



Proposed Decision Rules for 4D Interpolator-Based Dissolved Oxygen Criteria Assessment

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Criteria Assessment Protocol Workgroup
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4D Interpolator Decision Rules

CFD Selection
From Multiple
Realizations

Allowable
exceedance
frequency

Designated Use
Determination

General Decision Rules

- Bay Segmentation Scheme
- Averaging period for IM criteria
- Delineation of periods (high frequency data only)
- Minimum temporal coverage (high frequency data only)
- Significant Figures
- Pycnocline Depth Determination

SMLE Decision Rules

Data requirements in
different habitats

Low-Frequency
Data Stipulations

Designated Use
Determination

Allowable Exceedance
frequency

How different lines of
evidence are to be integrated

Priority for 2026

Guiding principles of criteria assessment methods:

- Scientific soundness
- Protectiveness
- Regulatory defensibility
- Consistency with existing state assessment policies/procedures
- Transparency and ability to communicate methods
- Reproducibility

Types of Decision Rules for Post-Processing 4D Interpolator Output

Rules for how to temporally aggregate the output of the 4D Interpolator

Rules for determining which Interpolator cells are to be assessed against a criterion in cases where the pycnocline depth is important

Rules for how to determine criteria attainment

Proposed Decision Rules

Rules for how to temporally aggregate the output of the 4D Interpolator

1. Hourly average for IM criteria

Proposed Decision Rules

Rules for how to temporally aggregate the output of the 4D Interpolator

1. Hourly average for IM criteria

Rationale:

- Some mortality was observed in test organisms within two hours of exposure to hypoxia in laboratory testing (USEPA, 2003).
- The criteria are called “instantaneous”, which implies a very brief duration.

Note:

Cruise averages have been used to evaluate the Deep Channel IM criterion. A cruise is approximately two weeks long. So going with an hourly duration would be a significant change.

Proposed Decision Rules

Rules for how to temporally aggregate the output of the 4D Interpolator

1. Hourly average for IM criteria
2. Rolling, non-overlapping periods for 30-day and 7-day mean calculations (as opposed to calendar periods).

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Rules for how to temporally aggregate the output of the 4D Interpolator

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Rolling, non-overlapping 7-day periods for the summer seasons			Weeks for the summer seasons		
period starts...	period ends...	number of days	period starts...	period ends...	number of days
6/1/2027	6/7/2027	7	6/1/2027	6/5/2027	5
6/8/2027	6/14/2027	7	6/6/2027	6/12/2027	7
6/15/2027	6/21/2027	7	6/13/2027	6/19/2027	7
6/22/2027	6/28/2027	7	6/20/2027	6/26/2027	7
6/29/2027	7/5/2027	7	6/27/2027	7/3/2027	7
7/6/2027	7/12/2027	7	7/4/2027	7/10/2027	7
7/13/2027	7/19/2027	7	7/11/2027	7/17/2027	7
7/20/2027	7/26/2027	7	7/18/2027	7/24/2027	7
7/27/2027	8/2/2027	7	7/25/2027	7/31/2027	7
8/3/2027	8/9/2027	7	8/1/2027	8/7/2027	7
8/10/2027	8/16/2027	7	8/8/2027	8/14/2027	7
8/17/2027	8/23/2027	7	8/15/2027	8/21/2027	7
8/24/2027	8/30/2027	7	8/22/2027	8/28/2027	7
8/31/2027	9/6/2027	7	8/29/2027	9/4/2027	7
9/7/2027	9/13/2027	7	9/5/2027	9/11/2027	7
9/14/2027	9/20/2027	7	9/12/2027	9/18/2027	7
9/21/2027	9/27/2027	7	9/19/2027	9/25/2027	7
9/28/2027	9/30/2027	3	9/26/2027	9/30/2027	5
6/1/2028	6/7/2028	7	6/1/2028	6/3/2028	3
6/8/2028	6/14/2028	7	6/4/2028	6/10/2028	7
6/15/2028	6/21/2028	7	6/11/2028	6/17/2028	7
6/22/2028	6/28/2028	7	6/18/2028	6/24/2028	7
6/29/2028	7/5/2028	7	6/25/2028	7/1/2028	7
7/6/2028	7/12/2028	7	7/2/2028	7/8/2028	7
7/13/2028	7/19/2028	7	7/9/2028	7/15/2028	7
7/20/2028	7/26/2028	7	7/16/2028	7/22/2028	7
7/27/2028	8/2/2028	7	7/23/2028	7/29/2028	7
8/3/2028	8/9/2028	7	7/30/2028	8/5/2028	7
8/10/2028	8/16/2028	7	8/6/2028	8/12/2028	7
8/17/2028	8/23/2028	7	8/13/2028	8/19/2028	7
8/24/2028	8/30/2028	7	8/20/2028	8/26/2028	7

Proposed Decision Rules

Rules for how to temporally aggregate the output of the 4D Interpolator

1. Hourly average for IM criteria
2. Rolling, non-overlapping periods for 30-day and 7-day mean calculations (as opposed to calendar periods).
3. Dates and date-hours for 1-day mean and instantaneous minimums.

Proposed Decision Rules

Rules for how to temporally aggregate the output of the 4D Interpolator

1. Hourly average for IM criteria
2. Rolling, non-overlapping periods for 30-day and 7-day mean calculations (as opposed to calendar periods).
3. Dates and date-hours for 1-day mean and instantaneous minimums.
4. A minimum 50% temporal coverage for assessing 30-day and 7-day means.

A minimum 50% temporal coverage for assessing 30-day and 7-day means

Example #1

Open Water 7-Day Mean Pre-Processing Table for an Interpolator Cell			
period starts...	period ends...	number of days with Interpolator output	Compute 7-Day DO Mean?
6/1/2027	6/7/2027	7	YES
6/8/2027	6/14/2027	7	YES
6/15/2027	6/21/2027	7	YES
6/22/2027	6/28/2027	7	YES
6/29/2027	7/5/2027	7	YES
7/6/2027	7/12/2027	7	YES
7/13/2027	7/19/2027	7	YES
7/20/2027	7/26/2027	7	YES
7/27/2027	8/2/2027	7	YES
8/3/2027	8/9/2027	7	YES
8/10/2027	8/16/2027	7	YES
8/17/2027	8/23/2027	7	YES
8/24/2027	8/30/2027	7	YES
8/31/2027	9/6/2027	7	YES
9/7/2027	9/13/2027	7	YES
9/14/2027	9/20/2027	7	YES
9/21/2027	9/27/2027	7	YES
9/28/2027	9/30/2027	3	NO

Must have at least 4 days represented by output

A minimum 50% temporal coverage for assessing 30-day and 7-day means

Example #2

Migratory Fish Spawning and Nursery 7-Day Mean Pre-Processing Table for an Interpolator Cell				
period starts...	period ends...	number of days with Interpolator output	number of days with mean salinity < 0.5 ppt	Compute 7-Day DO Mean?
2/1/2027	2/7/2027	7	7	YES
2/8/2027	2/14/2027	7	7	YES
2/15/2027	2/21/2027	7	7	YES
2/22/2027	2/28/2027	7	6	YES
3/1/2027	3/7/2027	7	6	YES
3/8/2027	3/14/2027	7	7	YES
3/15/2027	3/21/2027	7	7	YES
3/22/2027	3/28/2027	7	5	YES
3/29/2027	4/4/2027	7	5	YES
4/5/2027	4/11/2027	7	6	YES
4/12/2027	4/18/2027	7	4	YES
4/19/2027	4/25/2027	7	3	NO
4/26/2027	5/2/2027	7	3	NO
5/3/2027	5/9/2027	7	3	NO
5/10/2027	5/16/2027	7	2	NO
5/17/2027	5/23/2027	7	2	NO
5/24/2027	5/30/2027	7	0	NO

Must have at least 4 days
represented by output
AND that meet the salinity
condition.

Proposed Decision Rules

Rules for how to temporally aggregate the output of the 4D Interpolator

1. Hourly average for IM criteria
2. Rolling, non-overlapping periods for 30-day and 7-day mean calculations.
3. Dates and date-hours for 1-day mean and instantaneous minimums.
4. A minimum 50% temporal coverage for assessing 30-day and 7-day means.

Proposed Decision Rules

Rules for how to temporally aggregate the output of the 4D Interpolator



Rules for determining which Interpolator cells are to be assessed against a criterion in cases where the pycnocline depth is important

Rules for how to determine criteria attainment

Proposed Decision Rules

Rules for determining which Interpolator cells are to be assessed against a criterion in cases where the pycnocline depth is important

Procedure for Interpolator cells in segments designated for Deep Water or Deep Channel, when assessing summer Open Water, Deep Water, or Deep Channel criteria:

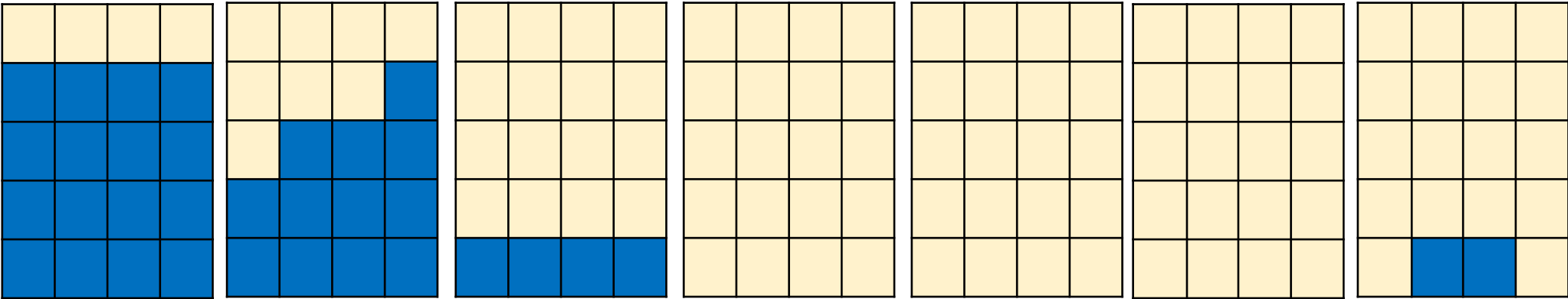
- For each Interpolator cell, assign each hourly DO estimate to a designated use based on its vertical position with respect to the same-day average pycnocline boundary depth(s).
- For each Interpolator cell-criterion combination, determine the frequency of the cell's inclusion within the appropriate designated use over the duration of the criterion.
- To be eligible for the assessment of a criterion, a cell must have been within the appropriate designated use at least 50% of the time over the criterion's duration.
- Only the hourly estimates matched to a particular designated use should be used to assess the applicable criteria of that designated use.

Above Pycnocline

Below Upper Boundary of Pycnocline

Open Water 7-Day Mean Criterion Assessment

6/1/2027 6/2/2027 6/3/2027 6/4/2027 6/5/2027 6/6/2027 6/7/2027



Assess Open Water 7-Day Mean

Don't Assess Open Water 7-Day Mean

Temporal frequency of OW use

100%	100%	100%	100%
86%	86%	86%	71%
86%	71%	71%	71%
71%	71%	71%	71%
57%	43%	43%	57%

We would exclude the magenta cells from the assessment of the OW 7-day mean criterion for this 7-day period because the Open Water use appears infrequently over this period in those cells.

However, the above-pyc hourly DO estimates of the magenta cells would still be subject to the Open Water IM criterion.

Proposed Decision Rules

Rules for how to aggregate the output of the 4D Interpolator



Rules for determining which Interpolator cells are to be assessed against a criterion in cases where the pycnocline depth is important



Rules for how to determine criteria attainment

Proposed Decision Rules

Rules for how to determine criteria attainment

1. Assessment values (e.g., a 30-day DO mean) should be rounded to the tenth's place prior to being compared to a criterion.

Open Water 7-Day Mean Assessment Table for an Interpolator Cell						
period starts...	period ends...	number of days with Interpolator output	Compute 7-Day DO Mean?	7-Day DO Mean	Rounded 7-Day DO Mean	Less than 4.0 mg/L?
6/1/2027	6/7/2027	7	YES	6.753	6.8	NO
6/8/2027	6/14/2027	7	YES	7.446	7.4	NO
6/15/2027	6/21/2027	7	YES	6.541	6.5	NO
6/22/2027	6/28/2027	7	YES	5.492	5.5	NO
6/29/2027	7/5/2027	7	YES	5.501	5.5	NO
7/6/2027	7/12/2027	7	YES	5.029	5.0	NO
7/13/2027	7/19/2027	7	YES	4.959	5.0	NO
7/20/2027	7/26/2027	7	YES	5.001	5.0	NO
7/27/2027	8/2/2027	7	YES	4.533	4.5	NO
8/3/2027	8/9/2027	7	YES	3.985	4.0	NO
8/10/2027	8/16/2027	7	YES	3.942	3.9	YES
8/17/2027	8/23/2027	7	YES	3.995	4.0	NO
8/24/2027	8/30/2027	7	YES	5.349	5.3	NO
8/31/2027	9/6/2027	7	YES	4.988	5.0	NO
9/7/2027	9/13/2027	7	YES	5.974	6.0	NO
9/14/2027	9/20/2027	7	YES	6.952	7.0	NO
9/21/2027	9/27/2027	7	YES	6.541	6.5	NO

The computation of 1-day, 7-day, and 30-day DO means should only be performed on unrounded DO estimates to prevent compounding rounding errors. However, IM criteria should be only assessed using rounded DO estimates.

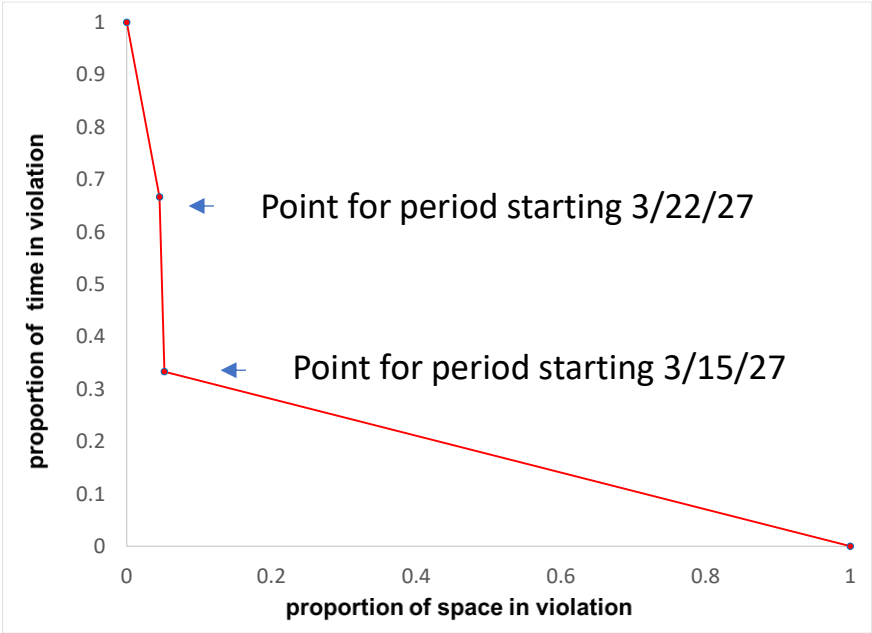
Proposed Decision Rules

Rules for how to determine criteria attainment

1. Assessment values (e.g., a 30-day DO mean) should be rounded to the tenth's place prior to being compared to a criterion.
2. A segment CFD must have a minimum of four assessment points for it to be used to determine criteria attainment.

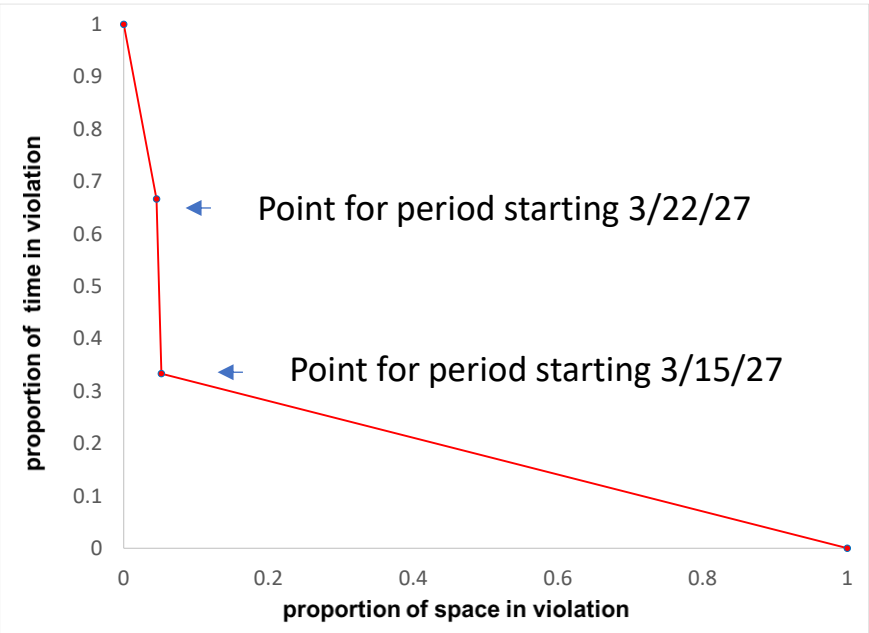
Scenario #1: There are only two criteria periods that meet the salinity condition for assessment in a segment.

Migratory Fish Spawning and Nursery 7-Day Mean Assessment Table for a Segment		
period starts...	period ends...	Spatial Exceedance Rate
2/1/2027	2/7/2027	Not calculated due to high salinity
2/8/2027	2/14/2027	Not calculated due to high salinity
2/15/2027	2/21/2027	Not calculated due to high salinity
2/22/2027	2/28/2027	Not calculated due to high salinity
3/1/2027	3/7/2027	Not calculated due to high salinity
3/8/2027	3/14/2027	Not calculated due to high salinity
3/15/2027	3/21/2027	5.20%
3/22/2027	3/28/2027	4.53%
3/29/2027	4/4/2027	Not calculated due to high salinity
4/5/2027	4/11/2027	Not calculated due to high salinity
4/12/2027	4/18/2027	Not calculated due to high salinity
4/19/2027	4/25/2027	Not calculated due to high salinity
4/26/2027	5/2/2027	Not calculated due to high salinity
5/3/2027	5/9/2027	Not calculated due to high salinity
5/10/2027	5/16/2027	Not calculated due to high salinity
5/17/2027	5/23/2027	Not calculated due to high salinity
5/24/2027	5/30/2027	Not calculated due to high salinity



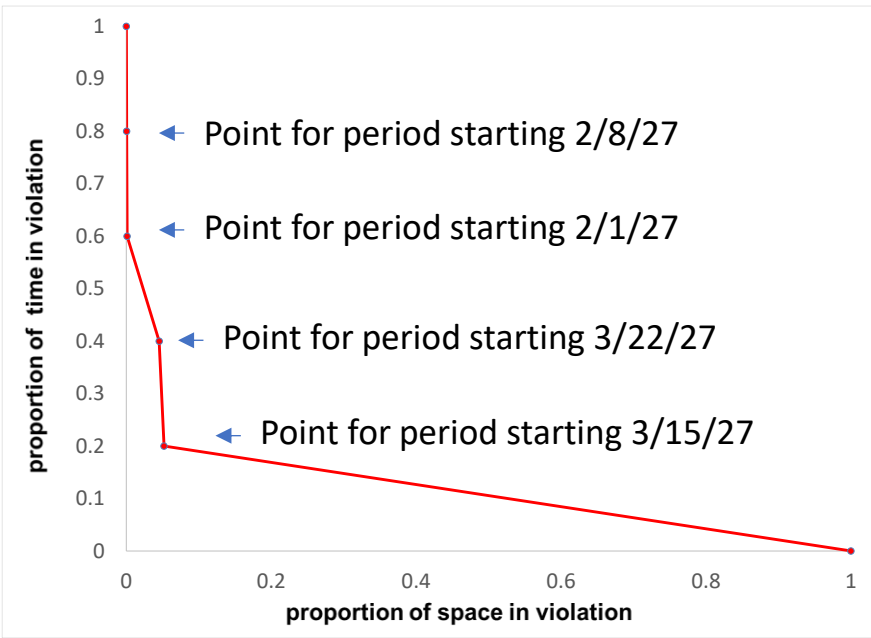
Scenario #1: There are only two criteria periods that meet the salinity condition for assessment in a segment.

Migratory Fish Spawning and Nursery 7-Day Mean Assessment Table for a Segment		
period starts...	period ends...	Spatial Exceedance Rate
2/1/2027	2/7/2027	Not calculated due to high salinity
2/8/2027	2/14/2027	Not calculated due to high salinity
2/15/2027	2/21/2027	Not calculated due to high salinity
2/22/2027	2/28/2027	Not calculated due to high salinity
3/1/2027	3/7/2027	Not calculated due to high salinity
3/8/2027	3/14/2027	Not calculated due to high salinity
3/15/2027	3/21/2027	5.20%
3/22/2027	3/28/2027	4.53%
3/29/2027	4/4/2027	Not calculated due to high salinity
4/5/2027	4/11/2027	Not calculated due to high salinity
4/12/2027	4/18/2027	Not calculated due to high salinity
4/19/2027	4/25/2027	Not calculated due to high salinity
4/26/2027	5/2/2027	Not calculated due to high salinity
5/3/2027	5/9/2027	Not calculated due to high salinity
5/10/2027	5/16/2027	Not calculated due to high salinity
5/17/2027	5/23/2027	Not calculated due to high salinity
5/24/2027	5/30/2027	Not calculated due to high salinity



Scenario #2: There are only four criteria periods that meet the salinity condition for assessment in a segment.

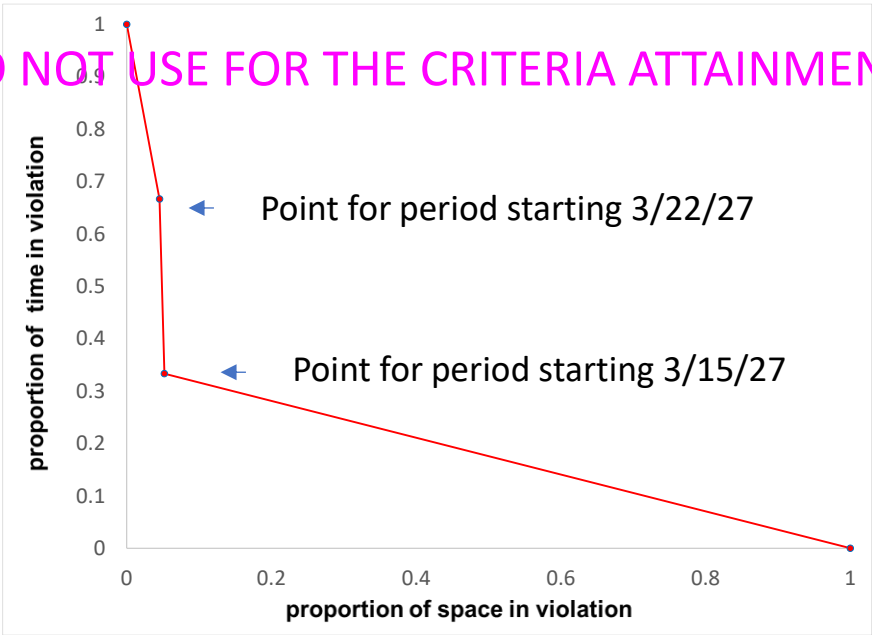
Migratory Fish Spawning and Nursery 7-Day Mean Assessment Table for a Segment		
period starts...	period ends...	Spatial Exceedance Rate
2/1/2027	2/7/2027	0.10%
2/8/2027	2/14/2027	0.04%
2/15/2027	2/21/2027	Not calculated due to high salinity
2/22/2027	2/28/2027	Not calculated due to high salinity
3/1/2027	3/7/2027	Not calculated due to high salinity
3/8/2027	3/14/2027	Not calculated due to high salinity
3/15/2027	3/21/2027	5.20%
3/22/2027	3/28/2027	4.53%
3/29/2027	4/4/2027	Not calculated due to high salinity
4/5/2027	4/11/2027	Not calculated due to high salinity
4/12/2027	4/18/2027	Not calculated due to high salinity
4/19/2027	4/25/2027	Not calculated due to high salinity
4/26/2027	5/2/2027	Not calculated due to high salinity
5/3/2027	5/9/2027	Not calculated due to high salinity
5/10/2027	5/16/2027	Not calculated due to high salinity
5/17/2027	5/23/2027	Not calculated due to high salinity
5/24/2027	5/30/2027	Not calculated due to high salinity



Scenario #1: There are only two criteria periods that meet the salinity condition for assessment in a segment.

Migratory Fish Spawning and Nursery 7-Day Mean Assessment Table for a Segment		
period starts...	period ends...	Spatial Exceedance Rate
2/1/2027	2/7/2027	Not calculated due to high salinity
2/8/2027	2/14/2027	Not calculated due to high salinity
2/15/2027	2/21/2027	Not calculated due to high salinity
2/22/2027	2/28/2027	Not calculated due to high salinity
3/1/2027	3/7/2027	Not calculated due to high salinity
3/8/2027	3/14/2027	Not calculated due to high salinity
3/15/2027	3/21/2027	5.20%
3/22/2027	3/28/2027	4.53%
3/29/2027	4/4/2027	Not calculated due to high salinity
4/5/2027	4/11/2027	Not calculated due to high salinity
4/12/2027	4/18/2027	Not calculated due to high salinity
4/19/2027	4/25/2027	Not calculated due to high salinity
4/26/2027	5/2/2027	Not calculated due to high salinity
5/3/2027	5/9/2027	Not calculated due to high salinity
5/10/2027	5/16/2027	Not calculated due to high salinity
5/17/2027	5/23/2027	Not calculated due to high salinity
5/24/2027	5/30/2027	Not calculated due to high salinity

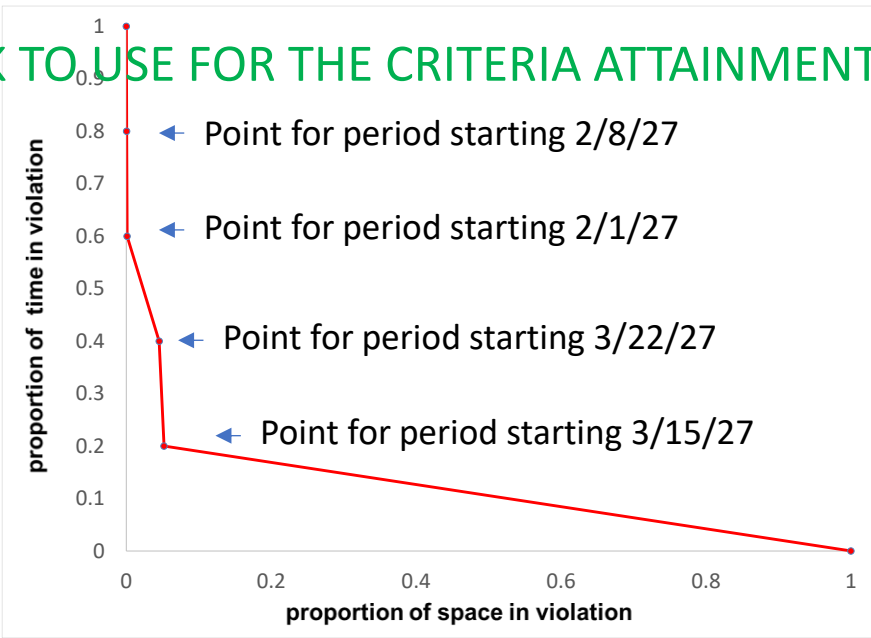
DO NOT USE FOR THE CRITERIA ATTAINMENT DECISION



Scenario #2: There are only four criteria periods that meet the salinity condition for assessment in a segment.

Migratory Fish Spawning and Nursery 7-Day Mean Assessment Table for a Segment		
period starts...	period ends...	Spatial Exceedance Rate
2/1/2027	2/7/2027	0.10%
2/8/2027	2/14/2027	0.04%
2/15/2027	2/21/2027	Not calculated due to high salinity
2/22/2027	2/28/2027	Not calculated due to high salinity
3/1/2027	3/7/2027	Not calculated due to high salinity
3/8/2027	3/14/2027	Not calculated due to high salinity
3/15/2027	3/21/2027	5.20%
3/22/2027	3/28/2027	4.53%
3/29/2027	4/4/2027	Not calculated due to high salinity
4/5/2027	4/11/2027	Not calculated due to high salinity
4/12/2027	4/18/2027	Not calculated due to high salinity
4/19/2027	4/25/2027	Not calculated due to high salinity
4/26/2027	5/2/2027	Not calculated due to high salinity
5/3/2027	5/9/2027	Not calculated due to high salinity
5/10/2027	5/16/2027	Not calculated due to high salinity
5/17/2027	5/23/2027	Not calculated due to high salinity
5/24/2027	5/30/2027	Not calculated due to high salinity

OK TO USE FOR THE CRITERIA ATTAINMENT DECISION

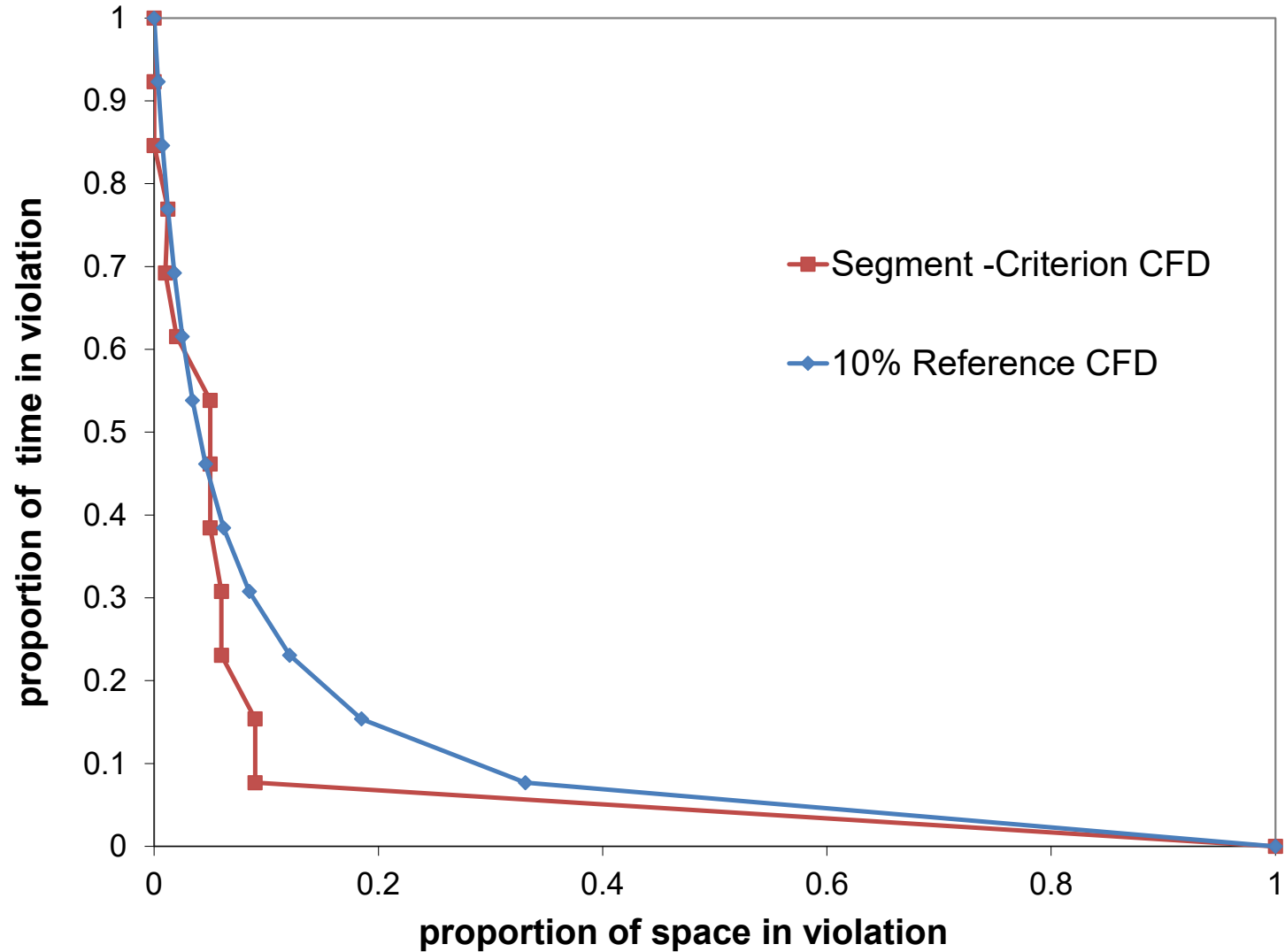


Proposed Decision Rules

Rules for how to determine criteria attainment

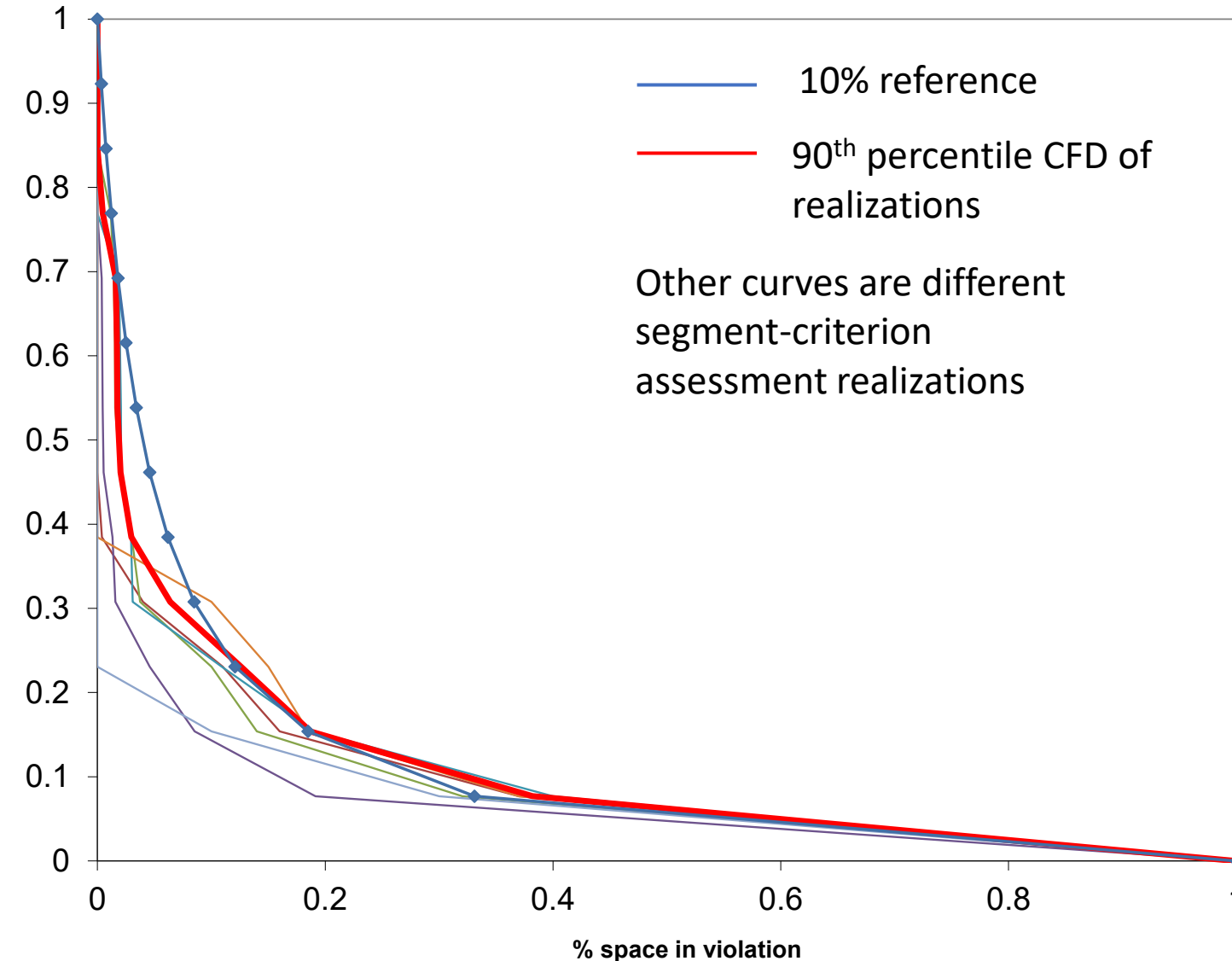
1. Assessment values (e.g., a 30-day DO mean) should be rounded to the tenth's place prior to being compared to a criterion.
2. A segment CFD must have a minimum of four assessment points for it to be used to determine criteria attainment.
3. **Assessment CFDs should be selected from the 90th percentile of realization CFDs.**

3D Interpolator CFD Procedure



Under the current procedure, we develop a single CFD to evaluate against the reference curve.

We will have multiple “realization” CFDs to choose from in 4D Interpolator world



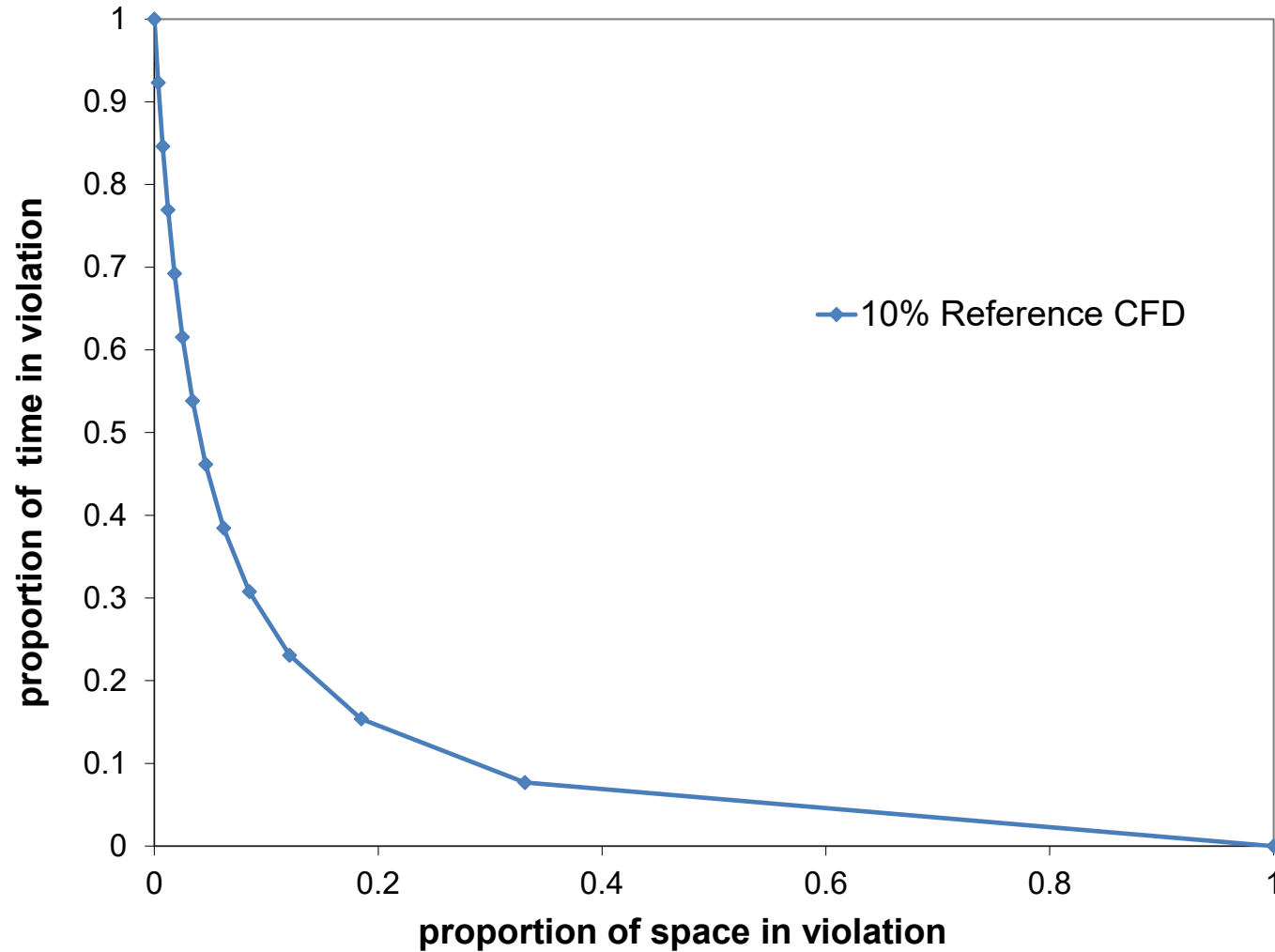
- Multiple simulations (“realizations”) will be performed with the 4D Interpolator.
- For the proposed 4D Interpolator procedure, the 90th percentile CFD of “realization” CFDs would be selected to represent a segment’s criterion space-time exceedance frequency.

Proposed Decision Rules

Rules for how to determine criteria attainment

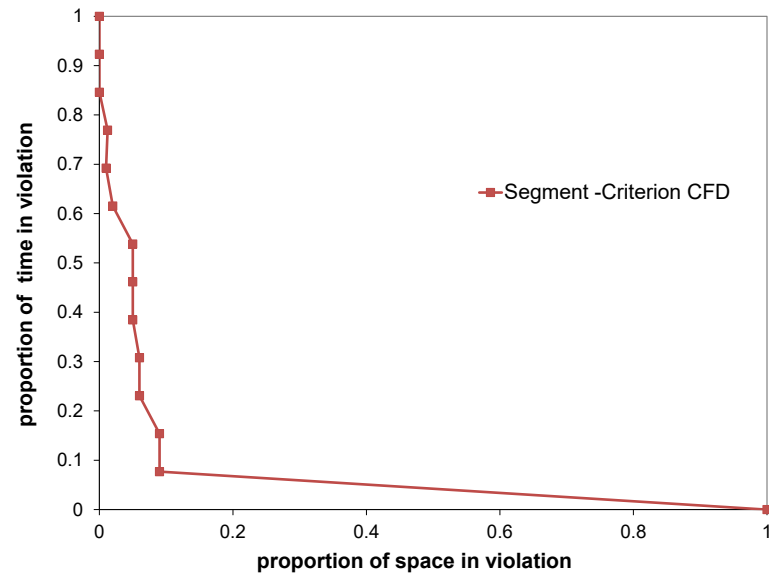
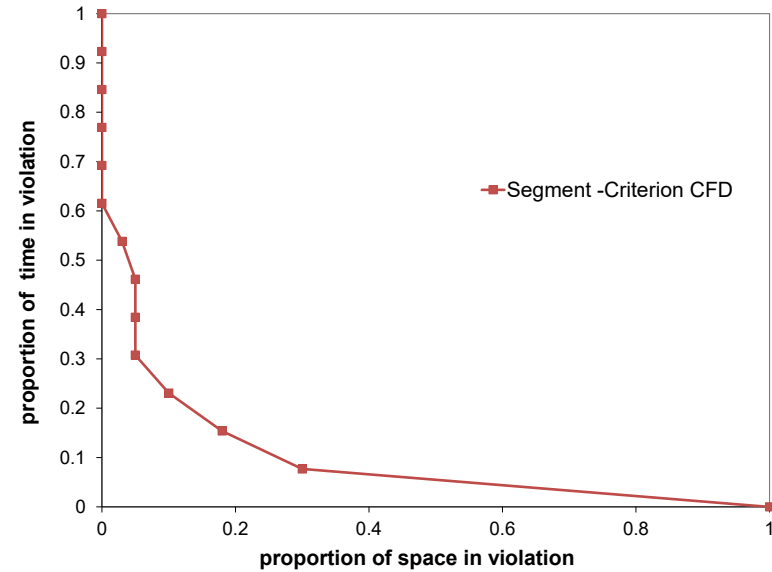
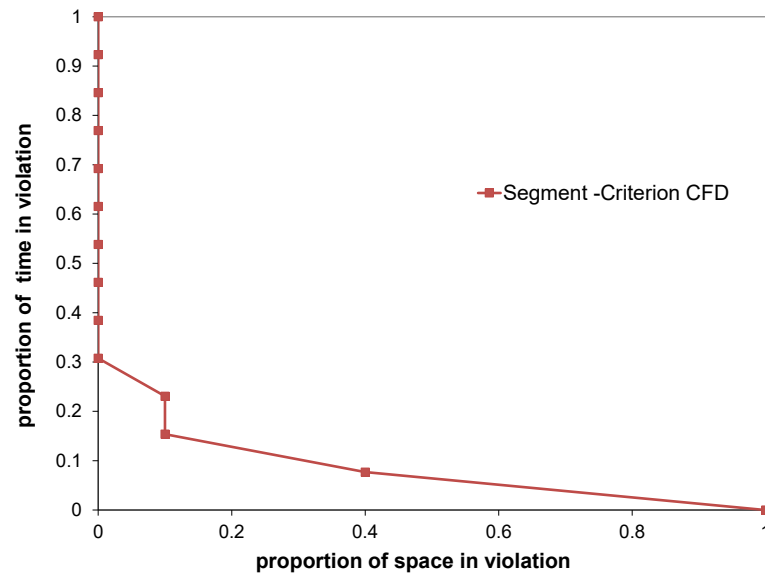
1. Assessment values (e.g., a 30-day DO mean) should be rounded to the tenth's place prior to being compared to a criterion.
2. A segment CFD must have a minimum of four assessment points for it to be used to determine criteria attainment.
3. Assessment CFDs should be selected from the 90th percentile of realization CFDs.
4. Subtract the area (as a percentage) under the reference curve from the area under the segment-criterion CFD and round to the hundredth's place. If the difference is greater than 0.00%, the segment should be judged as failing the criterion.

3D Interpolator CFD Procedure

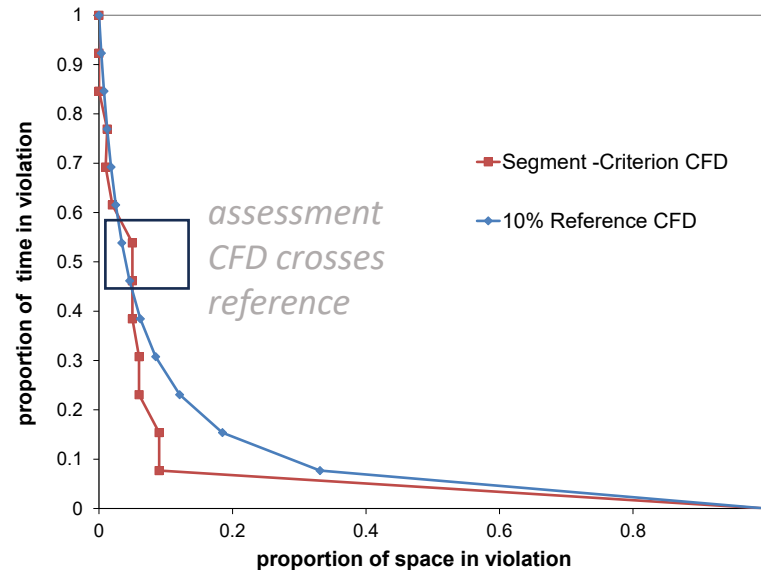
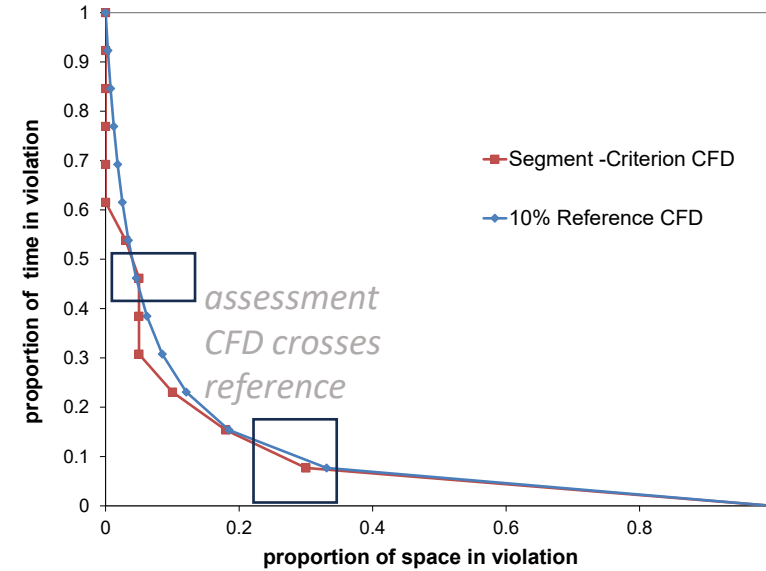
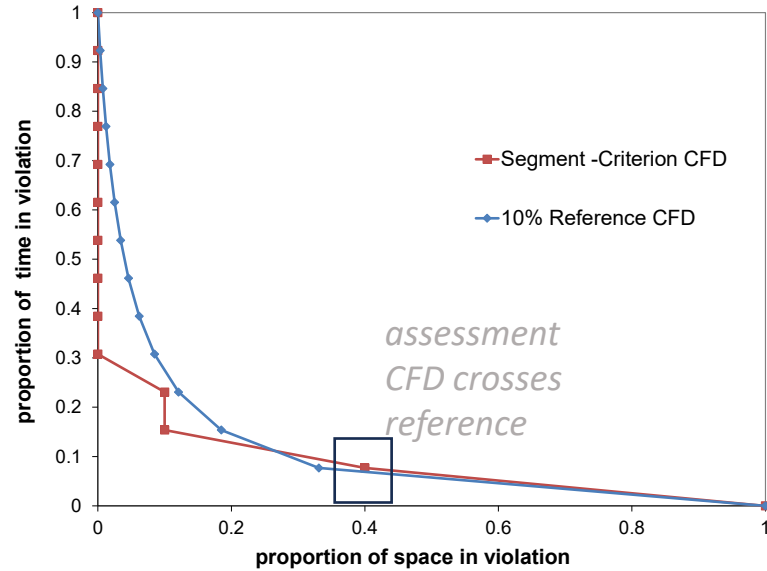


Under the current procedure, we use a reference curve to delineate how much space-time exceedance is allowed in a segment.

Which of these CFDs indicate criteria attainment?



Under the current procedure, they all indicate nonattainment...despite the fact that each one “outperforms” the theoretical reference. This is because the shape of the CFD matters more than the magnitude of the area under the CFD.

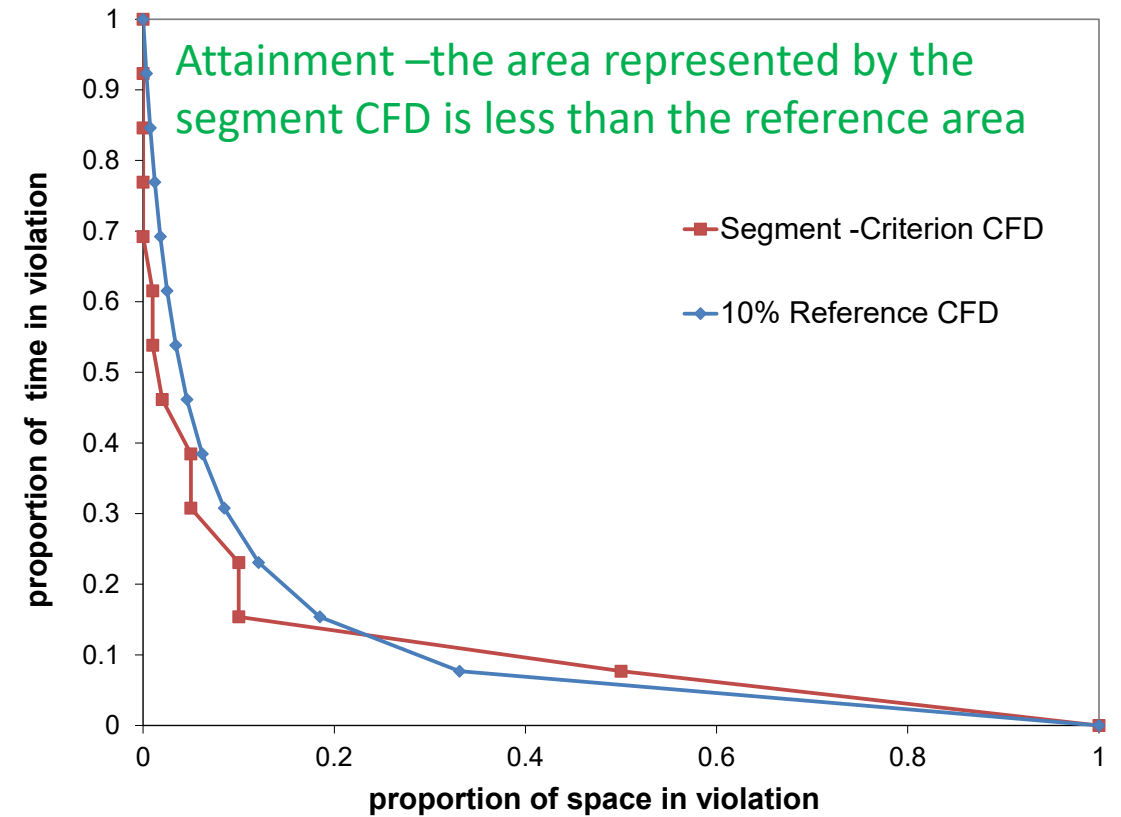
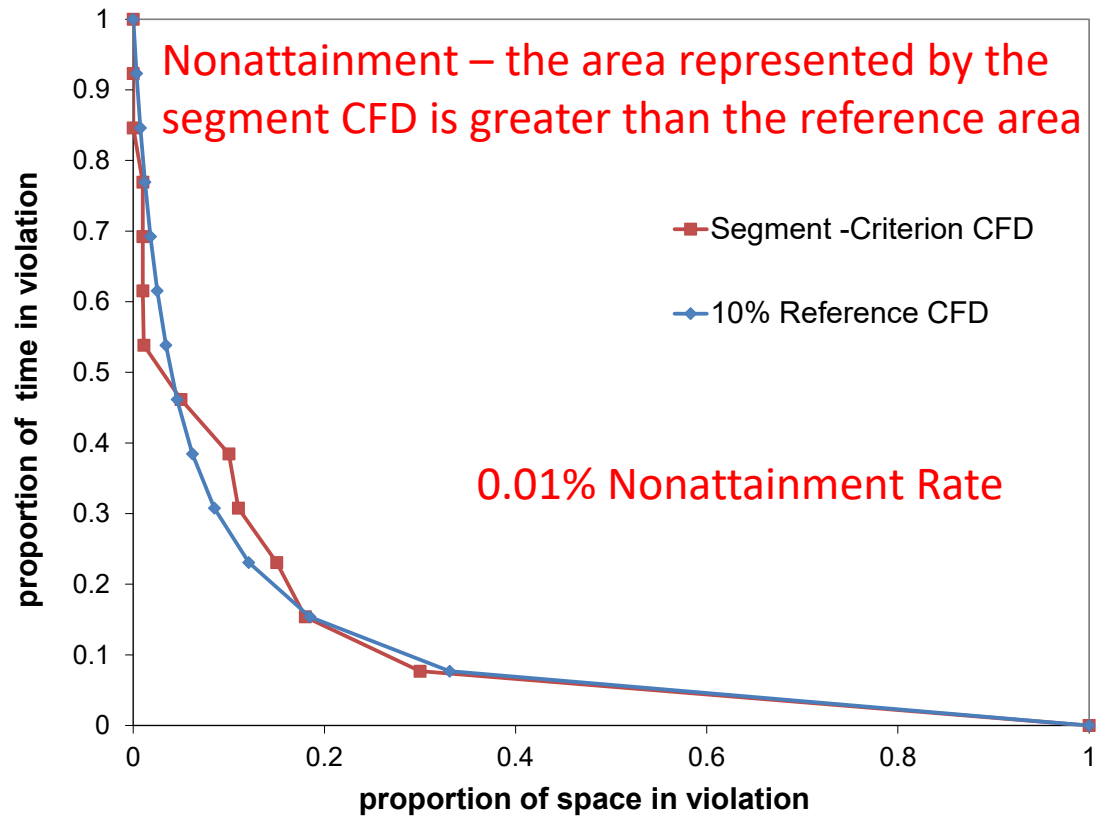


Proposed 4D Interpolator CFD Procedure

For each segment-criterion:

- Generate the default reference curve using the procedure described in USEPA (2007). The reference curve should be segmented by the same number of points as the segment-criterion CFD.
- Calculate the area (as a percentage) under the reference curve.
- Calculate the area (as a percentage) under the segment-criterion CFD.
- Subtract the area under the reference curve from the area under the segment-criterion CFD. Round the result to the hundredth's place.
- If the value is greater than 0.00%, the segment fails the criterion.
- If the value is less than or equal to 0.00%, the segment meets the criterion.

The proposed CFD procedure does not require an evaluation of the shape of the assessment CFD. Only the magnitude of the space-time exceedance frequency represented by the CFD is evaluated.



Rationale for adopting a new approach to the reference curve

Argument	Guiding Principle
There is no peer-reviewed science to support the current practice.	• Scientific soundness • Regulatory defensibility
The proposed change uses the overall exceedance frequency for the basis of an assessment decision—a policy that is in line with non-Bay assessment protocols used by MD and VA and national assessment guidance recommendations from EPA.	• Consistency with existing policies/procedures
The proposed change allows us to more accurately communicate that segments are granted a “10% allowable” exceedance frequency.	• Transparency and clear communication

Proposed Decision Rules

Rules for how to determine criteria attainment

1. Assessment values (e.g., a 30-day DO mean) should be rounded to the tenth's place prior to being compared to a criterion.
2. A segment CFD must have a minimum of four assessment points for it to be used to determine criteria attainment.
3. Assessment CFDs should be selected from the 90th percentile of realization CFDs.
4. Subtract the area (as a percentage) under the reference curve from the area under the segment-criterion CFD and round to the hundredth's place. If the difference is greater than 0.00%, the segment should be judged as failing the criterion.
5. A bioreference CFD can be used to determine the allowable exceedance frequency if it is approved by the WQS and WQA staff of the tidal Bay jurisdictions.

Proposed Decision Rules for the 4D Interpolator-Based DO Assessment

1. Hourly average for IM criteria
2. Rolling, non-overlapping periods for 30-day and 7-day mean calculations.
3. Dates and date-hours for 1-day mean and instantaneous minimums.
4. A minimum 50% temporal coverage for assessing 30-day and 7-day means.
5. An Interpolator cell should be evaluated against a criterion when it was present in the appropriate designated use at least 50% of the time over the criterion's duration¹.
6. Assessment values (e.g., a 30-day DO mean) should be rounded to the tenth's place prior to being compared to a criterion.
7. A segment CFD² must have a minimum of four assessment points for it to be used to determine criteria attainment.
8. Assessment CFDs should be selected from the 90th percentile of realization CFDs.
9. Subtract the area³ (as a percentage) under the reference curve⁴ from the area under the segment-criterion CFD and round to the hundredth's place. If the difference is greater than 0.00%, the segment should be judged as failing the criterion.
10. A bioreference CFD can be used to determine the allowable exceedance frequency if it is approved by the WQS and WQA staff of the tidal Bay jurisdictions.

¹ Pycnocline boundary depths should be calculated using the procedure outlined on page 15 of [USEPA \(2008\)](#).

² Assessment CFDs should be computed using the procedure outlined on page 10 of [USEPA \(2007\)](#).

³ Areas should be calculated using the trapezoidal rule, as specified on page B-3 of [USEPA \(2007\)](#).

⁴ The default reference curve should be computed using Equation 1 on page 13 of [USEPA \(2007\)](#).