# Virginia's Tentative Approach for Implementing All Chesapeake Bay DO Criteria Using Readily Available Datasets

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# Presentation Outline

- Background
- Description of Virginia's tentative approach
- Discussion



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# Background

- There are eleven DO criteria applicable to the tidal waters of the Chesapeake Bay and its tributaries.
- Since their adoption into regulation in 2005, only three of these criteria have been implemented.
- A complete evaluation of the success of the TMDL cannot be done until all DO criteria/designated uses are assessed.

**Table II-1**. Chesapeake Bay dissolved oxygen water quality criteria.

| Designated Use | Criteria Concentration/Duration | Protection Provided | Temporal Application |
|---|---|---|---|
| Migratory fish spawning and nursery use | 7-day mean ≥ 6 mg/L (tidal habitats with 0-0.5 salinity) | Survival/growth of larval/juvenile tidal-fresh resident fish; protective of threatened/endangered species | February 1-May 31 |
| | Instantaneous minimum ≥ 5 mg/L | 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 criteria apply | | Year-round |
| Open-water fish and shellfish use[1] | 30-day mean ≥ 5.5 mg/L (tidal habitats with ≤0.5 salinity) | Growth of tidal-fresh juvenile and adult fish; protective of threatened/endangered species | Year-round |
| | 30-day mean ≥ 5 mg/L (tidal habitats with >0.5 salinity) | Growth of larval, juvenile and adult fish and shellfish; protective of threatened/endangered species | |
| | 7-day mean ≥ 4 mg/L | Survival of open-water fish larvae | |
| | Instantaneous minimum ≥ 3.2 mg/L | Survival of threatened/endangered sturgeon species[1] | |
| Deep-water seasonal fish and shellfish use | 30-day mean ≥ 3 mg/L | Survival and recruitment of bay anchovy eggs and larvae | June 1-September 30 |
| | 1-day mean ≥ 2.3 mg/L | Survival of open-water juvenile and adult fish | |
| | Instantaneous minimum ≥ 1.7 mg/L | 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/L | 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. When water column temperatures are greater than 29 °C, an open water dissolved oxygen criterion for the instantaneous minimum of 4.3 mg/L is applied to protect habitat for survival of shortnose sturgeon.

Currently assessed



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# Background

Assessment methods have been developed by the CAP workgroup for some of the criteria, as presented in USEPA (2017, EPA 903-R-17-002).

- Conditional probability analysis, which allows an inference to be made about attainment of a 7-day mean criterion using Interpolator 30-day mean concentrations.



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# Conditional Probability/Attainment

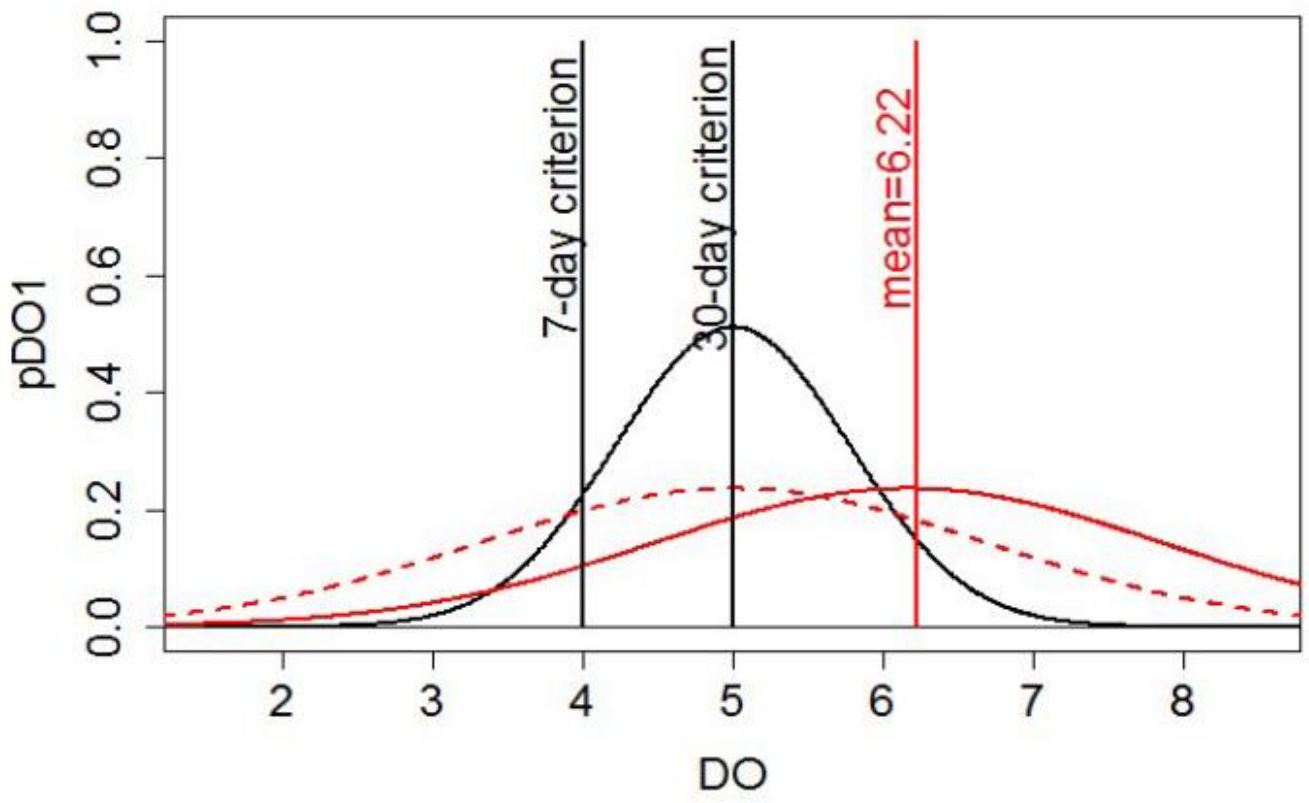


**Figure II-3.** Illustration of the shift—from red dashed line to red solid line—in the monthly mean required to meet 10% risk tolerance for the 7-day criterion when the weekly mean deviation of 1.74 accounting for the uncertainty in estimating the mean due to small sample sizes (n=2).



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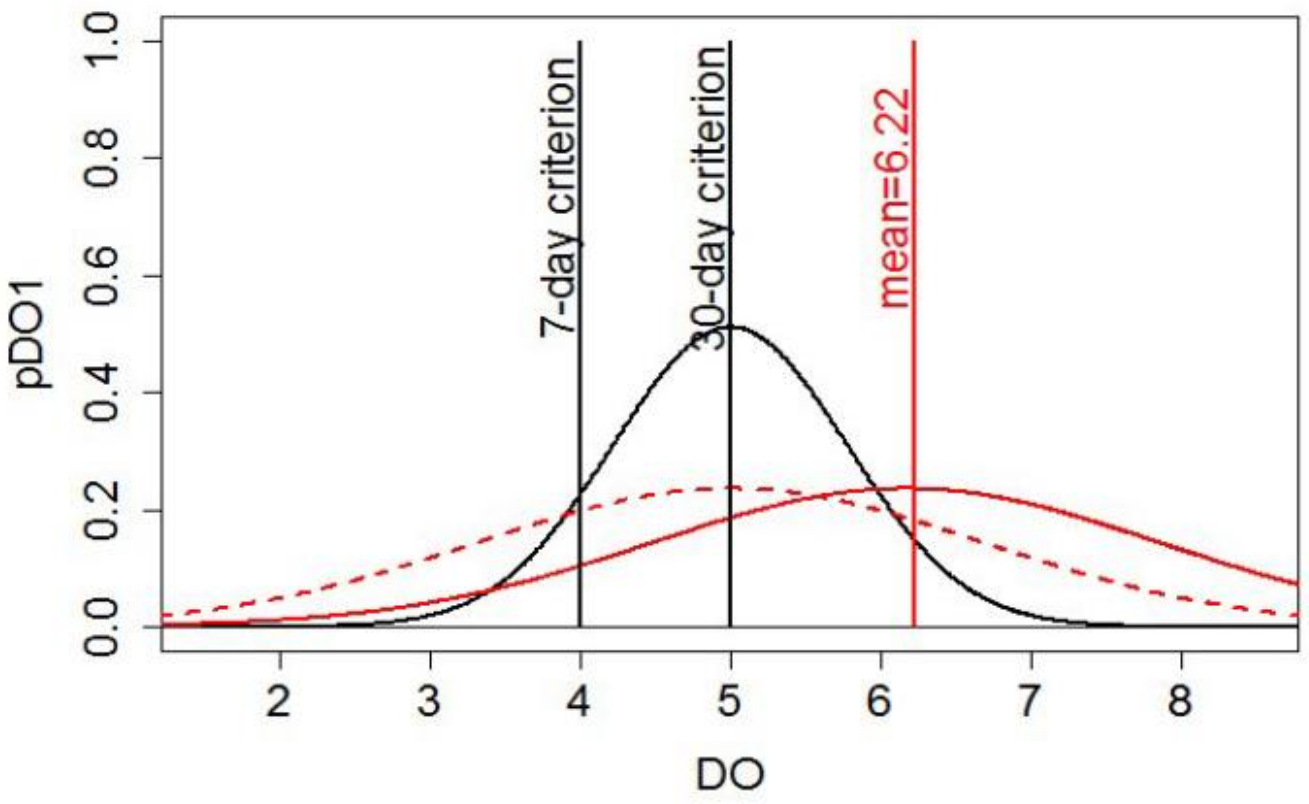
# Conditional Probability/Attainment




- Only recommended for the Open Water 7-day mean criterion.
- Can only be used to say a segment is meeting the criterion (cannot be used to conclude nonattainment)
- Requires some judgment calls that may be challenging for the jurisdictions.
- Unusual method for 303(d)/305(b)

**Figure II-3.** Illustration of the shift—from red dashed line to red solid line—in the monthly mean required to meet 10% risk tolerance for the 7-day criterion when the weekly mean deviation of 1.74 accounting for the uncertainty in estimating the mean due to small sample sizes (n=2).



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# Background

Assessment methods have been developed by the CAP workgroup for some of the criteria, as presented in USEPA (2017).

- Conditional probability analysis, which allows an inference to be made about attainment of a 7-day mean criterion using Interpolator 30-day mean concentrations.

- Subsegmentation of segments, to allow for “piecemeal” criteria assessments via enhanced monitoring.

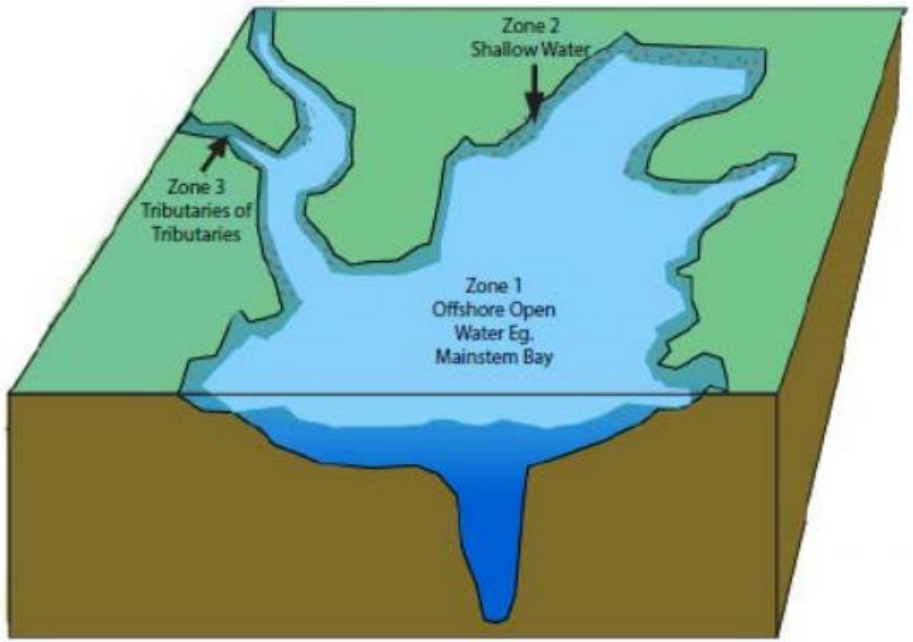


Figure II-4. Applying the concept of three zones to Chesapeake Bay open-water habitats.

Table II-4. Applicable criteria assessment procedures for each of the three zones within the open-water designated use.

| Zone | Zone Description | Applicable Criteria Assessment Procedures |
|---|---|---|
| 1 | Open, well-mixed mainstem Bay and tidal tributary waters | • CFD-based assessment of the 30-day mean<br>• CFD-based assessment of the 7-day mean with enhanced temporal frequency of monitoring<br>• Conditional attainment assessment of the 7-day mean<br>• Continuous monitoring-based assessment of the instantaneous minimum |
| 2 | Shallow-water waters | • Continuous monitoring-based assessment of the instantaneous minimum |
| 3 | Tributaries of tributaries off of the mainstem Chesapeake Bay and its tidal tributaries | • Discrete sampling-based assessment of the instantaneous minimum |



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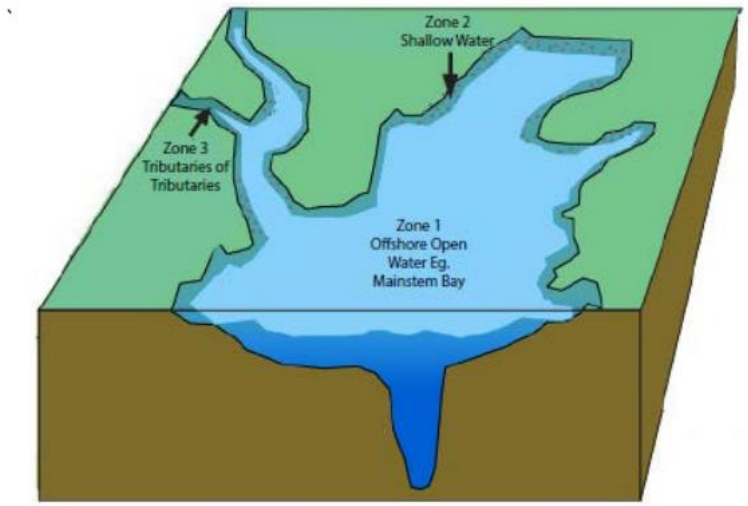


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- Why shouldn't ConMon data be used to assess all the criteria?
- The instantaneous minimum procedure for ConMon data is unlike anything else. (No more than two consecutive days with 2.5+ hours worth of exceedances in a three-year period.)
- Why not assess instantaneous minimum criteria wherever discrete data are collected?
- What about Profiler and array datasets? How should those data be assessed?
- An assessment approach that hinges on enhanced monitoring datasets means that only one or two segments will be assessed against some/most of the DO criteria in any given assessment cycle.



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## Background

In summary…

- The methods that have been worked out in the past have some significant downsides to them.
- We want a method that:
  - Allows us to assess all the criteria
  - Allows us to maximize the use of all datasets
  - Won't necessitate enhanced monitoring in all segments
  - Simple to implement and communicate
  - Utilizes decision rules that are already in practice in the world of 303(d)/305(b) assessments nationally.



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# Virginia's Tentative Assessment Approach for Bay DO criteria

A proposed solution to this problem:

"How can we assess all the Bay DO criteria using all readily available data?"

Combines two tools frequently used in risk assessment:

1. Screening values
2. Multiple lines of evidence



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# Screening Values

- A screening value is used in risk assessment to determine with high confidence where there is low probability of adverse risks.
- They allow for the rapid detection of sites where further investigation should be conducted (e.g., enhanced monitoring).
- Screening values are applied to instantaneous data rather than spatially or temporally-aggregated data.

# Bay DO Criteria

| Designated Use | Criteria Concentration/Duration | Temporal Application |
|---|---|---|
| Migratory fish spawning and nursery | 7-day mean 6 mg/l (tidal habitats with 0-0.5 ppt salinity) | February 1 - May 31 |
| | Instantaneous minimum 5 mg/l | |
| Open water[1] | 30-day mean 5.5 mg/l (tidal habitats with 0-0.5 ppt salinity) | year-round[2] |
| | 30-day mean 5 mg/l (tidal habitats with > 0.5 ppt salinity) | |
| | 7-day mean 4 mg/l | |
| | Instantaneous minimum 3.2 mg/l at temperatures < 29°C<br>Instantaneous minimum 4.3 mg/lat temperatures 29°C | |
| Deep water | 30-day mean 3 mg/l | June 1 - September 30 |
| | 1-day mean 2.3 mg/l | |
| | Instantaneous minimum 1.7 mg/l | |
| Deep channel | Instantaneous minimum 1 mg/l | June 1 - September 30 |

[1]In applying this open water instantaneous criterion to the Chesapeake Bay and its tidal tributaries where the existing water quality for dissolved oxygen exceeds an instantaneous minimum of 3.2 mg/l, that higher water quality for dissolved oxygen shall be provided antidegradation protection in accordance with 9VAC25-260-30 A 2.

[2]Open-water dissolved oxygen criteria attainment is assessed separately over two time periods: summer (June 1- September 30) and nonsummer (October 1-May 31) months.

# What if we turned all the Bay DO criteria into screening values by ignoring their durations?

| Designated Use | Criteria Concentration/Duration | Temporal Application |
|---|---|---|
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| | Instantaneous minimum 5 mg/l | |
| Open water[1] | 5.5 mg/l (tidal habitats with 0-0.5 ppt salinity) | year-round[2] |
| | 5 mg/l (tidal habitats with > 0.5 ppt salinity) | |
| | 4 mg/l | |
| | Instantaneous minimum 3.2 mg/l at temperatures < 29°C<br>Instantaneous minimum 4.3 mg/lat temperatures 29°C | |
| Deep water | 3 mg/l | June 1 - September 30 |
| | 2.3 mg/l | |
| | Instantaneous minimum 1.7 mg/l | |
| Deep channel | Instantaneous minimum 1 mg/l | June 1 - September 30 |

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[2]Open-water dissolved oxygen criteria attainment is assessed separately over two time periods: summer (June 1- September 30) and nonsummer (October 1-May 31) months.

# Screening value-based assessment

For each segment-designated use, using all discrete data collected in the segment within a three-year period:

- Calculate the exceedance rate of each applicable Bay DO “screening value”.
- An exceedance rate <=10% indicates a high likelihood the criterion was met, so we would say the criterion was attained.
- An exceedance rate >10% would indicate lack of criteria attainment and/or additional information is needed.



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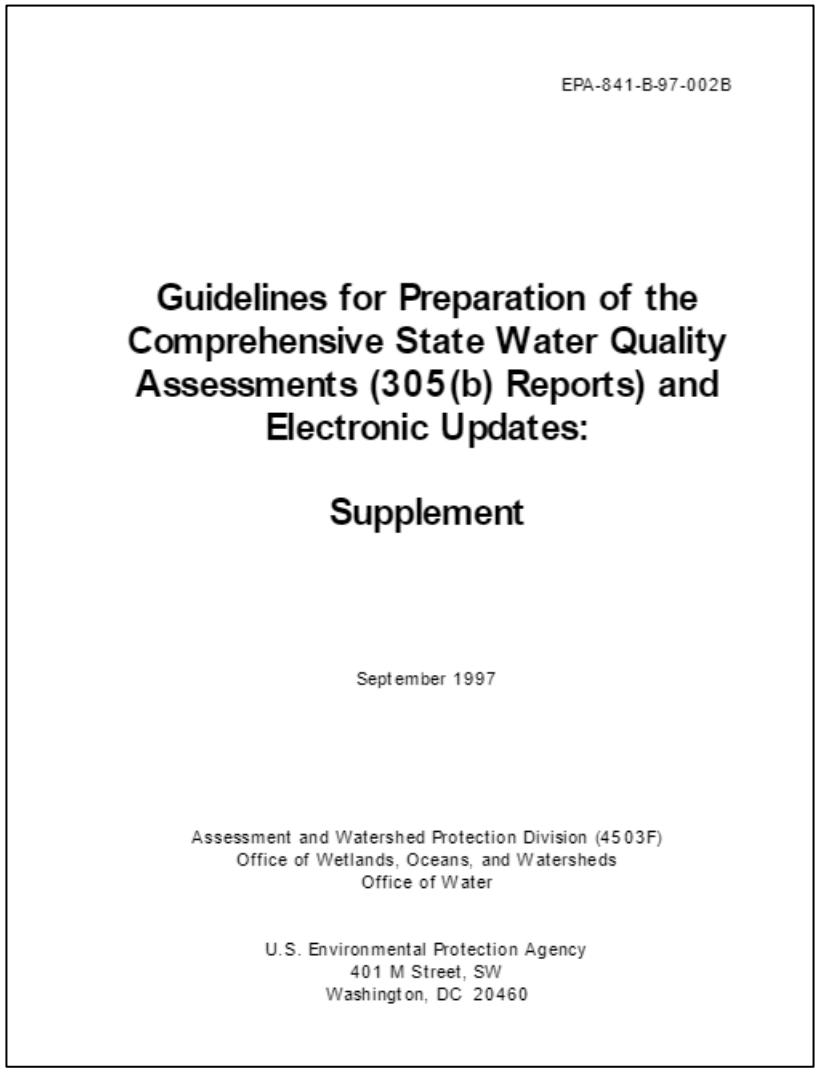
# USEPA (1997) provides justification for the allowable 10% exceedance rate in criteria assessments for conventional pollutants



EPA-841-B-97-002B

Guidelines for Preparation of the Comprehensive State Water Quality Assessments (305(b) Reports) and Electronic Updates:

Supplement

September 1997

Assessment and Watershed Protection Division (4503F)
Office of Wetlands, Oceans, and Watersheds
Office of Water

U.S. Environmental Protection Agency
401 M Street, SW
Washington, DC 20460



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# Assessment Results for a Hypothetical Segment

## This segment would be assessed as meeting all applicable DO criteria

| Designated Use | Criterion | No. of discrete data points assessed | Exceedance Rate |
|---|---|---|---|
| Migratory Fish Spawning Nursery Feb-May | 6 mg/L (7-Day Mean) | 43 | 0% |
| | 5 mg/L (Instant Min) | 12* | 0% |
| Open Water ROY Jan-May,Oct-Dec | 5.5 mg/L (30-Day Mean) | 305 | 0% |
| | 4 mg/L (7-Day Mean) | 305 | 0% |
| | 3.2 or 4.3 mg/L (Instant Min) | 33* | 0% |
| Open Water Summer July-September | 5.5 mg/L (30-Day Mean) | 157 | 3% |
| | 4 mg/L (7-Day Mean) | 157 | 1% |
| | 3.2 or 4.3 mg/L (Instant Min) | 26* | 4% |



* IM exceedance rates could be restricted to bottom DO measurements.

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# Assessment Results for a Hypothetical Segment

## This segment would NOT be assessed as meeting all applicable DO criteria

| Designated Use | Criterion | No. of discrete data points assessed | Exceedance Rate |
|---|---|---|---|
| Open Water ROY Jan-May,Oct-Dec | 5 mg/L (30-Day Mean) | 305 | 0% |
| | 4 mg/L (7-Day Mean) | 305 | 0% |
| | 3.2 or 4.3 mg/L (Instant Min) | 33* | 0% |
| Open Water Summer July-September | 5 mg/L (30-Day Mean) | 1109 | 1% |
| | 4 mg/L (7-Day Mean) | 1109 | 1% |
| | 3.2 or 4.3 mg/L (Instant Min) | 50* | 12% |
| Deep Water July-Sept | 3 mg/L (30-Day Mean) | 2000 | 16% |
| | 2.3 mg/L (1-Day Mean) | 2000 | 13% |
| | 1.7 mg/L (Instant Min) | 31 | 20% |

* IM exceedance rates could be restricted to bottom DO measurements.



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# Things that would need to be worked out:

- Minimum number of discrete samples
- Should an exceedance rate greater than 10% always indicate nonattainment, regardless of the criterion (30-day mean criterion versus IM criteria)?

# Virginia's Tentative Assessment Approach for Bay DO Criteria

A proposed solution to this problem:

"How can we assess all the Bay DO criteria using all readily available data?"

Combines two tools frequently used in risk assessment:

1. Screening values ✓
2. Multiple lines of evidence



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# Multiple Lines of Evidence

We have different data types:

- Discrete data
- ConMon data (shallow water, Profilers, arrays, etc.)

We can also process the discrete data in different ways:

- Interpolator/CFD Procedure
- Screening Value Procedure

Currently, our Bay DO assessments have been based on one data type (discrete) and one assessment procedure (Interpolator/CFD).



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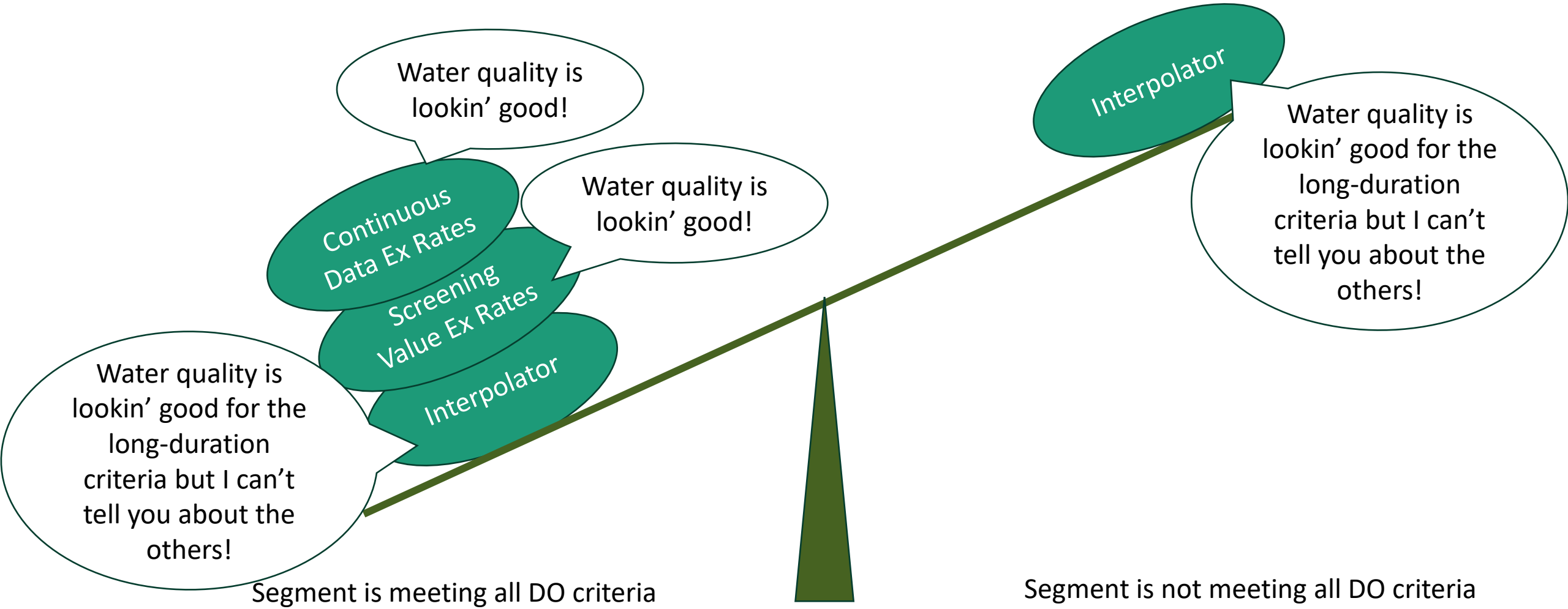
# A Weight of Evidence approach allows us to integrate multiple lines of evidence for decision-making

WOE decision-making is useful when all the evidence we have is rife with uncertainty.

- Discrete data – weak in the temporal dimension
- ConMon data – weak in the spatial dimension
- Screening Value Approach – not good at distinguishing marginally attaining/nonattaining segments
- Interpolator/CFD – not good at distinguishing marginally attaining/nonattaining segments (and currently not used for short-duration criteria assessments)

# Combining all the available information mitigates their individual weaknesses.



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Continuous Data Ex Rates

Calculate 30-day, 7-day, 1-day means and daily minimums (according to applicable criteria).

>10% exceedance rate = nonattainment

Screening Value Ex Rates

Apply criteria as screening values to discrete data.

>10% exceedance rate = nonattainment/more info needed

Interpolator/CFD

Any excursion of the reference CFD = nonattainment



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# Hypothetical Assessment

## This hypothetical segment would be assessed as meeting all applicable DO criteria

| Designated Use | Criterion | Shallow Water ConMon Exceedance Rate | Screening Value Exceedance Rate | Interpolator/CFD Nonattainment Rate |
|---|---|---|---|---|
| Migratory Fish Spawning Nursery | 6 mg/L (7-Day Mean) | 2% (rolling 7-day means) | 0% | Not Available |
| | 5 mg/L (Instant Min) | 0% (daily minimums) | 0% | Not Available |
| Open Water ROY Jan-May,Oct-Dec | 5.5 mg/L (30-Day Mean) | 0% (rolling 30-day means) | 0% | 0% |
| | 4 mg/L (7-Day Mean) | 0% (rolling 7-day means) | 0% | Not Available |
| | 3.2 or 4.3 mg/L (Instant Min) | 0% (daily minimums) | 0% | Not Available |
| Open Water Summer July-September | 5.5 mg/L (30-Day Mean) | 0% (rolling 30-day means) | 0% | 0% |
| | 4 mg/L (7-Day Mean) | 1% (rolling 7-day means) | 0% | Not Available |
| | 3.2 or 4.3 mg/L (Instant Min) | 5% (daily minimums) | 0% | Not Available |



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# Hypothetical Assessment

**This hypothetical segment would NOT be assessed as meeting all applicable DO criteria**

| Designated Use | Criterion | Profiler Exceedance Rate | Screening Value Exceedance Rate | Interpolator/CFD Nonattainment Rate |
|---|---|---|---|---|
| Open Water ROY Jan-May,Oct-Dec | 5.5 mg/L (30-Day Mean) | Not Available | 0% | 0% |
| | 4 mg/L (7-Day Mean) | Not Available | 0% | Not Available |
| | 3.2 or 4.3 mg/L (Instant Min) | Not Available | 0% | Not Available |
| Open Water Summer July-September | 5.5 mg/L (30-Day Mean) | 0% (rolling 30-day means) | 0% | 0% |
| | 4 mg/L (7-Day Mean) | 1% (rolling 7-day means) | 0% | Not Available |
| | 3.2 or 4.3 mg/L (Instant Min) | 1% (daily minimums) | 0% | Not Available |
| Deep Water July-September | 3 mg/L (30-Day Mean) | 8% (rolling 30-day means calculated at each depth) | 11% | 0.1% |
| | 2.3 mg/L (1-Day Mean) | 5% (rolling 1-day means calculated at each depth) | 6% | Not Available |
| | 1.7 mg/L (Instant Min) | 20% (daily minimum across all depths) | 9% | Not Available |



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# Things that would need to be worked out:

- What should be the minimum deployment duration of a ConMon dataset?
- How much of a particular period (1-day, 7-day, 30-day, etc.) should be observed by the ConMon for an average to be calculated (e.g., Is two days worth of data sufficient for calculating a 7-day mean?)
- How can array data be directly assessed in segments with the Deep Water/Deep Channel uses?
- Should we give more weight to Profiler results? How would we do this?



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# Discussion

Virginia's tentative approach to assessing Bay DO would allow us to:

- Get the most out of our monitoring data.
- Make use of all available data.
- Report on incremental progress.
- Identify segments where enhanced monitoring would be most beneficial.
- Make sound decisions despite the uncertainty.
- Have assessment results that can be readily understood and replicated by stakeholders and the general public.
- Have a process that can be implemented by the jurisdictions.
- Have a process that is in line with established procedures in other 303(d)/305(b) assessments.



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We would like the CAP workgroup to consider whether we should adopt this approach for Bay DO criteria assessments.  All ideas are welcome!

# Discussion