Information Supporting the Development of and Options for a Tidal Bay Water Temperature Change Indicator(s)

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CBP: Climate Resiliency Workgroup

Goal: Increase the resiliency of the Chesapeake Bay watershed, including its living resources, habitats, public infrastructure and communities, to withstand adverse impacts from changing environmental and climate conditions.

- Climate Monitoring & Assessment
  - Track changes in sea level, precipitation, water temperature and the resulting ecosystem response
- Climate Adaptation
  - Pursue, design, and implement restoration and protection management practices that enhance climate resilience of aquatic ecosystems

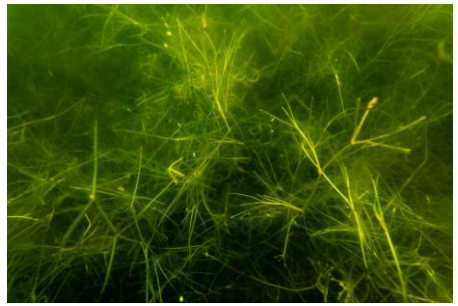
Connecting Change to Restoration Goals

Climate Change

Fish Habitat

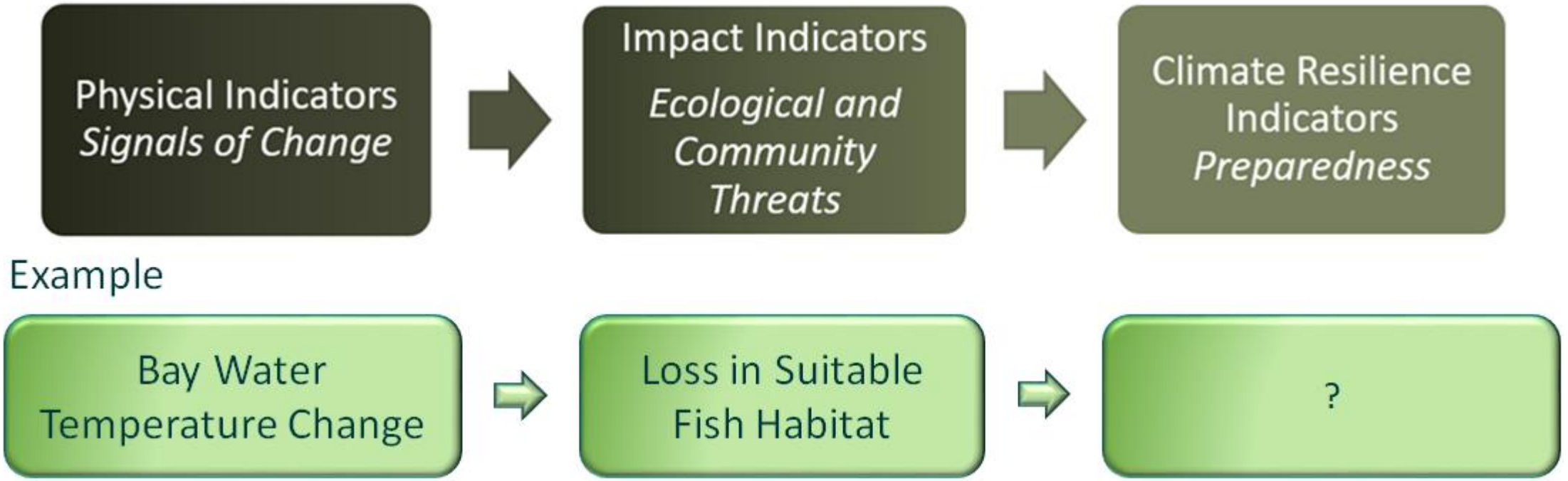
Forest Buffers

SAV

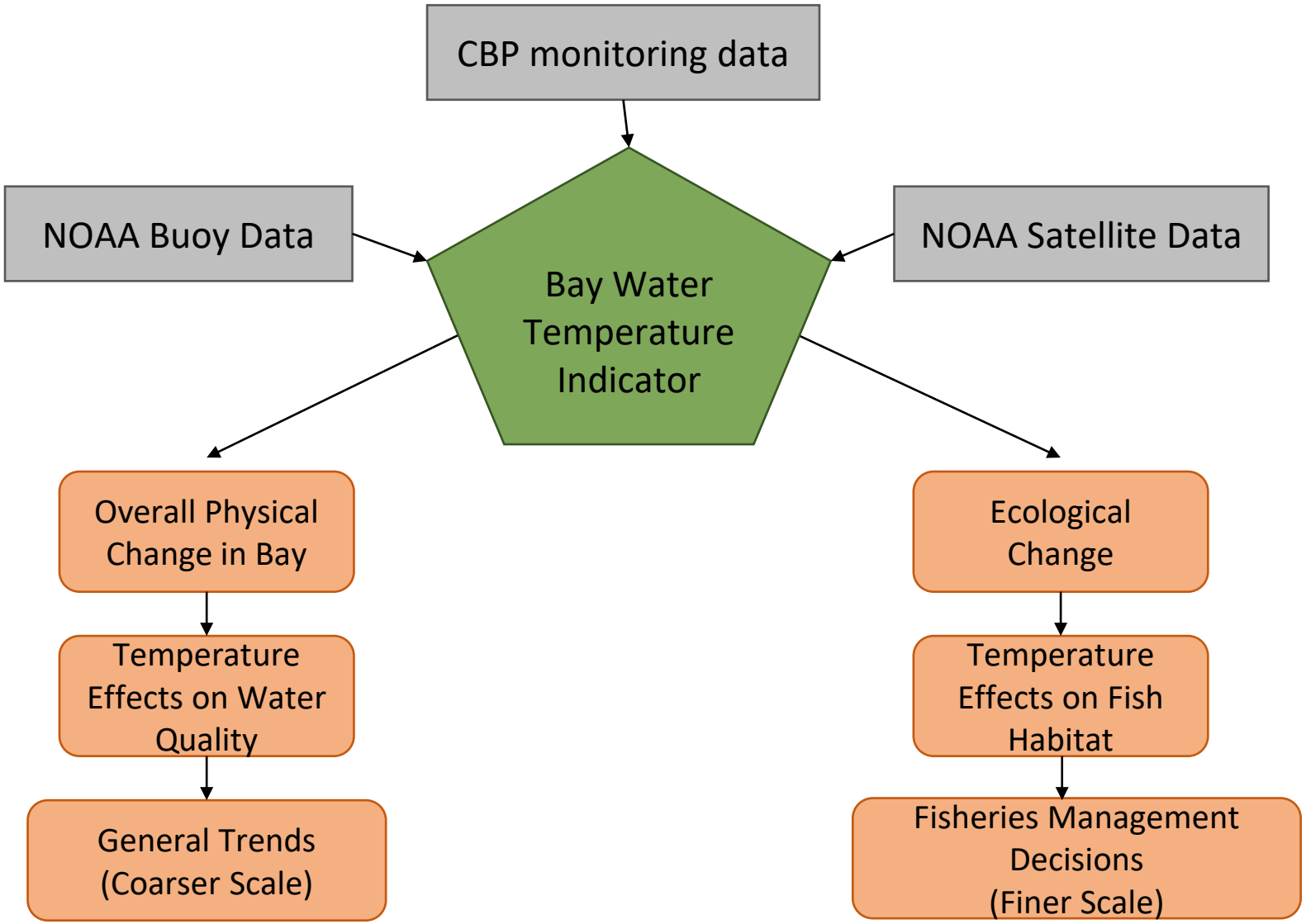


- Climate Change is going to impact the trajectory and scale of reaching key restoration goals
- Multi-disciplinary indicators can improve the monitoring and assessment of physical changes and their effect on habitats and living resources.

Climate Change Indicator Framework



Indicator Utility - What is the Management Need?

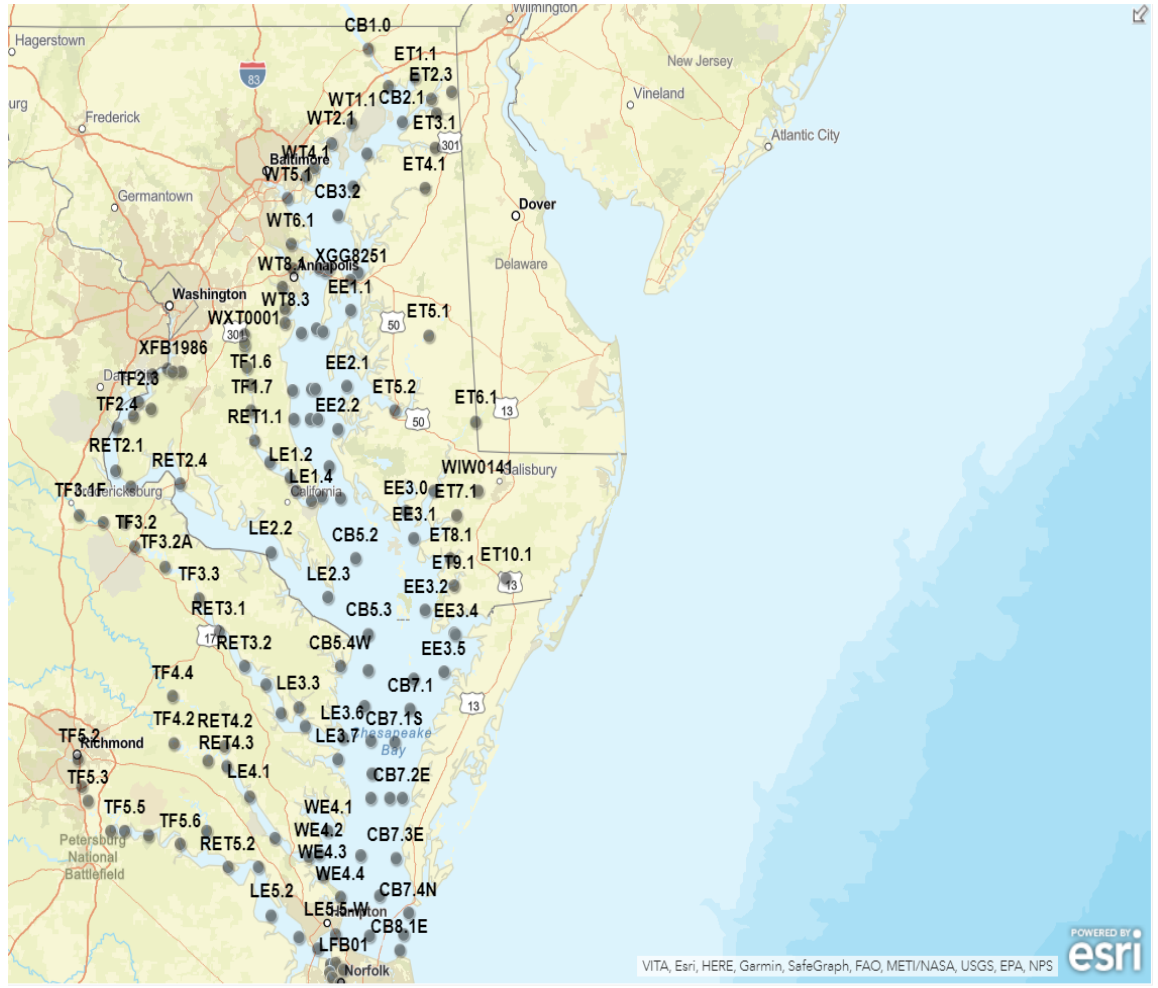


- Indicators can be applied in multiple ways
- Indicator purpose defines data needs and spatial and temporal scales

Bay Water Temperature Indicator: Data Sources

In-Situ Data Sources

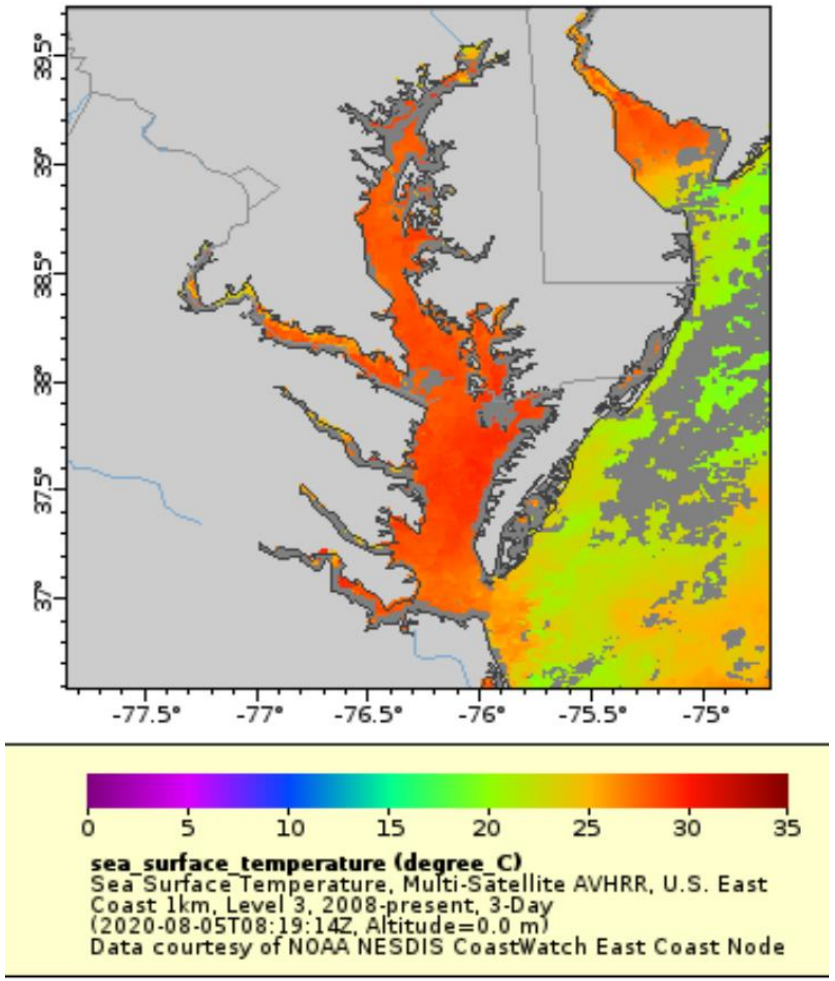
- CBP Long-term Monitoring Stations: 1985-present, Monthly
- CBIBS buoys: 2008-present, 5 buoys, 10-60 minute intervals
- CBL pier: 1938-present
- Thomas Pt. Lighthouse C-MAN station: 1985-present, hourly
- Citizen Monitoring Data



Bay Water Temperature Indicator: Data Sources

Satellite Data Sources

- **Multi-Satellite AVHRR**:
  2008-present, Daily, 1km - *shorter record*
- **Geo-Polar Blended**:
  2002-present, Daily, 5km - *coarser spatial res*
- **Landsat**:
  1982-present, Daily, 30m - *less accurate*
- **European Climate Change Initiative**:
  1981-2016, Daily, 5km - *only avail to 2016*
- **and more data sources!** - *to be included in synthesis report*



NO DATA SET MEETS ALL CRITERIA
(temporal extent, temporal interval, spatial interval, accuracy, ongoing record, institutional support, etc.)

NOAA has plans for best-of-all data set - availability TBD

Bay Water Temperature Indicator: Data Sources

	SHIP	BUOY/MOORING	SATELLITE
Advantages	• bay-wide • vertical profile	• highest temporal sampling interval • surface-only or vertical profile	• bay-wide • highest spatial sampling interval • high temporal sampling interval
Limitations	• low temporal sampling interval • low spatial sampling interval	• lowest spatial sampling interval	• surface only

All Data Sources have Advantages and Limitations

Water Temperature Indicator Examples

Physical Change

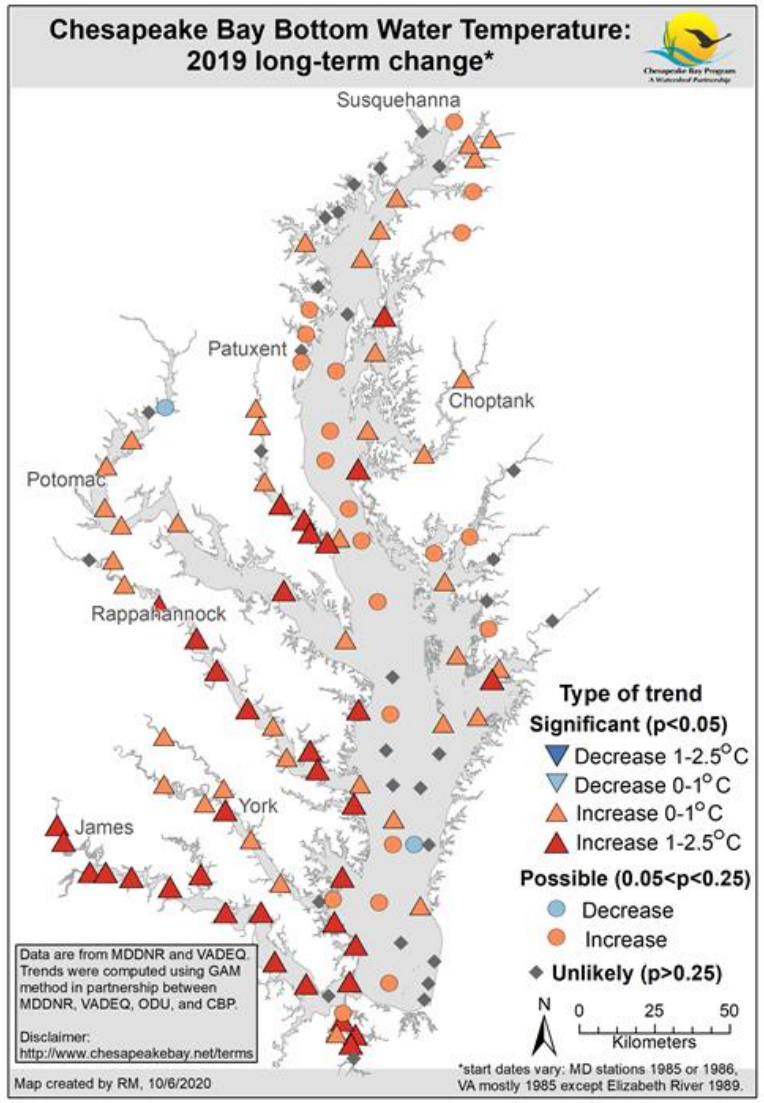
1) Integrated trends analysis of Bay water temperature change (R. Murphy, UMCES, and J. Keisman, USGS)
2) Indicator for National Estuary Program extended to Chesapeake Bay (R. Vogel, NOAA, M. Craghan, USEPA, and M. Tomlinson, NOAA)

Connecting Water Temperature Change to Ecological Impacts

3) Fish spawning habitat (S. Fadullon, NOAA-CRC Internship)

Integrated Trends (Murphy et al.)

- MDDNR, VADEQ, DC and others have been sampling at 150+ stations since the 1980s, 1-2 times/month
- Water Temperature available for surface & bottom and long-term & short-term
- Long-standing coordinated effort to analyze trends using GAMs in these data between the partners
- Maps of 2019 available on CBP ITAT page



www.chesapeakebay.net/who/group/integrated_trends_analysis_team

U.S. EPA National Estuary Program (Vogel et al.)

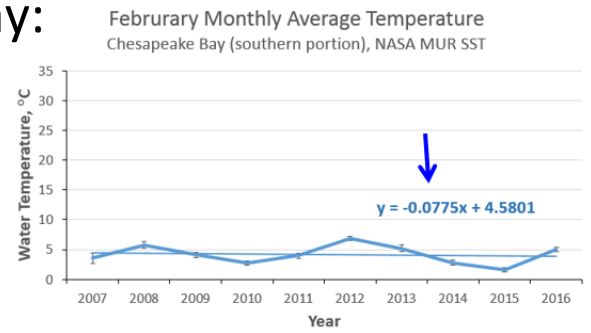
- Developed for U.S. EPA National Estuary Program—extended to Chesapeake Bay
- Satellite data only—many estuaries nationwide have no monitoring programs
- Available at NOAA CoastWatch: eastcoast.coastwatch.noaa.gov/time_series_sst_regions.php

Monthly averages, all years

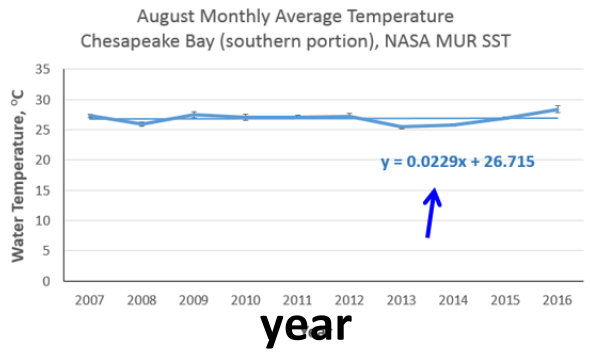
Seasonal difference in rate of change

Chesapeake Bay:

FEB

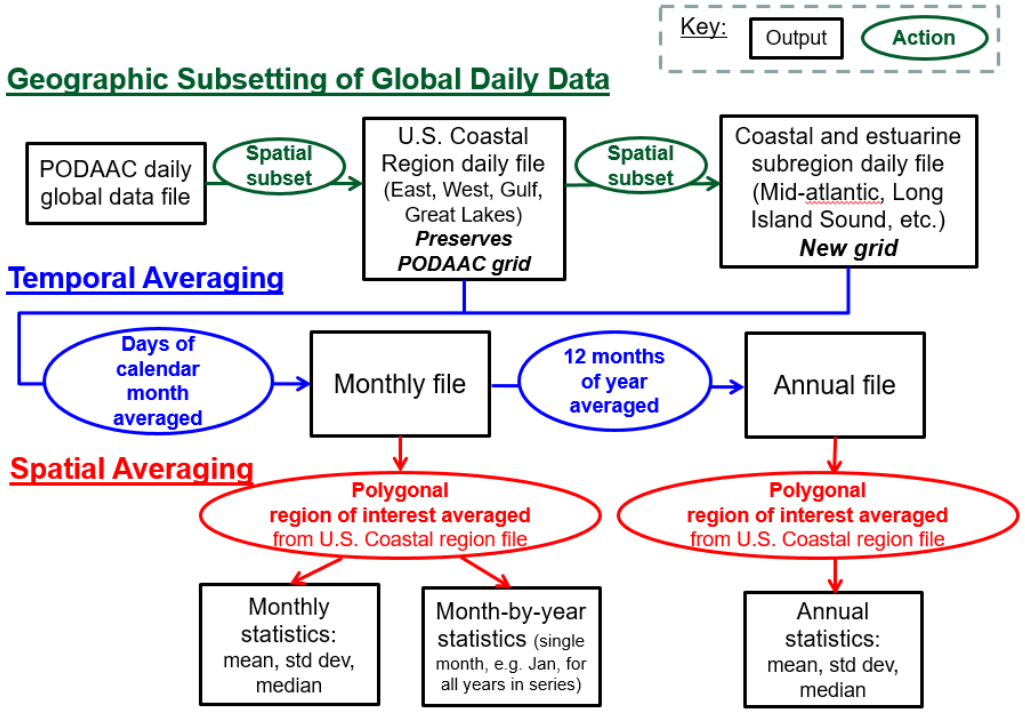


AUG



Methodology: temporal & spatial averaging

Follows CBP STAC 2008 Climate Report



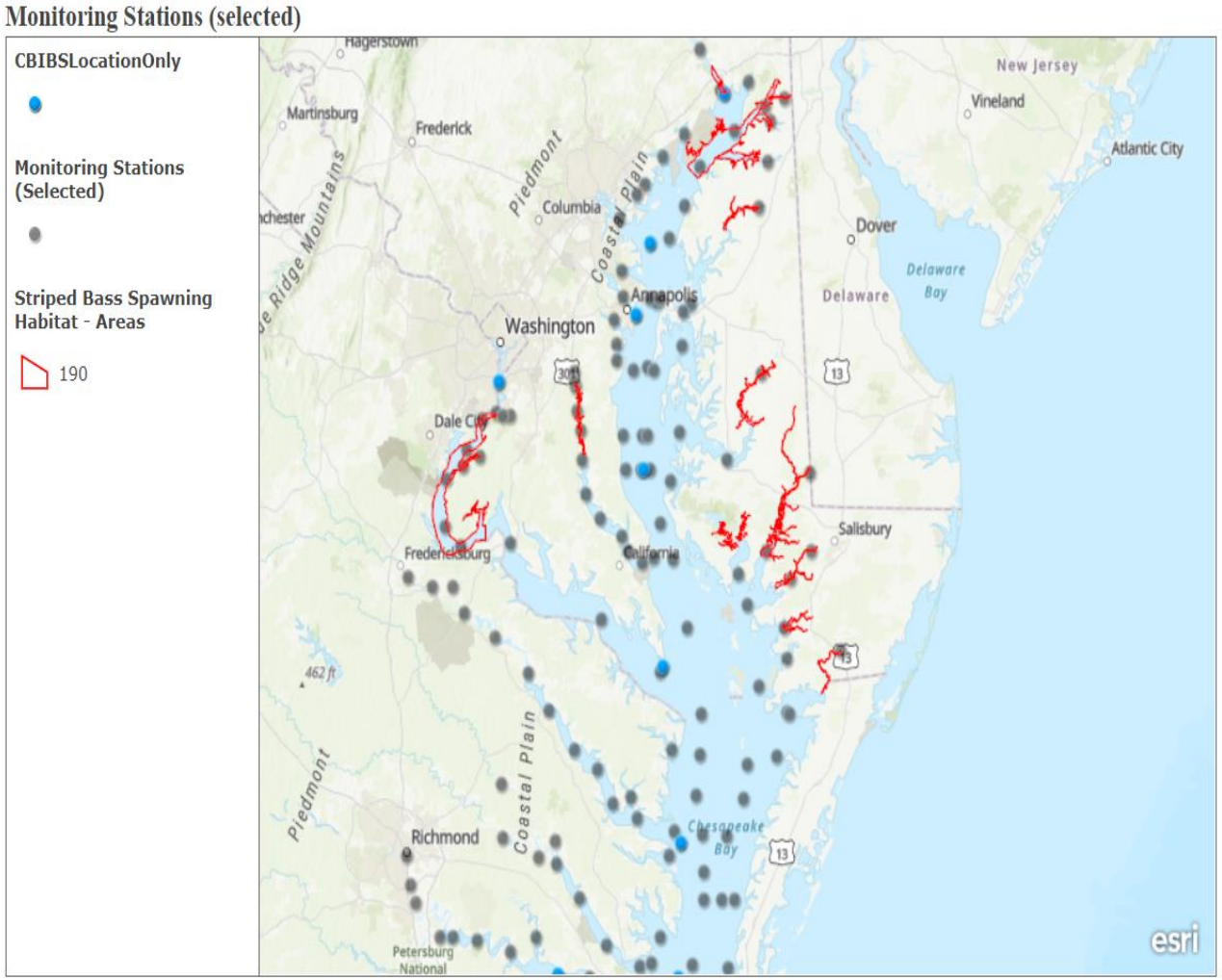
Scale Considerations: Fish Spawning Habitat (S. Fadullon)

Spatial Considerations:

- Evaluated satellite daily data not available for narrow tributary areas—other sources still to be explored
- Long-term monthly monitoring data available far up in narrow tributaries.

Temporal considerations:

- **For spawning habitat**, fisheries managers are interested in **daily data** for certain seasonal timeframes
- Long-term monthly averages may not be suited for management decisions related to spawning habitat—may suffice for tracking general adult distribution changes



Analysis Support: Shalom Fadullon, CRC-NOAA Internship Program and Breck Sullivan, CRC

Findings and Gaps (So Far)

Findings:

1) There exists physical water temperature change indicators from other sources
2) Working towards an ecological impact indicator needs to consider potential management applications to eventually connect with resilience progress
3) Given data limitations, a multi-source data approach could allow for a more robust indicator

Gaps:

1) Scientific understanding of management needs
2) Synthesis of indicator methodologies
3) Linkage between physical change and ecological impacts
4) Incorporation of climate change projections