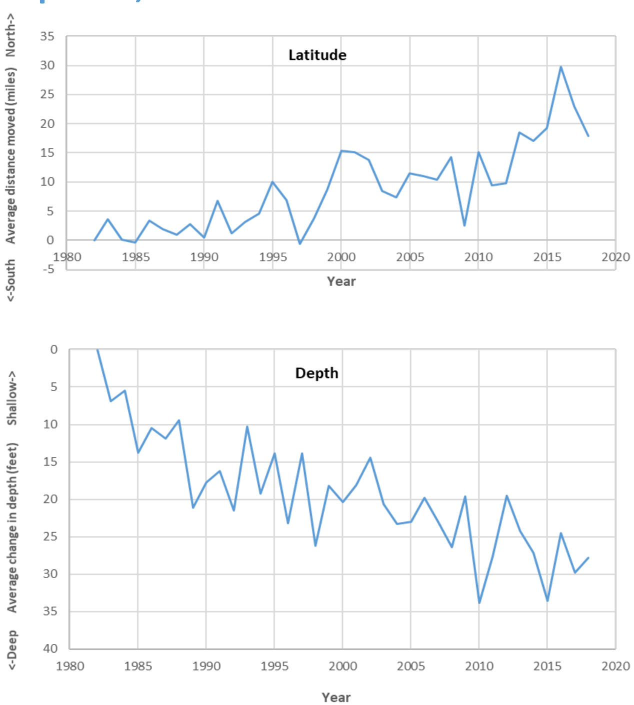
Appendix

Marine Species Distribution

This indicator examines changes in the location of fish, shellfish, and other marine species along U.S. coasts.

- As ocean waters have warmed, the average center of biomass for 140 marine species shifted northward by about 20 miles between 1982 and 2018. These species also moved an average of 21 feet deeper.
- In waters off the northeastern U.S., several economically important species have shifted northward since the late 1960s. The three species shown have moved northward by an average of 119 miles.

Change in Latitude and Depth of Marine Species, 1982-2018

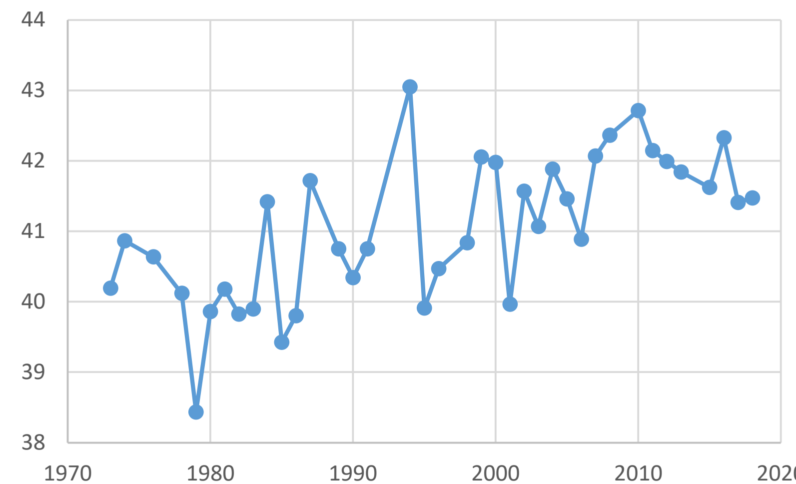


This graph shows the annual change in latitude (movement in miles) and depth (feet) of 140 marine species' along the Northeast coast and in the eastern Bering Sea. Changes in the centers of biomass have been aggregated across all 140 species.

Data source: NOAA, National Fisheries Service; Rutgers University-OceanAdapt, 2019

Runs are much diminished, due to the usual human causes: pollution, overfishing, and blockages like dams that closed off spawning grounds.

Change for American Shad - Alosa sapidissima, 1973-2018



American Shad are rated to have a High biological sensitivity; Very High climate exposure. Hare et al. 2016

Implications – SLR and Saltwater Intrusion

- **Changes in coastal flood regime:**
  - Increase the risk of flooding and flood related damage to wastewater and other infrastructure **(NPDES)**
  - Alter the boundaries, physical habitat, and water mixing and circulation in estuaries and coastal wetlands (**Estuaries, Wetlands**)
- **Exacerbate salt water intrusion** to coastal aquifers and waterbodies:
  - Risk to drinking water intakes (**Drinking Water**)
  - Harm many aquatic plants and animals; affect the spatial distribution and ecological condition of coastal habitats and wetlands (**Estuaries, Wetlands**)
- **Increasing acidity:** threatens the viability of shellfish, corals and other aquatic life (**Estuaries**)