Review: CBP Response to STAC recommendations on the Umbrella Criterion Report

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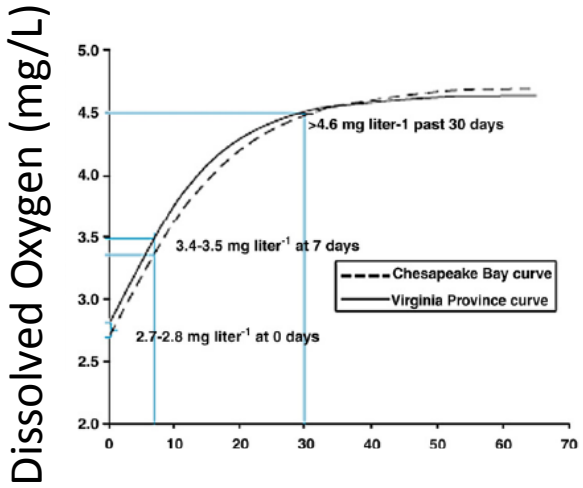
March 18, 2014

Context:

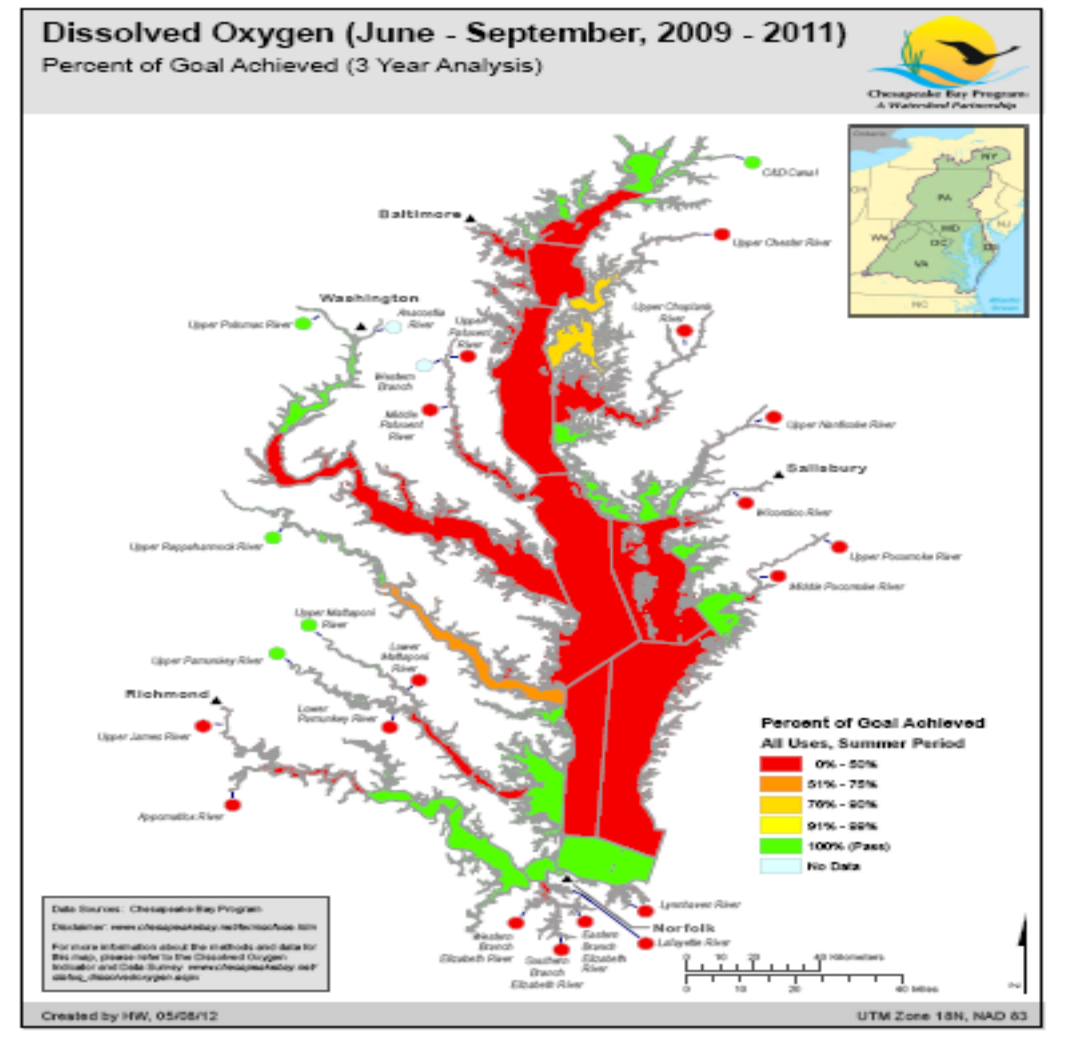
Chesapeake Bay Criteria: Multiple scales of dissolved oxygen criteria to meet simultaneously within a season. E.g. Summer season (June 1-Sept 30)

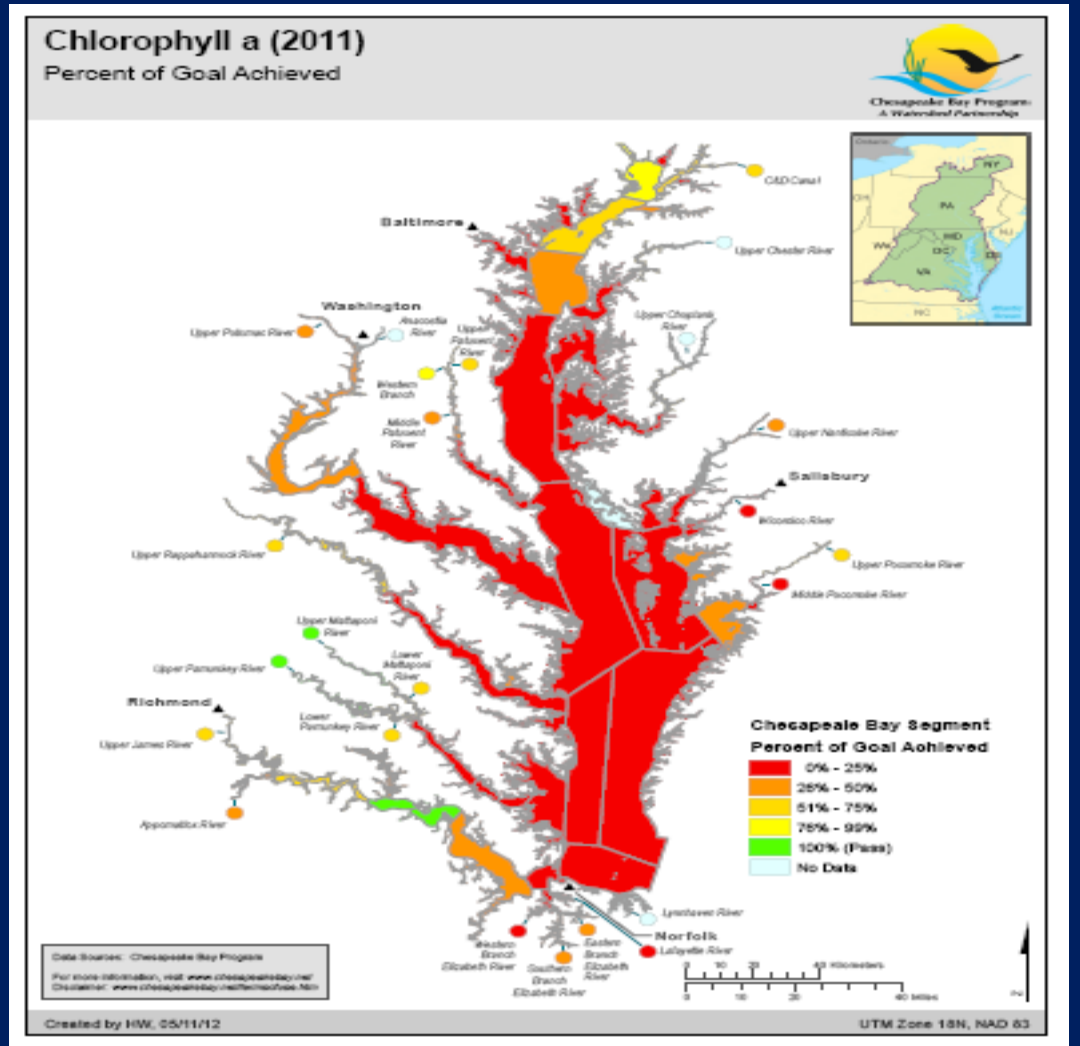
- 30-day mean ≥ 5 mg/L (tidal habitats with >0.5 salinity): Growth of larval, juvenile and adult fish and shellfish; protective of threatened/endangered species
- 7-day mean ≥ 4 mg/L: Survival of open-water fish larvae.
- Instantaneous minimum ≥ 3.2 mg/L; Survival of threatened/endangered sturgeon species



Larval recruitment effects curve (see U.S. EPA 2003a)

Water Quality Standards Attainment





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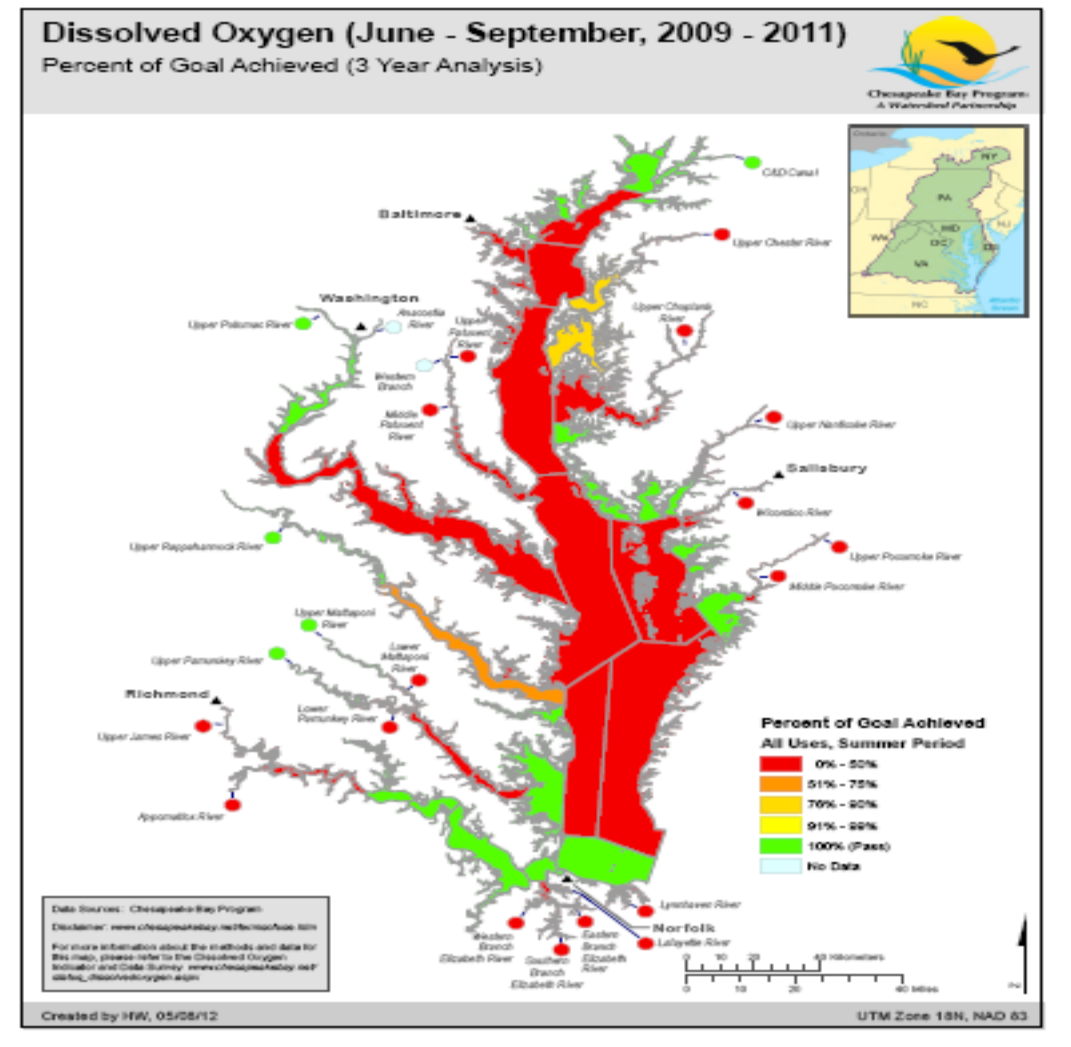


Either you're in…or your out!

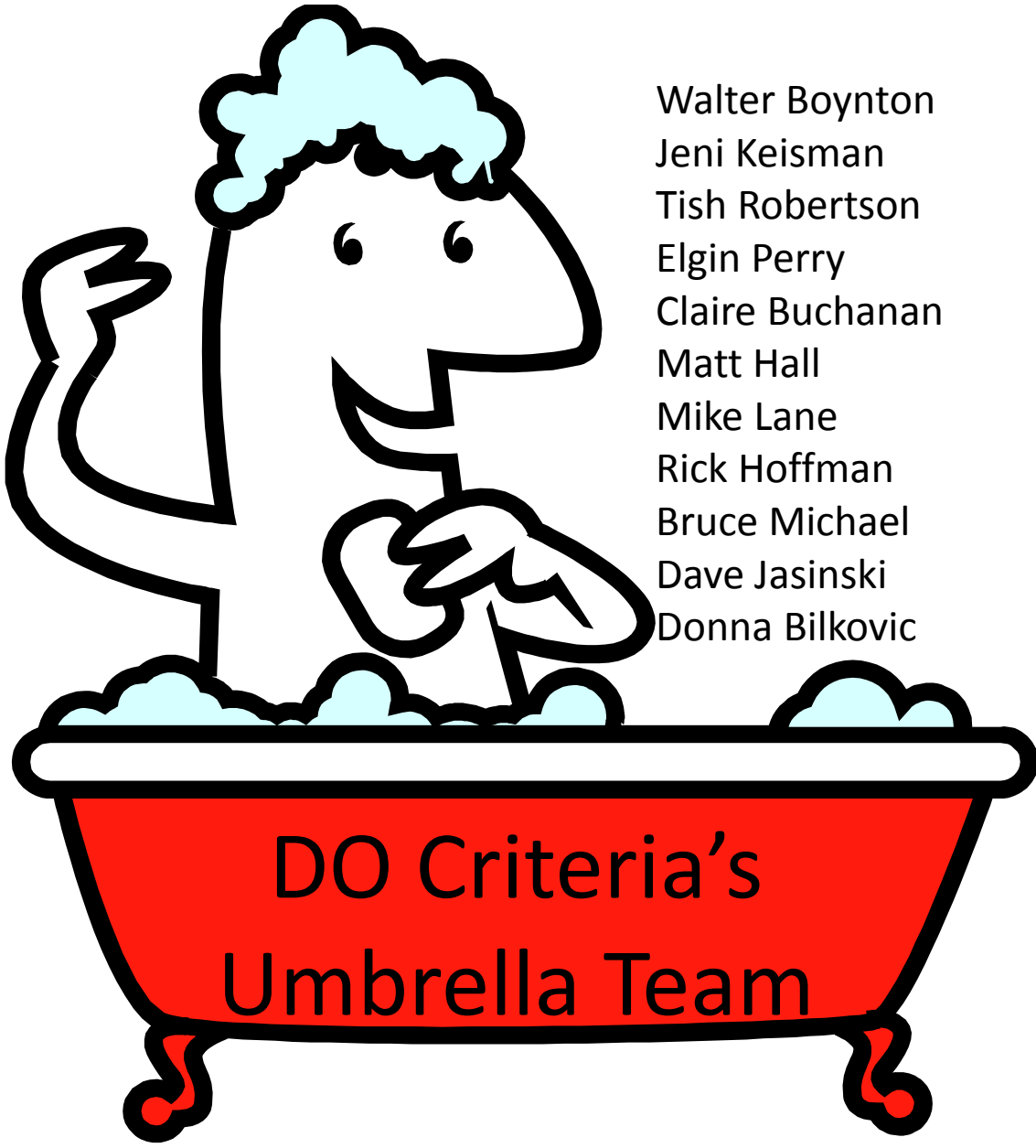
Can we extend the use of existing monitoring data for more efficient, cost effective water quality monitoring? *Enter, the Umbrella Criterion considerations*.

- The Umbrella Criterion Concept parallels Conservation Biology's use of Umbrella species (Wilcox 1984).
    - Some scientists have found that the umbrella effect provides a simpler way to manage ecological communities.
- U.S. EPA (2004) first assessment of Umbrella Criterion principles
- U.S. EPA CBPO Shenk and Batiuk (2010) evaluated Bay model output for Umbrella protection of measurements made by the existing water quality monitoring program to protect short duration criteria.

Umbrella Criteria Report – review STAC responses

- Umbrella Criteria Assessment Team (UCAT) formed 2010.
  - Objective: Further evaluate the Umbrella Criterion Concept using Bay water quality monitoring data.
  - UCAT, Tidal Monitoring and Assessment WG, Criteria Assessment Protocol WG, STAC supported workshop.
  - Final report provided to STAC

- 10 recommendations were provided by STAC to CBP
- Here today to review the responses from November 2013 CBP letter to STAC (and a little more ☺).



Walter Boynton
Jeni Keisman
Tish Robertson
Elgin Perry
Claire Buchanan
Matt Hall
Mike Lane
Rick Hoffman
Bruce Michael
Dave Jasinski
Donna Bilkovic

1) Spectral casting and conditional probability analysis are recommended as useful tools for future comparative assessments of DO criteria protection evaluations.

- Set spectral casting aside please.
  - Technically feasible, however,
  - no gains in uncertainty
  - Reductions in uncertainty were limited by our sampling strategy, i.e. a low frequency long term water quality monitoring program.

- Conditional Probability Analysis/Simulation analyses established an understanding of applying the Umbrella Criterion approach with risk-based decision-making assessments of water quality conditions.
  - Illustration of the application follows.
  - Needs a final decision on an acceptable level for risk of nonattainment of short duration criteria.

Chesapeake Bay EMAP sensor data set was evaluated to compare criterion failure rates.

Does passing the Open Water 30-day mean DO criterion (5.0 mg/L) provide an adequate measure of protection for passing the 7-day mean DO criterion?

Monthly Mean Dissolved Oxygen (mg/L)	Failure rate of the Open Water 7-day mean dissolved oxygen criterion
5.01	

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Monthly Mean Dissolved Oxygen (mg/L)	Failure rate of the Open Water 7-day mean dissolved oxygen criterion
5.01	17.7%

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Monthly Mean Dissolved Oxygen (mg/L)	Failure rate of the Open Water 7-day mean dissolved oxygen criterion	Failure rate of the OW Instantaneous minimum DO criterion
5.01	17.7%	44.9%

EPA Rule of Thumb level of protection with criterion assessments: 10% allowable exceedances. So, is our glass half full or half empty?

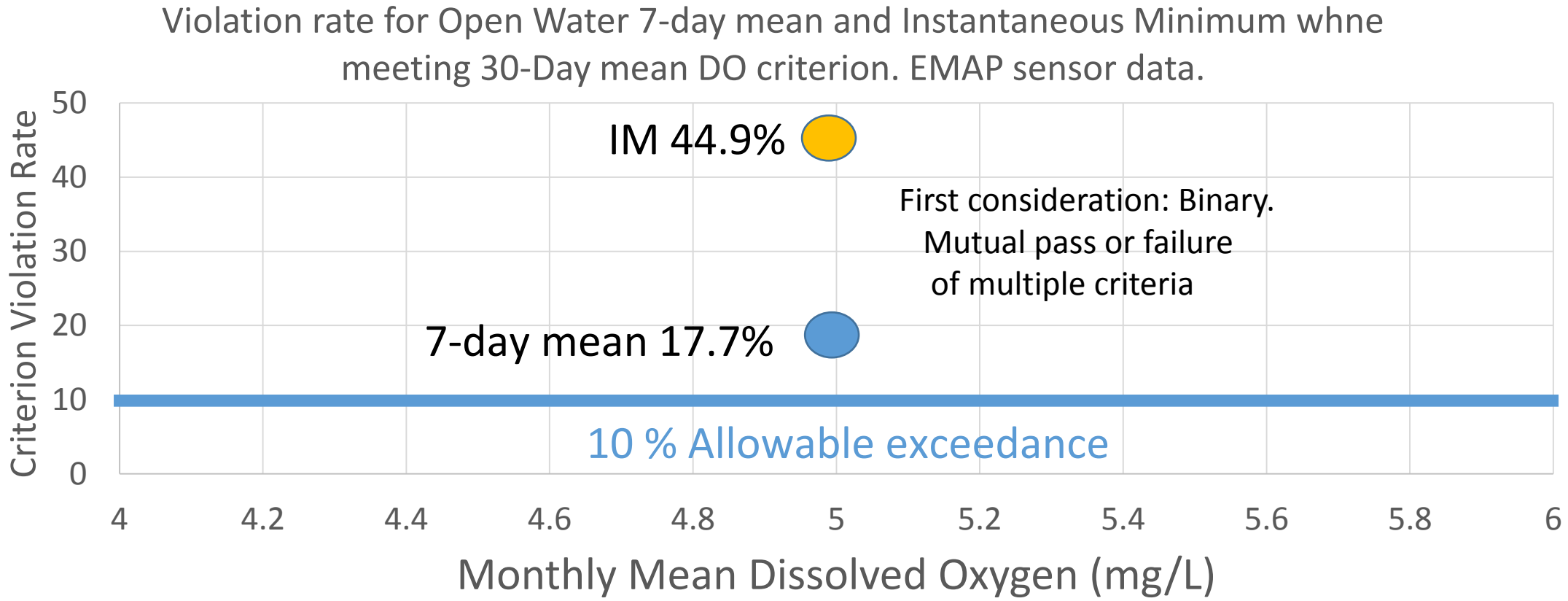
Half Empty:

- We meet the 30-day mean DO criterion, but
- we fail to meet the 7 day and instantaneous minimum criteria
- even with a 10% allowable exceedance.

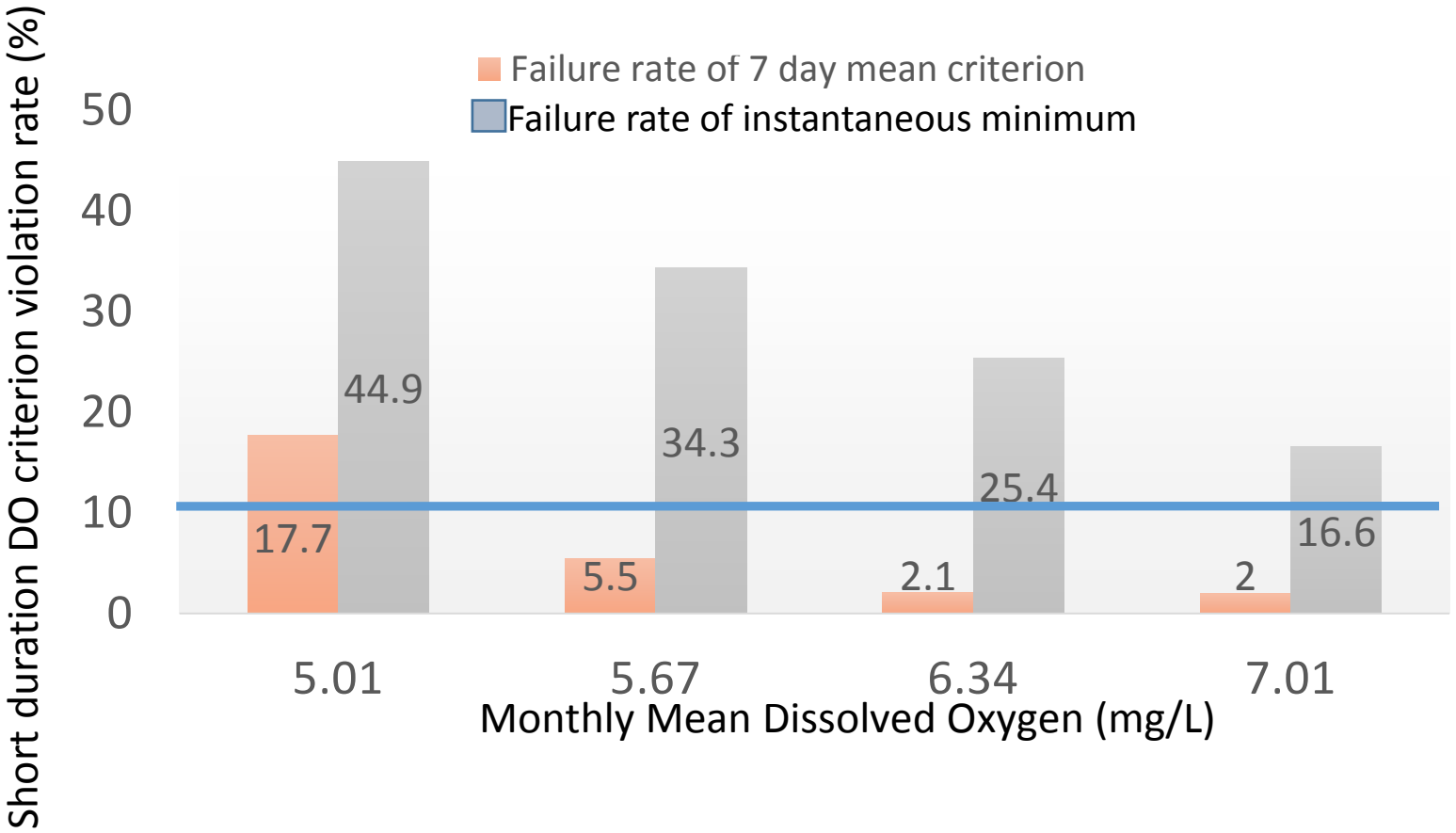
Half Full:

- We meet the 30-day mean DO criterion,
- Our short-duration criteria might be considered protected
  - Protected IF our criteria or allowable exceedance for violations were different.
  - (Or, there might be another option….)

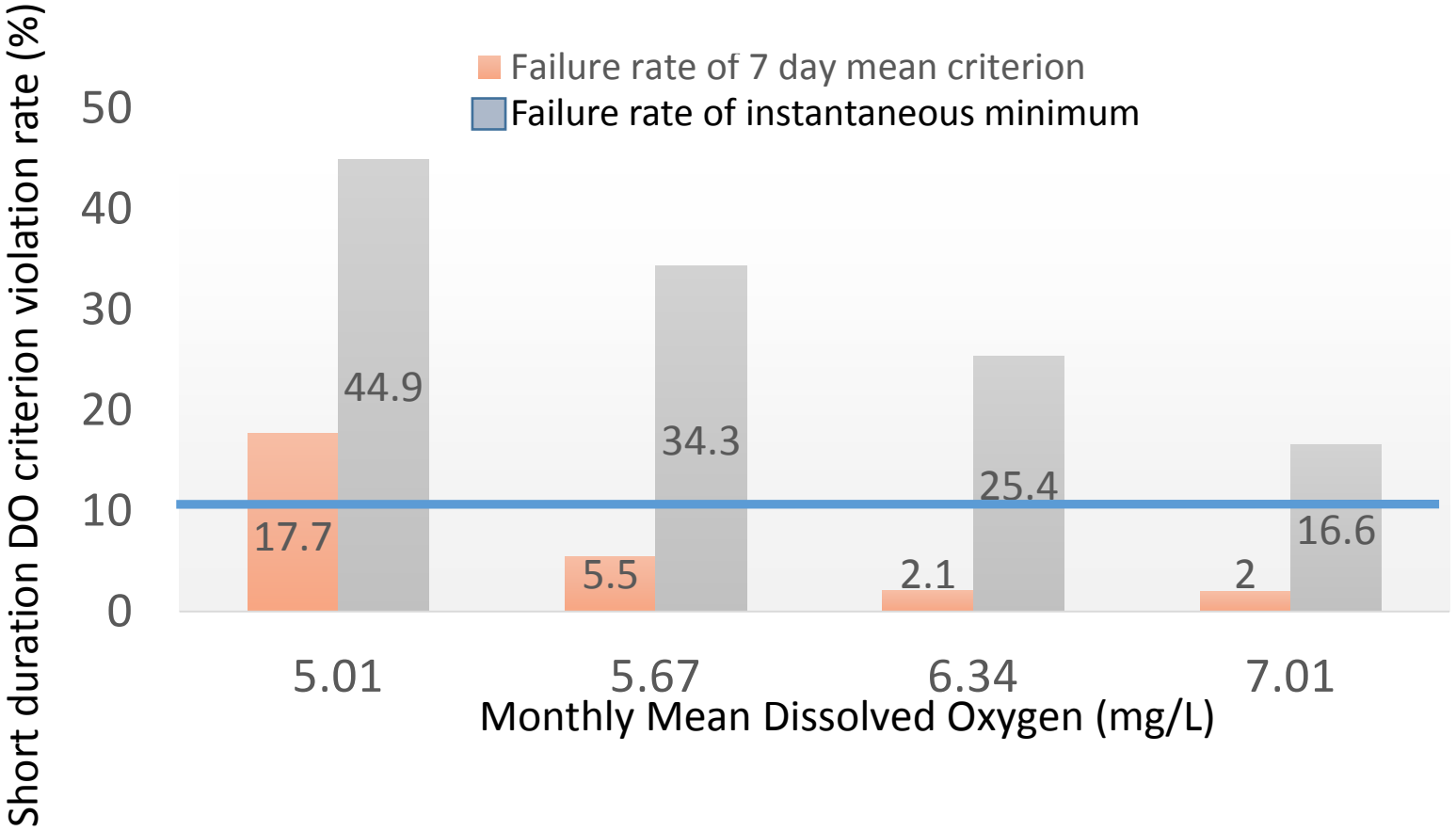
Can we use more of the analysis information available from the water quality standards attainment assessment to allow for a viable Umbrella Criterion approach?



UCAT analysis of 4 high frequency DO times series showed that as the monthly mean DO concentration increases, the associated short-duration criteria violation rates decline.



As the monthly mean dissolved oxygen concentration increases, the associated violation rate for short-duration criteria declines.



- Suggestion: Instead of relating protection for short duration criteria only on the pass-fail assessment, use the information on monthly means to understand the level of risk of violating short-duration criteria.

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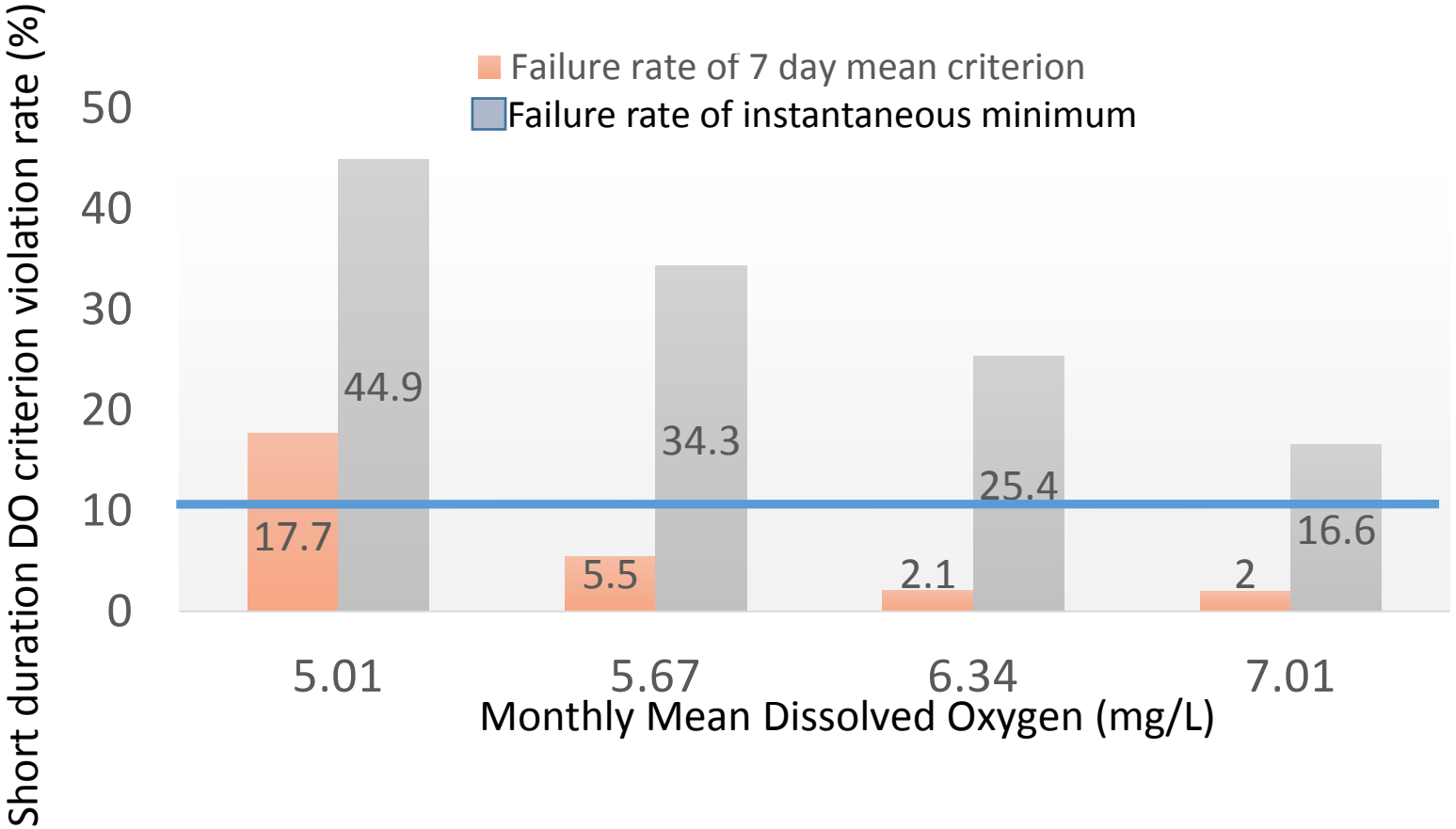
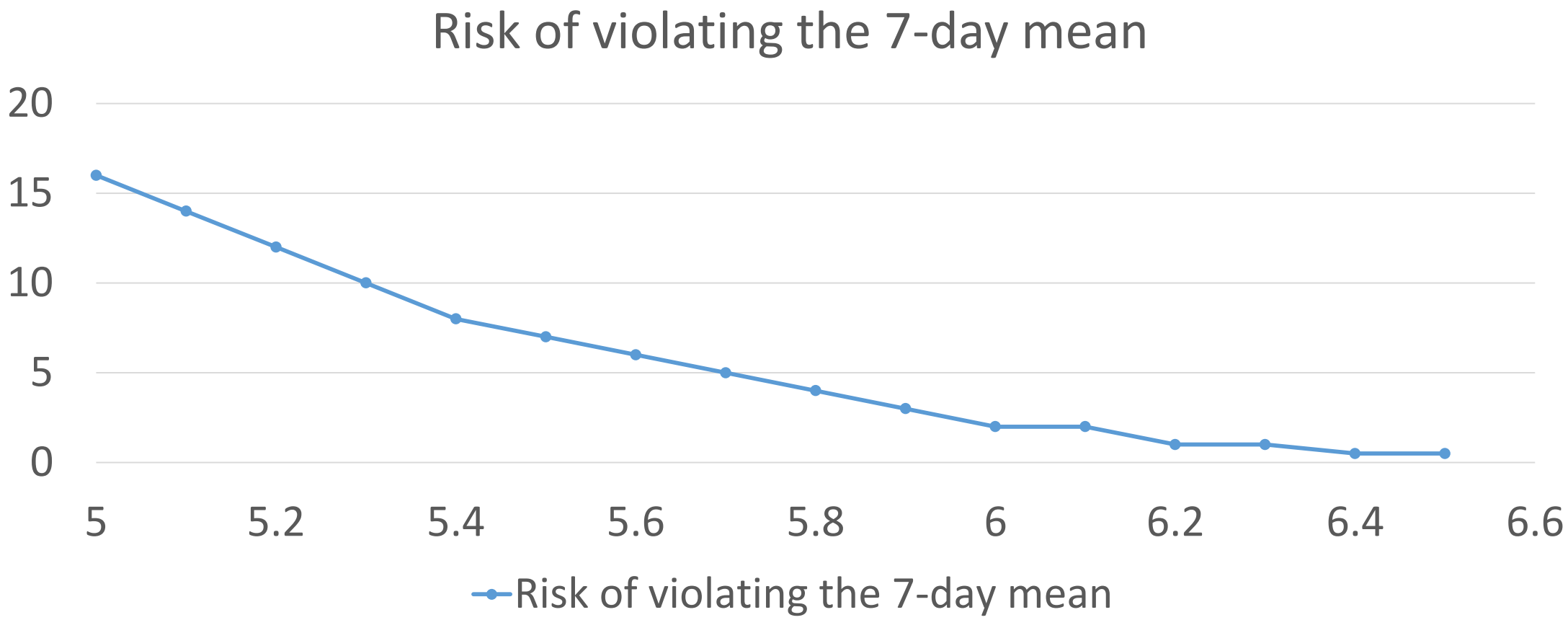


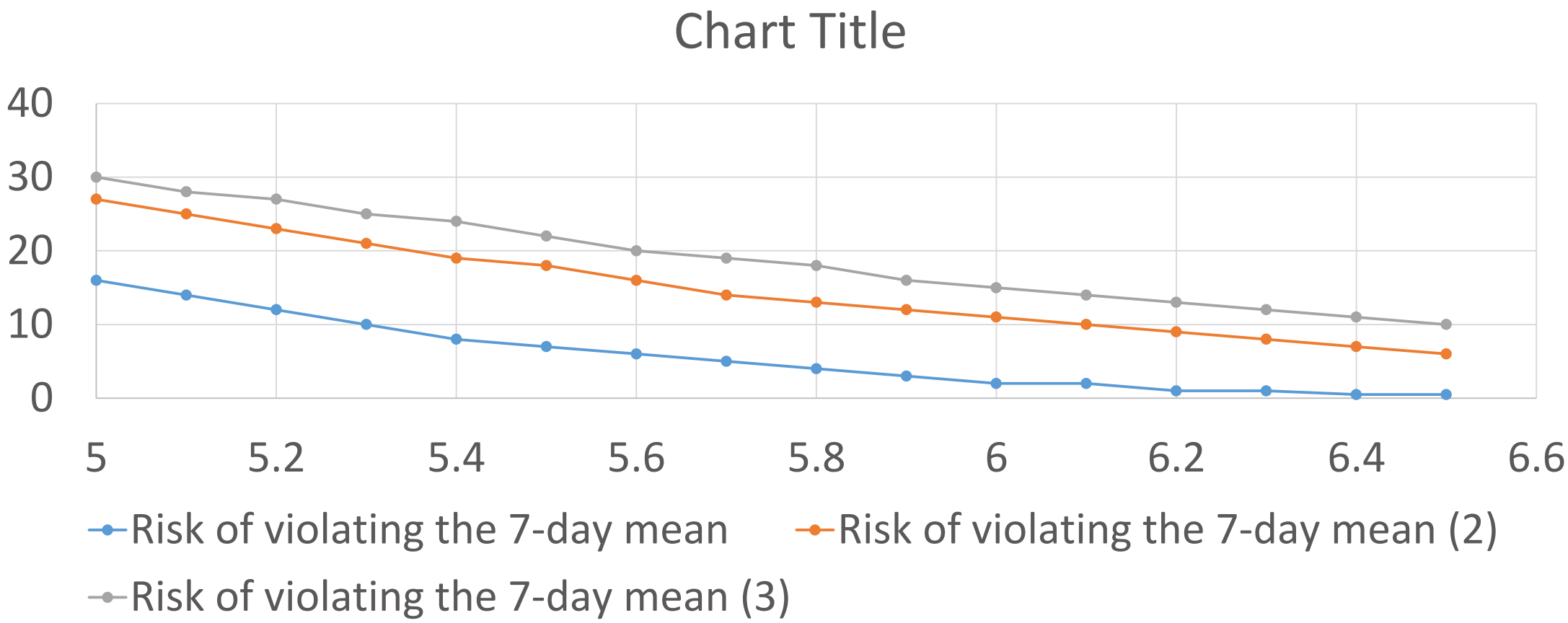
- Suggestion: Instead of basing protection for short-duration criteria only on the pass-fail assessment, use the information on monthly means to understand the level of risk of violating short-duration criteria.

Simulation analysis based on subsampling continuous DO monitoring data filled in the gaps on risk for nonattainment based on 30-day means.

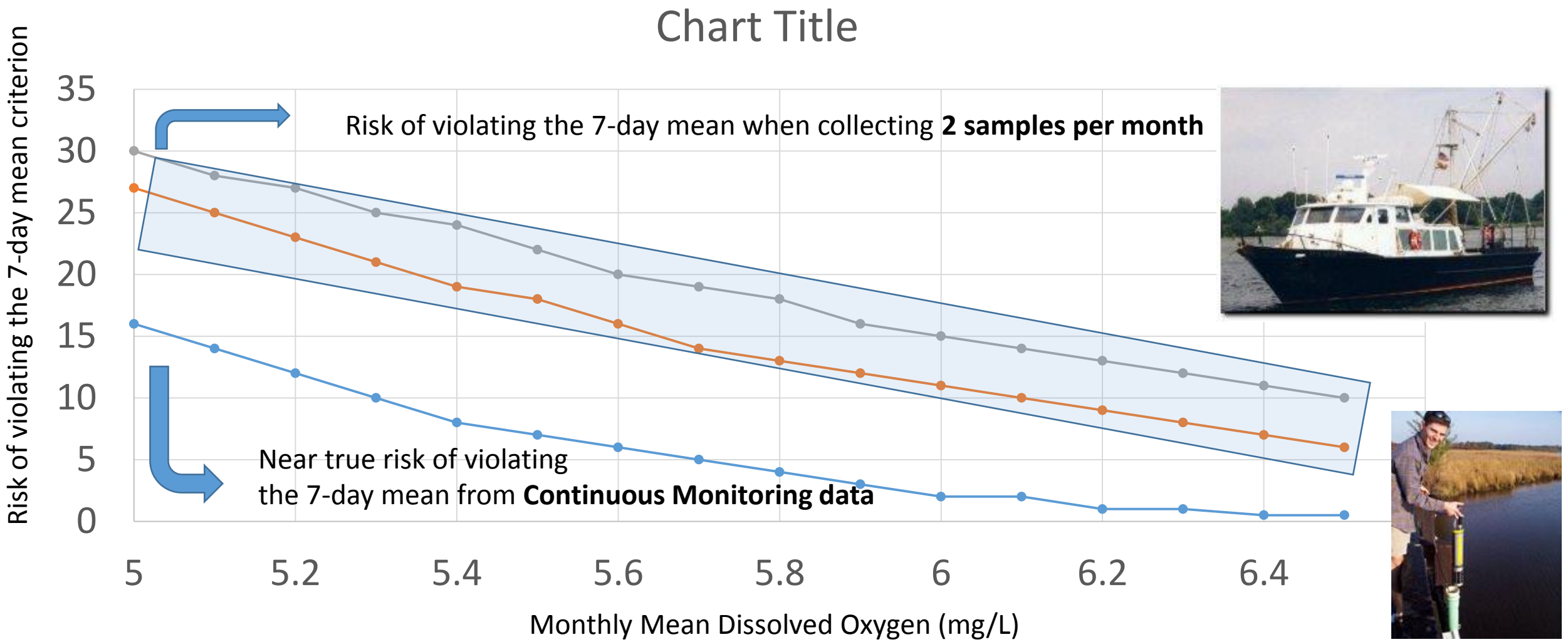



20
15
10
5
0
5
5.2
6.4
6.6
Risk of violating the 7-day mean
BUT WAIT, THERE'S MORE!

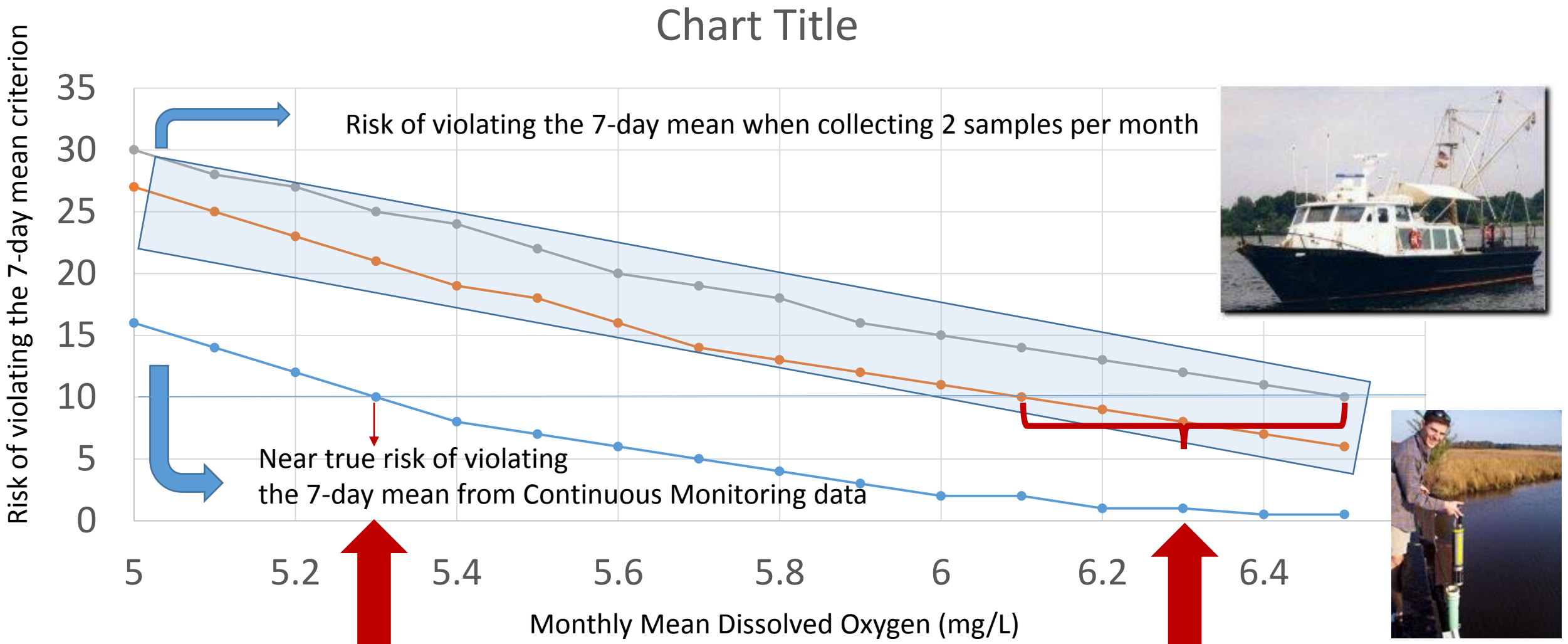
A family of curves exist to support decision-making.



The family of curves relates to the risk of nonattainment f(sampling effort).



Our low frequency data (2x/month) requires that we achieve a higher monthly mean to establish a low risk of nonattainment for short-duration criteria compared with near real-time (15 min) assessments.

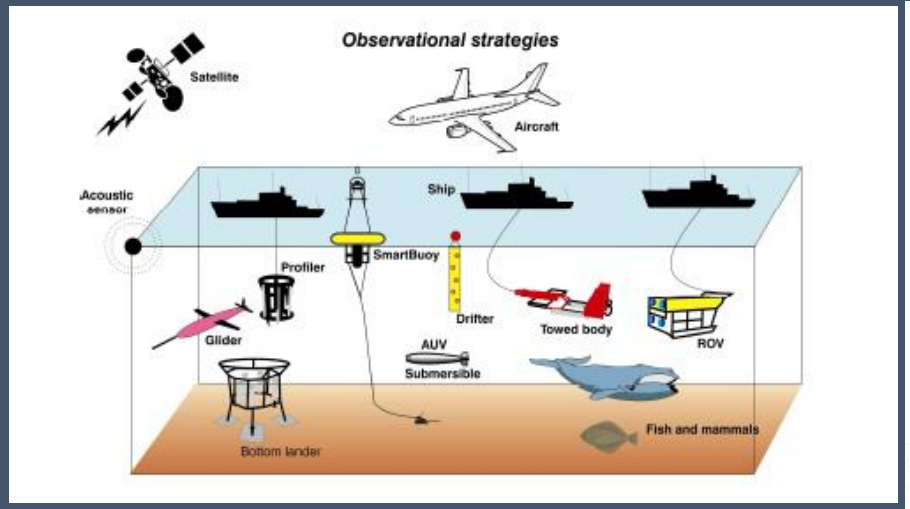


RESULTS

- An Umbrella Protection Effect exists for protecting multiple criteria using a single scale of measurement.
  1. The size of the Umbrella Effect varies depend on the density of measurements used to assess the criterion.
  2. Levels of protection provided by a monthly mean dissolved oxygen value are different depending on what criteria you choose to protect.

Two Choices for Assessing Short-Duration Criteria in Chesapeake Bay

- Measure water quality at high temporal frequency. Apply CFD approach.



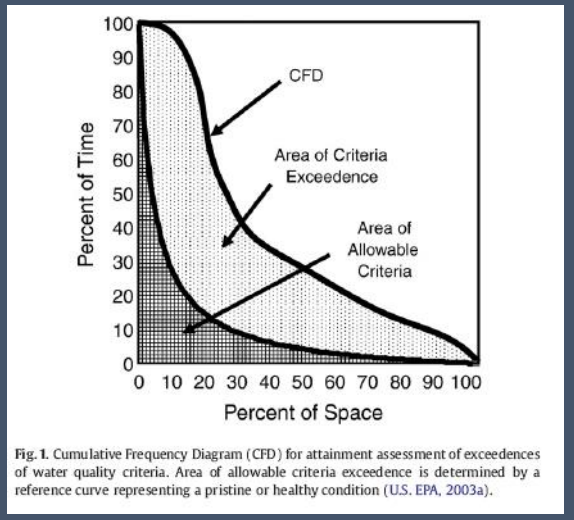


Fig. 1. Cumulative Frequency Diagram (CFD) for attainment assessment of exceedences of water quality criteria. Area of allowable criteria exceedence is determined by a reference curve representing a pristine or healthy condition (U.S. EPA, 2003a).

- Use the Umbrella Criterion Approach defining the acceptable risk of nonattainment for the unmeasured criteria

2) Provide recommendations for incorporating high frequency DO measurements into the DO criteria assessments.

- We are in the final stages of using results of the Instantaneous Minimum workshop for providing suggestions on using high frequency dissolved oxygen data.
  - E.g. Pooling Shallow water ConMon data from a management segment to represent shallow water habitat and providing partial segment delisting decisions.
  - E.g. Vertical interpolation of surface and bottom ConMon results to address open water short duration criteria assessments.
  - E.g. Use vertical profiler data when and where it is available (York River polyhaline in VA, Harris Creek in MD)

3) Future assessments of Model outputs and monitoring data should be conducted using reali time DO data.

- The “ribbon model” calibration and verification is making use of high frequency water quality monitoring data sets from the Bay.

- As the Bay model moves its calibration data sets forward in time, overlap will occur with the time frames for which vertical profiler data sets are available.

4) Complete a Bay-wide assessment of summer season open water and deep water 30 day mean protection for the short duration criteria.

- A Bay-wide assessment was provided in U.S. EPA 2004. Recommendations were provided on the application of Umbrella Criteria approach.

- The CBP Criteria Assessment Protocol Workgroup did not have the time or resources to complete such a Bay-wide assessment, however, it addressed method options to support assessments in the future.

5) Provide recommendations for the best approach for assessing the short-duration DO criteria.

- Two basic approaches are being suggested
  - Provide high frequency water quality monitoring data collections in space and time allowing the CFD approach to be used for each of the short duration criterion assessments.
  - An Umbrella Criterion approach that accounts for risk of violating the short duration criteria and allowable exceedances.

6) Assess alternative definitions of ‘instantaneous minimum’ and present options for a new definition in the context of previous criteria assessments.

- Option 1. The instantaneous minimum is the absolute minimum allowable value at one instant in time.

- Option 2. U.S. EPA Standards Handbook indicates IM can be interpreted as a 1-hr average DO. Most states apply IM as a daily minimum.
  - Alternative definition: IM is 1 hr average not to be exceeded daily. Allowable exceedance proposed is 2.5% of the season based on the Chesapeake Bay larval recruitment curve. (IMPROVE ON THIS).

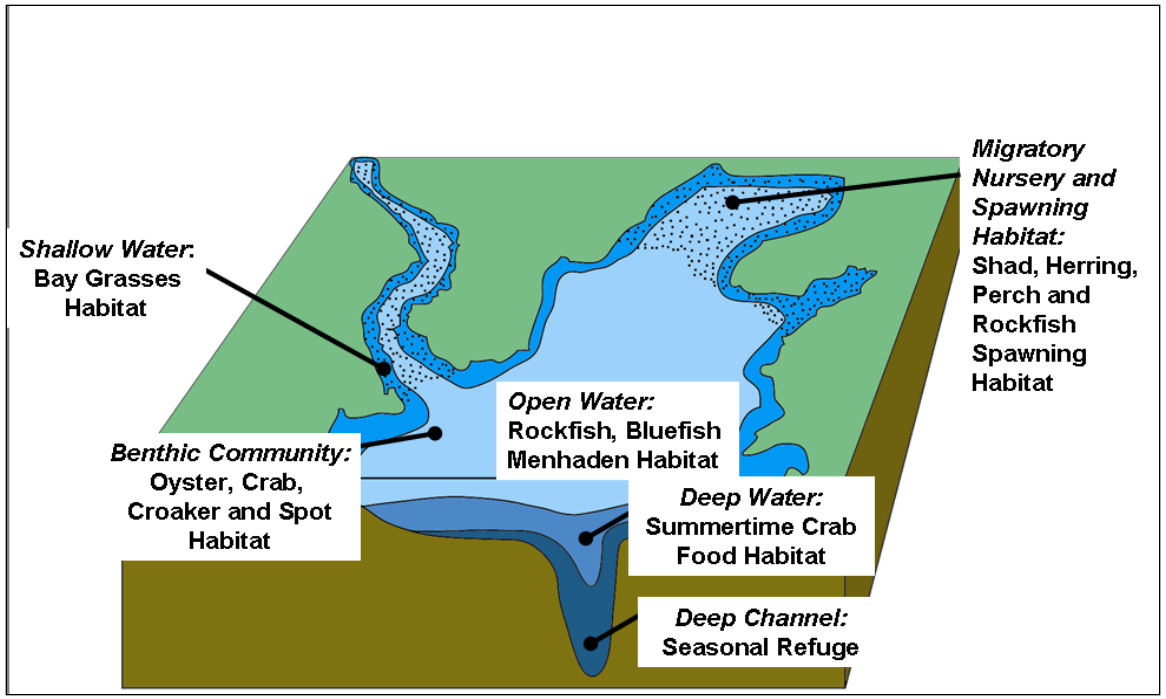
7) Consider and Assess implications of separating shallow water and offshore water for DO criteria asssessments.

Background

- Interest was expressed by the CBP community in possibly assessing shallow water habitat separately from offshore habitats for dissolved oxygen criteria attainment:
  - Monitoring Realignment (MRAT process)
  - Umbrella Criteria Assessment Team
  - CBP-STAC workshop 2011

Summer Season
Open Water Designated Use

- *From June 1 through September 30 the open-water designated use included tidally influenced waters extending horizontally from the shoreline to the adjacent shoreline.*



U.S. EPA 2003

- Insufficient information was available regarding differences in dissolved oxygen dynamics between offshore and shallow, nearshore habitat to support separating the two habitats into their own designated use assessments.

April 2013 CAP WG Shallow water Workshop Challenge:

- Review available analyses comparing nearshore and offshore dissolved oxygen behavior. Conduct additional analyses if necessary and as time permits.
- Evaluate 3 potential cases for policy makers to consider in assessing shallow water habitat.

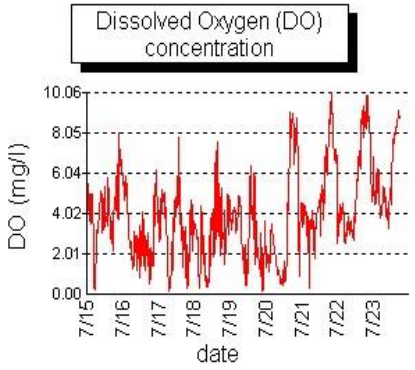
- Case I. Keep shallow water embodied within the open water designated use

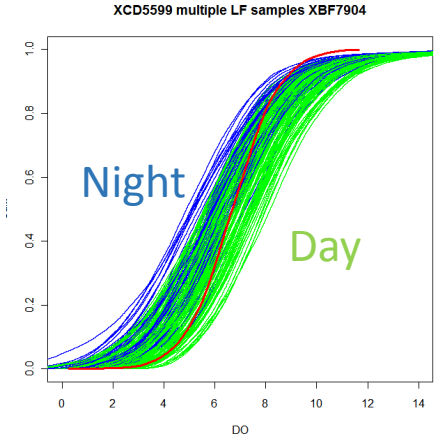
- Case II. Separate shallow water from the open water designated use Bay-wide as a dissolved oxygen based designated use.

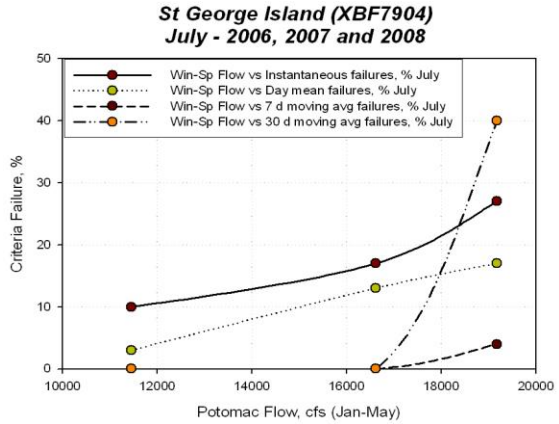
- Case III. Allow sub-segmentation of shallow water habitat in special cases.

Umbrella Criteria Assessment Team Shallow water Characterization of Dissolved Oxygen Behavior

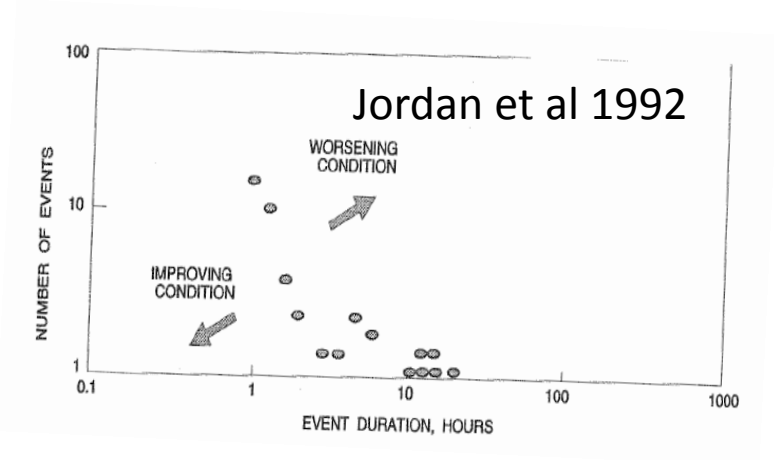
- Intrasite variability
  - Low DO events, Duration of events, day vs. night
- Intersite variability
  - Changes along condition gradients
- Seasonal variability
- External factors
  - River flow, eutrophication, temperature, solar angle



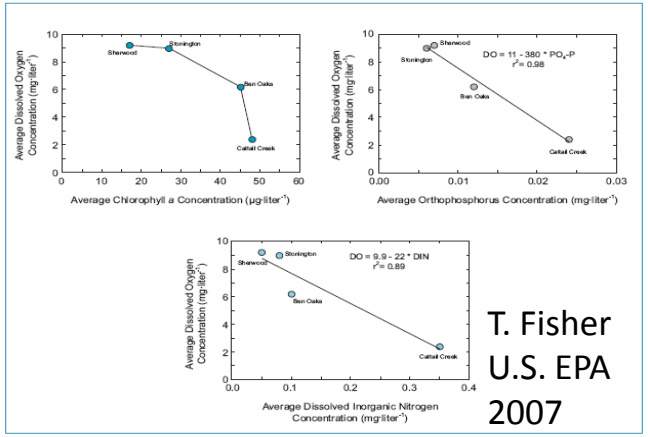




UCAT Findings:
Nearshore and Offshore DO behaviors may not be identical but appear parallel in response to stressor gradients

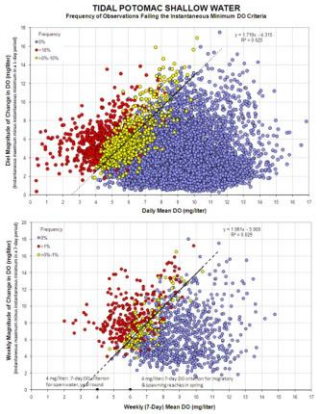


Jordan et al 1992

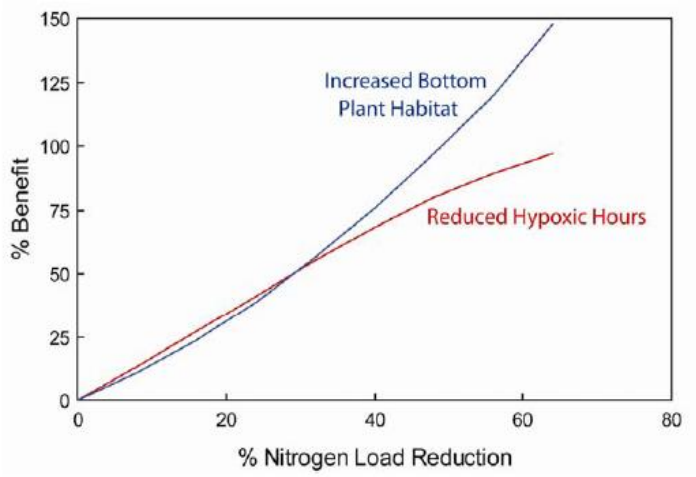


T. Fisher
U.S. EPA
2007

Figure IV-11. Significant relationships among average concentrations of the continuous monitoring surface chlorophyll *a*, orthophosphorous, and dissolved inorganic nitrogen data versus dissolved oxygen concentrations for the tidal Magothy and Severn rivers.



C. Buchanan:
UCAT 2012



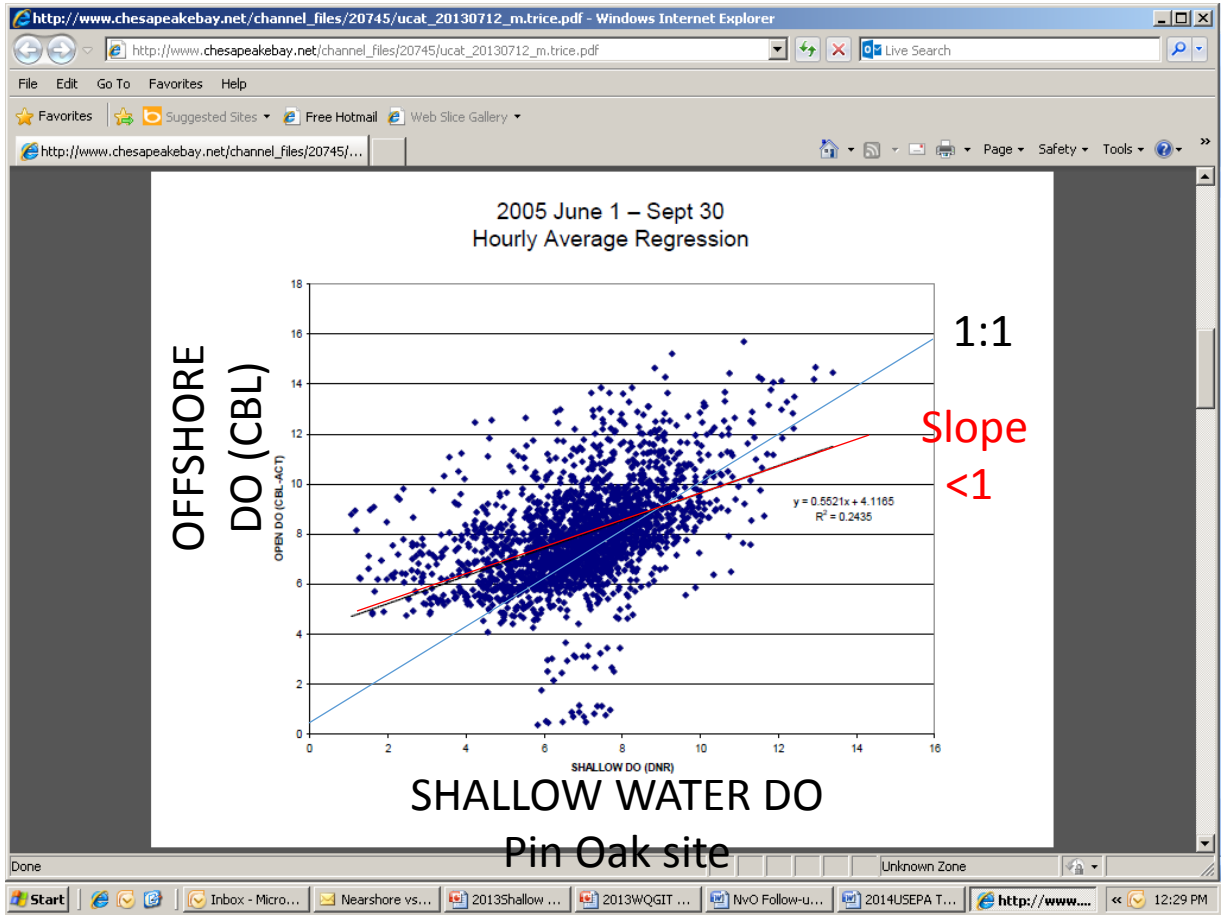
Boynton et al.

sensor depth	6	5	4	3
Monthly Mean DO	5.0058	5.6732	6.3407	7.0082
7 day criterion failure rate	16.6%	5.5%	1.5%	0.5%
rate of instantaneous criterion > 10%	47.6%	32.5%	25.3%	18.5%

E. Perry:
UCAT 2012

UCAT Findings

- Umbrella Criteria Analysis Team results showed high frequency shallow water dissolved oxygen measures can be biased low and offshore measures biased high relative to each other.
  - As a result we can find higher violation rates in shallow water than offshore water.



Recommendation: Part 1.

- The UCAT does not support separating all shallow water as a dissolved oxygen based sub-segment from the open water designated use.

  - A Bay-wide separation of the habitats would require assessments that have not been a part of analyses to date such as:

    I. Determining if the SAV 2m boundary definition of shallow water in the Bay represents an appropriate Bay-wide dissolved oxygen habitat boundary.

    II. Are the same seasons and their definitions applicable if we separated the two habitats into different designated uses?

    III. Would we need to establish separate criteria – what are they and why?

    IV. Monitoring is done on a subset of segments each year – would our monitoring network be suitable for the annual Bay-wide assessment?

    V. Assessment procedures could need further revision.

Recommendation: Part 2.

- Continue to support the CBP partners option for assigning subsegmentation of shallow water habitat in special cases.
  - Umbrella Criteria Analysis Team results showed high frequency shallow water dissolved oxygen measures can be biased low and offshore measures biased high relative to each other.
    - As a result we can find higher violation rates in shallow water than offshore water.

Recommendation: Part 3.

- Shallow water as a habitat for dissolved oxygen assessment remains within the open water designated use.
  - Data show parallel ecosystem response of dissolved oxygen to changes in water quality indicator gradients

8) Further assess the effects of hydrodynamics and climate change impacts on the validity of the umbrella criterion protection assumptions.

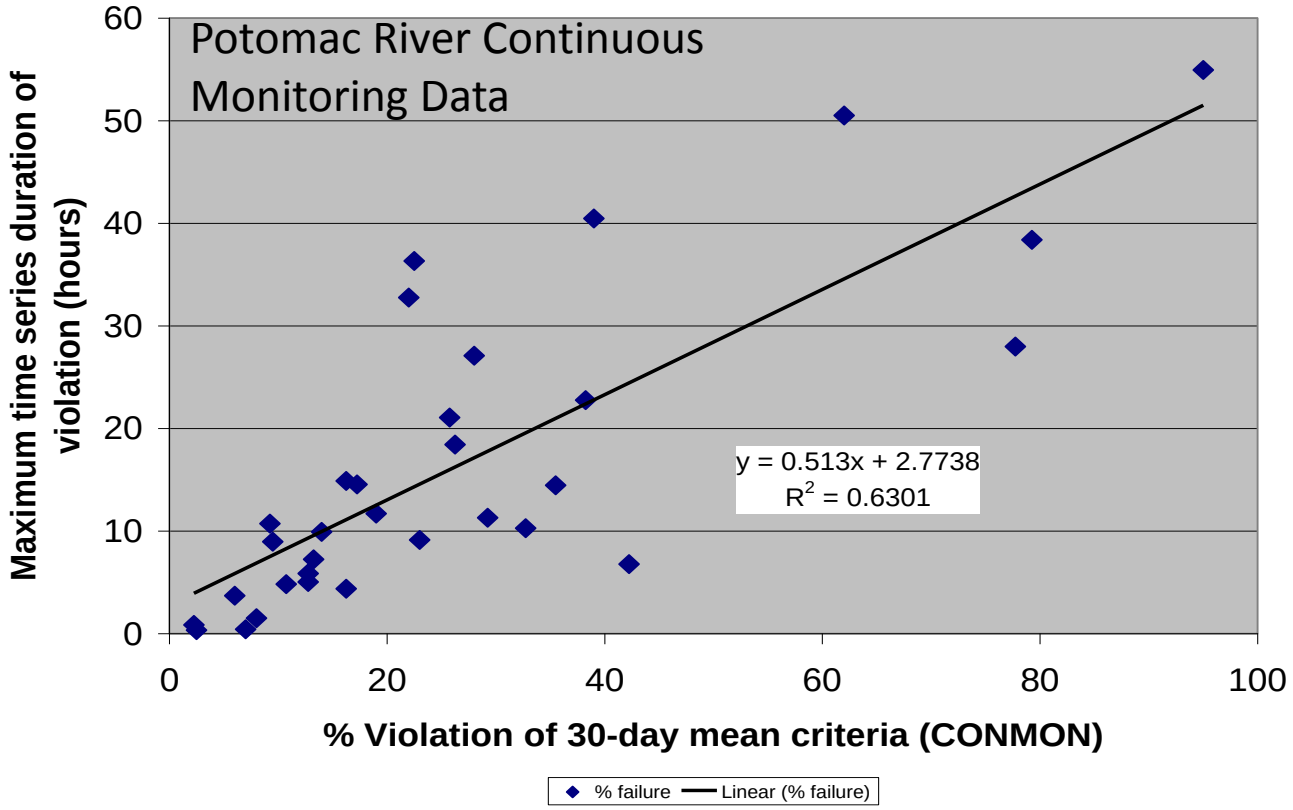
- The issues are understood to be important but were outside the scope of the present work plans developing the concept of Umbrella Criterion protections.

9) Present options for illustrating attainment uncertainty beyond our cumulative frequency distribution assessment methodology.

- The UCAT used the conditional probability analysis and introduction of risk of nonattainment of the short duration criteria into the suggested application of the Umbrella Criterion as a means of illustrating previously undescribed uncertainty in the water quality standards attainments.

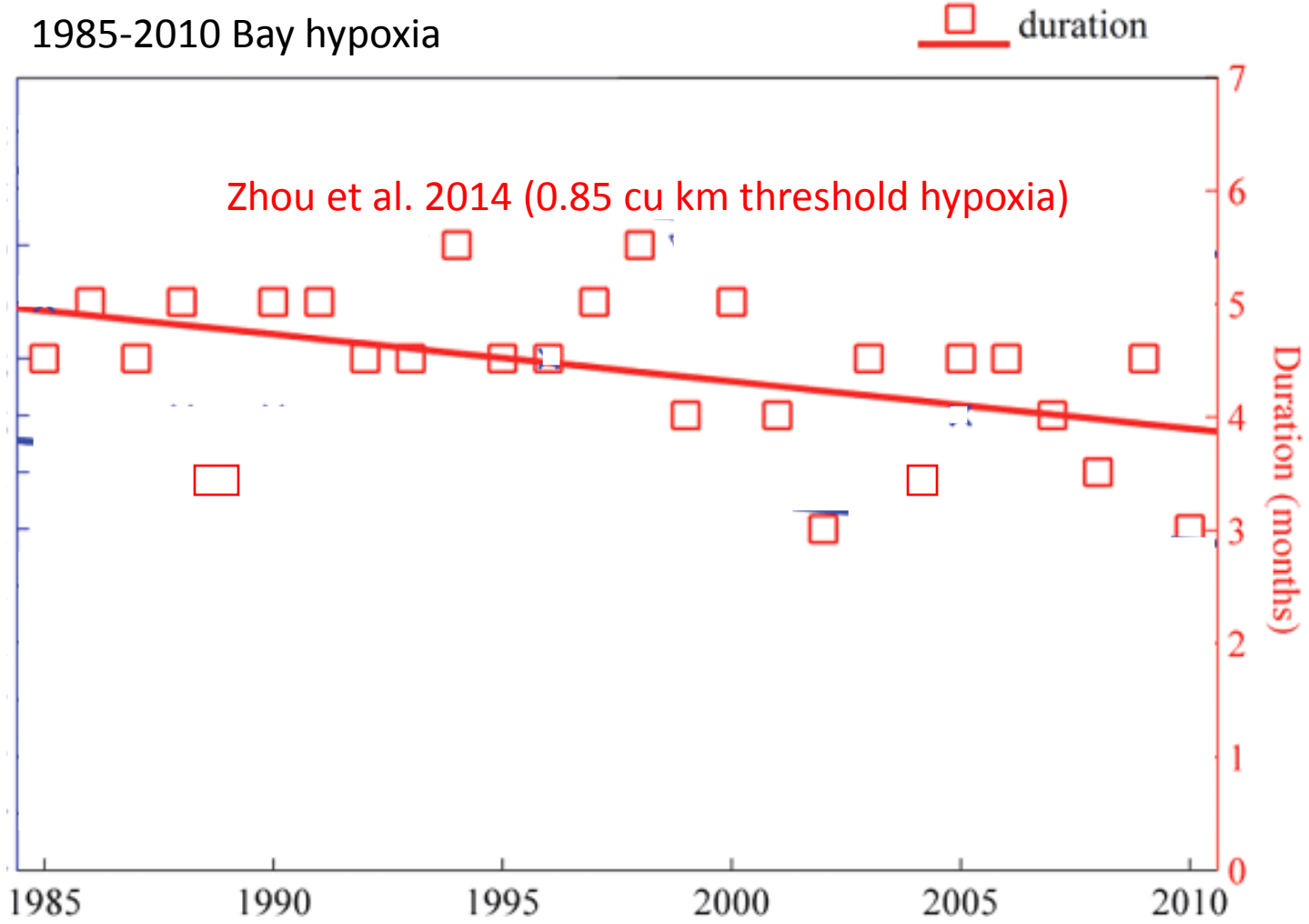
10) Recognize the importance of violation duration and assess whether DO event duration is inherently captured by the CFD assessment. Provide alternatives if necessary.

Event Duration appears Implicit within our Water Quality Standards Violation assessments



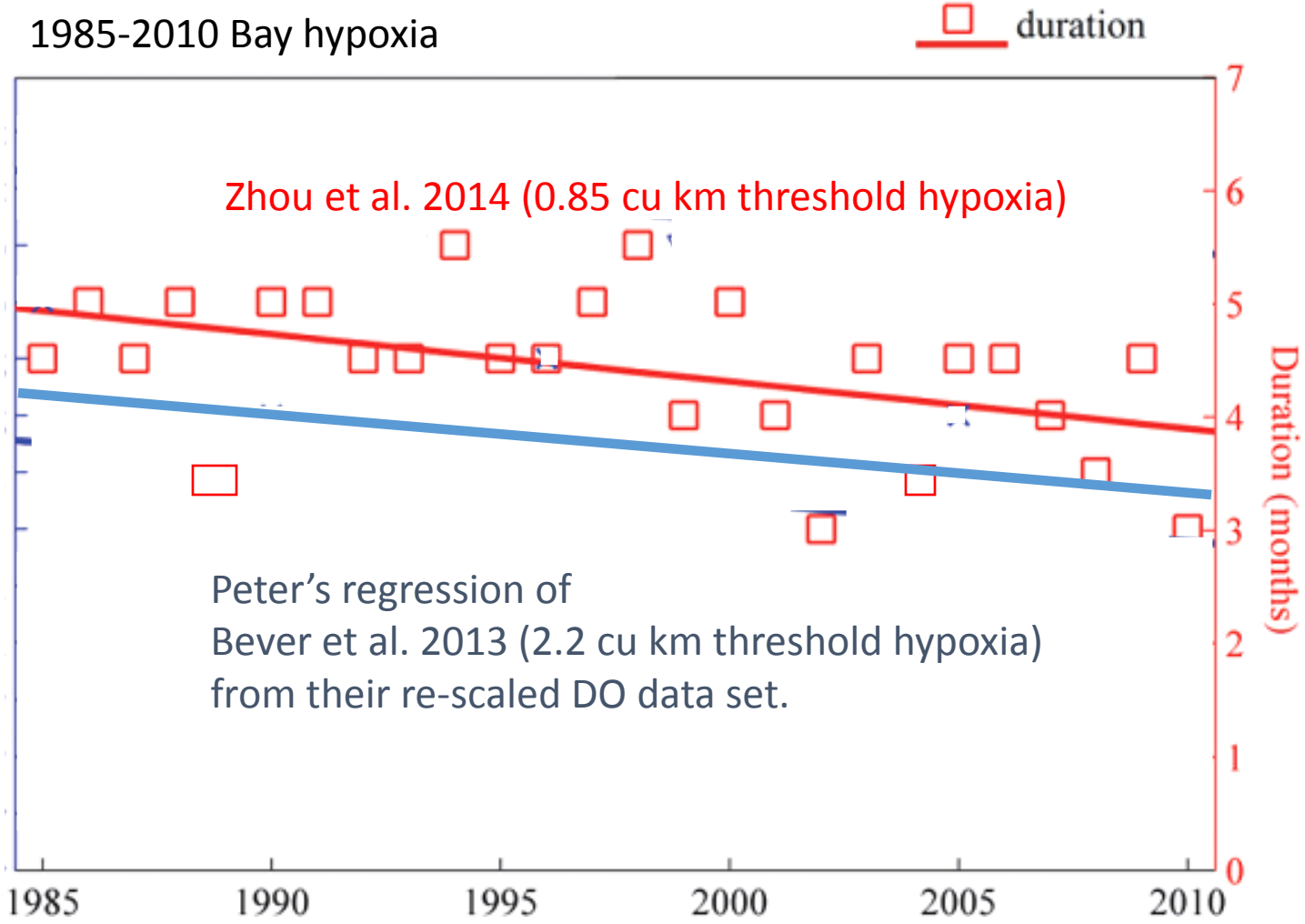
Event Duration may be a particularly sensitive measure of changes in Bay health; e.g. hypoxia

1985-2010 Bay hypoxia



Event Duration may be a particularly sensitive way to measure and track of changes in Bay health; e.g. hypoxia.
Opportunity to develop the indicator(s) for communicating incremental progress.

1985-2010 Bay hypoxia



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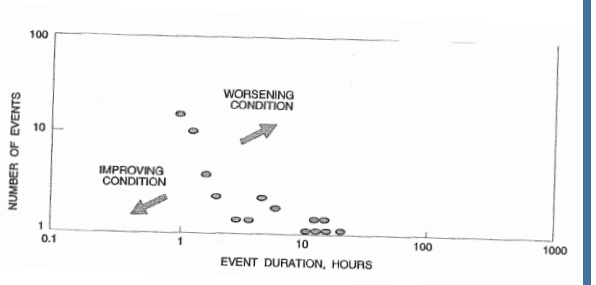
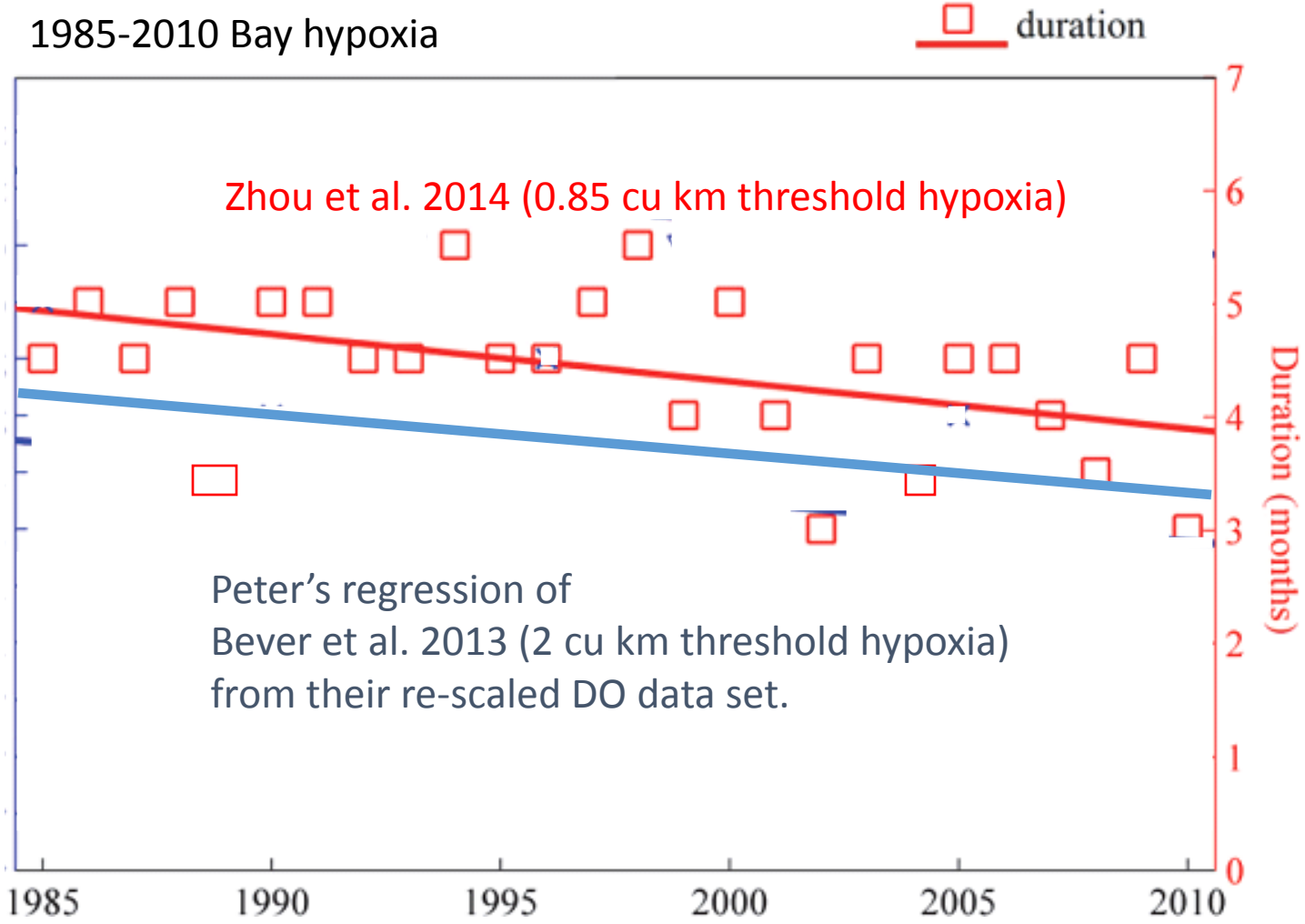


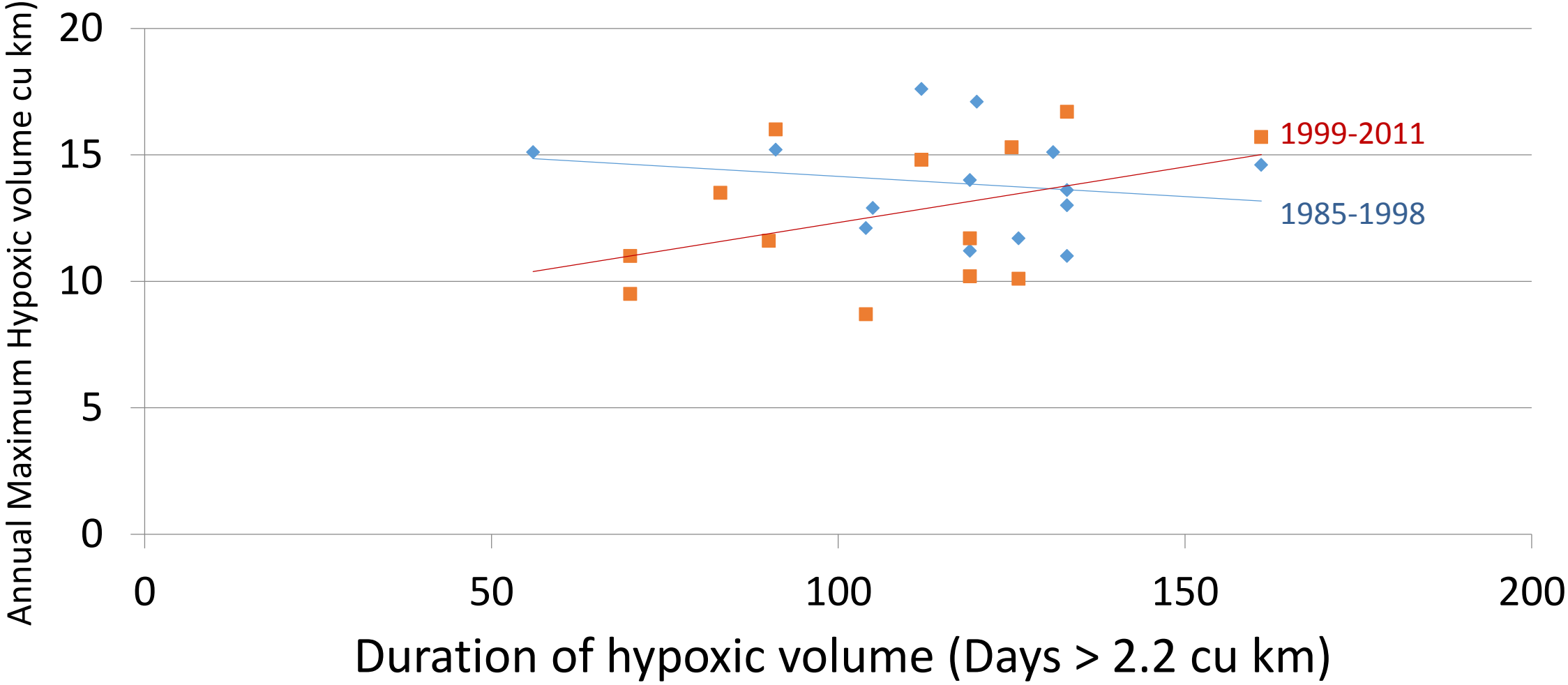
Reflections of suggestions for tracking change from Jordan et al. 1992.

1985-2010 Bay hypoxia



Event Duration may be more responsive measure of change than maximum hypoxic volume.

Exploratory insights with Bever et al. 2013 scaled monitoring date.



Next steps

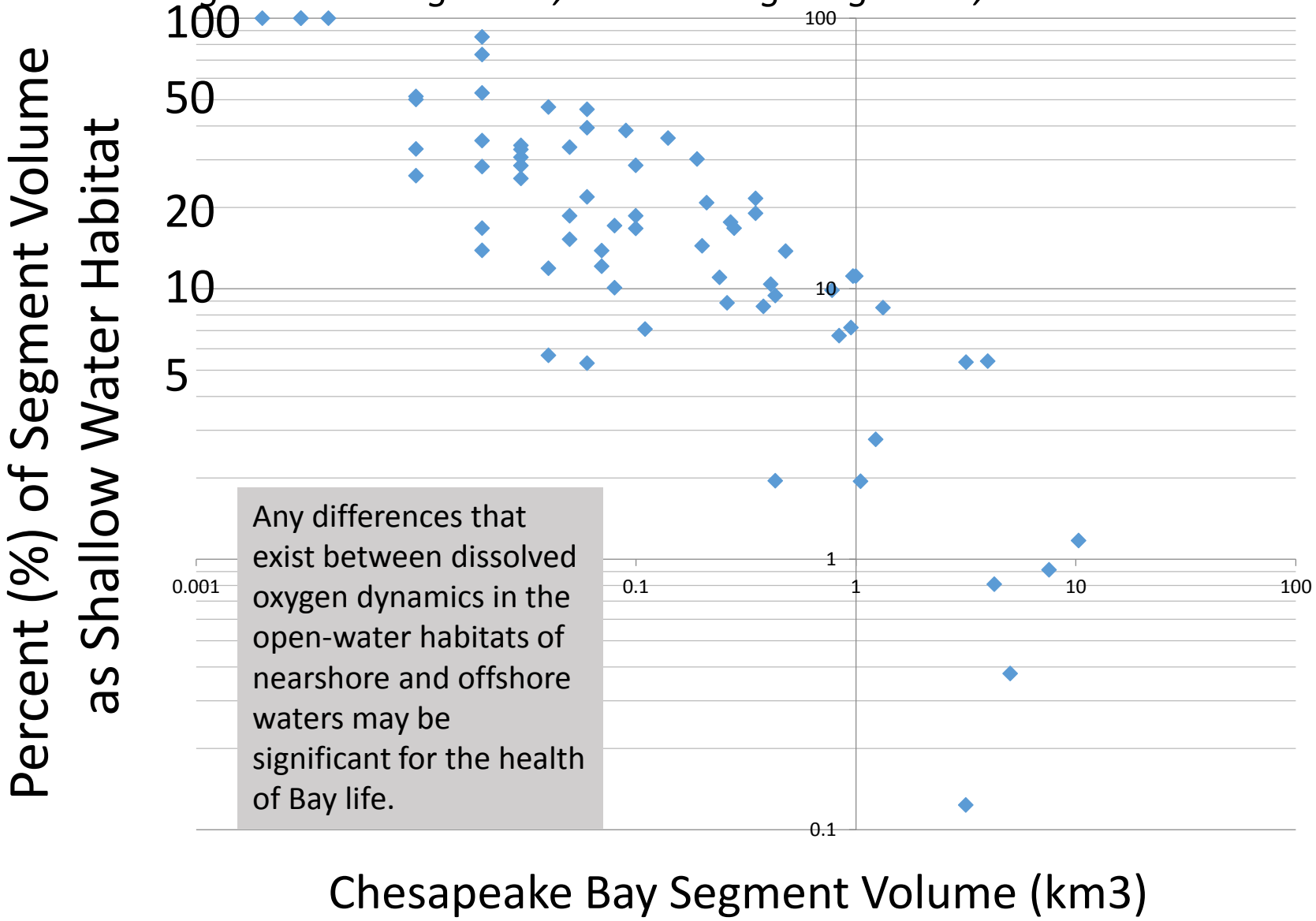
- A new Ambient Water Quality Criteria Technical Addendum is being drafted.
- Reviews and meetings with CBP Workgroups, EPA and the CBP Water Quality GIT.
- Request for a STAC peer review of the next Ambient Water Quality Criteria Technical Addendum
  - Updated findings and recommendations for implementation of approaches to assessing short-duration criteria.
  - Ties together loose ends on additional criteria protocol assessments, goals.

The Chesapeake Bay Program has had a Continuing Interest in Understanding Shallow Water Habitat Conditions

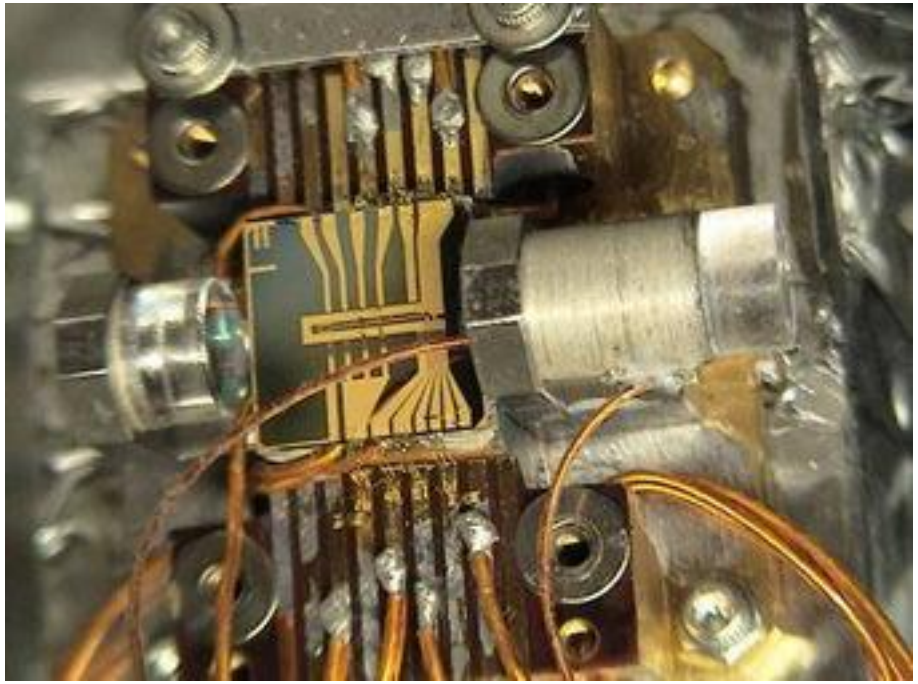
- Batiuk et al. 2000 SAV Technical Synthesis
  - Includes synthesis of mid-channel to nearshore water quality comparisons
- CBP Water Quality Monitoring Programming Changes 2003-04:
  - Defunded Zooplankton Monitoring
  - Funded new Shallow Water Monitoring Program
    - Fixed site continuous monitoring
    - DATAFLOW
- USEPA 2007 comparison analysis

The Importance of Shallow Water in Chesapeake Bay

The percent of shallow water habitat is
large in small segments, small in large segments, overall abundant

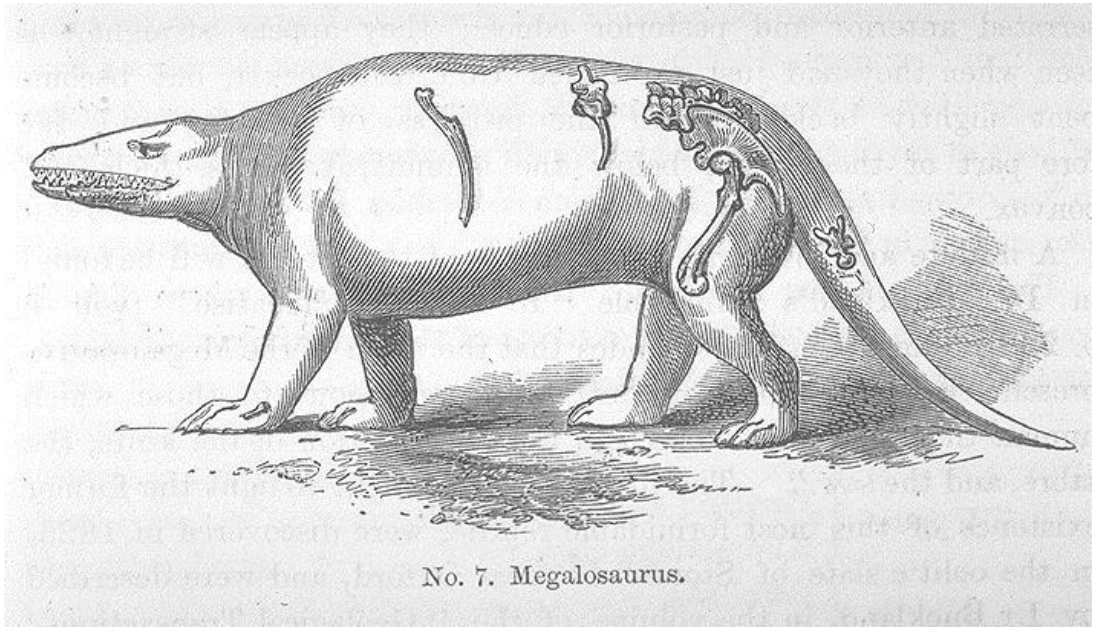


What people think we do:



Detector counts atom by atom!
(For 18 trillion gallons of Bay water of course)

What we kind of do:



Have a few pieces of the puzzle and create our best picture of the beast!