Guidance for Implementation of the Saltwater Dissolved Oxygen Criteria

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Suffocating?
Where and how bad is the DO problem?

- National Coastal Condition Report (2001 and 2004) finding-
  - DO quality is good, and contributes less than other indicator (including eutrophic condition, contaminated sediments, benthos, fish tissue concentrations and coastal wetlands loss)

- Degraded benthos and eutrophic condition are both correlated with low DO…

So, are DO condition assessments accurate, and do they need to be?

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Addressing Low D.O. in Impaired Waters

- Long Island Sound nitrogen TMDL to control hypoxia
- Chesapeake Bay Program- nutrient strategy to control hypoxia and turbidity
- Gulf of Mexico Hypoxia study- National task force to study causes, effects and cost-benefit analyses of the D.O. problem
- Narragansett Bay- ongoing DEM surveys and recent extreme events are sparking a nutrient/D.O. debate

We need to resolve the D.O. assessment question to determine appropriate management for nutrients.

D.O. Criteria and How to Use Them

- *Ambient Aquatic Life Criteria for Dissolved Oxygen (Saltwater)* (U.S. EPA, 2000), a.k.a. Virginian Province D.O. (VPDO) Criteria
- *Implementation Guidance For The Saltwater Aquatic Life Criteria For Dissolved Oxygen*: Draft Final (SAIC, April 2004)
- This presentation:
  - Overview of the criteria
  - Demonstration applications with various data types
  - Applying site-specific modifications to the criteria
  - Criteria applications in the context of nutrient management

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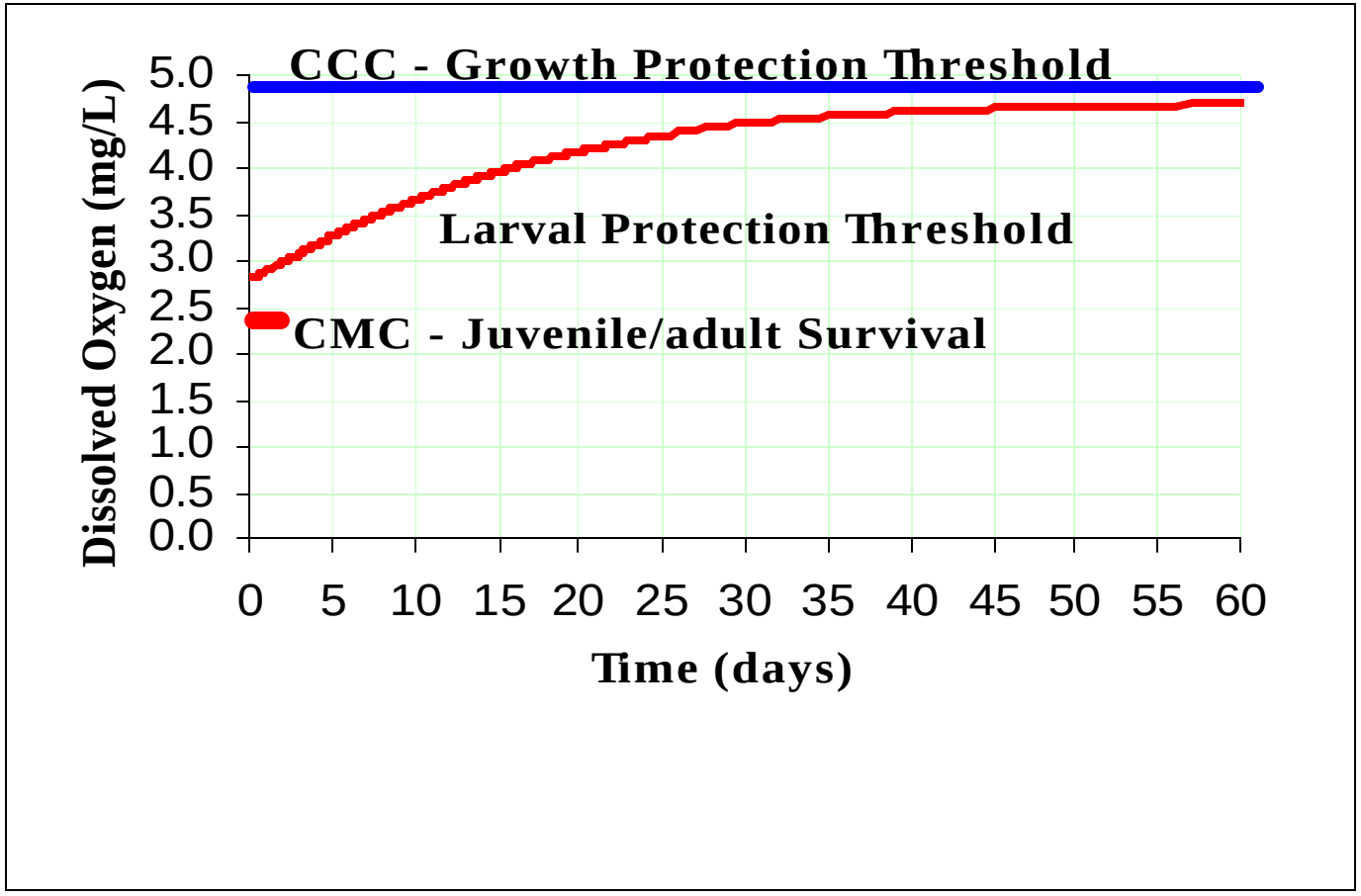
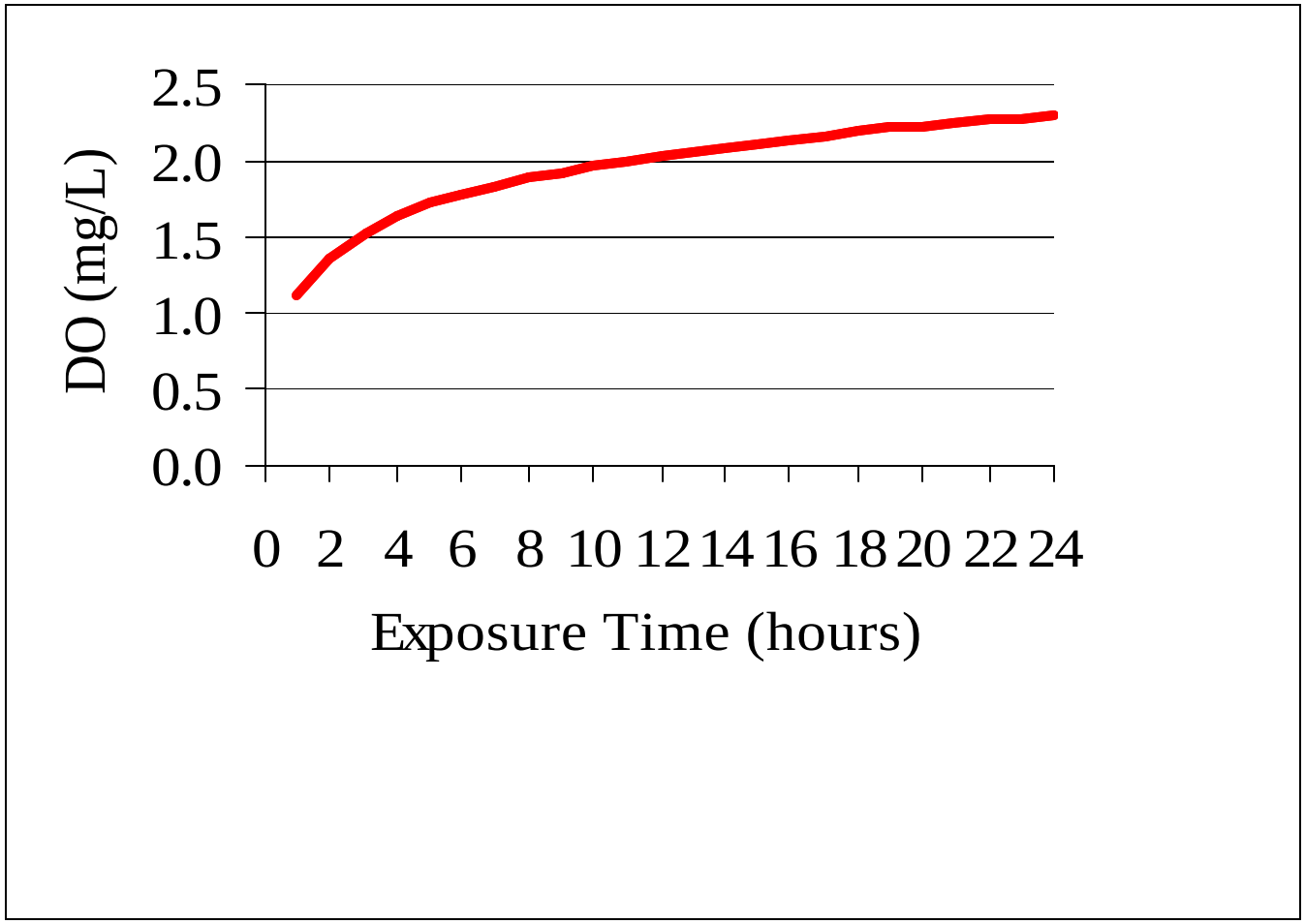
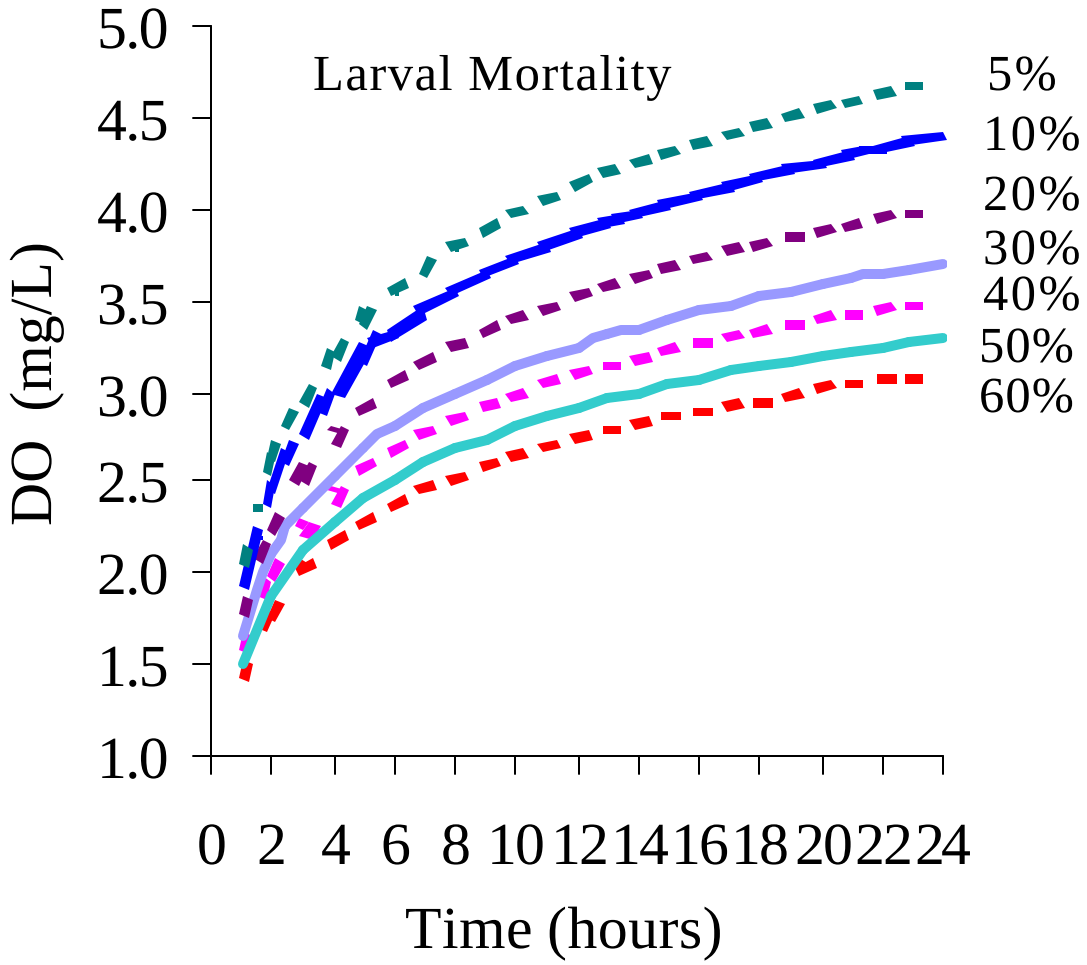
What are the VPDO criteria limits?



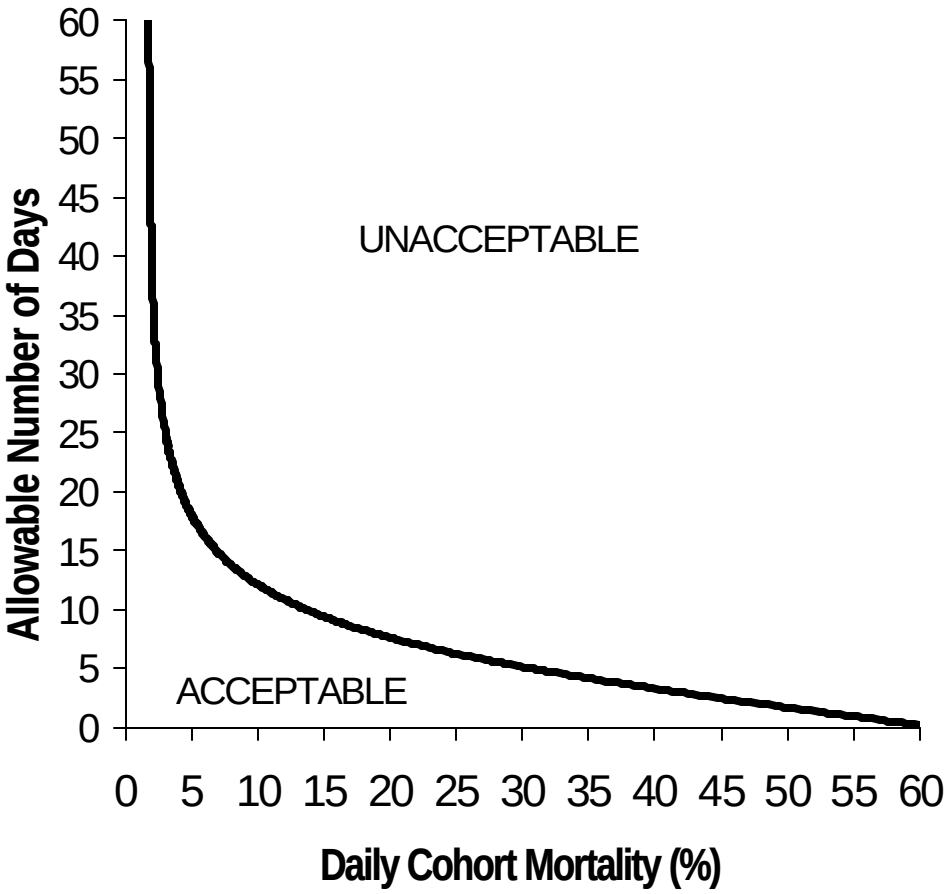
Short Term Limits for Juveniles/Adults



Short Term Limits for Larvae



Larval Protection Limits



Are the available data sufficient?

1) Are the beginning and end of seasonal hypoxia well represented (e.g., Is there a well documented gradual decline from 4.8 mg/L or more to a representative minimum, and a well-documented re-aeration in late summer or early autumn?)

2) Do the available data closely approximate likely minimum conditions (e.g., taken from the hottest, calmest, cloudy days of the summer).

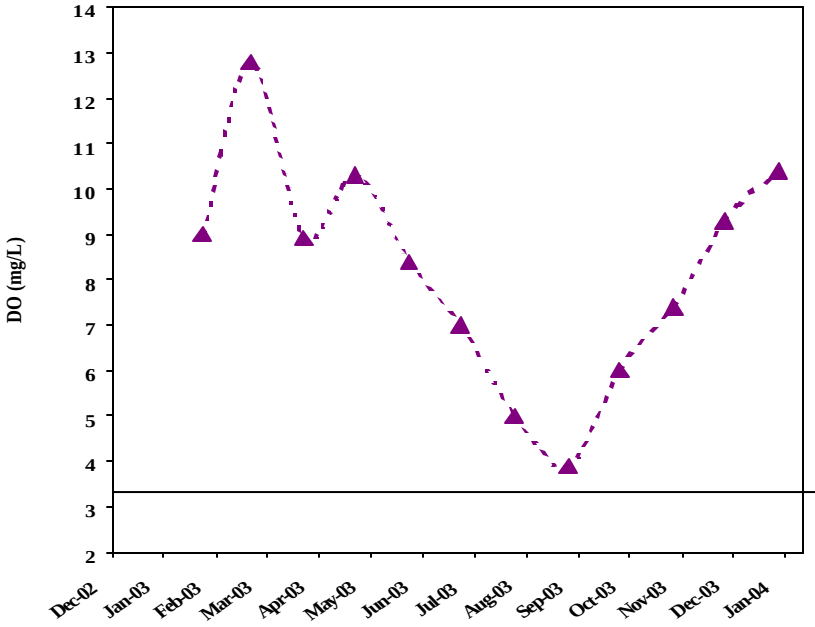
3) Is it possible to characterize the short-term variation in DO, and Its potential periodicity (i.e, tidal, diel and weather-driven dynamics)?

4) If data are not available for each year (e.g., three or five year monitoring cycle), do the data represent a season of bad hypoxia (generally associated with wet spring and a hot, calm summer)?

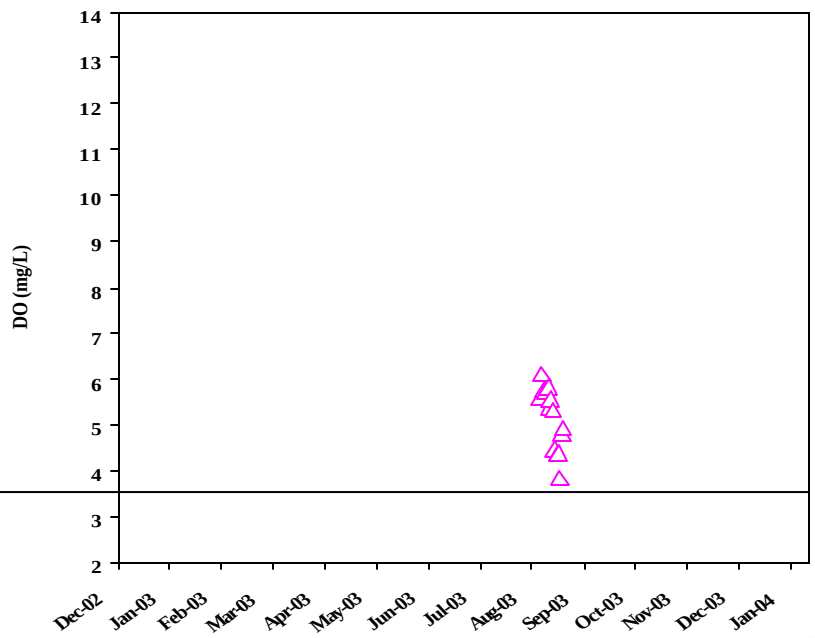
Are the available data sufficient?

1) Are the beginning and end of seasonal hypoxia well represented (e.g., Is there a well documented gradual decline from 4.8 mg/L or more to a representative minimum, and a well-documented re-aeration in late summer

Data from daytime grabs:



Beginning and end represented: Yes



Representative minimum: Yes

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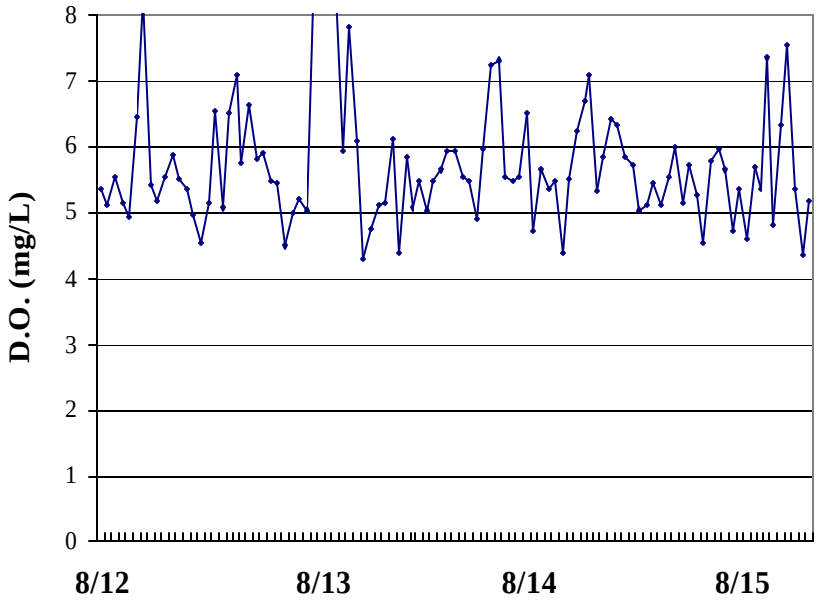
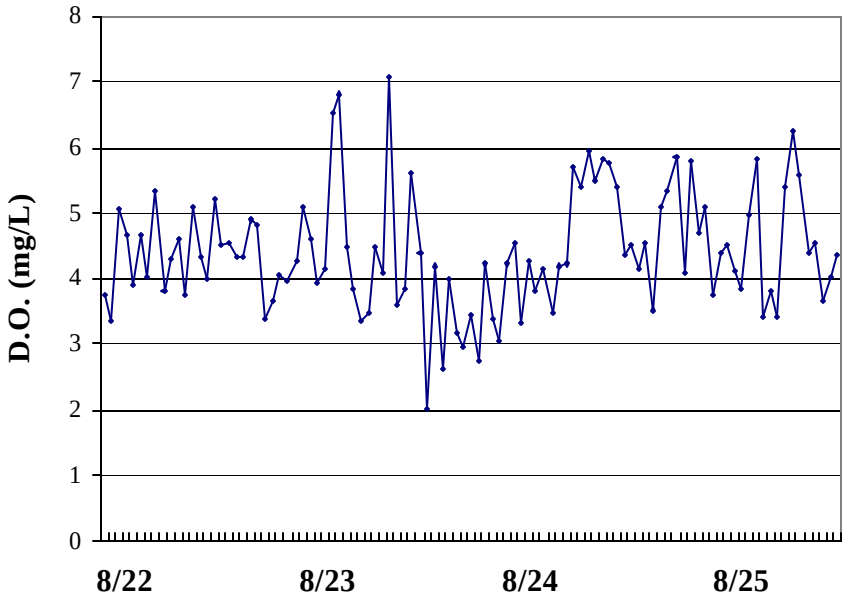
Are the available data sufficient?

2) Do the available data closely approximate likely minimum conditions (e.g., taken from the hottest, calmest, cloudy days of the summer)?



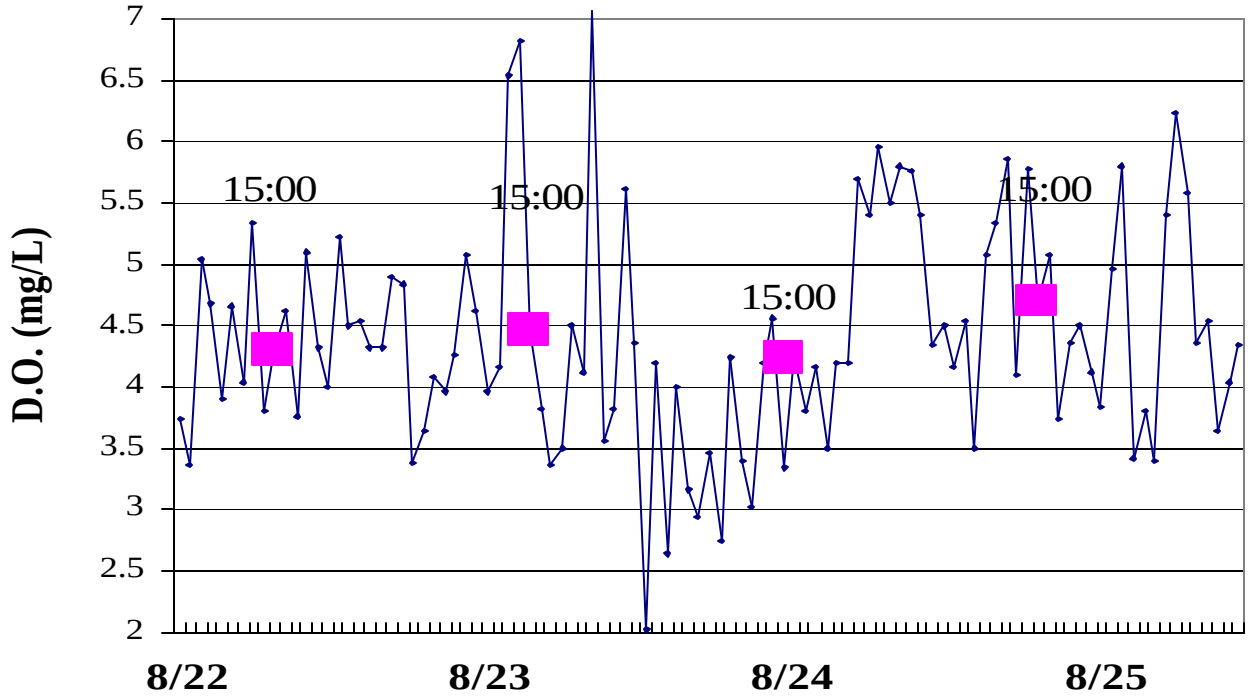
Near Minimum: No



Near Minimum: Yes

Are the available data sufficient?

3) Is it possible to characterize the short-term variation in DO, and its potential periodicity (i.e, tidal, diel and weather-driven dynamics)?



Short term variance requires simulation or estimation when data are lacking

Are the available data sufficient?

4) If data are not available for all years, do existing data represent relatively severe hypoxia (generally associated with wet spring and a hot, calm summer, extreme tide)?

Multiple years data:

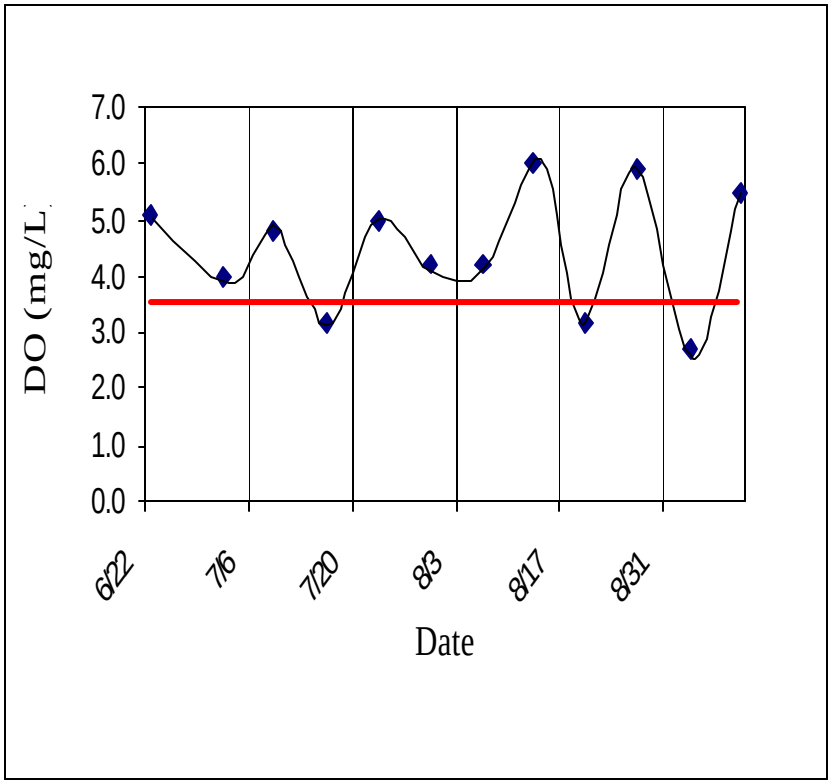
Duration of Low D.O. (days) LIS Oyster Bay*			
DO (mg/L)	1987	1988	1991
4-5	60	96	31
3-4	54	78	22
2-3	34	35	10
1-2	22	14	3
< 1	0	0	0
Total Days	170	223	66

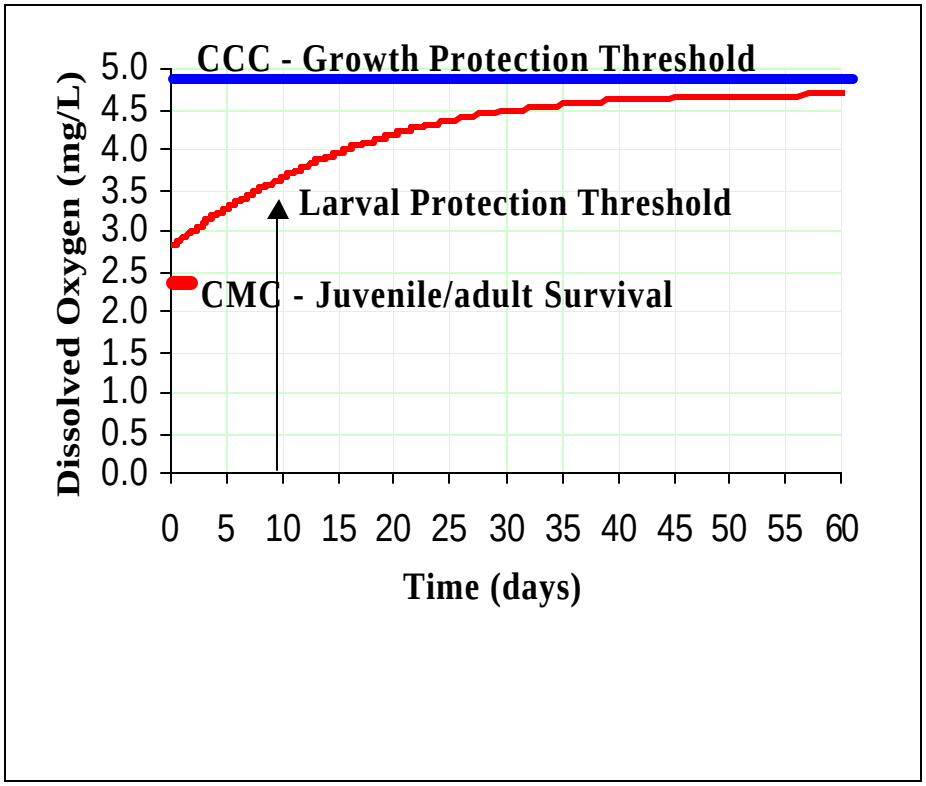
Single year data:

Duration of Low D.O. (days) LIS Greenwich, CT*	
DO (mg/L)	1987
4-5	64
3-4	57
2-3	35
1-2	29
< 1	0
Total Days	185

Use similar site data when available, to gage severity. Otherwise, use weather and local knowledge.

Handling Low Resolution Data Sets





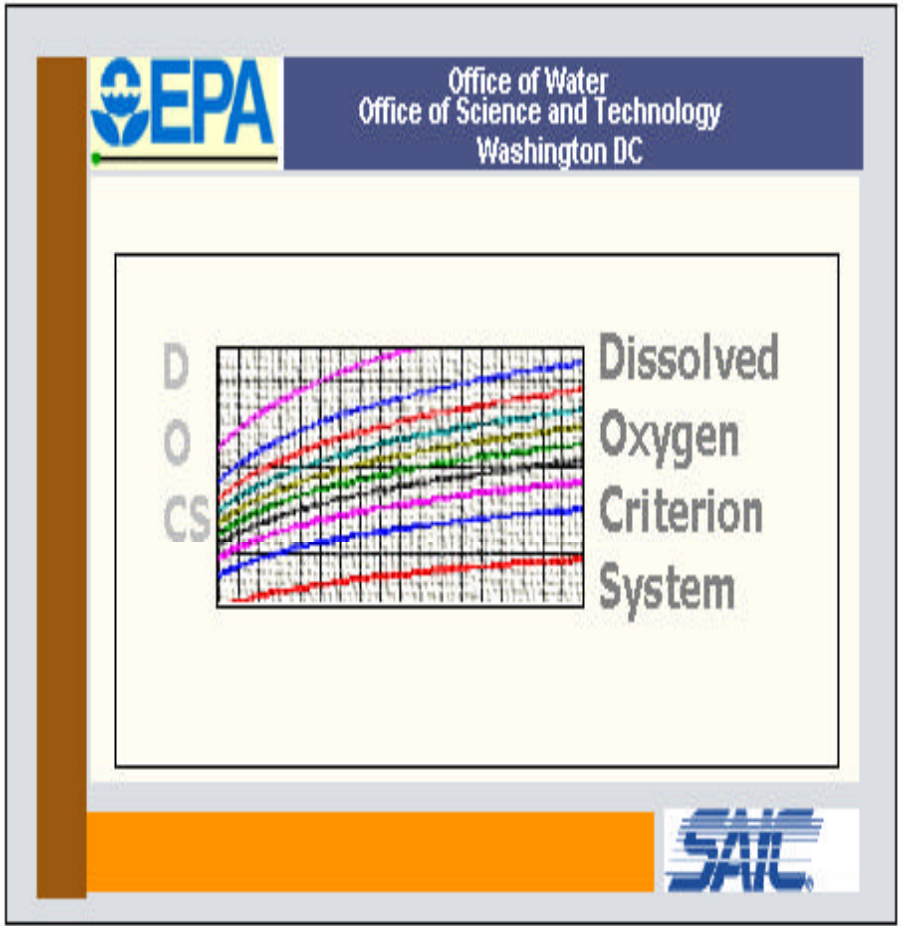
9 days < 3.5 mg/L

Criteria not attained

6-7 days < 3.5 mg/L = Criteria Limit

Data Synthesis and Application of the Criteria

Software to interpret data and conduct sensitivity analyses



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What site-specific methods are applicable to the VPDO criteria?

Standard site-specific criteria derivation methods (U.S. EPA 1994)

1) ‘Recalculation Procedure’

   Deletion or addition resident species to recalculate CMC and CCC

2) ‘Indicator Species Procedure’

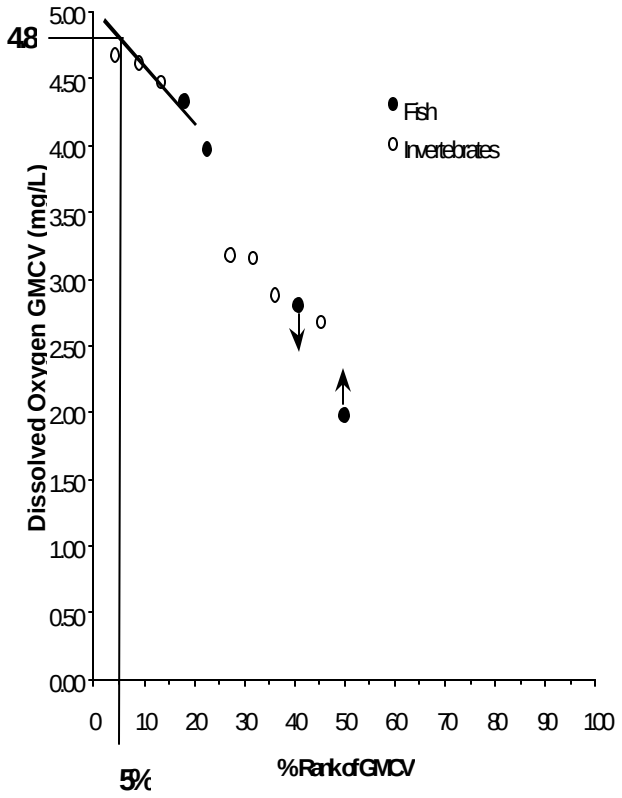
   Test one fish and one invertebrate under site conditions (e.g., temp)

3) ‘Resident Species Procedure’

   Test both the potential difference in sensitivity of a local population, and the potential influence of water quality characteristics- Generally not practical for D.O.

Species List for Site-Specific Recalculations

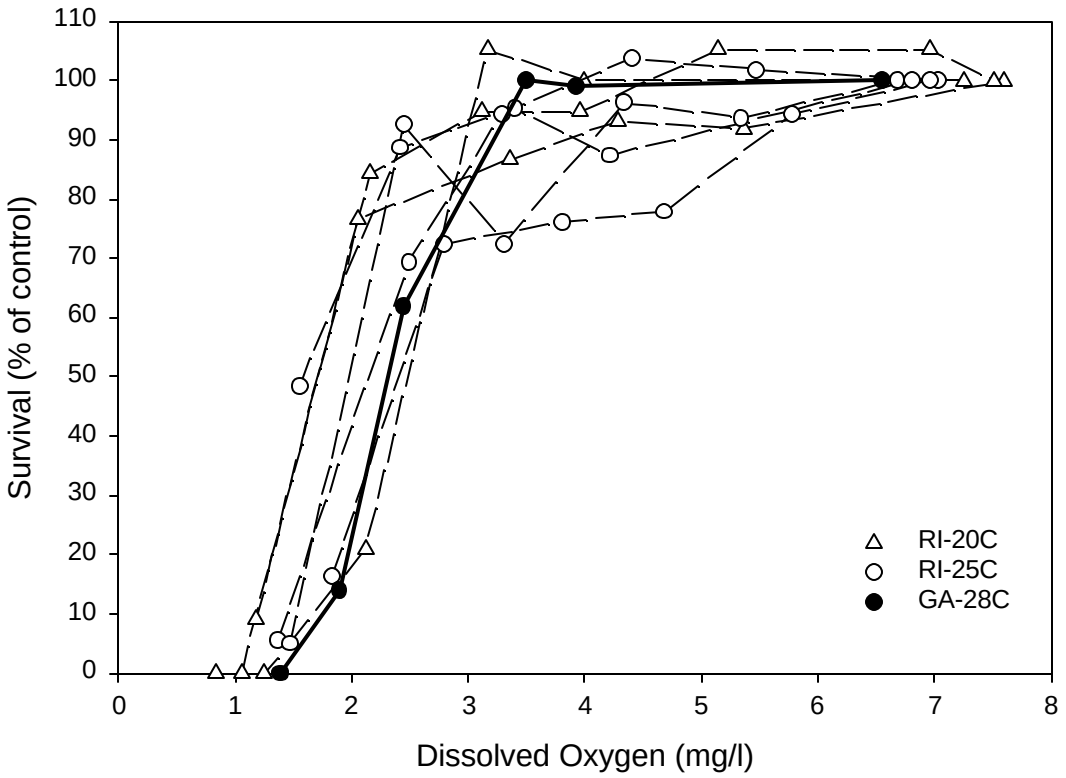
Ranked Sensitivity	Common name	Genus Mean Chronic (growth) Value in mg/L
1	Longnose spider crab	4.7
2	Sayi mud crab	4.7
3	American lobster	4.5
4	Summer flounder	4.0
5	Atlantic silverside	3.3
6	Hardshell clam	3.2
7	Grass shrimp	3.2
8	Atlantic rock crab	2.9
9	Striped bass	2.8
10	Mysid	2.7
11	Sheepshead minnow	2.0



Information for Indicator Species Adjustments

Temperature Dependence Evaluated

Dyspanopeus sayi Larvae



from Coiro et al., 2002

Endangered, threatened and commercially important species

"If data indicate that a site-specific criterion would not adequately protect a critical species (e.g., threatened or endangered), the site-specific criterion probably should be lowered" (for chemicals; hence raised for D.O.).

For sturgeon:

CMC = 3.2 mg/L @ 26 ºC

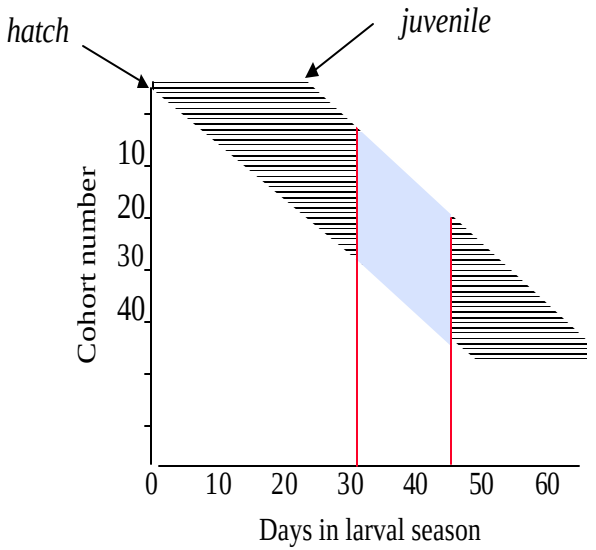
CMC = 4.3 mg/L @ 29 ºC

(based on Campbell and Goodman, 2003; Secor and Gunderson,1998)

Site-specific Parameters for the Larval Recruitment Criteria

1) Duration of the larval season;
2) Duration of the larval development time for individual larvae; and

3) Percentage of larvae that are distributed into hypoxic bottom waters



Steps for Nutrient TMDL Development

Assessment

- Apply site specific modifications
- Collect current monitoring information
- Compliance Assessment
- Spatial Analysis
- Source identification and quantification
- Model simulations of nutrient reduction
- Work from watershed scale to small scale
- Conduct parallel assessment with nutrient Criteria approach

Management

- Apply most restrictive criteria and/or weight of evidence, dependent on uncertainties
- Conduct cost-benefit analyses and optimize remedial benefits
- Consider effective use of ‘exchange ratios’
- Develop and revise plans on a regular review cycle or as new information becomes available

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Effective Uses of the VPDO Criteria

Improve Comparative Assessments:

- Three criteria approach integrates temporal variation for
  - Sites with differing types of cycles and periodicities.
  - Inter-annual variability or trends in sites as well as whole systems.

Evaluate technology relative to results:

- Interpret end of the pipe to watershed-based estuarine water quality model output

Improve monitoring strategies:

- Design monitoring to improve resolution of assessments.

Issues Raised through Preliminary Applications of the VPDO Criteria

- When should site specific modifications be applied?
- What approach will improve trend analyses for assessment programs such as EMAP, MAIA- focus on continuous monitoring stations?
- How can the D.O. Criteria and Nutrient Criteria work jointly for better management of nutrient problems?
- What other assessment models would improve D.O. assessments
  - (e.g. incorporate benthic effects)?
- How can a D.O. risk-framework improve management of degraded systems?

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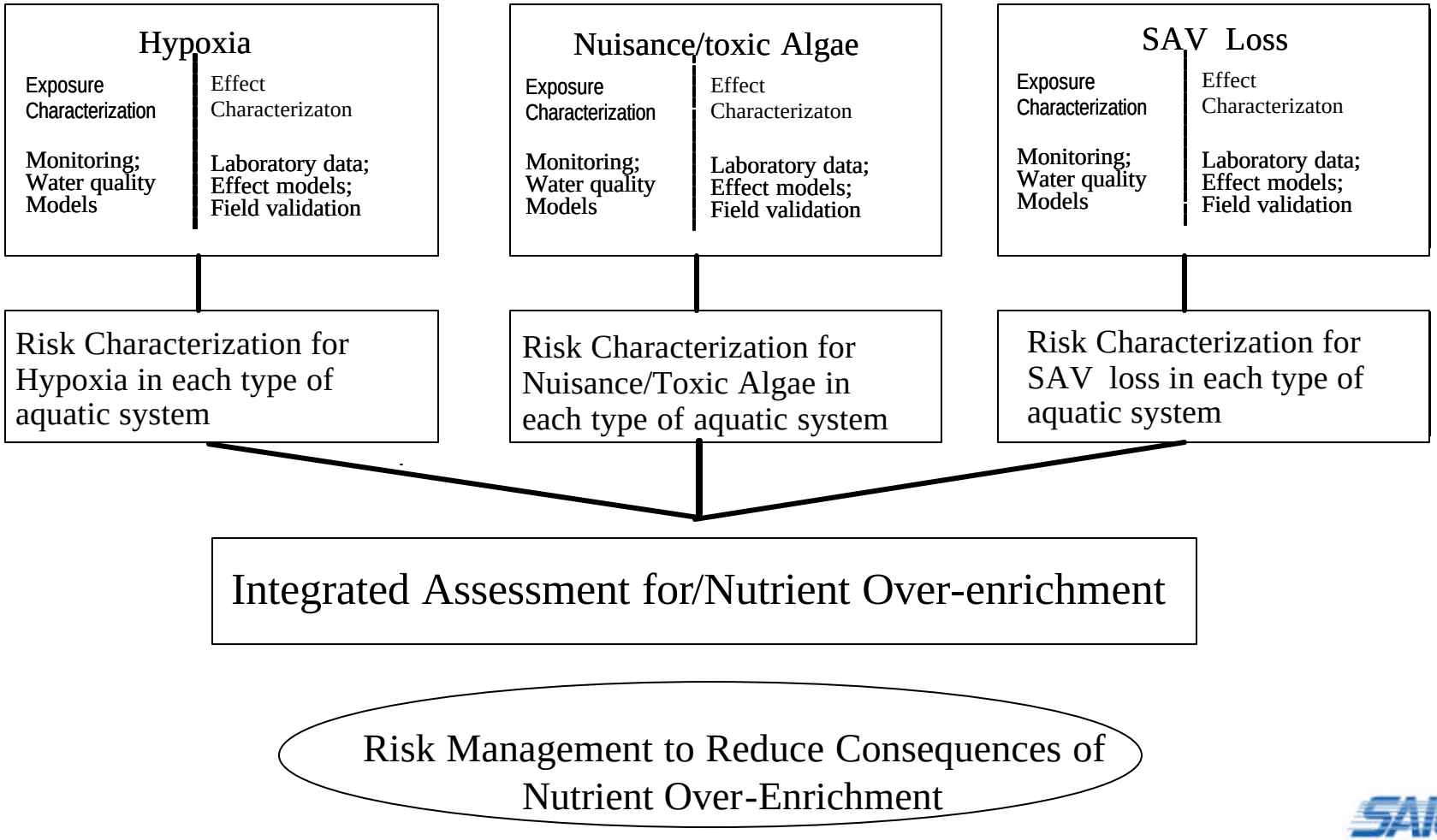
Problem Formulation for Assessment of Nutrient Over-Enrichment in Aquatic Systems



Advantages and Disadvantages of DO Criteria for Nutrient Management

Advantages:

- Laboratory study based aquatic life criteria (derived from controlled single-parameter stress conditions)
- Integrate short-term and seasonal variability of measured/modeled concentrations- precise assessment uses all available data
- Can be applied to model output associated with nutrient reduction scenarios

Limitations:

- May have data-intense requirements to be accurate
- Requirements of benthic infauna have not been addressed

Assessments also needed for:

- SAV
- Harmful algal blooms

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