Monitoring for Measures of Progress: Good Practices and Considerations in Your Work Ahead

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- Chesapeake Bay Monitoring Coordinator
- STAR

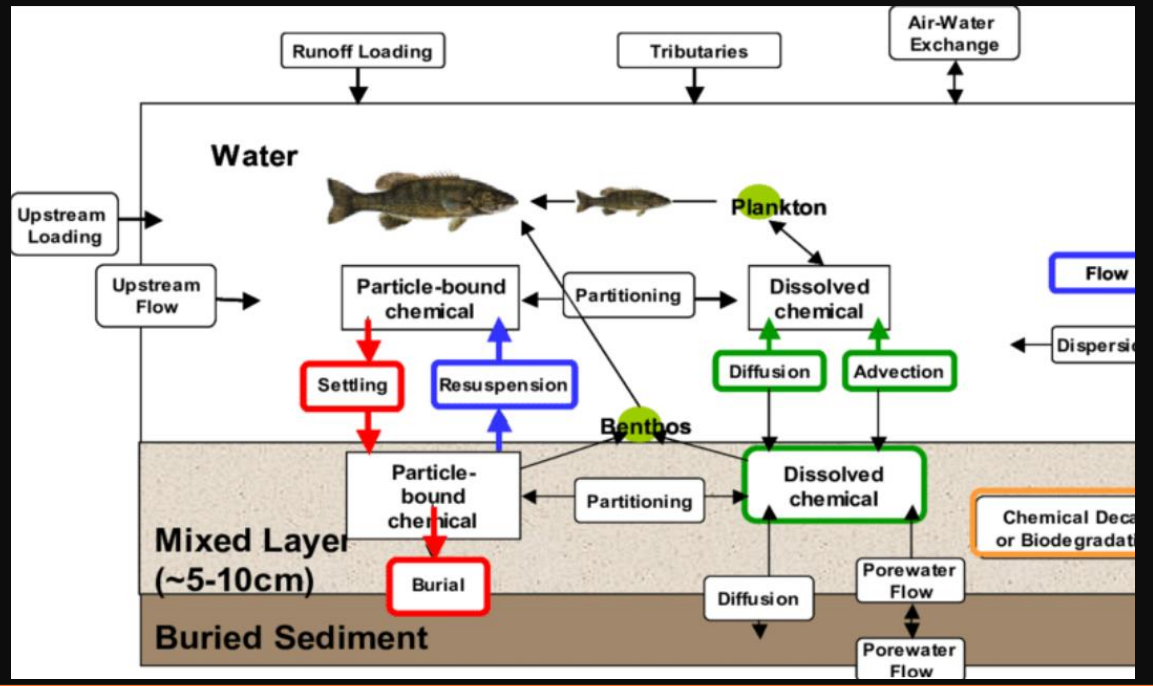
- 2/25/2026

Tracking progress:
I. Fundamental data quality standards

- Choose measures sensitive to management

- Create, borrow, use conceptual models to organize understanding of system connections

  - Consider influencing factors on your measure = *EXPLAINABILITY*.



Tracking progress: I. Fundamental data quality standards

- Rely on credible data collection methods = DEFENSIBILITY
- Robust, peer reviewed support of the methods and analyses to hang your hat on = BELIEVABILITY

Estuaries and Coasts (2022) 45:1012–1027
https://doi.org/10.1007/s12237-019-00651-w

SPECIAL ISSUE: SHALLOW WATER MAPPING

Long-term Annual Aerial Surveys of Submersed Aquatic Vegetation (SAV) Support Science, Management, and Restoration

Robert J. Orth · William C. Dennison · Cassie Gurbisz · Michael Hannam · Jeni Keisman · J. Brooke Landry · Jonathan S. Lefcheck · Kenneth A. Moore · Rebecca R. Murphy · Christopher J. Patrick · Jeremy Testa · Donald E. Weller · David J. Wilcox · Richard A. Batiuk

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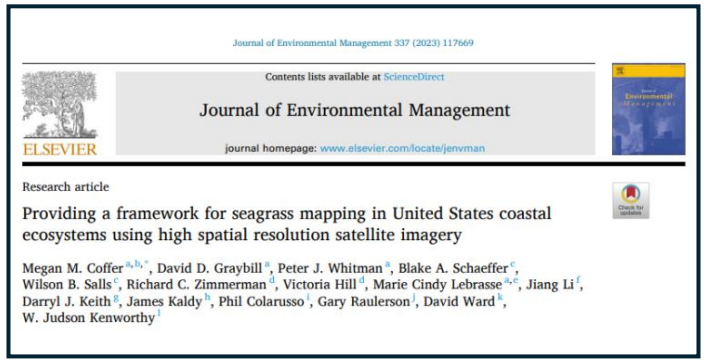
Abstract

Aerial surveys of coastal habitats can uniquely inform the science and management of shallow, coastal zones, and when repeated annually, they reveal changes that are otherwise difficult to assess from ground-based surveys. This paper reviews the utility of a long-term (1984–present) annual aerial monitoring program for submersed aquatic vegetation (SAV) in Chesapeake Bay, its tidal tributaries, and nearby Atlantic coastal bays, USA. We present a series of applications that highlight the program's importance in assessing anthropogenic impacts, gauging water quality status and trends, establishing and evaluating restoration goals, and understanding the impact of commercial fishing practices on benthic habitats. These examples demonstrate how periodically quantifying coverage of this important foundational habitat answers basic research questions locally, as well as globally, and provides essential information to resource managers. New technologies are enabling more frequent and accurate aerial surveys at greater spatial resolution and lower cost. These advances will support efforts to extend the applications described here to similar issues in other areas.



Journal of Environmental Management 337 (2023) 117669

Contents lists available at ScienceDirect

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journal homepage: www.elsevier.com/locate/jenvman

Research article

Providing a framework for seagrass mapping in United States coastal ecosystems using high spatial resolution satellite imagery

Megan M. Coffer, David D. Graybill, Peter J. Whitman, Blake A. Schaeffer, Wilson B. Salls, Richard C. Zimmerman, Victoria Hill, Marie Cindy Lebrasse, Jiang Li, Darryl J. Keith, James Kaldy, Phil Colarusso, Gary Raulerson, David Ward, W. Judson Kenworthy

Article

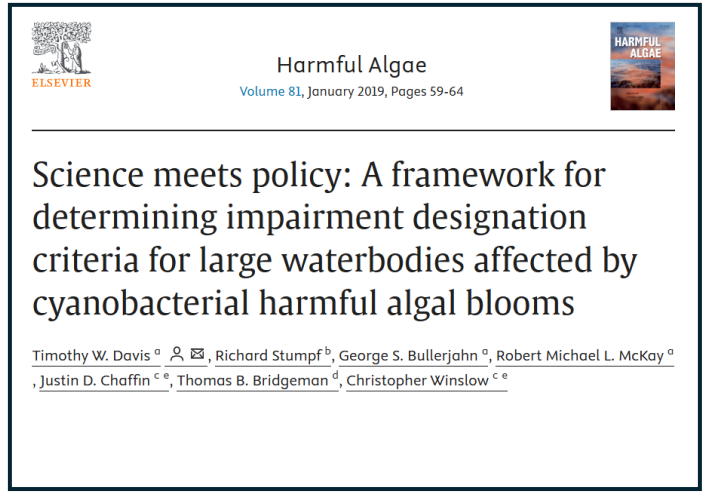
Chesapeake Bay recovery and factors affecting trends: Long-term monitoring, indicators, and insights

December 2015 · Regional Studies in Marine Science 4
DOI:10.1016/j.rsma.2015.11.010

Authors:

Peter Tango
United States Geological Survey

Richard A. Batiuk

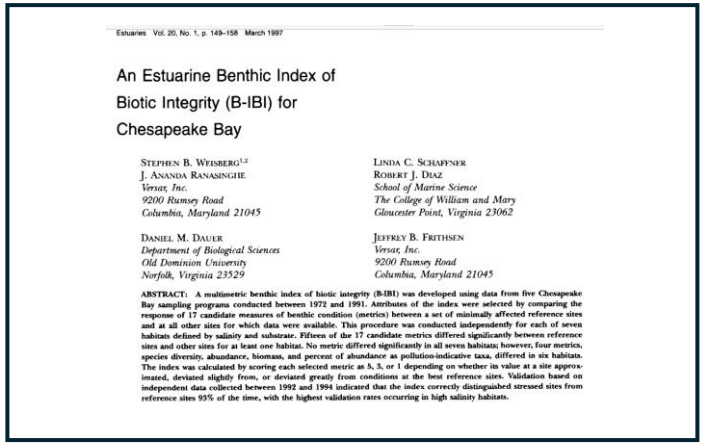


ELSEVIER

Harmful Algae
Volume 81, January 2019, Pages 59-64

Science meets policy: A framework for determining impairment designation criteria for large waterbodies affected by cyanobacterial harmful algal blooms

Timothy W. Davis, Richard Stumpf, George S. Bullerjahn, Robert Michael L. McKay, Justin D. Chaffin, Thomas B. Bridgeman, Christopher Winslow



Estuaries Vol. 20, No. 1, p. 149–158 March 1997

An Estuarine Benthic Index of Biotic Integrity (B-IBI) for Chesapeake Bay

Stephen B. Weisberg, J. Ananda Ranasinghe, Versar, Inc., 9200 Rumsey Road, Columbia, Maryland 21045

Linda C. Schaffner, Robert J. Diaz, School of Marine Science, The College of William and Mary, Gloucester Point, Virginia 23062

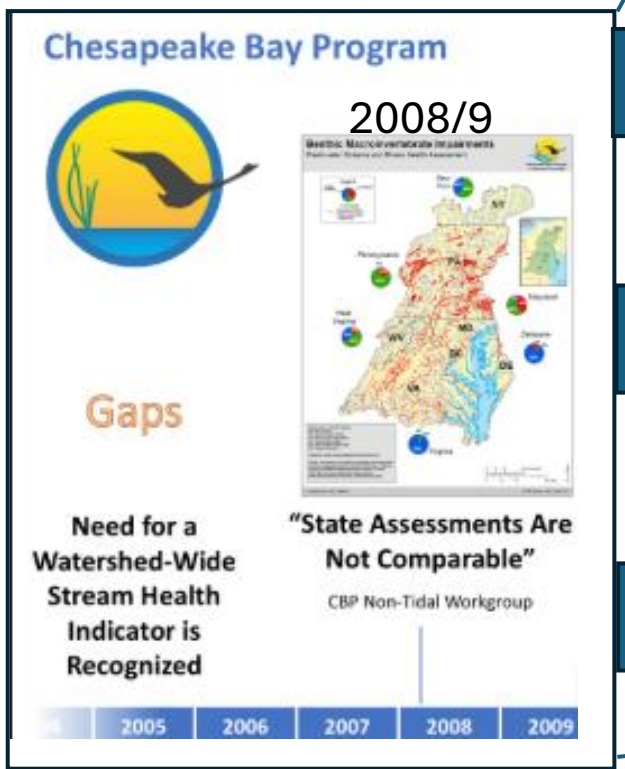
Daniel M. Dauer, Department of Biological Sciences, Old Dominion University, Norfolk, Virginia 23529

Jeffrey B. Frithsen, Versar, Inc., 9200 Rumsey Road, Columbia, Maryland 21045

ABSTRACT: A multimetric benthic index of biotic integrity (B-IBI) was developed using data from five Chesapeake Bay sampling programs conducted between 1972 and 1991. Attributes of the index were selected by comparing the response of 17 candidate measures of benthic condition (metrics) between a set of minimally affected reference sites and at all other sites for which data were available. This procedure was conducted independently for each of seven habitats defined by salinity and substrate. Fifteen of the 17 candidate metrics differed significantly between reference sites and other sites for at least one habitat. No metric differed significantly in all seven habitats; however, four metrics, species diversity, abundance, biomass, and percent of abundance as pollution-indicative taxa, differed in six habitats. The index was calculated by scoring each selected metric as 5, 3, or 1 depending on whether its value at a site approximated, deviated slightly from, or deviated greatly from conditions at the best reference sites. Validation based on independent data collected between 1992 and 1994 indicated that the index correctly distinguished stressed sites from reference sites 93% of the time, with the highest validation rates occurring in high salinity habitats.

Tracking progress:
I. Fundamental data quality standards

- Consistency of applying methods is important



Development of a Basin-wide Benthic Index of Biotic Integrity for Non-tidal Streams and Wadeable Rivers in the Chesapeake Bay Watershed:

Final Report to the Chesapeake Bay Program
Non-Tidal Water Quality Workgroup

May 9, 2011

2011:
2 yrs to indicator

Claire Buchanan[1]
Katherine Foreman[2]
Jacqueline Johnson[3]
Adam Griggs[1]

Refinement of the Basin-Wide Index of Biotic Integrity for Non-Tidal Streams and Wadeable Rivers in the Chesapeake Bay Watershed

REPORT

May 25, 2017

Zachary M. Smith
Claire Buchanan
Andrea Nagel

2017

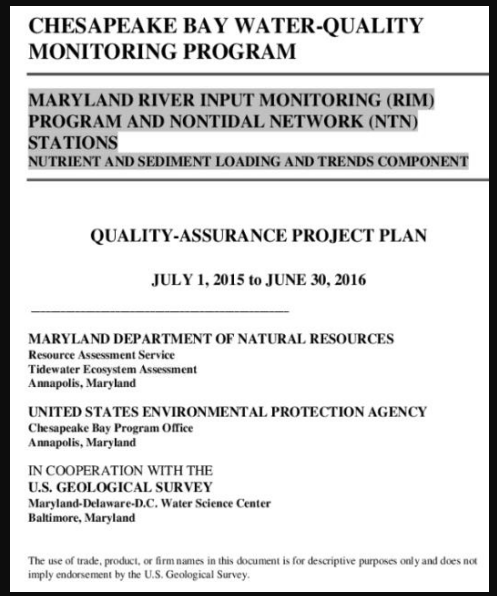
Methods and Procedures for Calculating the Chesapeake Basin-wide Index of Biotic Integrity (Chessie BIBI)

December 19, 2025

Emily Young (eyoung@chesapeakebay.net)
Rikke Jepsen (rjepsen@icprb.org)
Claire Buchanan (cbuchan@icprb.org)

Tracking progress:
I. Fundamental data quality standards

- Data integrity for transparency and accountability
  - Foundational to progress assessment integrity.



CHESAPEAKE BAY WATER-QUALITY MONITORING PROGRAM

MARYLAND RIVER INPUT MONITORING (RIM) PROGRAM AND NONTIDAL NETWORK (NTN) STATIONS
NUTRIENT AND SEDIMENT LOADING AND TRENDS COMPONENT

QUALITY-ASSURANCE PROJECT PLAN

JULY 1, 2015 to JUNE 30, 2016

MARYLAND DEPARTMENT OF NATURAL RESOURCES
Resource Assessment Service
Tidewater Ecosystem Assessment
Annapolis, Maryland

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Chesapeake Bay Program Office
Annapolis, Maryland

IN COOPERATION WITH THE
U.S. GEOLOGICAL SURVEY
Maryland-Delaware-D.C. Water Science Center
Baltimore, Maryland

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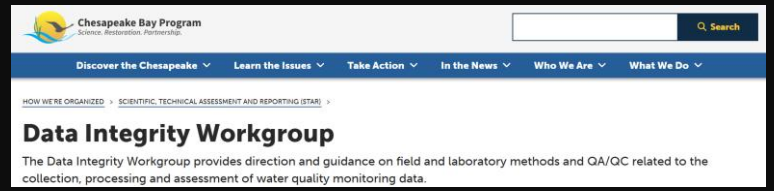
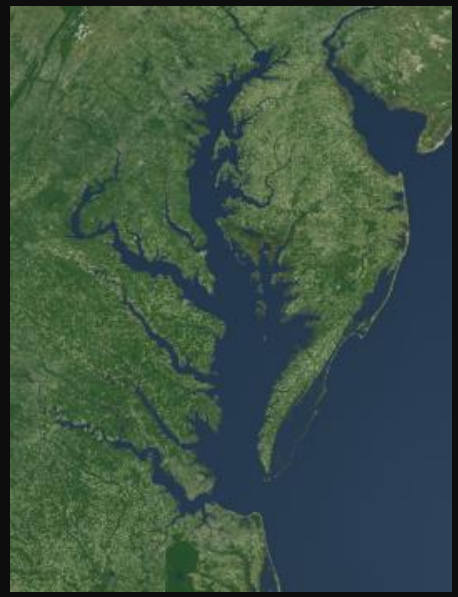


Tracking progress:
II. Fundamental data quality standards

For baseline and progress assessment purposes

- Spatial coverage
- Spatial resolution
- Temporal coverage
- Temporal resolution



Prepare your Meta-data

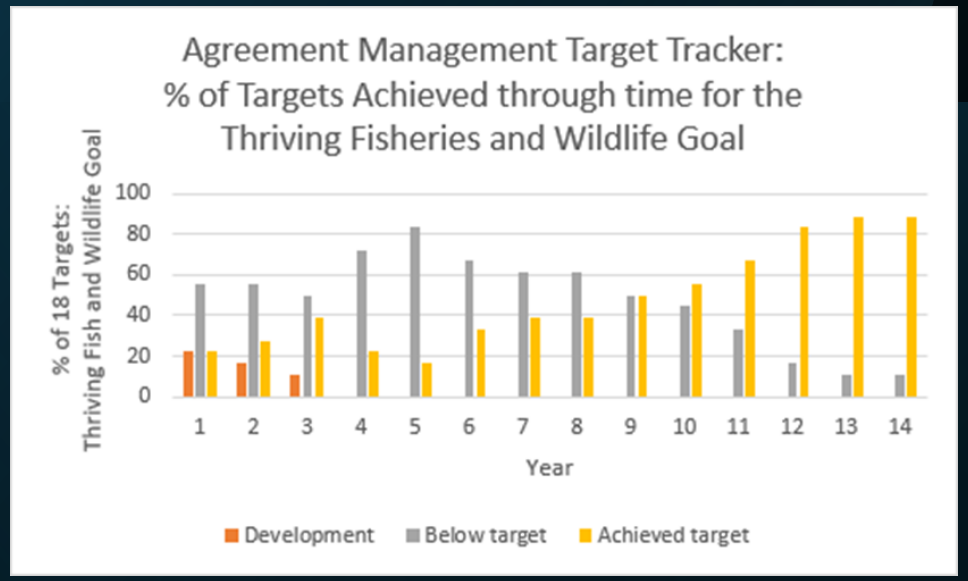
(example)

Data Source Information

Dataset	CBP protected lands dataset.
Source description	Compilation of federal and state mapping layers.
Organization that collects the data	CPBO collects data from states and USGS Protected Areas Database of the United States (PAD-US). Data provided directly from: • USGS PAD-US (includes National Conservation Easement Dataset) • Delaware Department of Natural Resources and Environmental Control (Division of Fish and Wildlife) • Freshwater Institute (West Virginia Protected Lands) • Maryland Department of Natural Resources • Maryland Department of Planning • Pennsylvania Bureau of Farmland Preservation • Pennsylvania Department of Conservation and Natural Resources • Virginia Department of Conservation and Recreation
Data source contact	Renee Thompson, rthompso@chesapeakebay.net.
Rationale for selection	Data source for existing indicator that meets the stated need for this topic.
Temporal coverage	Multiple iterations of protected area datasets (2006, 2011, 2013, 2015/2016), although comparisons over time are limited by methodological variations.
Frequency	Updated approximately every 2 years.
Spatial coverage	Chesapeake watershed.
Spatial scale/resolution	Generally 1:24,000.
Access to data	Available through the CBPO.

Protected land GIS layers are available from various sources, but the existing CBP dataset provides the most topically relevant and readily available source of data. Many of the protected land layers published by other agencies and organizations are derived from the same underlying sources as the CBP dataset. For example, the Chesapeake Conservation Partnership helps to support the LandScope Chesapeake initiative, which provides extensive information about priority lands for protection, but the data layers that LandScope provides on the protected status of lands appear to be derived from the USGS PAD-US dataset described above.

Envision our future – *What will your progress reporting look like for managers going into 2040?*



Time series target, outcome, goal tracking

Goal	Outcome	Target	'27	'28	'29	'30	'31	'32	'33	'34	'35	'36	'37	'38	'39	'40
TFW	Blue Crab	Abund met?	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
		Harvest rate met?	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y
		Report annually?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Brook Trout	Increase miles occupied?	10	30	65	98	120	152	199	215	240	249	249	255	295	302
		10 sites Increase Abund?	1	3	3	3	4	6	8	8	9	9	10	10	10	10
		Lower threats by 15%?	1%	1%	2%	2%	2%	4%	7%	10%	13%	14%	14%	15%	15%	15%
	Fish Habitat	Shw improved above base?	N -3%	N -1%	Y 2%	N -2%	N -1%	Y +2%	Y +3%	N -1%	Y +3%	Y +4%	Y +5%	Y +4%	Y +6%	Y +5%
		Forage report delivered?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
		NT Fish Hab better?	D	D	Y 2%	N -2%	N -1%	Y +2%	Y +3%	N -1%	Y +3%	Y +4%	Y +5%	Y +4%	Y +6%	Y +5%
		270 Miles AMD fixed?	10	30	65	98	120	152	199	205	215	230	249	275	295	302
		10 Mussel plans developed/5implemented?	2/0	2/0	4/1	4/1	6/2	6/2	8/2	8/3	8/3	8/4	10/4	10/4	10/5	10/5

Are you ready for assessment and progress reporting? A framework.

Stage 1.	Measure(s) & metric(s) defined?
Stage 2.	Data collection in place?
Stage 3.	Methods selected for data translation?
Stage 4.	Data processed?
Stage 5.	Reporting framework developed for Chesapeake?

Topic	Type of indicator	Stage 1: Indicator and metric(s) defined	Stage 2: Data collection program in place	Stage 3: Methods selected to transform data into an indicator	Stage 4: Data processed	Stage 5: Indicator developed for the Chesapeake
Group A: Chesapeake indicator already exists						
Protected Lands	Resilience or response	✓	✓	✓	✓	✓
Restored Habitat	Resilience or response	✓	✓	✓	✓	✓
Group B: Existing national indicator just needs to be clipped or cropped						
Air Temperature	Physical stressors	✓	✓	✓	✓	
Coastal Flooding	Impacts	✓	✓	✓	✓	
Precipitation	Physical stressors	✓	✓	✓	✓	
Sea Level Change	Physical stressors	✓	✓	✓	✓	
Stream Water Temperature	Physical stressors	✓	partial	✓	✓	
Upstream Flooding	Impacts	✓	✓	✓	✓	
Group C: Indicator defined, but need to process data and develop indicator						
Acidification	Physical stressors	✓	✓			
Bay Water Temperature	Physical stressors	✓	✓	partial		
Harmful Algal Blooms	Impacts	✓	✓	✓	partial	partial
Property at Risk or Damaged	Impacts	partial	✓			
Urban Tree Canopy	Resilience or response	✓	✓			
Wetland Extent and Physical Buffering Capacity	Impacts	✓	partial	partial		
Group D: Data likely exist, but need to define and develop indicator						
Bird Species Ranges	Impacts		✓			
BMPs and Green Infrastructure	Resilience or response					
Land Use/Land Cover	Resilience or response		✓			
Shoreline Condition	Resilience or response		✓			
Wetland Migration Corridors	Resilience or response		✓			
Group E: Could require a new data collection program						
Fish Population Distribution	Impacts / resilience or response					
Submerged Aquatic Vegetation Composition	Impacts / resilience or response					

ERG 2017 for CBP CRWG


Thank
you

In the absence of measurement, accountability can be hard to establish.
Hence: U.S. Government passed **Government Performance and Results Acts (1993, 2010)**

Government Performance and Results Act (GPRA), 1993

Intended to shift the focus of Government officials and managers from program inputs toward program execution — what results (outcomes & outputs) are being achieved & how well are programs meeting expected objectives

REQUIRES
Long-term goals
Annual performance targets
Annual reporting of actual performance

The **Government Performance and Results Act (GPRA) of 2010**, also known as the GPRA Modernization Act, aims to enhance the effectiveness of federal programs through performance management. Key provisions include:

- Mandating federal agencies to develop **strategic plans** and **annual performance plans** that include quantifiable measures of progress.
- Ensuring agencies engage in performance management tasks such as setting goals, measuring results, and reporting progress. 1

Cite this article

Kenney, M.A., Gerst, M.D. Synthesis of Indicators, Datasets, and Frameworks Available to Establish Resilience and Adaptation Indicators: Case Study of Chesapeake Bay Region, USA. *Curr Clim Change Rep* **7**, 35–44 (2021). https://doi.org/10.1007/s40641-021-00170-6

Criterion	Definition
1. Fundamental data quality standards that every proposed indicator must be able to meet, either now or in the future	
Topical relevance	The indicator provides information about physical climate trends, ecological or societal response, or programmatic progress toward resilience. The connection to climate change is documented or can be explained easily.
Spatial coverage	The indicator provides information that is specific to the Chesapeake Bay, the Chesapeake Bay watershed, or geographic sub-units within the watershed.
Temporal coverage	Multiple years of data are available to describe changes or trends, and the latest available data are timely.
Actual observations	The indicator is based on observed data. Modeling and statistical inference (if any) is limited to spatial interpolation between data points, such as the process used to generate a gridded map.
Credible methods	The indicator is based on sound data collection and analytical methods that reflect the state of the science.
Data quality and integrity	The data provider uses quality assurance procedures to ensure data quality and management systems to protect the integrity of the data.
Objectivity	The indicator is developed and presented in a clear, complete, and unbiased manner that accurately represents the underlying trends in physical conditions.
Uncertainty	Sources of uncertainty are known and understood.

Criterion	Definition
Transparency and reproducibility	The specific data used and the specific assumptions, analytical methods, and statistical procedures employed are clearly stated. Documentation is sufficient to allow the indicator to be reproduced independently.
Feasibility	The indicator is feasible to construct, and a program is in place to continue to collect data, thereby allowing the indicator to be updated in the future.
Peer-review validation	If an indicator is based on physical measurements of environmental conditions, it must use data from a peer-reviewed publication, a program that uses peer-reviewed methods to collect and analyze data, and/or a program whose data have been used and validated in peer-reviewed publications. This criterion will likely apply to all indicators in the *physical climate trends* bin and certain indicators in the other two bins (for example, a measure of benthic community condition). For indicators that are not based on physical measurements, peer review is ideal but not required.

2. "Desirable" data quality considerations to help select the best data source or metric for a given topic, if multiple sources are available	
Relationship to other indicators	The ideal indicator will complement other indicators rather than duplicating them. It fills a vital role in the organizational framework. Where possible, an ideal indicator will have established causal relationships with other indicators, which can be evaluated.
Spatial coverage	The ideal indicator will use data collected throughout the Bay and its major tributaries or throughout the watershed, as opposed to indicators that are only measured at a few locations.
Spatial resolution	The ideal indicator will provide at least a total or an average for the Bay, the watershed, or the individual states that are part of the watershed. Where possible, the ideal indicator will support local-scale analysis by providing data that are downscaled further—for example, data for individual sampling sites, sub-watersheds (e.g., HUC-12), NOAA climate divisions (up to 10 per state), or a gridded map.
Temporal coverage	The ideal indicator will have many years of data available. The best indicators will have at least 30 years of data, which is a common threshold for climatological analysis. The ideal indicator will also have a defined baseline, particularly if it is used to assess progress toward resilience.
Temporal resolution	The ideal indicator will have data with at least annual frequency, with sub-annual frequency if appropriate (e.g., where seasonal variations are important to consider).
Consistency of methods	The ideal indicator will be based on data collection and analytical methods that are comparable across time and space. In some cases, it may be appropriate to use data that were collected or analyzed using multiple methods—for example, supplementing short-term records with longer-term

Criterion	Definition
	records from a different source. In such cases, the data visualization should distinguish between the different sources, such as by inserting a discontinuity in a time series or plotting multiple lines on a graph. The CBNERR indicators by UMCES and Chesapeake Data provide a good example of this approach.
Uncertainty	The ideal indicator will have low uncertainty—for example, small error bars or narrow confidence intervals.
Other limitations	The ideal indicator will have few confounding factors or other limitations that make it difficult to interpret the data or draw conclusions.
Understandability	The ideal indicator will provide a clear depiction of observations that can be understood by both technical and non-technical users.

3. "Value-added" criteria to prioritize indicators that will provide the most relevant and useful information for the CBPO and its mission	
Rate of change	To what extent is an indicator on this topic likely to show change over time? In other words, would a graph show a fairly flat line over time, or might we expect to see a more noticeable change?
Significance of consequences	How significant are the consequences for society or ecosystems? One could think about consequences in terms of severity, scale, probability, and/or timeframe. For physical climate stressors and societal/ecological impacts, one could consider the impact of the changes that are projected under commonly accepted climate scenarios. For suggested indicators that involve adaptation actions, one could consider the consequences if such actions are not taken.
Significant advancement in our understanding of climate	Would an indicator on this topic significantly advance the scientific and policy community's understanding of climate change, impacts, and resiliency in the Chesapeake watershed? In other words, would this indicator reveal something important that we don't already know or we aren't already tracking?
Known new need	Would an indicator on this topic address a data or tracking need that has been strongly expressed by program staff or stakeholders?
Relevance to CBP management actions	Does the proposed indicator track an attribute that the CRWG and the Chesapeake Bay Program could reasonably expect to be able to influence through management actions?
Relevance to climate resiliency goal and outcomes	This criterion focuses on the strength of each topic's connection to climate change. For physical measures and impacts, one can focus on the extent to which climate change is a key stressor that will drive any apparent trends in the indicator, as opposed to situations where climate change is just one of many factors. For resilience indicators, to what extent will each attribute or action convey resilience against climate change?