Partner Questions: Take 1.

Background on how a particular DO criterion was measured during the original criterion development work, what endpoint it protects (e.g., spawning), and how it was intended to be assessed.

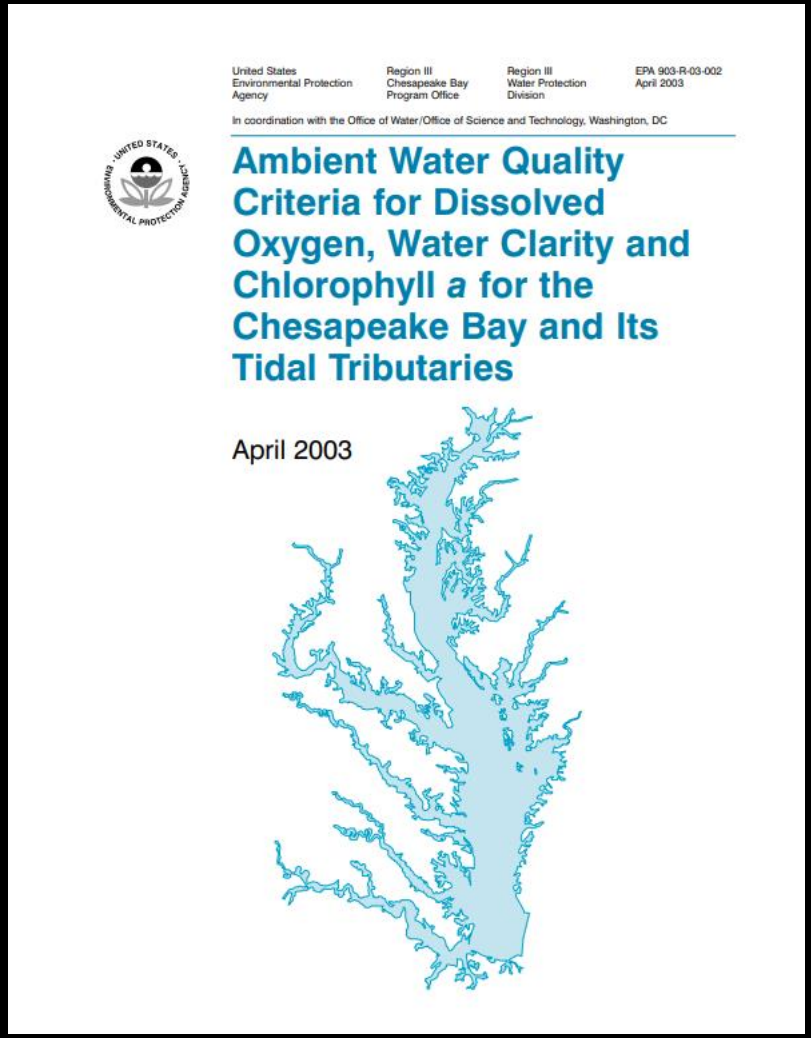
Highlights from USEPA 2003 to open the conversation

Peter Tango

CAP WG meeting

10/8/2024

USEPA 2003: Criteria derivation



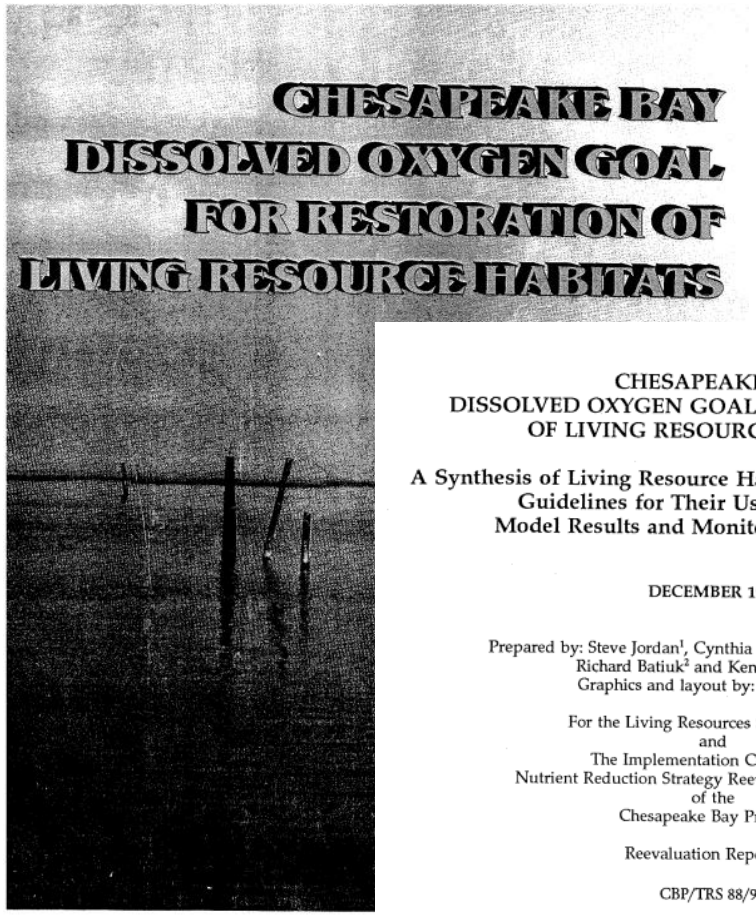
United States Environmental Protection Agency | Region III Chesapeake Bay Program Office | Region III Water Protection Division | EPA 903-R-03-002 April 2003

In coordination with the Office of Water/Office of Science and Technology, Washington, DC

Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll *a* for the Chesapeake Bay and Its Tidal Tributaries

April 2003

Strong foundations of criteria derivation and application: 1992



CHESAPEAKE BAY
DISSOLVED OXYGEN GOAL FOR RESTORATION
OF LIVING RESOURCE HABITATS

A Synthesis of Living Resource Habitat Requirements with
Guidelines for Their Use in Evaluating
Model Results and Monitoring Information

DECEMBER 1992

Prepared by: Steve Jordan[1], Cynthia Stenger[1], Marcia Olson[3],
Richard Batiuk[2] and Kent Mountford[2]
Graphics and layout by: Lamar Platt[1]

For the Living Resources Subcommittee
and
The Implementation Committee's
Nutrient Reduction Strategy Reevaluation Workgroup
of the
Chesapeake Bay Program

Reevaluation Report #7c

CBP/TRS 88/93

[1]Maryland Department of Natural Resources, Chesapeake Bay Research and Monitoring Division
[2]United States Environmental Protection Agency, Chesapeake Bay Program Office
[3]Chesapeake Bay Program Office, Computer Sciences Corporation

Annapolis, Maryland

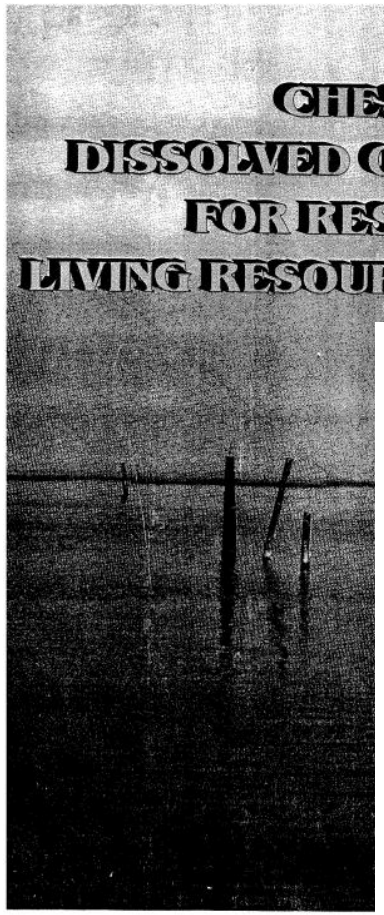
The Chesapeake Bay Dissolved Oxygen Goal for Restoration of Living Resource Habitats is:

to provide for sufficient dissolved oxygen to support survival, growth and reproduction of anadromous, estuarine and marine fish and invertebrates in Chesapeake Bay and its tidal tributaries by achieving, to the greatest spatial and temporal extent possible, the following four target concentrations of dissolved oxygen, and by maintaining the existing minimum concentration of dissolved oxygen in areas of Chesapeake Bay and its tidal tributaries where dissolved oxygen concentrations are above the recommended targets.

TARGET DO CONCENTRATIONS	TIME AND LOCATION
DO ≥1.0 mg/L	ALL TIMES, EVERYWHERE;
1.0 mg/L ≤DO ≤3.0 mg/L	FOR NO LONGER THAN 12 HOURS, INTERVAL BETWEEN EXCURSIONS AT LEAST 48 HOURS, EVERYWHERE;
MONTHLY MEAN DO ≥5.0 MG/L	ALL TIMES, THROUGHOUT ABOVE-PYCNOCLINE WATERS;
DO ≥5.0 mg/L	ALL TIMES, THROUGHOUT ABOVE-PYCNOCLINE WATERS, IN SPAWNING REACHES, SPAWNING RIVERS AND NURSERY AREAS.

The pycnocline is the portion of the water column where density changes rapidly because of salinity and temperature

Strong foundations of criteria derivation and application: 1992… and 1991 synthesis



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Annapolis, Maryland

APPENDIX A
EFFECTS OF LOW DISSOLVED OXYGEN
ON CHESAPEAKE BAY TARGET SPECIES

Tabulated from chapters in
Habitat Requirements for Chesapeake Bay Living Resources, 1991 Revised Edition,
and other sources

17 pages of studies summarized

32

Species/ Life Stage	Dissolved Oxygen (mg/L)	Temp (°C)	Salinity (ppt)	Duration	Effect	Comments and References
TARGET SPECIES						
BLUE CRAB *Callinectes sapidus*						
MORTALITY						
Juvenile	anoxic	20/30	10	<1 day	LT50	Stickle *et al.* 1989
Juvenile (28-54 mm)	4.6	30	10	7 days	LC50	65% saturation (Stickle *et al.* 1989)
Juvenile (28-54 mm)	5.7	30	10	28 days	LC50	79% saturation (Stickle *et al.* 1989)
Adult	<0.5	32		2 hours	Lethal	Lowery and Tate 1986
Adult	<0.5	25		4.3 hours	Lethal	Lowery and Tate 1986
Adult	0.14	24-26		13 hours	LC50	Carpenter and Cargo 1957
Adult	0.63	24-26		24 hours		Carpenter and Cargo 1957
Adult	0.3	28-30				Carpenter and Cargo 1957
Adult	0.63	28-30				Carpenter and Cargo 1957
Adult	0.45	30				100% mort. (Carpenter and Cargo 1957)
TOLERATE						
Adult	1.0	28-30				5-20% mort. (Carpenter and Cargo 1957)
Adult	2.8-3.2	21-23				<20% mort. of adult males at 35.5 to 39% saturation (deFur *et al.* 1990)
Adult	2.8-3.2	21-23				No mort.; adult males (deFur *et al.* 1990)
FIELD OBSERVATIONS						
Adult	0	25				100% mort. (Carpenter and Cargo 1957)
Adult	0.1-3.0					Catch was much reduced and crabs in pots dead or nearly so (Abbe 1983)
Adult	0.7-1.6	26				10% mort. (Carpenter and Cargo 1957)
Adult	0.7-1.6	26				15% mort. (Carpenter and Cargo 1957)
Adult	<2.0					≥50% dead in pots below 7m (Carpenter and Cargo 1957)
Adult	~2.5	~30				32-36% saturation lethal to animals in pots (Carpenter and Cargo 1957)
Adult	3.6	27				3% mort. (Carpenter and Cargo 1957)

Some alignment, some adjustments deriving criteria 1992 to 2003

Seasonality and geography considerations factored in for 2003

The Chesapeake Bay Dissolved Oxygen Goal for Restoration of Living Resource Habitats is:

to provide for sufficient dissolved oxygen to support survival, growth and reproduction of anadromous, estuarine and marine fish and invertebrates in Chesapeake Bay and its tidal tributaries by achieving, to the greatest spatial and temporal extent possible, the following four target concentrations of dissolved oxygen, and by maintaining the existing minimum concentration of dissolved oxygen in areas of Chesapeake Bay and its tidal tributaries where dissolved oxygen concentrations are above the recommended targets.

TARGET DO CONCENTRATIONS	TIME AND LOCATION
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The pycnocline is the portion of the water column where density changes rapidly because of salinity and temperature

Table III-10. Chesapeake Bay dissolved oxygen criteria.

Designated Use	Criteria Concentration/Duration	Protection Provided	Temporal Application
Migratory fish spawning and nursery use	7-day mean ≥ 6 mg liter^{-1} (tidal habitats with 0-0.5 ppt salinity)	Survival/growth of larval/juvenile tidal-fresh resident fish; protective of threatened/endangered species.	February 1 - May 31
	Instantaneous minimum ≥ 5 mg liter^{-1}	Survival and growth of larval/juvenile migratory fish; protective of threatened/endangered species.	
	Open-water fish and shellfish designated use criteria apply		June 1 - January 31
Shallow-water bay grass use	Open-water fish and shellfish designated use criteria apply		Year-round
Open-water fish and shellfish use	30-day mean ≥ 5.5 mg liter^{-1} (tidal habitats with 0-0.5 ppt salinity)	Growth of tidal-fresh juvenile and adult fish; protective of threatened/endangered species.	Year-round
	30-day mean ≥ 5 mg liter^{-1} (tidal habitats with >0.5 ppt salinity)	Growth of larval, juvenile and adult fish and shellfish; protective of threatened/endangered species.	
	7-day mean ≥ 4 mg liter^{-1}	Survival of open-water fish larvae.	
	Instantaneous minimum ≥ 3.2 mg liter^{-1}	Survival of threatened/endangered sturgeon species.[1]	
Deep-water seasonal fish and shellfish use	30-day mean ≥ 3 mg liter^{-1}	Survival and recruitment of bay anchovy eggs and larvae.	June 1 - September 30
	1-day mean ≥ 2.3 mg liter^{-1}	Survival of open-water juvenile and adult fish.	
	Instantaneous minimum ≥ 1.7 mg liter^{-1}	Survival of bay anchovy eggs and larvae.	
	Open-water fish and shellfish designated-use criteria apply		October 1 - May 31
Deep-channel seasonal refuge use	Instantaneous minimum ≥ 1 mg liter^{-1}	Survival of bottom-dwelling worms and clams.	June 1 - September 30
	Open-water fish and shellfish designated use criteria apply		October 1 - May 31

[1] At temperatures considered stressful to shortnose sturgeon (>29°C), dissolved oxygen concentrations above an instantaneous minimum of 4.3 mg liter^{-1} will protect survival of this listed sturgeon species.

Jordan et al. 1992

USEPA 2003

Some alignment, some adjustments deriving criteria 1992 to 2003

Example of life-stage considerations
Larval fish protections considered

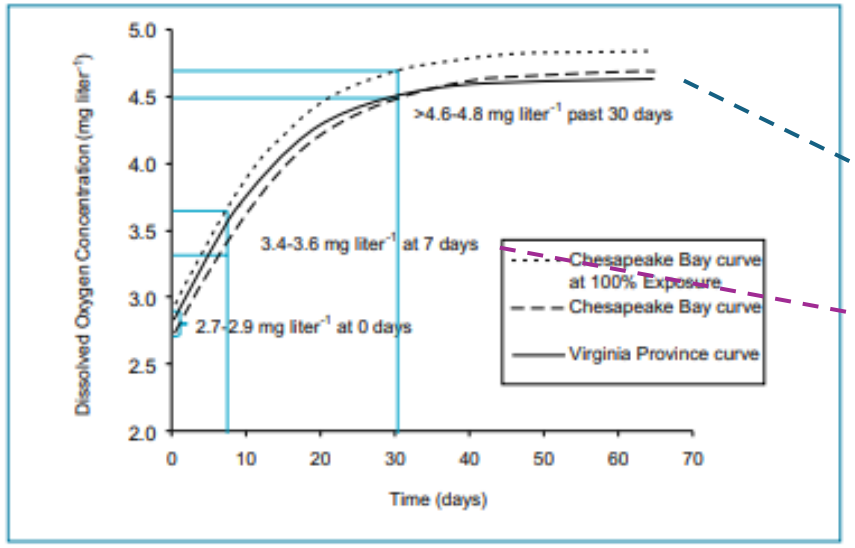

Figure III-5. Comparison of the Virginian Province-wide (—) and Chesapeake Bay specific larval recruitment effects at variable (---) and 100 percent (. . .) exposures.

USEPA 2003

Table III-10. Chesapeake Bay dissolved oxygen criteria.

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Open-water fish and shellfish use	30-day mean ≥ 5.5 mg liter^{-1} (tidal habitats with 0-0.5 ppt salinity)	Growth of tidal-fresh juvenile and adult fish; protective of threatened/endangered species.	Year-round
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[1] At temperatures considered stressful to shortnose sturgeon (>29°C), dissolved oxygen concentrations above an instantaneous minimum of 4.3 mg liter^{-1} will protect survival of this listed sturgeon species.

USEPA 2003

USEPA 2003

The derivation of these criteria followed the EPA's national guidelines; the EPA, National Marine Fisheries Science and U.S. Fish and Wildlife Service's joint national endangered species consultation guidelines; and the risk-based approach used in developing the EPA's Virginian Province saltwater dissolved oxygen criteria (for estuarine and coastal waters from Cape Cod, Massachusetts to Cape Hatteras, North Carolina). The resulting criteria reflect the needs and habitats of Chesapeake Bay estuarine living resources and are structured to protect five tidal-water designated uses (Figure 2).

USEPA 2003

Criteria for the migratory fish spawning and nursery, shallow-water bay grass and open-water fish and shellfish designated uses were set at levels to prevent impairment of growth, and to protect the reproduction and survival of all organisms (Table 1). Criteria for deep-water seasonal fish and shellfish designated use habitats during seasons when the water column is significantly stratified were set at levels to protect juvenile and adult fish, shellfish and the recruitment success of the bay anchovy. Criteria for deep-channel seasonal refuge designated use habitats in summer were set to protect the survival of bottom sediment-dwelling worms and clams.

Assessment

CRITERIA IMPLEMENTATION

EPA Region III also is presenting Chesapeake Bay criteria implementation procedures as additional regional guidance in accordance with Section 117(b)(2) of the Clean Water Act to the Chesapeake Bay watershed states and other agencies, institutions, groups or individuals considering how to apply the criteria to determine the degree of attainment. The EPA expects that these procedures will promote consistent, baywide application of the criteria across jurisdictional boundaries.

The criteria were derived specifically to protect species and communities in the five tidal-water designated uses during specific time periods. For example, dissolved oxygen criteria have been derived for application to each of the five designated uses, whereas the chlorophyll *a* criteria apply only to open-water fish and shellfish designated use habitats and the water clarity criteria only to the shallow-water bay grass designated use habitats.

Documentation
Providing guidance toward consistent, baywide application of criteria across jurisdictional boundaries

USEPA 2003

Assessment continued

* CFD method further described
* Interpolation described
* Applications to point, transect, and remote sensing data

The cumulative frequency distribution methodology for defining criteria attainment addresses the circumstances under which the criteria may be exceeded in a small percentage of instances, by integrating the five elements of criteria definition and attainment: magnitude, duration, return frequency, space and time. The methodology summarizes the frequency of instances in which the water quality threshold (e.g., dissolved oxygen concentration) is exceeded, as a function of the area or volume affected at a given place and over a defined period of time. Acceptable and protective combinations of the frequency and spatial extent of such instances are defined using a biologically based reference curve.

Using this approach to define criteria attainment, the EPA recommends a procedure to quantify the spatial extent (area or volume) to which the water quality criterion has been achieved or exceeded for each monitoring event. For example, under a monthly monitoring program, the spatial extent to which the criterion has been achieved or exceeded would be estimated for each month. This could be accomplished through interpolation of the available point, transect and remote-sensing data. The criteria measure could thus be estimated at all locations in a given spatial unit. The spatial extent to which a water quality criterion had been exceeded for a given monitoring event would be defined as the fraction of the total area or volume (expressed as a percent) that exceeds the criterion.

USEPA 2003

Chapter 5. Recommended Implementation Procedures (USEPA 2003)

DEFINING CRITERIA ATTAINMENT

DISSOLVED OXYGEN CRITERIA

The Chesapeake Bay dissolved oxygen criteria were derived to protect species and communities in the five tidal-water designated uses during specific seasons (Table VI-1). See Chapter III for detailed information on the designated use-specific criteria and appropriate periods for applying them. Refer to Appendix A and the *Technical Support Document for the Identification of Chesapeake Bay Designated Uses and Attainability* (U.S. EPA 2003) for details on the five designated uses and their boundaries. The Chesapeake Bay dissolved oxygen criteria should not be applied to a designated use or during a period of the year for which they were not specifically derived (see Chapter III).

The EPA expects the states to adopt the full set of dissolved oxygen criteria that will protect the refined tidal-water designated uses, presented in Table VI-1. Given recognized limitations in direct monitoring at the temporal scales required for assessing attainment of the instantaneous minimum, 1-day mean and 7-day mean criteria (see section titled "Monitoring to Support the Assessment of Criteria Attainment" for more details), states can waive attainment assessments for these criteria until monitoring at the required temporal scales is implemented or apply statistical methods to estimate probable attainment. Where sufficient data at these temporal scales exist for specific regions or local habitats, states should assess attainment of the full set of applicable dissolved oxygen criteria.

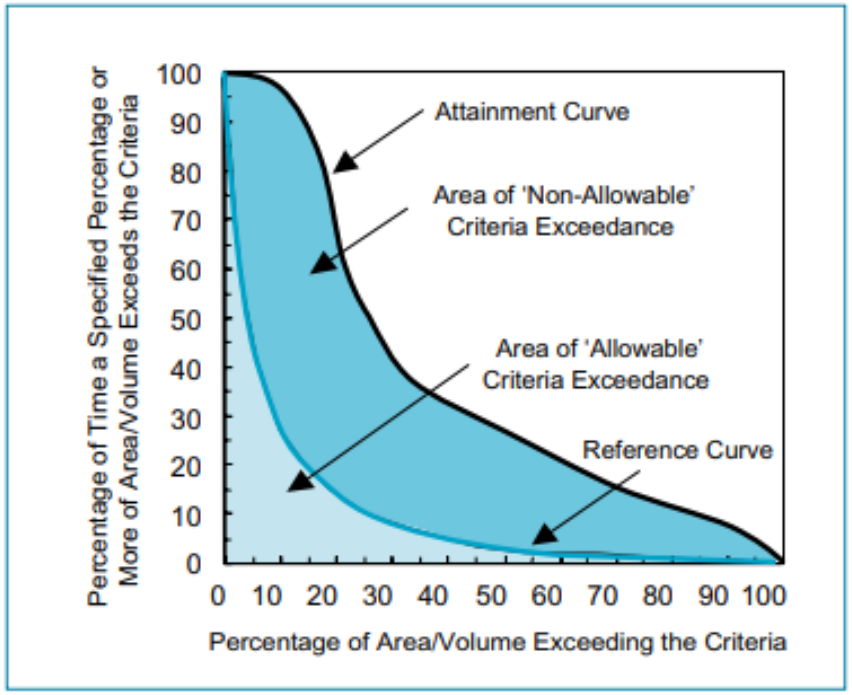

Figure VI-9. Light area reflects amount of 'allowable' criteria exceedance defined as the area under the reference curve (light line). Dark area reflects the amount of 'non-allowable' criteria exceedance defined as the area between the attainment curve (black line) and the reference curve.

Chapter 5. Recommended Implementation Procedures (USEPA 2003)

DEFINING CRITERIA ATTAINMENT

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Development of a multimetric water quality Indicator for tracking progress towards the achievement of Chesapeake Bay water quality standards

Ana L Hernandez Cordero [1], Peter J Tango [2], Richard A Batiuk [3]

Affiliations + expand

PMID: 31907685 DOI: 10.1007/s10661-019-7969-z

Abstract

A multimetric water quality standards (WQS) attainment indicator (MMI) was created to assess the habitat quality of the Chesapeake Bay and its tidal tributaries. The indicator uses metrics of dissolved oxygen concentrations, water clarity assessments, underwater bay grass acreages, and season-specifi chlorophyll a distributions. This suite of metrics is recognized as symptomatic of eutrophication and

Just FYI - This work looks at probable attainment.
The indicator provides an estimate of attainment.

Assessments:

- USEPA 2003 provided a recommended approach to assessing criterion attainment using interpolation and the CFD
- The TMDL planning targets are built upon applying the CFD approach in a baywide common method between monitoring and modeled data assessments in a partnership-wide consistent manner.
- We have strived to have a cross-jurisdictional common approach to the criteria assessment and other watershed agreement outcome assessment in the bay and across the watershed
- We recognize EPA does not approve assessment procedures but evaluates assessment results considering protocols used to make the assessment decisions

Assessments

Going forward, CAP WG:

- We will continue the path of the summer 2024 meeting and build our list of questions on the criteria and their assessment.
- We will continue to vet our Questions and Answers on the criteria and their assessment
- Coincident with ongoing methods developments, CAP WG will document a common community understanding on the issues
- Our documentation historically gets summarized in a Technical Document, reviewed, and published through EPA as guidance to support updates to criteria or their assessment and assessment framework
- We will likely need some homework and longer meetings for addressing these topics

Agenda planning with additional questions: capturing our list of questions to document answers, resolution during CAP WG meetings.

Further questions for our CAP WG – can we add to this list as topics for this and future meetings?

For a given criterion-season application

* **Discuss ideas for how we would use discrete data to assess this criterion, if at all.**
- **Discuss ideas for how we would use continuous data (i.e., profilers, arrays, surface Conmon devices) to assess this criterion.**
- **Discuss how many stations we would need spatially to assess a particular DO criterion/Designated Use combination**
- **Discuss how many measurements at any individual station (minimum data threshold) we would need to temporally assess a particular DO criterion/Designated Use combination**

From August 2024 CAP WG minutes: Developing detailed decision rules for an assessment methodology for the short duration criteria (and even the 30 day mean DO criteria).

- Answering the following questions:
  - How to interpret DO criteria (e.g., Does instant. min = never to exceed? One exceedance in 3 yrs? 10% exceedance? 1% exceedance?)
  - How should we calculate a 7-day mean?
  - What is the minimum spatial and temporal data threshold to be met to assess a segment-designated use combination?
  - What zones (e.g., trib of trib, shallow water, etc) within each designated use should have data for assessment?

Transition ☺

Topic 2. Computational definitions for means and instantaneous minimum.

Instantaneous min (USEPA 2017)

- Based on the above published state methods and EPA guidance, the CBP Scientific, Technical Assessment and Reporting Team's Criteria Assessment Protocol Workgroup worked with U.S. EPA Region III Office staff to develop options for assessing attainment of season-long, high frequency data (e.g., every 15 minutes) for criterion assessment that protects the designated use. The Criteria Assessment Protocol Workgroup then considered three options for instantaneous minimum criterion assessment that account for concerns of living resource protection over an entire season at a conservative level.

Some guidance to start with for using Con-Mon and the IM criterion assessment (USEPA 2017)

- Rule 1. No more than 10 percent of days during a single season with an exceedance— 9 total of 12 days can have a single exceedance. This translates into about 30 minutes x 12 or 5 hours total per season, and given 2880 hours in a summer season, about 0.17 percent of the summer season.
- Rule 2. No more than 1 day with 10 percent time (>2.5 hours) exceedance during a single season. This translates into 3 or more hours or about 0.1 percent of the summer season.
- Rule 2-Alternate. No more than two consecutive days with 10 percent time (>2.5 hours) exceedance during a single season. This translates into 6 or more hours or about 0.2 percent of the summer season.