Revisiting the Chesapeake Bay Water Quality Criteria Biological Reference Curves

Briefing for the CBP Scientific and Technical Advisory Committee Review Team

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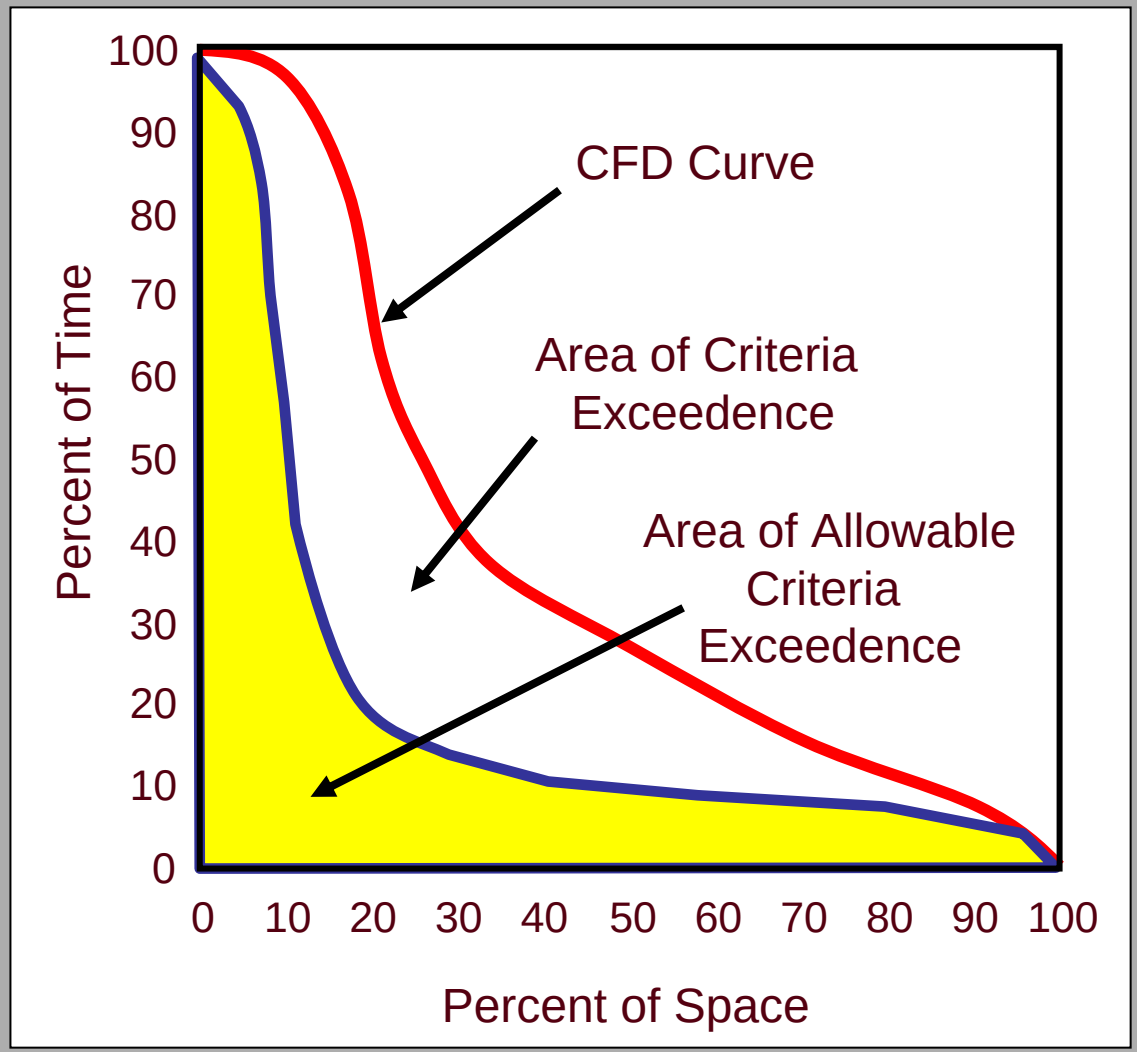
Background

What is a reference curve?

A bioreference curve is a cumulative frequency distribution that is used to determine “unacceptable” exceedance of the criteria.



Source: U.S. EPA 2003

Background

The biologically-based reference curve

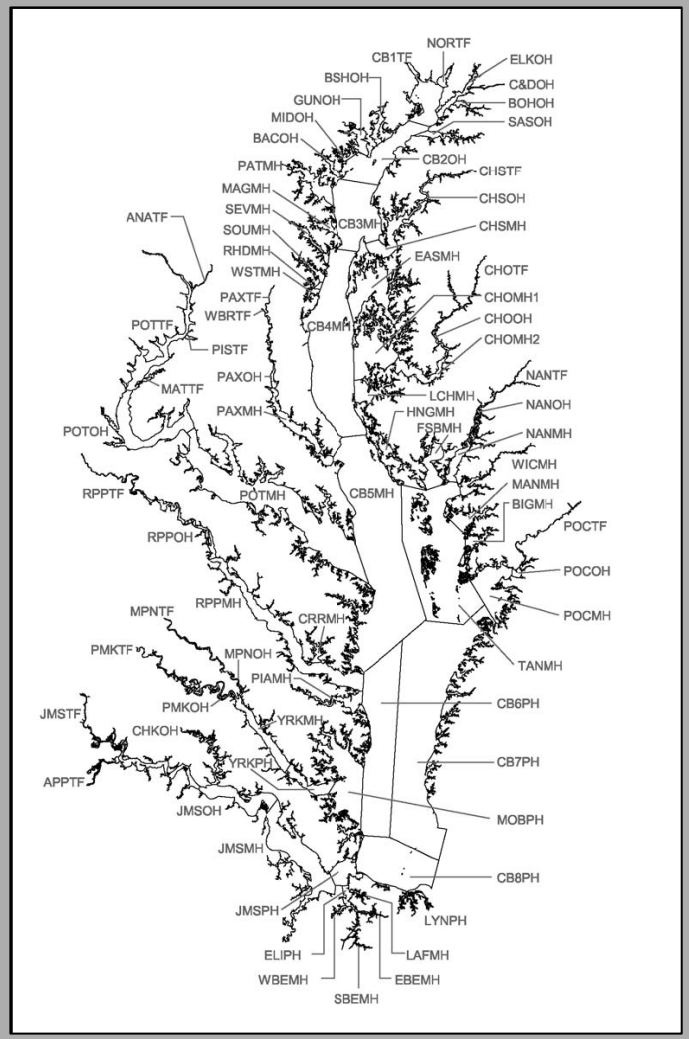
Goal: to identify the amount of spatial and temporal criteria exceedance that can occur without causing significant ecological degradation

- **Identify an indicator of biological health.**
- **Identify "healthy" measurements of this indicator, for use as a "reference".**
- **Calculate exceedance rates of the target criteria that correspond, in space and time, with these "healthy" reference measurements. These are your "acceptable exceedances."**
- **Formulate a CFD from these "acceptable exceedance" rates. This is your "bioreference curve."**
- **Compare exceedance rates for each segment-du-assessment period to this bioreference curve, to determine whether exceedances extend beyond the "allowable" threshold (represented by the bioreference curve).**

Source: U.S. EPA 2003

Background

The Chesapeake Bay benthic index of biotic integrity (B-IBI)



Benthic community

- **Minimum B-IBI score ≥ 3.0**
- **No sample size requirement**
- **Time period is single year**

CBP Segment	Year
APPTF	2004
BOHOH	2004
CB1TF	2004
CB2OH	2002
CB3MH	1995
CB6PH	1993
CB8PH	1996
FSBMH	2005
NANMH	1987
RPPMH	1988
RPPTF	1996
WICMH	1999
…	…

Source: Weisberg et al. 1997

Background

Acceptable exceedances form the bioreference curve

CBP Segment	Year
APPTF	2004
BOHOH	2004
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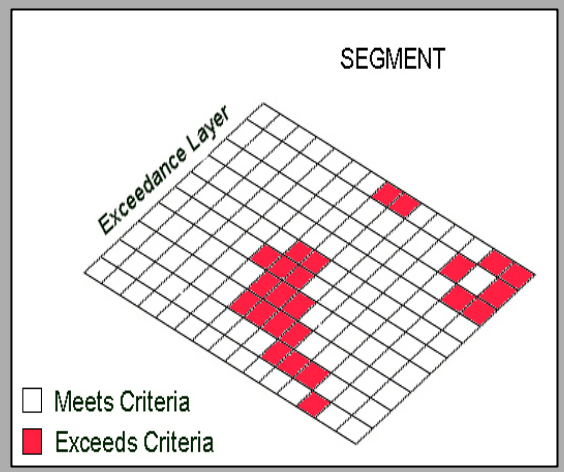
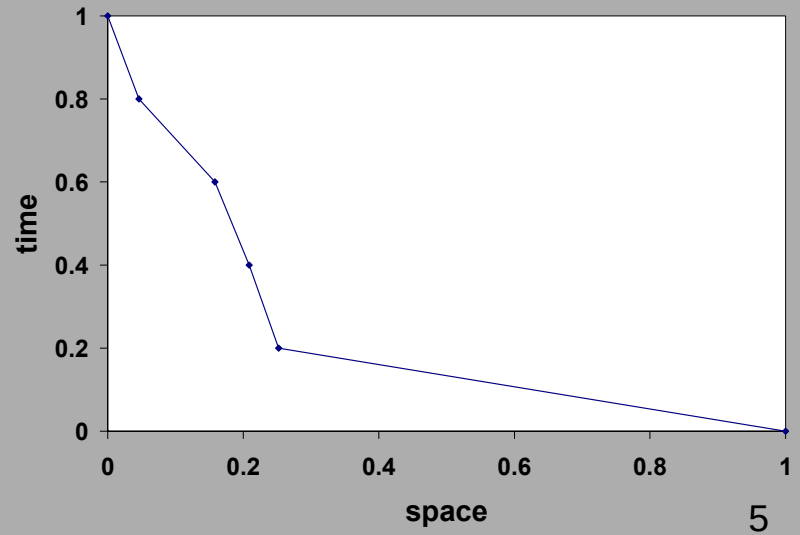


CBSEG	Year	Month	Violation Rate
CB3MH	1987	6	0.2522068
CB3MH	1987	7	0.208657
CB3MH	1987	8	0.1582181
CB3MH	1987	9	0.0461538

CB3MH 1987

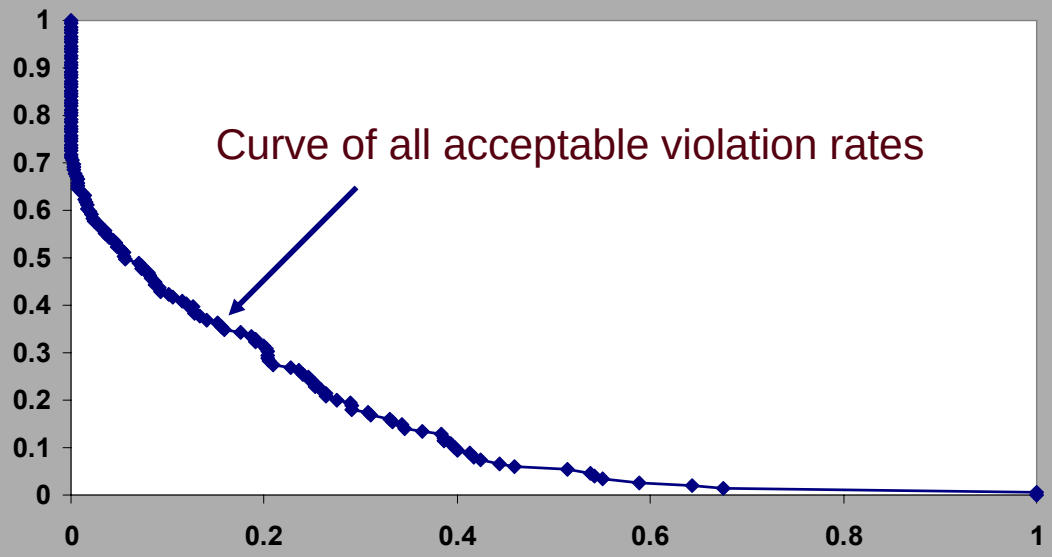


Source: U.S. EPA 2003

Background

All acceptable violation rates combined

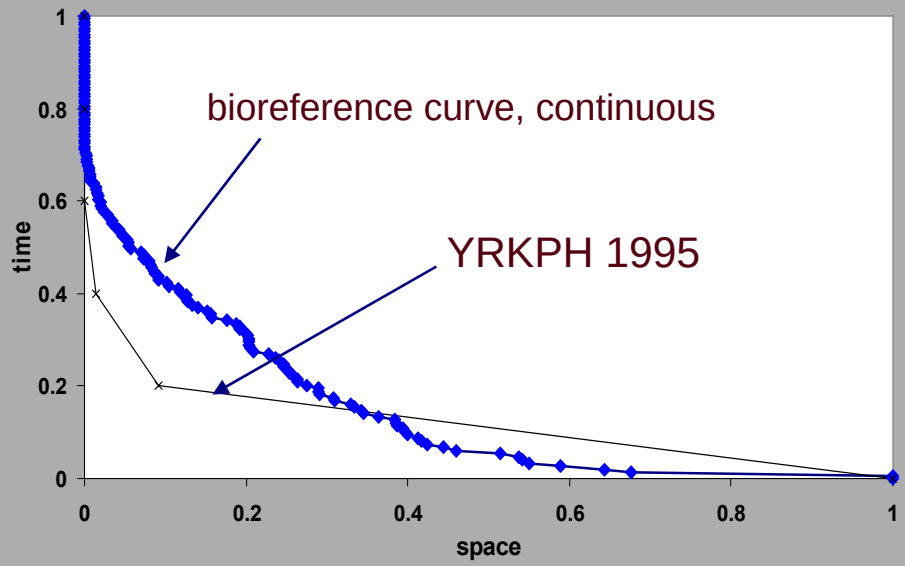
CBSEG	Year	Month	Violation Rate
CB3MH	1987	6	0.2522068
CB3MH	1987	7	0.208657
CB3MH	1987	8	0.1582181
CB3MH	1987	9	0.0461538
CB4MH	1998	6	0.5882037
CB4MH	1998	7	0.5375158
CB4MH	1998	8	0.399928
CB4MH	1998	9	0.4234667
CB6PH	2001	6	0
CB6PH	2001	7	0
CB6PH	2001	8	0.0204819
CB6PH	2001	9	0

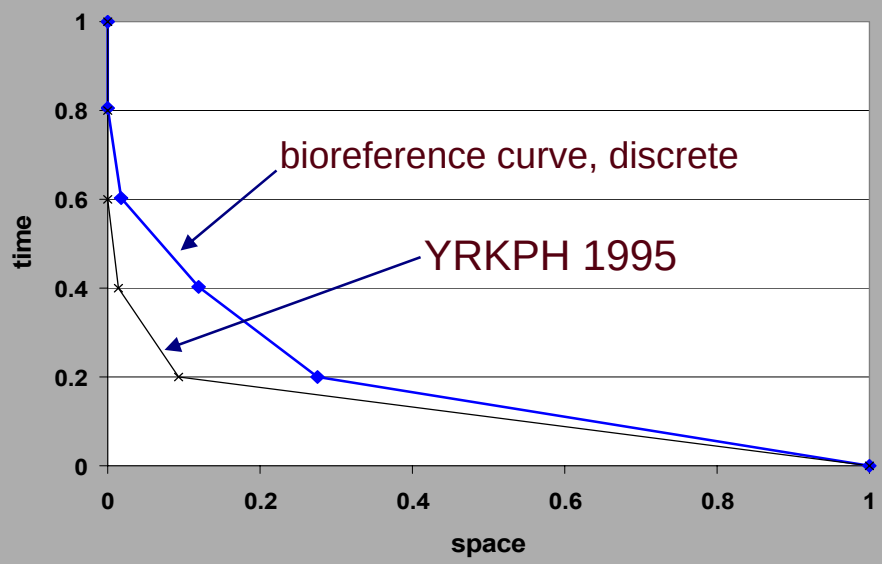


Source: U.S. EPA 2003

Background

Assessment curves evaluated at discrete points





Source: U.S. EPA 2007

Background

Concerns raised by reviewers

- **By combining violation rates from all healthy areas into one bioreference curve, we create a curve that, theoretically, will represent approximately the median of all curves included.**

- **Thus approximately half of all segment-years used to create the bioreference curve may fail an assessment conducted with that bioreference curve.**

- **Issue was raised verbally in discussions around the time of the STAC CFD Review (c. 2005-2006)**

- **We confirmed this concern.**

Source: Secor et al. 2006

Bioreference Curve Review

Some acceptable exceedances fail their own bioreference curve

CBSEG	Year	Month	Violation Rate
CB3MH	1987	6	0.2522068
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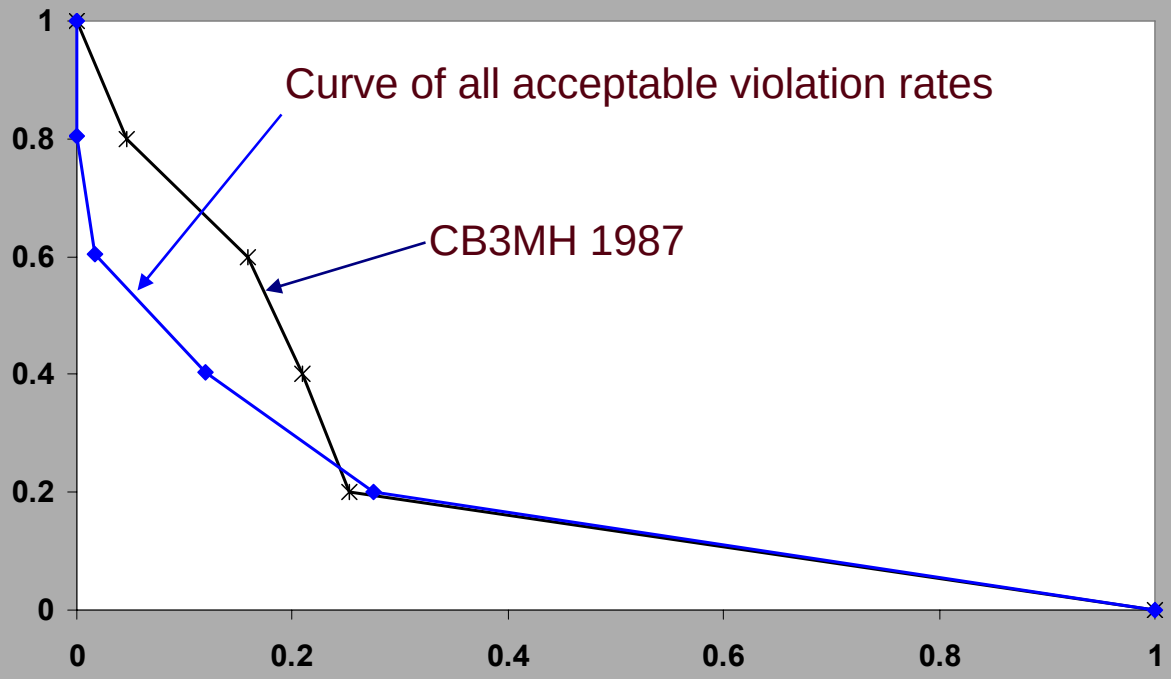
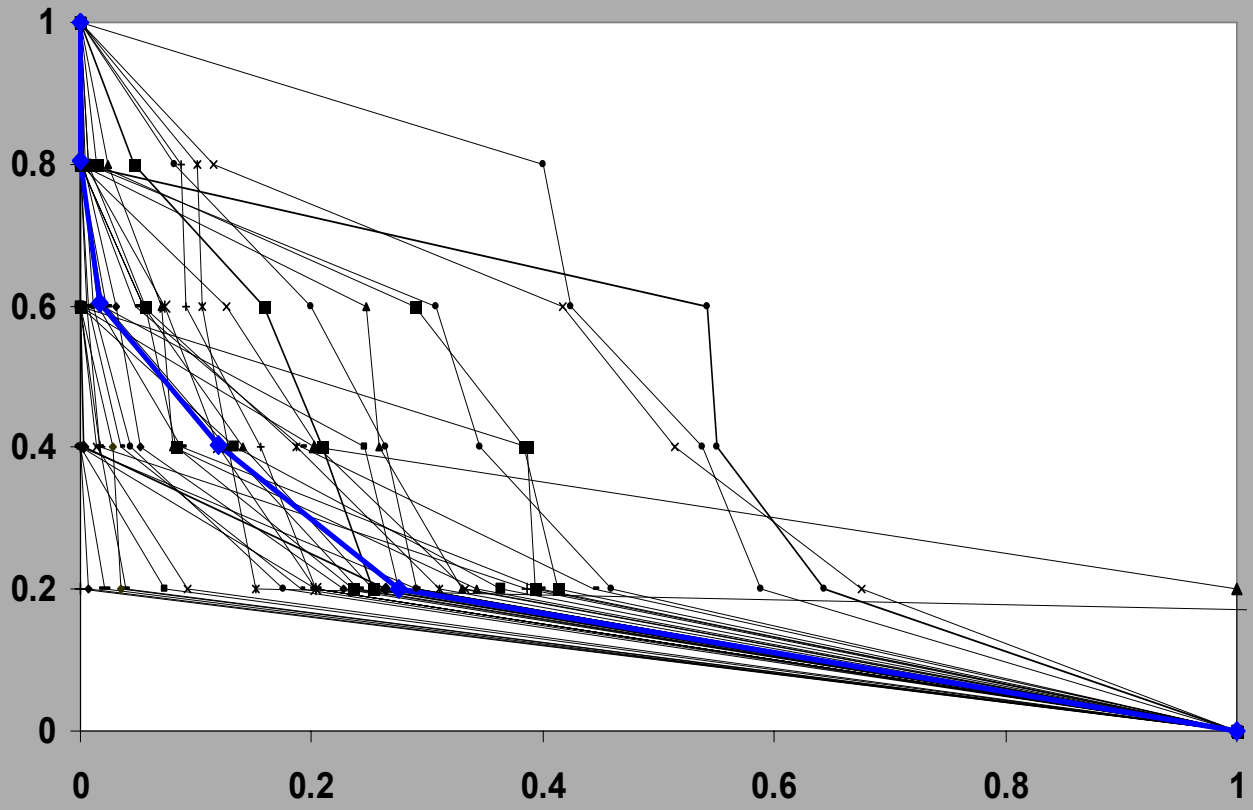


Bioreference Curve Review

Some acceptable exceedances fail their own bioreference curve



For deep water, 73% of segment-years with “acceptable” D.O. violation rates fail existing the deep water bioreference curve

Bioreference Curve Review

Are the errors “balanced”?

Percentage of segment-years failing the bioreference curve

Designated use[1]	Healthy BIBI	Degraded BIBI
DC	67%	98%
DW	73%	92%
OW	52%	47%

Percent error

Designated use	Healthy segs failing	Degraded segs passing
DC	67%	2%
DW	73%	8%
OW	52%	53%

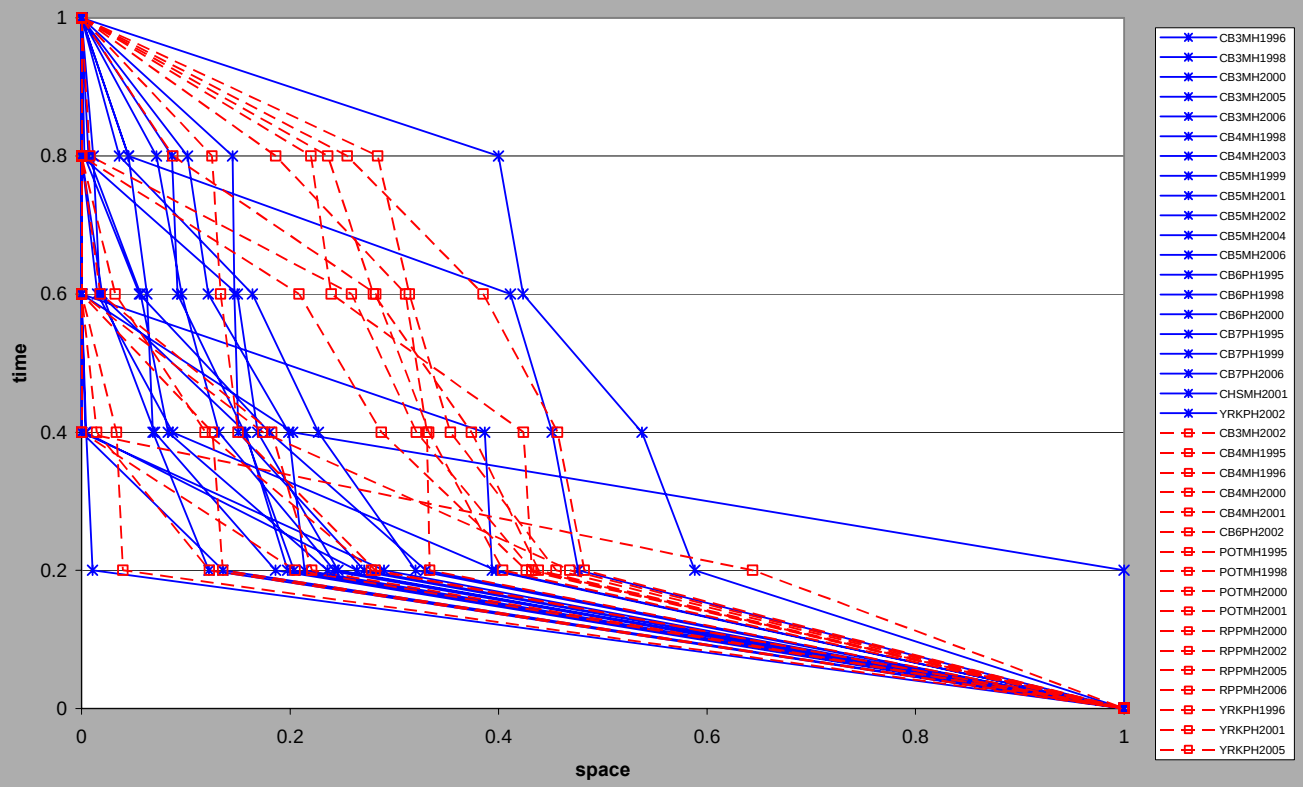
1. DC – deep channel; DW – deep water; OW – open water.

Bioreference Curve Review

Are we identifying distinct “healthy” and “degraded” reference communities?

Answer: no.

“Cloudplot” of deep water reference communities



Bioreference Curve Review

Proposed revisions to methodology

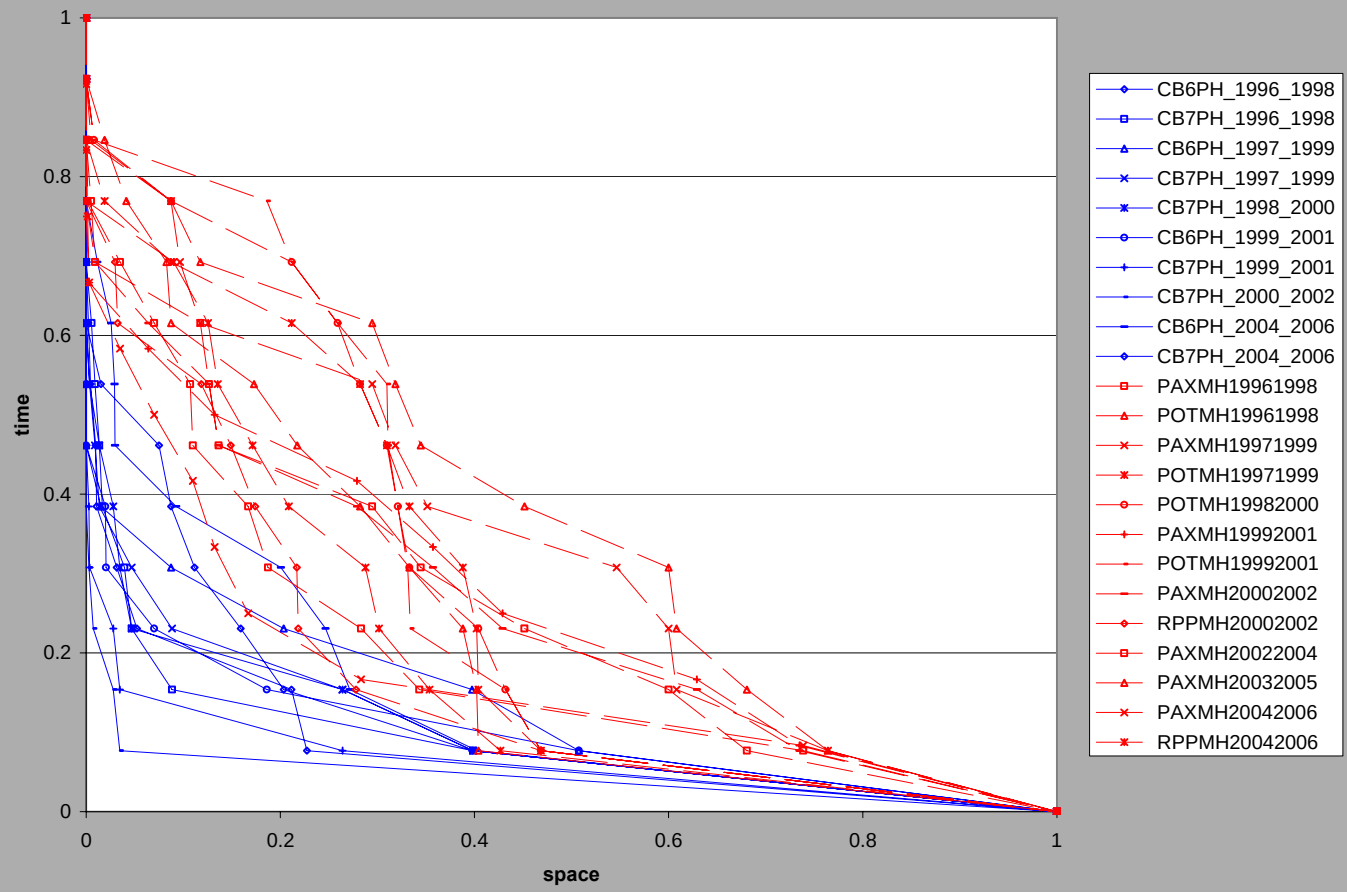
Current Method	Suggested Revisions
1. Obtain dataset of all Benthic Index of Biotic Integrity (B-IBI) scores for time period 1985-2006	Restrict dataset to 1996-2006 time period; for fixed station samples use grand score only
2. For relevant segments (those with Deep Water (DW) and Deep Channel (DC) DUs), match benthic stations and scores in dataset with monthly open water, deep water, and deep channel designated use boundaries. Boundaries are derived using the standardized, automated method for identifying pycnocline boundaries documented in EPA CBP's 2008 Technical Support for Criteria Assessment Addendum. Pycnocline boundaries are then interpolated using the CBP interpolator. Interpolator cells are matched with benthic station locations, and interpolated pycnocline boundaries are applied to each benthic station location.	None
3. Benthic stations (and their associated B-IBI scores) are assigned to a DU: OW, DW, or DC.	None
4. To define the biological reference community for each designated use, all segment-years for which the minimum B-IBI was ≥ 3.0 are identified	a. Use 3-year rolling time periods rather than single years. This brings the reference community ID method in better alignment with the DO criteria assessment method for which reference communities are being identified. b. Require a B-IBI score sample size >= 10. This improves the spatial representation of the B-IBI score c. "Healthy" reference communities are those with an **average** B-IBI score ≥ 3.0, standard deviation (SD) < 1.0, rather than a **minimum**. Using the **average** is consistent with methods used by benthic experts to assess benthic community impairment.
5. For the segment-years identified in step #4, the monthly (in the case of OW and DW) or instantaneous (DC) violation rates are obtained.	None
6. These violation rates (e.g. percentage of a segment-DU's volume failing the DO criteria in a given month; thus 4 measures per summer for OW and DW – June thru Sept) are used to define "acceptable" exceedances of the dissolved oxygen criteria, based on the logic that if a healthy benthic community existed in the segment-du in that summer, then the degree of DO criteria violation that occurred did not lead to an impaired benthic community.	None

Sources: U.S. EPA 2003, 2007; Weisberg et al. 1997

Bioreference Curve Review

Proposed revisions to methodology: deep water

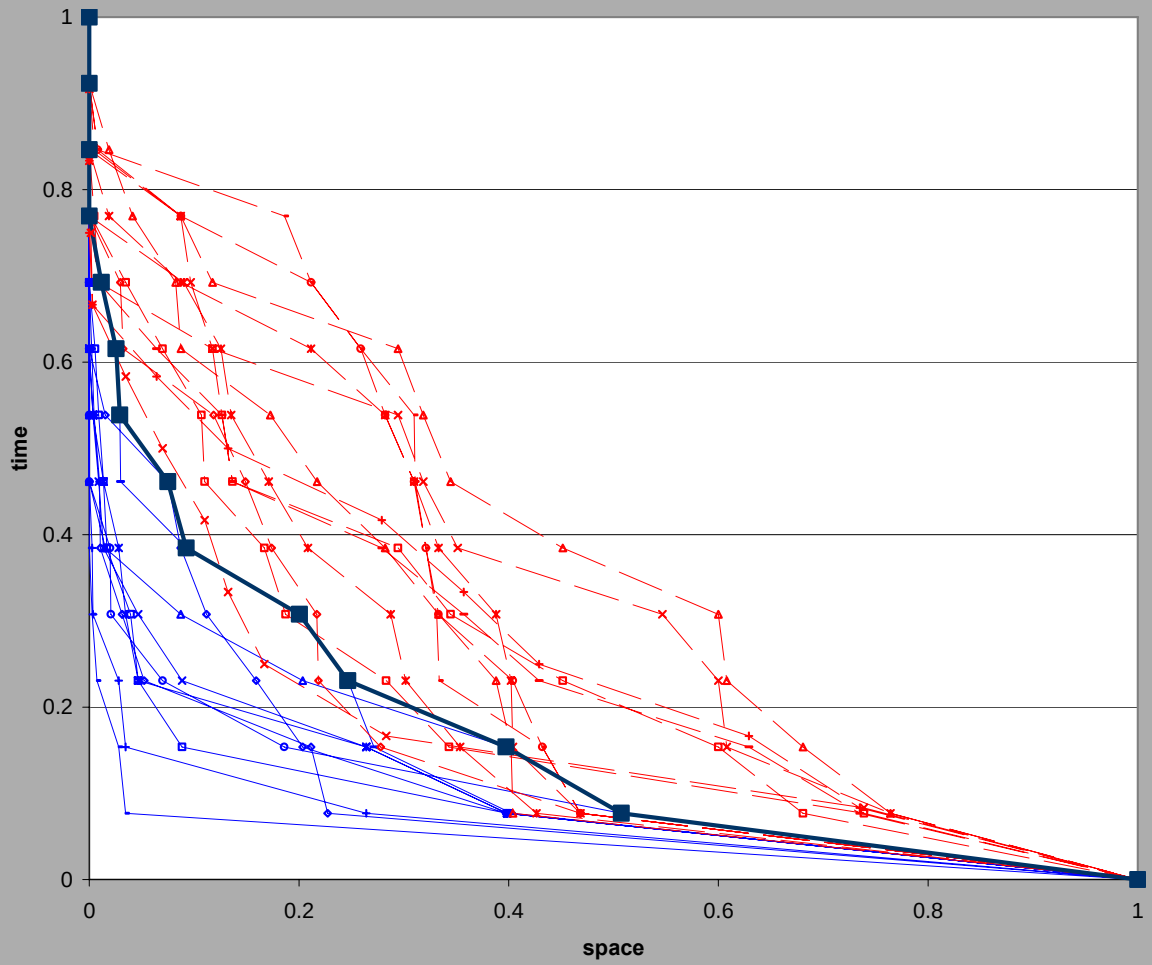
Cloudplot: new “deep water” reference communities



Bioreference Curve Review

Proposed revisions to methodology: deep water (DW)

"100th percentile" DW bioreference curve



Recommendation to CBP WQ Steering Committee:

- Adopt revised methodology and apply revised deep water bioreference curve.

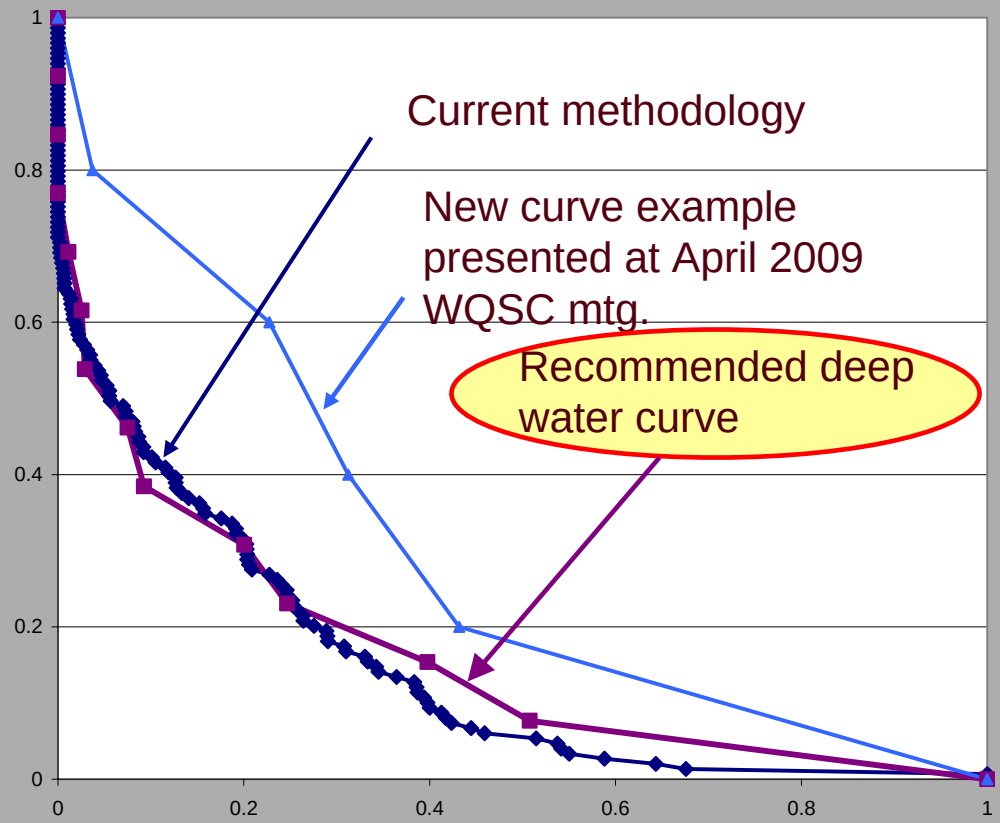
Rationale:

- Revised curve is derived from the 100th percentile of healthy D.O. violation rates at each time point.
- Resultant error rate (incorrect classification of a reference community): zero.

Bioreference Curve Review

Proposed revisions to methodology: deep water

Deep water bioreference curve comparison

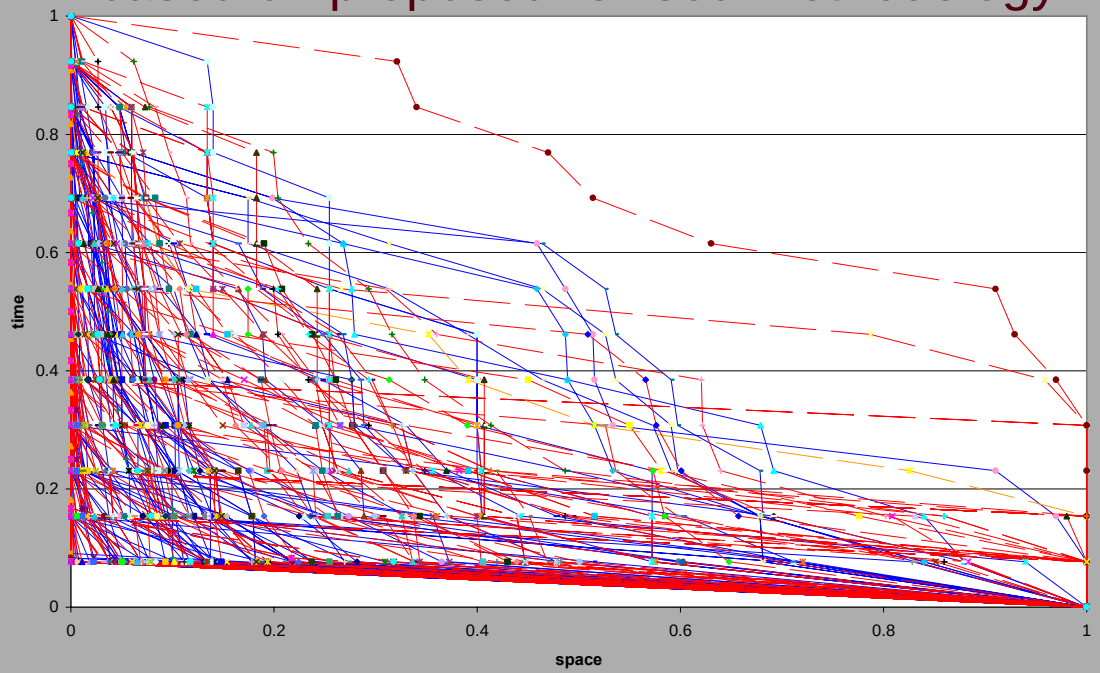


Bioreference Curve Review

Proposed revisions to methodology: open water (OW)

Cloudplot:

New “open water” reference communities based on proposed revised methodology



Conclusion:

- Benthic communities do not provide an appropriate biological reference for violations of the “open water” D.O. criteria.
- Consistent with findings reported in U.S. EPA 2003.

Recommendation to CBP WQ Steering Committee:

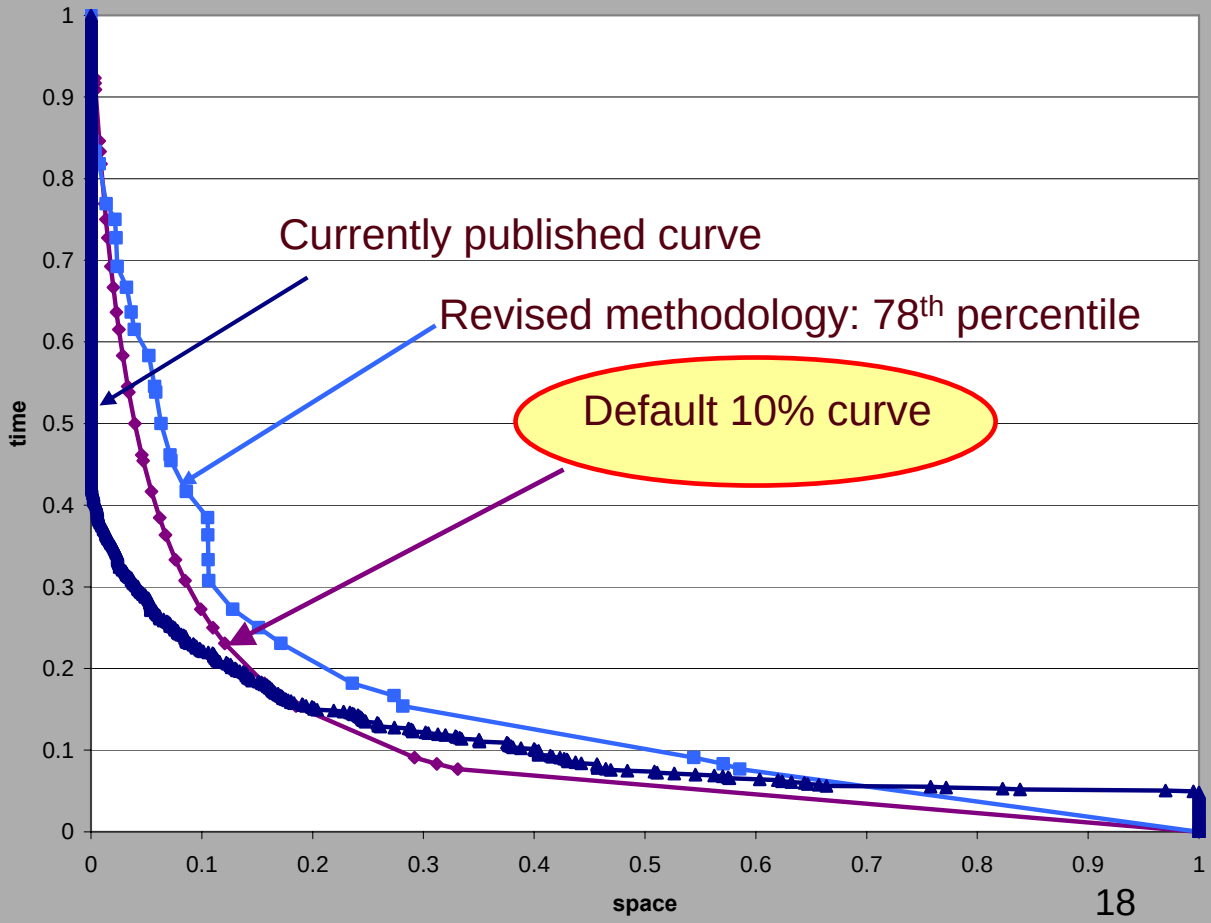
- Apply the default bioreference curve for assessing the OW D.O. criteria.

Bioreference Curve Review

Proposed revisions to methodology

Curve percentile	good fail	bad pass
0.10	87%	14%
0.20	84%	18%
0.30	76%	21%
0.40	73%	24%
0.50	67%	34%
0.60	62%	41%
0.70	59%	48%
0.77	51%	50%
0.78	**49%**	**50%**
0.79	46%	50%
0.80	42%	50%
0.90	25%	58%
1.00	0%	87%

Open Water bioreference curve



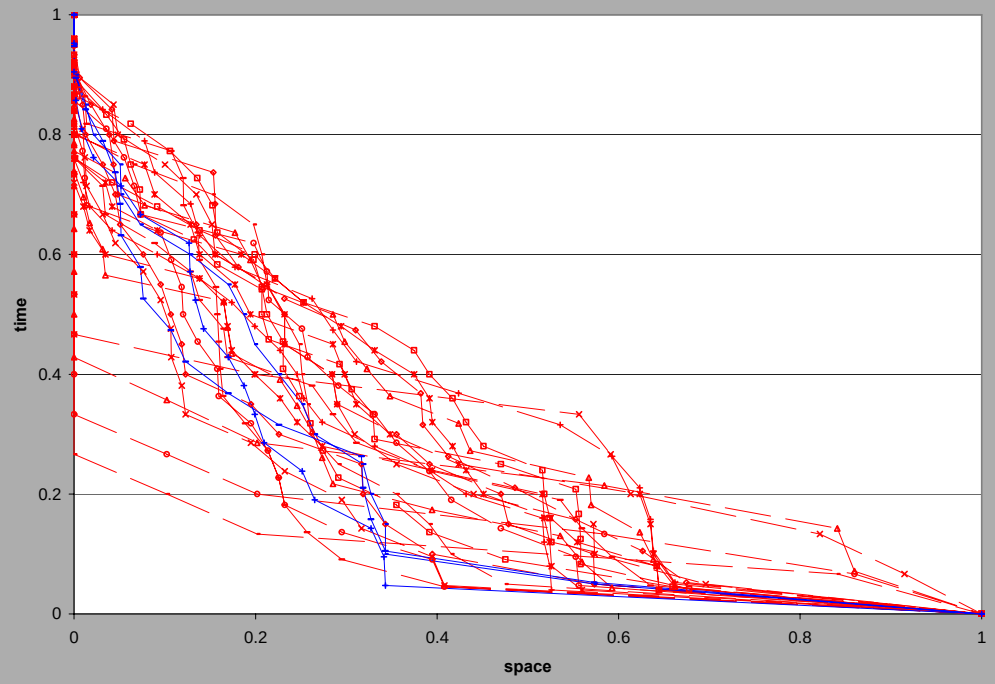
Sources: U.S. EPA 2003, 2007

Bioreference Curve Review

Proposed revisions to methodology: deep channel

Cloudplot:

Preliminary “deep channel” reference communities presented May 2009



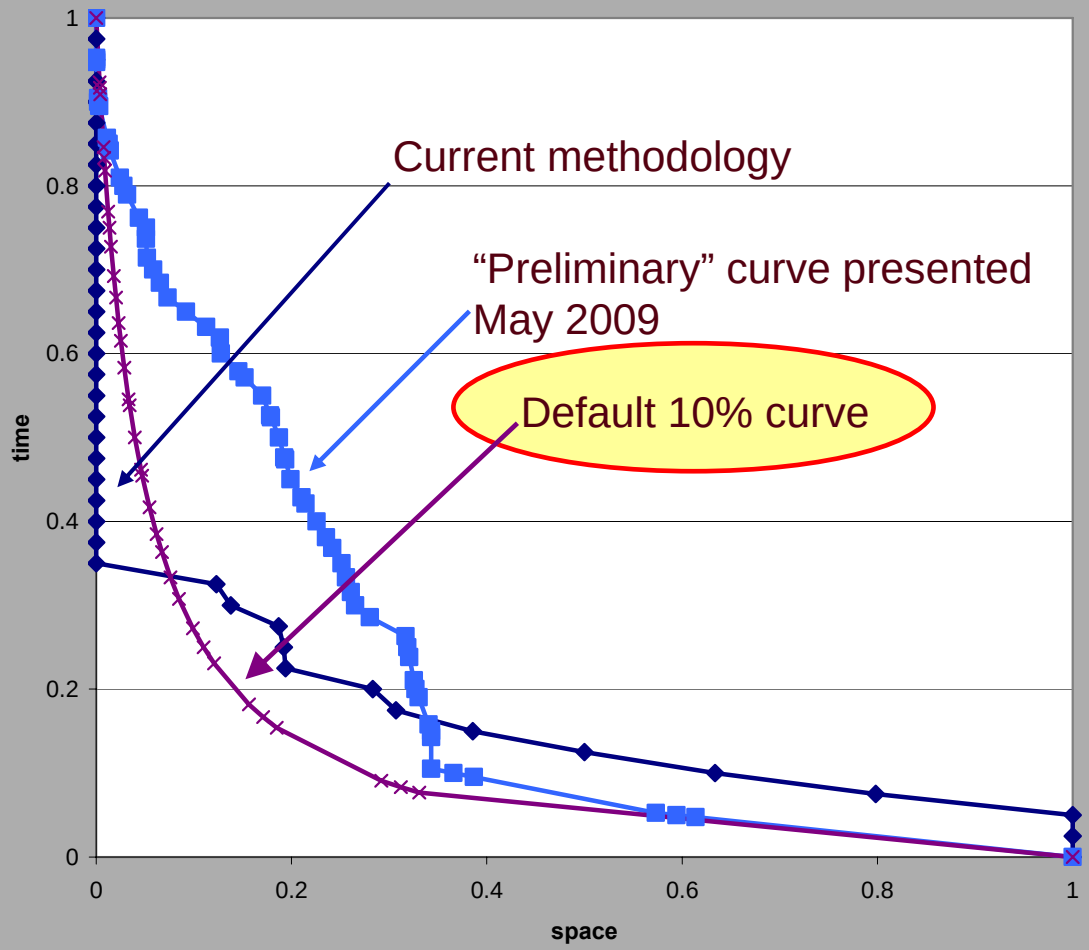
Findings:

- May 2009 preliminary results presented to the CBP Water Quality Steering Committee ***contained a calculation mistake.***
- Corrected analysis yielded **ZERO** “healthy” deep channel reference communities in the two decade data record.

Bioreference Curve Review

Proposed revisions to methodology: deep channel

Deep channel bioreference curve



Conclusion:

- Current conditions in the Chesapeake Bay deep channel habitat are not sufficient for identifying "acceptable" rates of D.O. violation.

Recommendation to CBP WQ Steering Committee:

- Until a time when "healthy" reference benthic communities can be identified **on the relevant spatiotemporal scale** in the deep channel, apply the default 10% curve for assessing D.O. criteria violation in the deep channel designated use.

Sources: U.S. EPA 2003, 2007

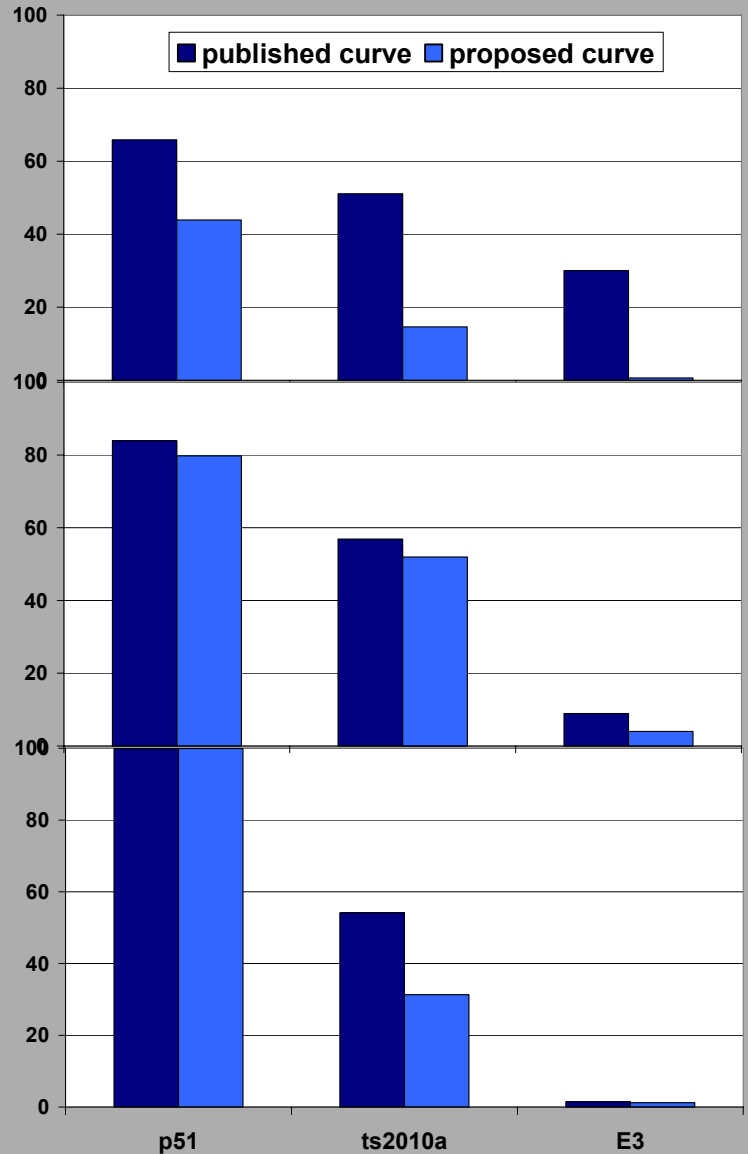
Bioreference Curve Review

Implications of proposed changes: average percent volume failing

Open Water Summer

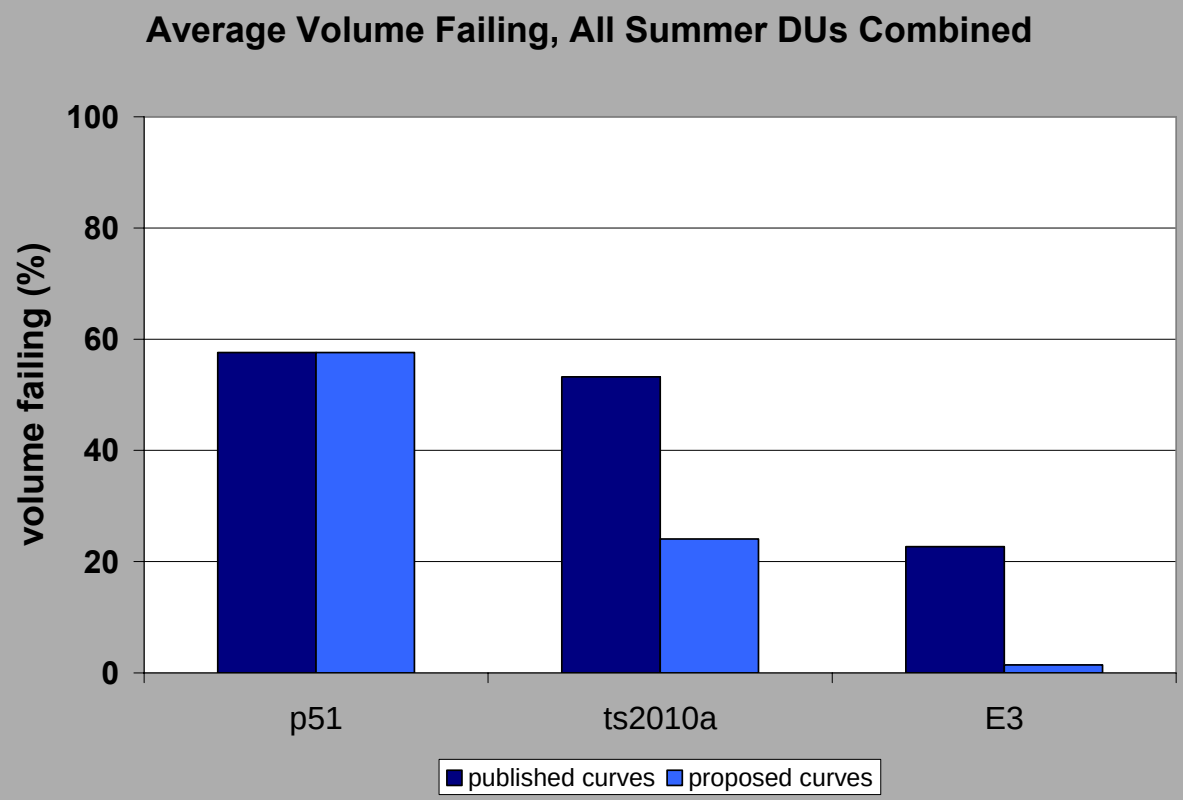
Deep Water Summer

Deep Channel Summer



Bioreference Curve Review

Implications of proposed changes: average percent volume failing



Current Status

At its June 22, 2009 conference call, the Chesapeake Bay Program's Water Quality Steering Committee approved application for the recommended open-water, deep-water and deep-channel reference curves pending the recommendations from the CBP Scientific and Technical Advisory Committee's sponsored peer review.

Sources

Secor, D., M. Christman, F. Curriero, D. Jasinski, E. Perry, S. Preston, K. Reckhow and M. Trice. 2006. The Cumulative Frequency Diagram Method for Determining Water Quality Attainment-Report of the Chesapeake Bay Program STAC Panel to Review of Chesapeake Bay Program Analytical Tools STAC Publication 06-9 October 2006. Chesapeake Research Consortium, Edgewater, MD

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Weisberg, S. B., J. A. Ranasinghe, D. M. Dauer, L. C. Schaffner, R. J. Diaz and J. B. Frithsen. 1997. An estuarine benthic index of biotic integrity (B-IBI) for Chesapeake Bay. *Estuaries* 20:149-158.

Bioreference Curve Review

Questions and comments

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