Coastal and Marine Dissolved Oxygen Criteria in Massachusetts: Stakeholder Outreach Meeting

May 14, 2019
MassDEP's Central Regional Office
Worcester, MA

May 15, 2019
John W. McCormack Building
Boston, MA

TETRA TECH, INC.

MassDEP
Commonwealth of Massachusetts
Department of Environmental Protection

NORMANDEAU
environmental consultants

Surface Water Quality Standards Disclaimer

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Agenda for Today

- Welcome, Meeting Goals, and Introductions
- Review of Marine Dissolved Oxygen (DO) Criteria:
  - Phases I, II and III
- Water Quality Criteria Terminology
- Details of MassDEP's Marine DO Criteria Review
- Q&A

Meeting Goals

- MassDEP has been conducting a multi-phase three-year review of our marine DO criteria
- Today we are here to:
  - Present the work conducted to date
  - Present the preliminary outcome of the criteria review
  - Hear your feedback

Project Team

- MassDEP
  - **Lealdon Langley, Kimberly Groff, Richard Carey and Anna Mayor**
- TetraTech, Inc.
  - **Benjamin Jessup and Jennifer Flippin**
- Normandeau and Associates, Inc.
  - **Debbie Rutecki and Harry Stewart**

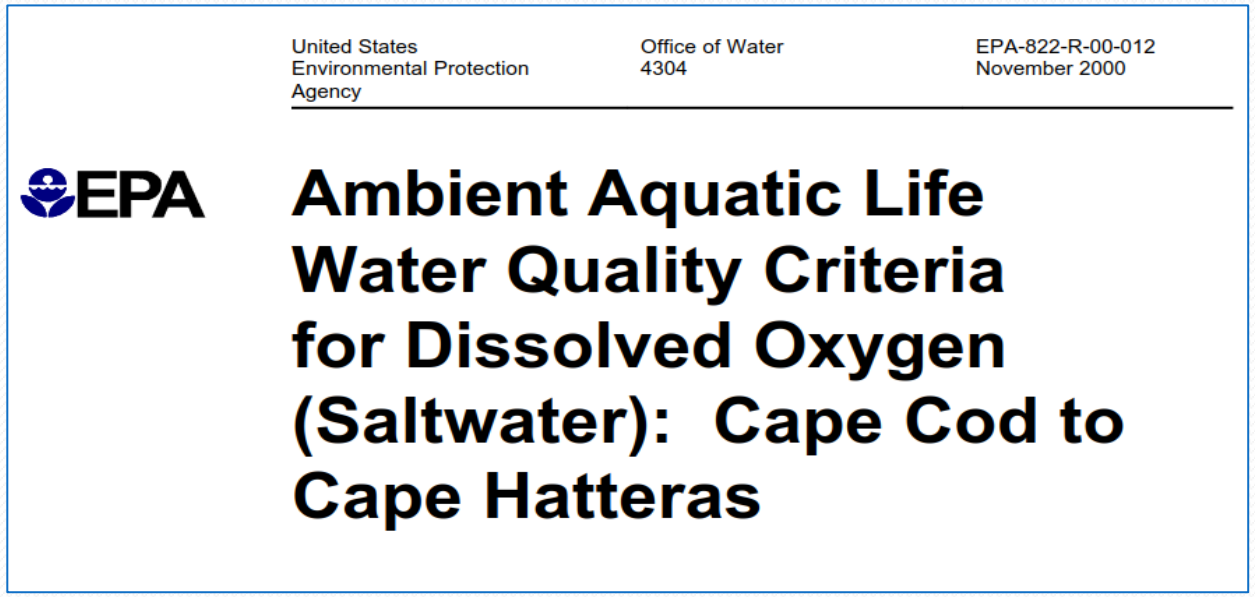
Technical Advisory Committee (TAC)

Name	Affiliation
Ralph Abele	EPA R1
Dan Arsenault	EPA R1
Phil Colarusso	EPA R1
Jim Hagy	EPA
Ivy Mlsna	EPA R1
Brenda Rashleigh	EPA
Toby Stover	EPA R1
Jeanne Voorhees	EPA R1
Paul Stacey	Footprints In The Water LLC
Todd Callaghan	MA Coastal Zone Management
John Logan	MA Department of Fish and Game
Jane Sawyers	RIDEM
Heidi Travers	RIDEM
Candace Oviatt	URI
Heather Stoffel	URI
Peter Tango	USGS Chesapeake Bay

The TAC provides expertise regarding available data, reviews deliverables and reports, and provides recommendations for developing criteria

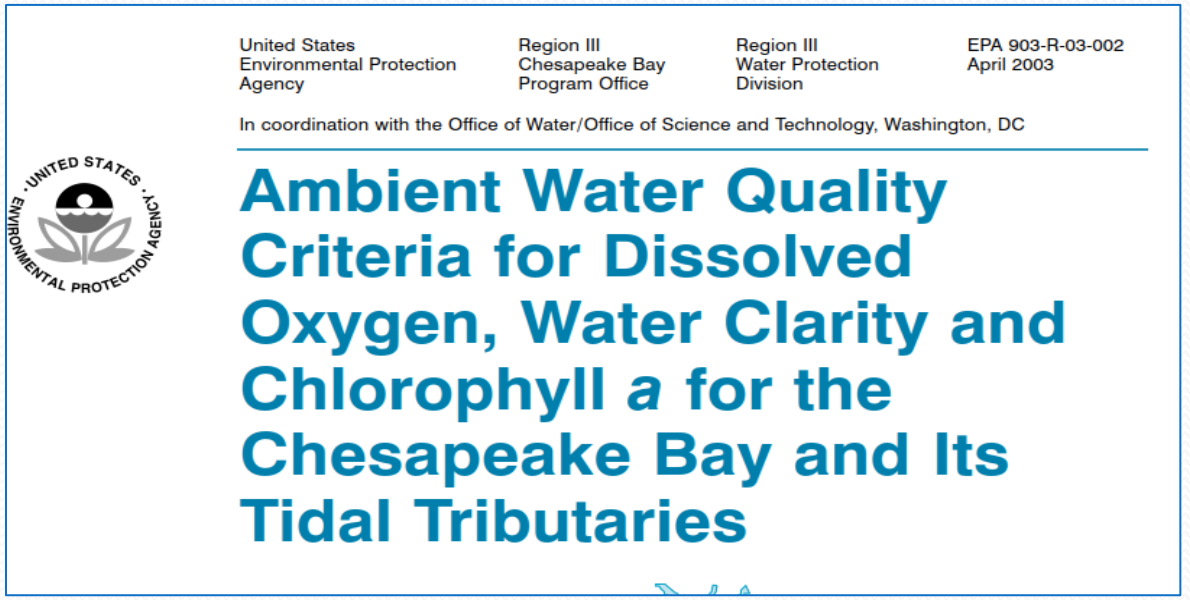
MA Coastal and Marine DO Criteria Review: Overview of Phases I, II and III

Why Review Marine DO Criteria in MA?


United States Environmental Protection Agency | Office of Water 4304 | EPA-822-R-00-012 November 2000

EPA

Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras


United States Environmental Protection Agency | Region III Chesapeake Bay Program Office | Region III Water Protection Division | EPA 903-R-03-002 April 2003

In coordination with the Office of Water/Office of Science and Technology, Washington, DC

Ambient Water Quality Criteria for Dissolved Oxygen, Water Clarity and Chlorophyll *a* for the Chesapeake Bay and Its Tidal Tributaries

- **2000**: EPA published guidance for developing DO criteria in saltwater from Cape Cod to Cape Hatteras
- **2003**: EPA published DO criteria refinements for the Chesapeake Bay and its tidal tributaries

Why Review Marine DO Criteria in MA?

- CT, NY, and RI updated their DO criteria for saltwater based on EPA (2000)
  - Specify numeric acute and chronic values
  - DO can occasionally fall below the chronic value if it does not exceed a specified duration and remains above the acute value
- MA has not updated coastal and marine DO criteria based on EPA (2000)
- As a part of our multi-phase DO criteria review, we evaluated EPA's recommended marine DO criteria and alternate approaches

Marine DO Criteria Review: Phases I, II and III

- **Phase I (2016 – 2017)**
  - Technical Advisory Committee (TAC)
  - Delineated Pilot Study Area
  - Reviewed Available Approaches
  - Developed Species List
  - Derived Draft Criteria Magnitude Options
  - Submitted a Draft Report to the TAC
- **Phase II (2017 – 2018)**
  - Received & Addressed Phase I Comments from the TAC
  - Reviewed responses with the TAC
  - Expanded Review Statewide
  - Refined Draft Criteria Magnitude Options
  - Revised Draft Report
- **Phase III (2018 – 2019)**
  - Refine Draft DO Criteria (Magnitude, Duration and Frequency)
  - Refine Draft Assessment and Monitoring Framework
  - Receive & Address TAC Feedback
  - Present to Stakeholders
  - Consultants Submit Draft Report to MassDEP

MassDEP Commonwealth of Massachusetts Department of Environmental Protection

United States Environmental Protection Agency

USGS science for a changing world

Commonwealth of Massachusetts Department of Fish & Game

The University of Rhode Island Graduate School of Oceanography

Tetra Tech, Inc.

Normandeau environmental consultants

CZM

DEM Rhode Island

MA Coastal and Marine DO Criteria Review: Water Quality Criteria Terminology

Designated Uses

Water quality criteria protect **designated uses**

- Management goals for the water body
- Protects aquatic life community and human health
- Chesapeake Bay example (EPA 2003)

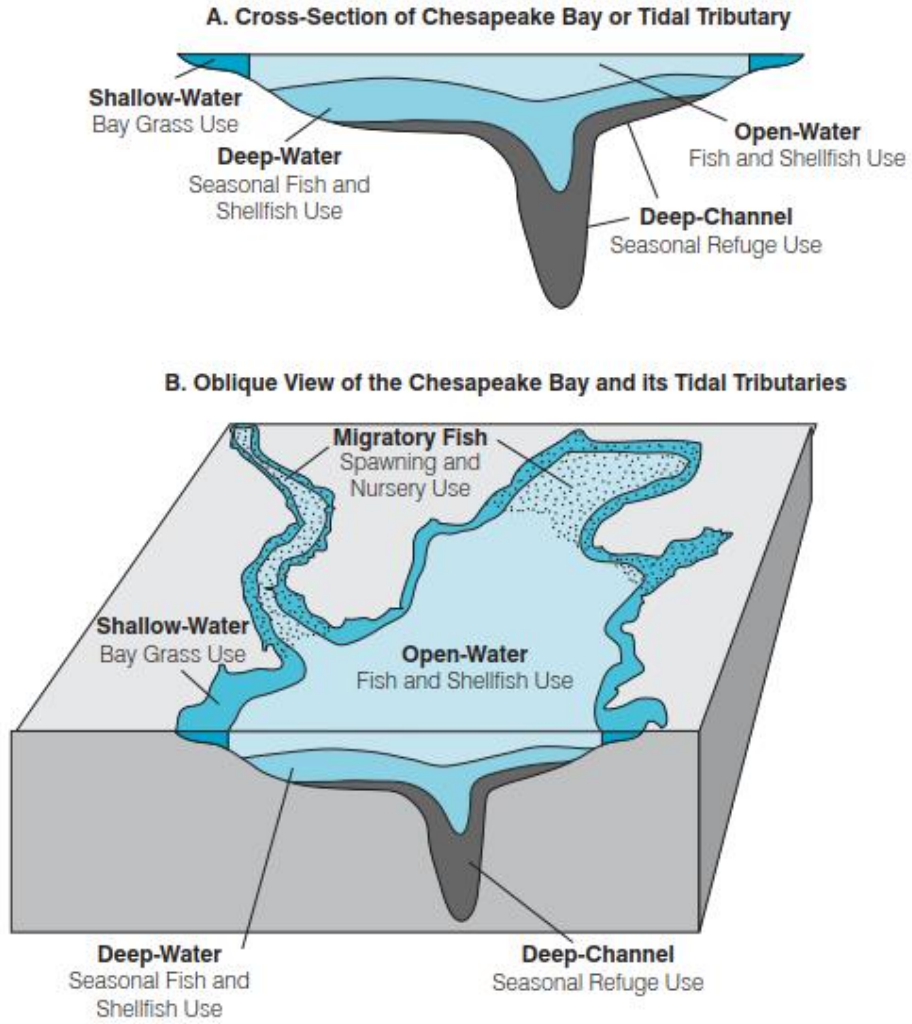


Figure 1. Conceptual illustration of the five Chesapeake Bay tidal water designated use zones.

Key Features of Water Quality Criteria

- Criteria **magnitude** (numeric values):
  - **Acute** magnitude -- protective of adverse short-term exposures
    - Lethality
  - **Chronic** magnitude -- protective of adverse long-term exposures
    - Growth and reproduction
- **Duration** – time frame to evaluate an exceedance of each criterion
- F**requency** -- allowable number of exceedances of each criterion

MA Surface Water Quality Standards

- Current marine DO criteria (314 CMR 4.00):
  - **<u>Class SA</u> -- DO shall not be less than 6.0 mg/l.** Where natural background conditions are lower, DO shall not be less than natural background. Natural seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained.
  - **<u>Class SB</u> -- DO shall not be less than 5.0 mg/l.** Seasonal and daily variations that are necessary to protect existing and designated uses shall be maintained. Where natural background conditions are lower, DO shall not be less than natural background.

Criteria Terminology: Use and Magnitude

- **314 CMR 4.00 contains instantaneous minimum magnitudes for DO to maintain water quality for designated uses. Marine surface waters are designated the following two classes in MA:**

- **Class SA:**
  - **USE**: an excellent habitat…for…aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions…
  - **MAGNITUDE**: dissolved oxygen not less than 6.0 mg/L
    (or not less than natural background; maintain natural variations)
- **Class SB:**
  - **USE**: a habitat…for…aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions…
  - **MAGNITUDE**: dissolved oxygen not less than 5.0 mg/L
    (or not less than natural background; maintain natural variations)

Criteria Duration

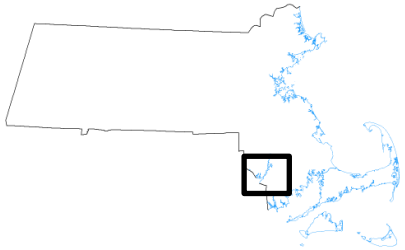
- **EPA recommends aquatic life criteria include a duration:** exposure time period over which measurements are to be averaged
- "[I]t is the purpose of the averaging period to allow concentrations above the [criteria] only if the total exposure will not cause any more adverse effect than continuous exposure to the [criteria] would cause." (EPA PB85-227049, 2010)
- Examples:
  - EPA-recommended averaging periods for toxics:
    - acute exposures -- average concentration over 1 hour
    - chronic exposures -- average concentration over 4 days (Source: EPA Water Quality Standards Handbook, Chapter 3)
  - Virginian Province Approach for marine DO (EPA 2000 guidance):
    - acute exposures – 24-hour continuous; can be used for shorter durations (conservative)
    - chronic exposures – applicable to any duration (but toxicity test duration range = 4-29 days)

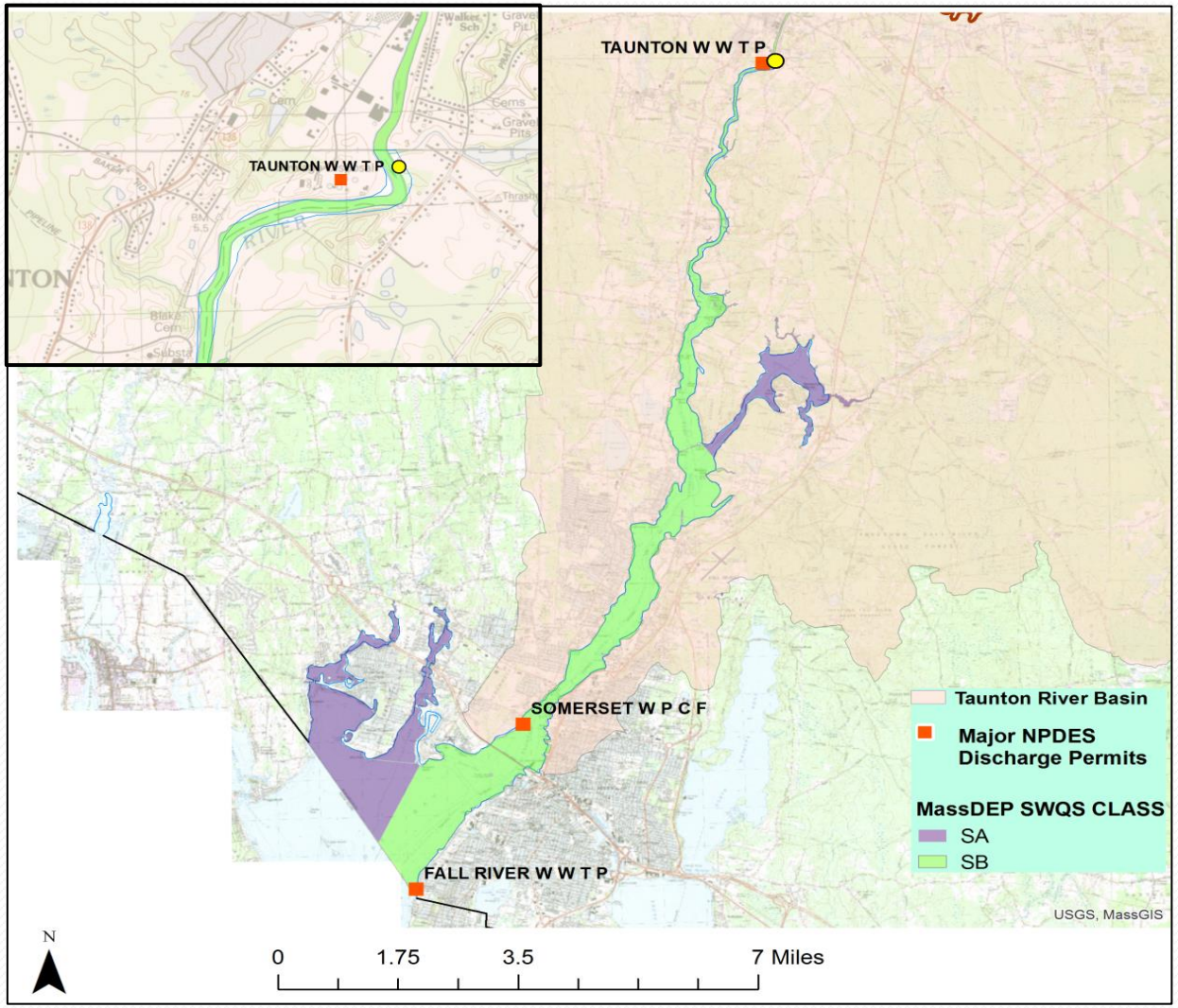
Criteria Frequency

- EPA: it is necessary to specify the allowable **frequency** for exceeding the criteria. EPA recommends an average exceedance frequency for both acute and chronic criteria of no more than one exceedance in 3 years (Source: EPA Water Quality Standards Handbook, Chapter 3)
- EPA 2000 DO guidance does not recommend an exceedance frequency
- RI: "not less than an instantaneous value of 4.8 mg/l more than once every 3 years" exceedance frequency for marine surface water DO (waters above a seasonal pycnocline). Below the pycnocline = more complex

MA Coastal and Marine DO Criteria Review: Phases I and II

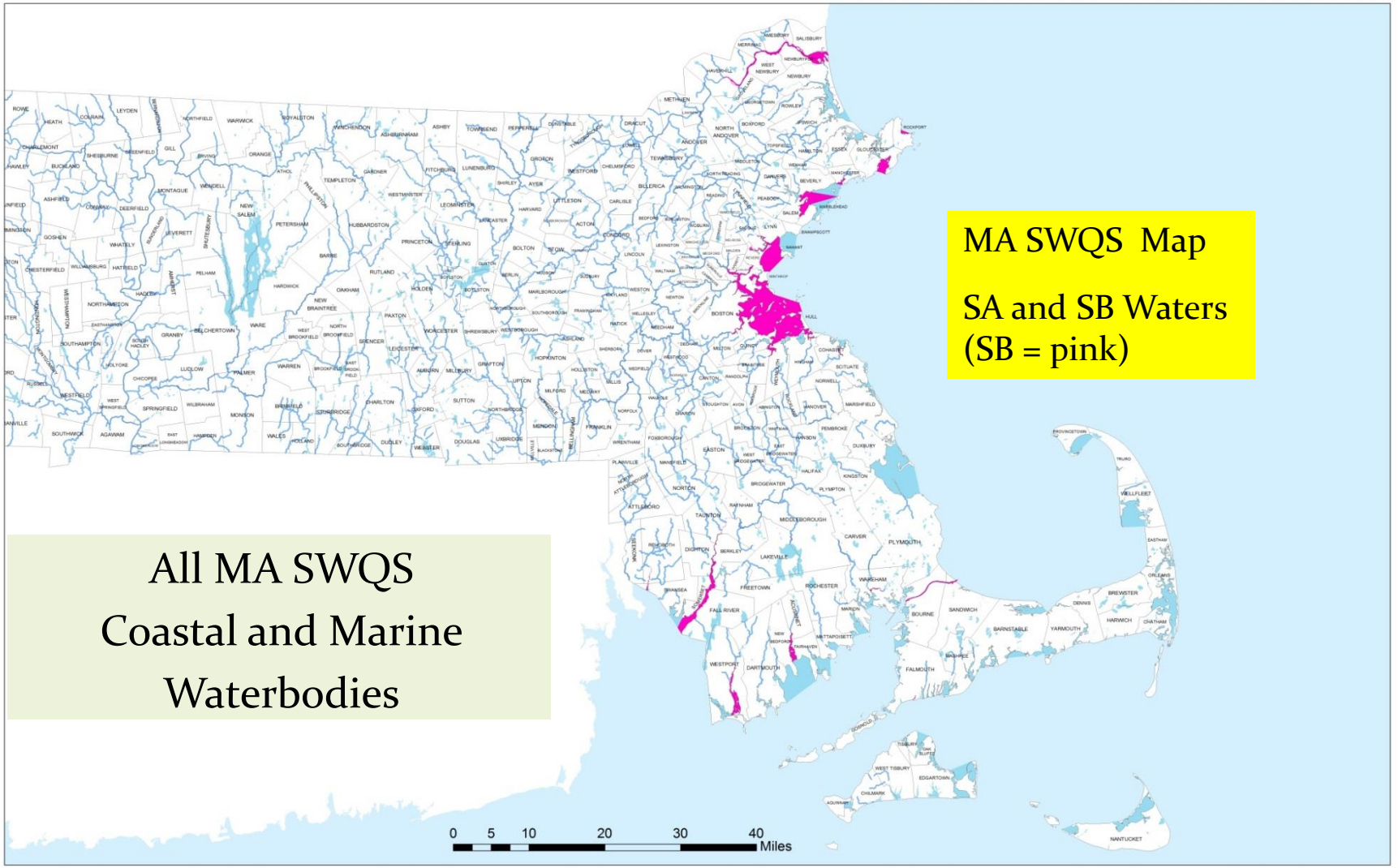
Study Area: Phase I





Mount Hope Bay and Taunton River Estuary

Study Area: Phases II and III



MA Coastal and Marine DO Criteria Review: Phases I and II Approaches Considered

Five Approaches Were Considered

1) **Reference Condition Approach**
   - Uses monitoring data from sites that are undisturbed or minimally-disturbed; data are used to calculate criteria that account for naturally occurring DO concentrations in waterbodies
   - Lack of data to determine appropriate values that represent minimally disturbed conditions

2) **Alignment with Marine DO Criteria of Neighboring States**
   - Numeric values were developed prior to newest National Marine Fisheries Service DO recommendations for sturgeon

3) **Chesapeake Bay Approach (EPA 2003)**
   - Increased monitoring complexity and lack of data to create biologically meaningful habitat designations

4) **Virginian Province Approach (EPA 2000)**

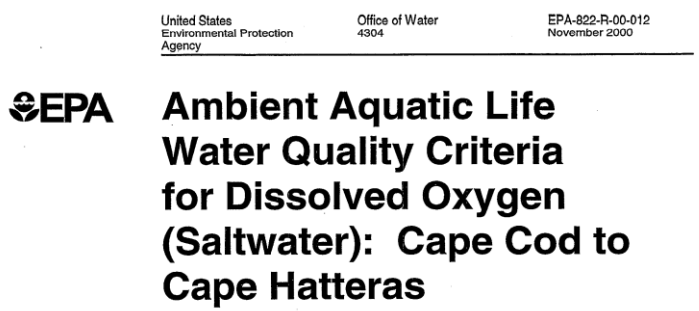
5) **Modified Virginian Province Approach**

MA Coastal and Marine DO Criteria Review: Phases I and II Virginian Province Approach

Virginian Province Approach (EPA 2000)

- **Method for developing DO criteria that is similar to that used for developing toxics criteria**
  - **Laboratory data** that produces LC50 values (**lethality**) and selected No Observed Effect Concentration/Highest Observed Effect Concentration value endpoints (**growth,** reproduction, etc.)
  - Relies primarily on the **4 most sensitive species** for which data are available and the total number of genera with data available

- Used to derive site specific water quality criteria for DO **using only the data for genera or surrogate species relevant to the study area**.


United States Environmental Protection Agency | Office of Water 4304 | EPA-822-R-00-012 November 2000

EPA

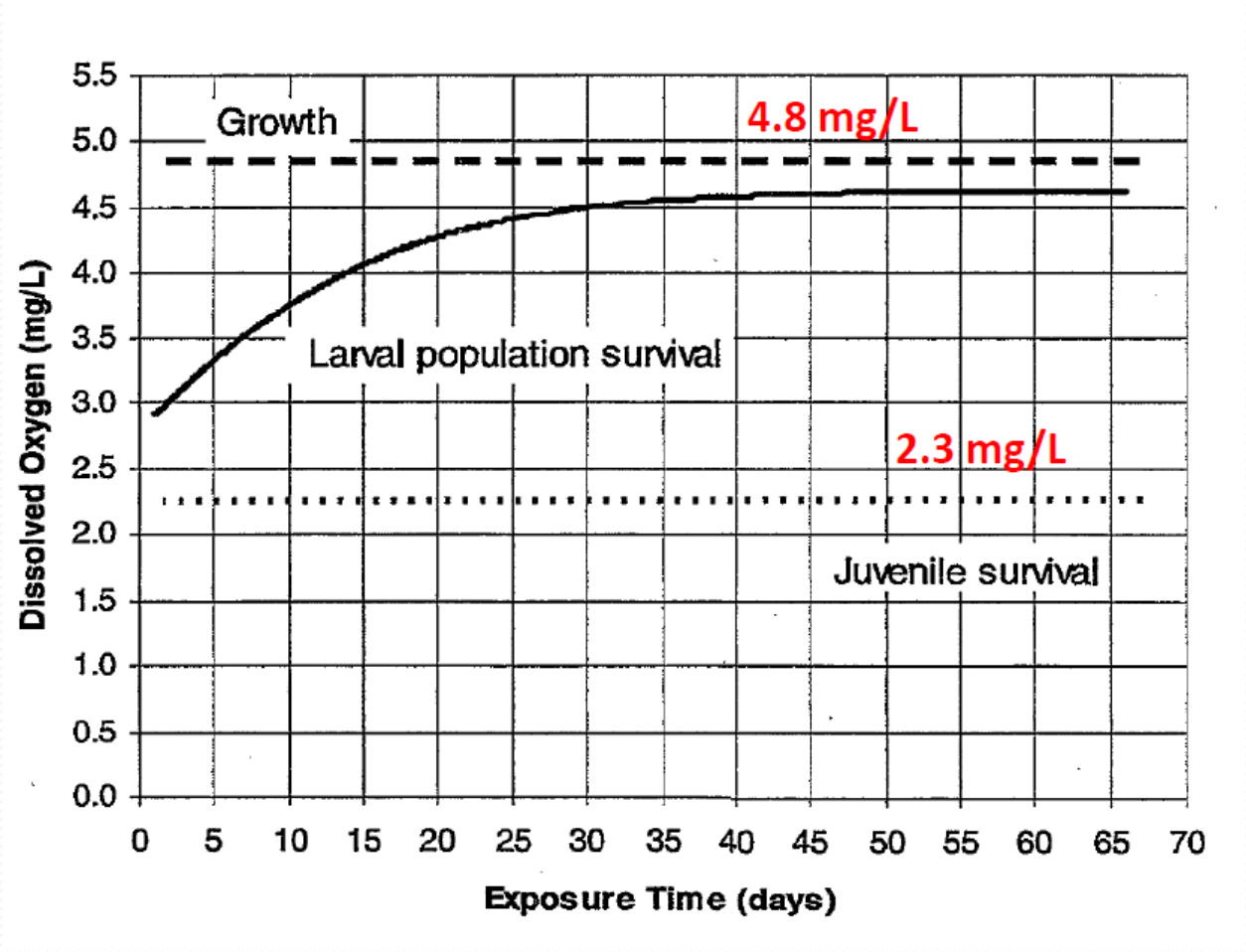
Ambient Aquatic Life Water Quality Criteria for Dissolved Oxygen (Saltwater): Cape Cod to Cape Hatteras

Virginian Province Approach (EPA 2000)

A map of the Virginian Biogeographic Province (Pelletier et al. 2010).

- Uses laboratory derived toxicity values to establish DO criteria protective of coastal and estuarine organisms
  - **Criterion Minimum Concentration (CMC)**
    - Minimum acceptable DO value that is not expected to cause lethality in young/sensitive life stages of aquatic organisms. Generally applied to a 24 hour period.
  - **Criterion Continuous Concentration (CCC)**
    - Not expected to cause chronic growth effects in aquatic organisms. Generally applied to a 4-30 day period.
  - **Larval Recruitment Curve**
    - A value that describes DO concentration that is expected to cause minimal lethality to larval populations. Results time dependent; a curve that allows the lowest DO concentrations for short durations and increased DO concentrations for longer durations.

Example:
Virginian Province Approach (EPA 2000)



Applying the Virginian Province Approach

- **Develop list of species present in the waterbody of interest**
  - Fish and invertebrates
  - Include seasonal residents, anadromous species, and species that use the area for spawning or other life stages
- **Identify previously reported toxicity values;** search literature for newly generated toxicity values (generally limited to about 30 species with appropriate data; fewer when applied site-specifically)
- Identify local species for which acute or chronic growth data are available
- Identify potential surrogate species to match DO data with local species
  - Genus level, family level
- **Identify four most sensitive endpoints for acute and chronic**
- **Calculate potential DO objectives (CMC, CCC, Larval Recruitment Curve)**

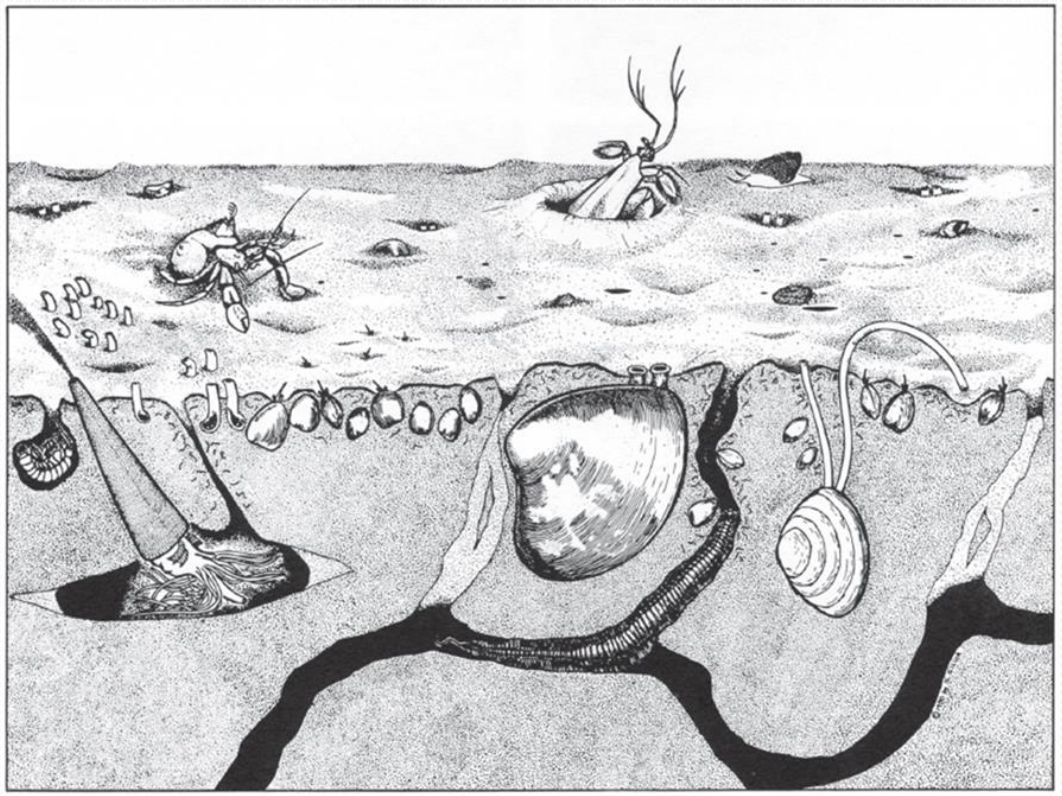
MA Coastal and Marine DO Criteria Review: Phases I and II
Modified Virginian Province Approach
Massachusetts Species Considerations

MA Marine DO Criteria: Species Considerations

- Refinement of MA marine DO criteria requires an understanding of local species
- MA waters have diverse biological communities and provide habitats for northern boreal, subtropical, and tropical species over an annual cycle
- For Mount Hope Bay and the Taunton River, publicly available literature was reviewed and 81 relevant species were identified (Phase I)
  - Commercial and recreational fish and shellfish
  - Ecological important species – e.g., prey species for fish, birds, and seals
  - Endangered and threatened species
- DO toxicity studies for these species were reviewed
- For statewide application, an additional 12 species were considered (Phases II and III)

MA Marine DO Criteria: Species Considerations

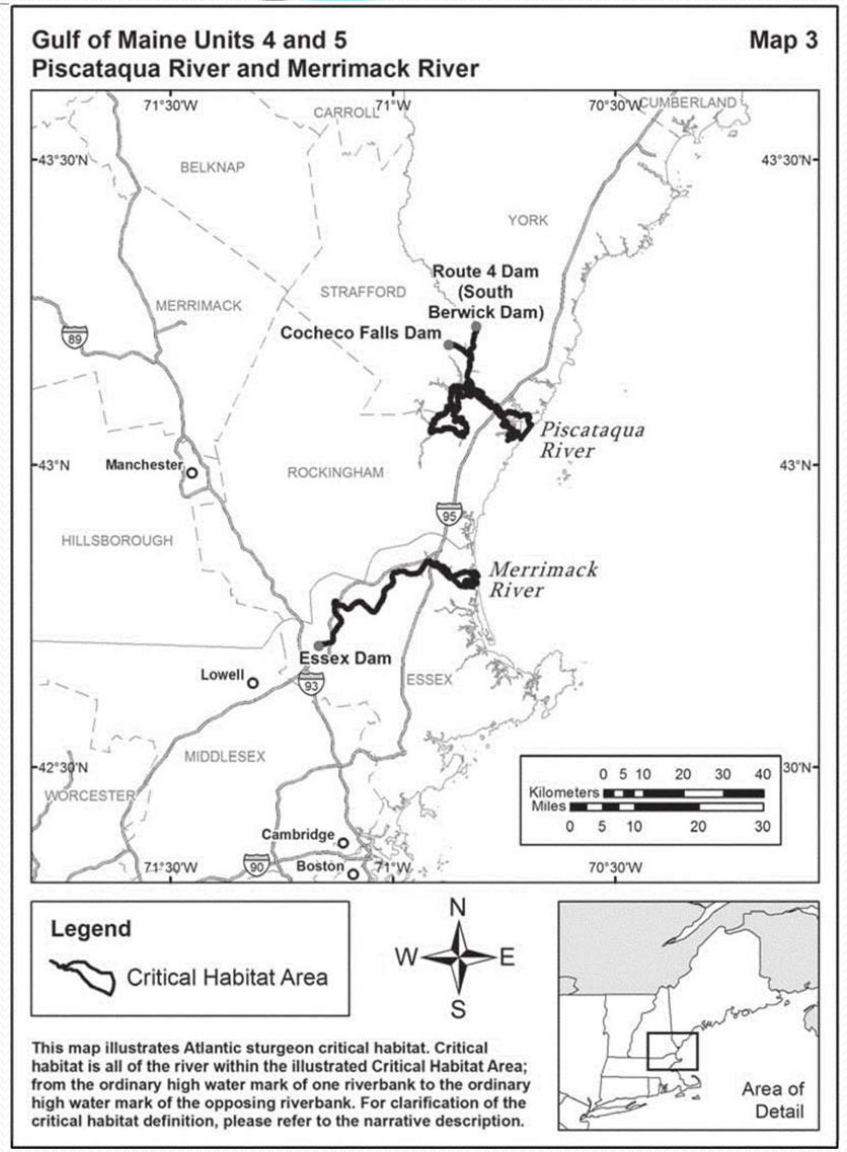
- Information reviewed for the relevant species included:
  - Life stages
  - Habitat
  - Occurrence
  - Importance
- Species selected for further focus depended on available DO data



Source: Olsen et al. 1984

MA Marine DO Criteria: Sturgeon Considerations

- The MA Division of Fisheries & Wildlife, Natural Heritage & Endangered Species Program, has identified sturgeon populations in the state
- MA waters contain two state and federally-listed endangered sturgeons, Atlantic Sturgeon (AS) and Shortnose Sturgeon (SNS)
- AS and SNS are bottom-dwelling species that feed in benthic (bottom) habitat
- Due to their sensitivity to low DO and endangered status, DO requirements for sturgeon were carefully reviewed



(Source: 82 FR 39160)

MA Marine DO Criteria: Sturgeon Considerations

- The Taunton River and Narragansett Bay are considered foraging habitat for subadult and adult life stages of AS (GARFO 2018a)
- The Merrimack River is designated critical habitat for AS of the Gulf of Maine distinct population segment and contains a spawning population of SNS (82 FR 39160, Kieffer and Kynard 1996, SSSRT 2010)
- The literature contains multiple endpoints, and non-lethal DO concentrations range between 3.0 mg/L and 6.0 mg/L at temperatures of ≤22 °C
  - Levels greater than 6.0 mg/L support optimal growth for YOY and juveniles
  - Increased mortality of for all life stages occurs at concentrations <3.0 mg/L
- **In our review, Shortnose and Atlantic Sturgeon were identified as the most sensitive species for acute and chronic impacts, respectively**

Virginian Province Approach: Test Duration

- ***Acute (Criterion Minimum Concentration [CMC] development)***
  - The duration of acute toxicity tests used to develop the CMC are between 1-4 days (24-96 hours). This suggests that the results are most applicable to understanding the adverse effects of DO experienced over a similar observed duration. The CMC is expected to protect against lethal concentrations of DO to juvenile and adult aquatic organisms because it is calculated using juvenile and adult LC50 values.
- ***Chronic (Criterion Continuous Concentration [CCC] development)***
  - The duration of chronic toxicity tests used to develop the CCC are between 4-29 days. This suggests that the results are most applicable to understanding the adverse effects of DO experienced over a similar observed duration. The CCC is expected to protect against growth effects for larval organisms because it is calculated using larval growth endpoints.

Acute DO Endpoints: Protection from Lethal Concentrations

Rank	Species	Common name	Genus	GMAV LC_5/LC_{50}	SMAV	GMAV
1	*Acipenser brevirostrum*	Shortnose sturgeon	*Acipenser*		2.41	**2.41**
2	*Harengula jaguana*	scaled sardines	*Harengula*		2.17	**2.17**
3	*Menidia beryllina*	inland silversides	*Menidia*		1.94	**1.94**
4	*Cynoscion nebulosus*	spotted seatrout	*Cynoscion*		1.88	**1.88**
5	*Trachinotus carolinus*	pompano	*Trachinotus*		1.74	**1.74**
6	*Syngnathus fuscus*	pipe fish	*Syngnathus*		1.63	**1.63**
7	*Lagodon rhomboides*	pinfish	*Lagodon*	1.17	1.61	**1.61**

Chronic DO Endpoints: Protection from Adverse Growth Effects

Rank	Species	Common name	Genus	GMCV
1	*Acipenser oxyrinchus*	Atlantic sturgeon	*Acipenser*	**4.83**
2	*Labinia dubia*	longnose spider crab	*Labinia*	**4.67**
3	*Dyspanopeus sayi*	say mud crab	*Dyspanopeus*	**4.67**
4	*Homarus americanus*	American lobster	*Homarus*	**4.47**
5	*Paralichthys dentatus*	summer flounder	*Paralichthys*	**3.80**
6	*Paralichthys lethostigma*	southern flounder	*Paralichthys*	**3.80**
7	*Menidia menidia*	Atlantic silverside	*Menidia*	**3.30**
8	*Mercenaria mercenaria*	northern quahog	*Mercenaria*	**3.17**

Calculated VPA Statewide Endpoints

- **Chronic Criterion (CCC)**
  - 4.8 mg/L
- **Acute Criterion (CMC)**
  - 3.1 mg/L (using 4 most sensitive species)
  - 3.3 mg/L (using most sensitive species, *Shortnose Sturgeon*)
  - The Species Mean Acute Value (SMAV) of a commercially or recreationally important species was higher than the calculated Final Acute Value (FAV), so the SMAV may replace a calculated FAV in order to provide protection for that important species as recommended by Stephan et al. (1985). The SMAV for *Shortnose Sturgeon* was 2.41 mg/L and thus greater than the calculated FAV, 2.3 mg/L, using the four most sensitive genera. The FAV using only *Shortnose Sturgeon* was multiplied by 1.38, the LC5 to LC50 ratio recommended in EPA 2000. This resulted in the CMC of 3.3 mg/L.

Adjustment of VPA Calculations & Endpoints

- Proposed criteria values are based on laboratory based toxicity values and field data describing avoidance of areas with low DO

- Adjustment of the calculated values was needed to be sufficiently protective and to reflect the differences between Class SA and SB waters: "excellent habitat" vs. "habitat"

Adjustment of VPA Chronic Criterion for Class SA Waters

- Calculated Chronic Criterion = 4.8 mg/L DO
- **Adjustment for SA Waters to 6.0 mg/L**
  - **Reflects the recommendation of the National Marine Fisheries Service (2017):**

    Water quality conditions, especially in the bottom meter of the water column, between the river mouths and spawning sites with temperature and oxygen values that support:

    *…Larval, juvenile, and subadult growth, development, and recruitment (e.g., 13 °C to 26 °C for spawning habitat and no more than 30 °C for juvenile rearing habitat, and **6 milligrams per liter (mg/L)** dissolved oxygen (DO) or greater for juvenile rearing habitat)….*

  - **Meets MA SWQS requirement for "excellent habitat" use**

Adjustment of VPA Chronic Criterion for Class SB Waters

- Calculated Chronic Criterion= 4.8 mg/L DO
- **Adjustment for SB Waters to 5.0 mg/L**
  - **The value is rounded to 5.0 mg/L for additional protection of species (an added "safety factor") and is consistent with other observations from primary literature:**
    - Vaquer-Sunyer and Duarte (2008) reviewed hypoxia/low DO literature and determined median sublethal concentrations as 4.41 mg/L (fish) and 3.21 mg/L (crustaceans)
    - Secor and Niklitschek (2002) suggested that bioenergetic and behavioral responses indicate that Atlantic Sturgeon (aged 30 to 200 days) experience a loss in growth in habitats with less than 60% oxygen saturation (4.3 mg/L to 4.7 mg/L at temperatures of 22°C to 27°C)
    - Moberg and DeLucia (2016) presented a relationship between recruitment observations and DO in the Delaware River indicating that during years when recruitment was observed (2009, 2011, and 2014), minimum daily DO was above 5.0 mg/L in 90% of the observations.

Adjustment of VPA Acute Criterion for Class SA Waters

- Acute Criterion = 3.3 mg/L
  - **Adjustment for SA Waters = 4.3 mg/L**
  - An additional safety factor of 1 mg/L was added for SA waters, which reflects "excellent habitat" use and is supported by observations from primary literature.

Draft Criteria Recommendations: Magnitudes

- Criteria magnitudes apply to coastal and marine waters at all depths
- Sampling the marine benthic habitat is critical to identify DO exposures

SWQS Class	Criteria Magnitude	Criteria Derivation
SA	6.0 mg/L (Chronic)	NMFS recommendation for protection of Atlantic Sturgeon
SB	5.0 mg/L (Chronic)	VPA calculation for Massachusetts waters and taxa, corroborated with avoidance behavior literature
SA	4.3 mg/L (Acute)	VPA calculation with an additional safety factor of 1 mg/L to parallel the magnitude difference between SA and SB for chronic exposure. The original VPA calculation already includes a safety factor.
SB	3.3 mg/L (Acute)	VPA calculation for Massachusetts waters using all available taxa, including Atlantic Sturgeon. Includes a safety factor of 1.35 (the average LC_5 to LC_{50} ratio).

MA Coastal and Marine DO Criteria Review: Phase III

Duration of Lab Tests

VPA standard test duration (EPA 2000):
Acute: 24-96 Hours
Chronic: 4-29 Days

Acute

Juvenile and Adult Survival

Data were used from tests with exposure ranging from 24 to 96 hr. This maximized the number of genera for the FAV calculation. Data for juveniles show that LC50 values calculated for 24 and 96 hr observations are very similar (Figure 1); therefore, all values are applied as 24 hr data. The restriction of the data set to tests of 96 hr duration or less was somewhat arbitrary; however, 96 hr is the duration used for most acute tests for traditional water quality criteria (Stephan et al., 1985). In addition, there are insufficient test data to compare 24 hr exposures versus those longer than 96 hr. Juvenile and adult mortality data from exposures longer than 96 hr are compared to the final criterion in the section, Other Laboratory Bioassay Data.

Chronic

dissolved oxygen on growth of saltwater animals. Data from individual t

Common Name	Life Stage	Duration (days)
sheepshead minnow	larval	14
sheepshead minnow	larval	7
mysid	<48 hr old juvenile	10
mysid	<48 hr old juvenile	28
striped bass	juvenile	21
Atlantic rock crab	larval stage 5 to megalopa	7
marsh grass shrimp	newly hatched	8
marsh grass shrimp	<16 hr old	7
marsh grass shrimp	<16 hr old	8
marsh grass shrimp	larval stage 1 to 3	7
marsh grass shrimp	postlarval	14
marsh grass shrimp	postlarval	14
marsh grass shrimp	postlarval	14
northern quahog	embryo	14
Atlantic silverside	embryo to larva	28
summer flounder	newly metamorphosed juvenile	14
summer flounder	newly metamorphosed juvenile	14
summer flounder	newly metamorphosed juvenile	14
summer flounder	newly metamorphosed juvenile	10
American lobster	larval stage 2 to 3	4
American lobster	larval stage 2 to 3	4
American lobster	larval stage 3 to 4	4
American lobster	larval stage 3 to 4	4
American lobster	larval stage 3 to 4	6
American lobster	postlarval stage 4 to 5	20
American lobster	juvenile stage 5 to 6	27
American lobster	juvenile stage 5 to 6	29
Say mud crab	<48 hr old	8
Say mud crab	larval stage 1 to 3	7
Say mud crab	larval stage 1 to 3	7
Say mud crab	larval stage 1 to 3	7
Say mud crab	larval stage 3 to 4	7
Say mud crab	larval stage 3 to megalopa	4
Say mud crab	larval stage 3 to megalopa	8
Say mud crab	larval stage 3 to megalopa	10
Say mud crab	larval stage 3 to megalopa	11
longnose spider crab	larval stage 1 to 2	7

Draft Acute DO Criteria Recommendations: Magnitude, Duration and Frequency

- **Acute criteria magnitudes: SA = 4.3 mg/L and SB = 3.3 mg/L**
- **Over what duration would acute criteria magnitudes be evaluated?**
  - **Continuous data (24 hours)**
    - Exceedance: each 24-hour period with DO concentration < acute criteria
    - Continuous datasets are preferred
  - **Grab data (instantaneous)**
    - Exceedance: DO concentration < acute criteria
- **How would the frequency of acute criteria exceedances be evaluated?**
  - **Exceedances in one or multiple index periods (June 1 – Sep 15)**
    - The index period is the time when low DO concentrations are most likely to occur
    - No more than one exceedance in an index period or no more than one exceedance over three consecutive index periods

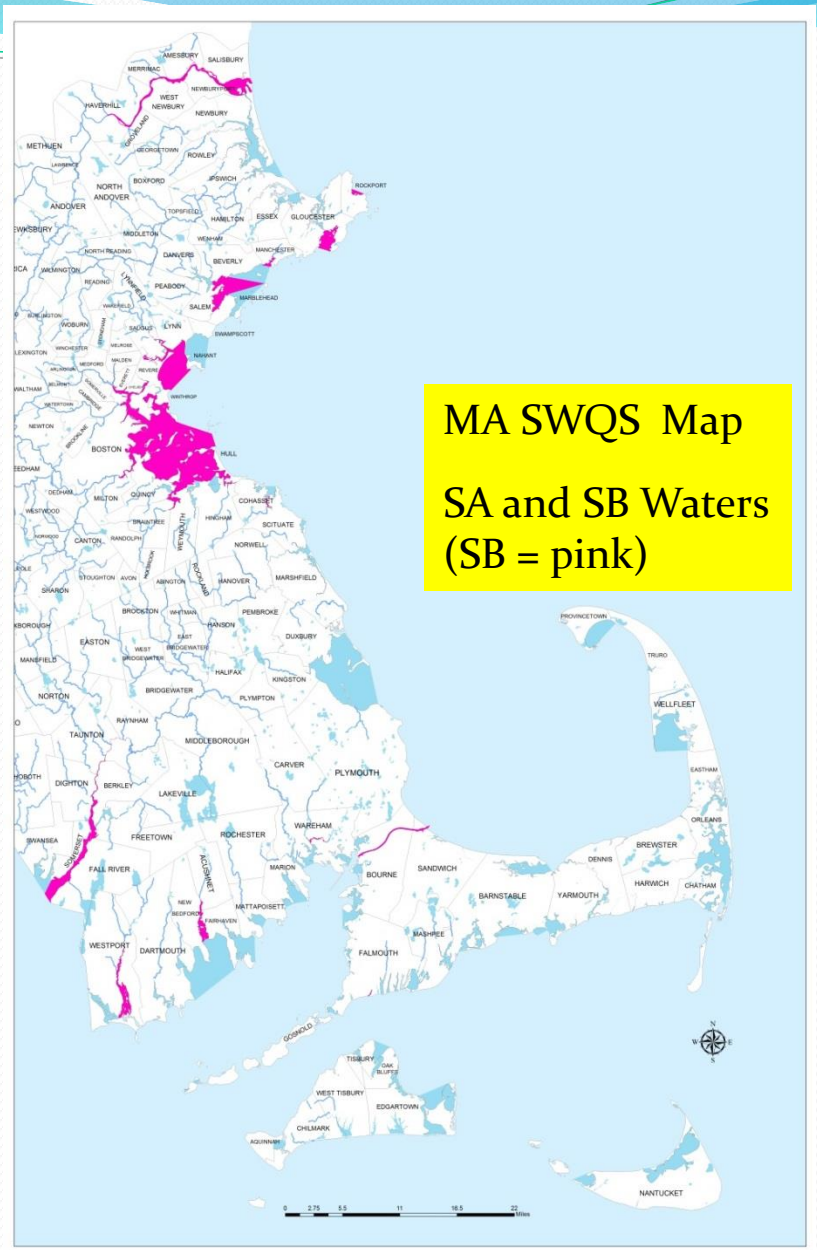
Draft Chronic DO Criteria Recommendations: Magnitude, Duration and Frequency

- **Chronic criteria magnitudes: SA = 6.0 mg/L and SB = 5.0 mg/L**
- **Over what duration would chronic criteria magnitudes be evaluated?**
  - **Continuous data (7 days)**
    - A 7-day period is generally consistent with MassDEP's current freshwater assessment methodology
    - Exceedance: 7-day rolling DO concentration average < chronic criteria
    - Continuous datasets are preferred
  - **Grab data (instantaneous)**
    - Exceedance: DO concentration < chronic criteria
- **How would the frequency of chronic criteria exceedances be evaluated?**
  - **Exceedances in an index period (June 1 – Sep 15)**
    - The index period is the time when low DO concentrations are most likely to occur
    - No more than a 10% exceedance in an index period or no more than a 10% exceedance over three consecutive index periods
    - A 10% exceedance is generally consistent with MassDEP's current estuarine assessment methodology

MA Coastal and Marine DO Criteria Review: Phase III Monitoring Framework

Spatial Extent of Sampling: Statewide Context

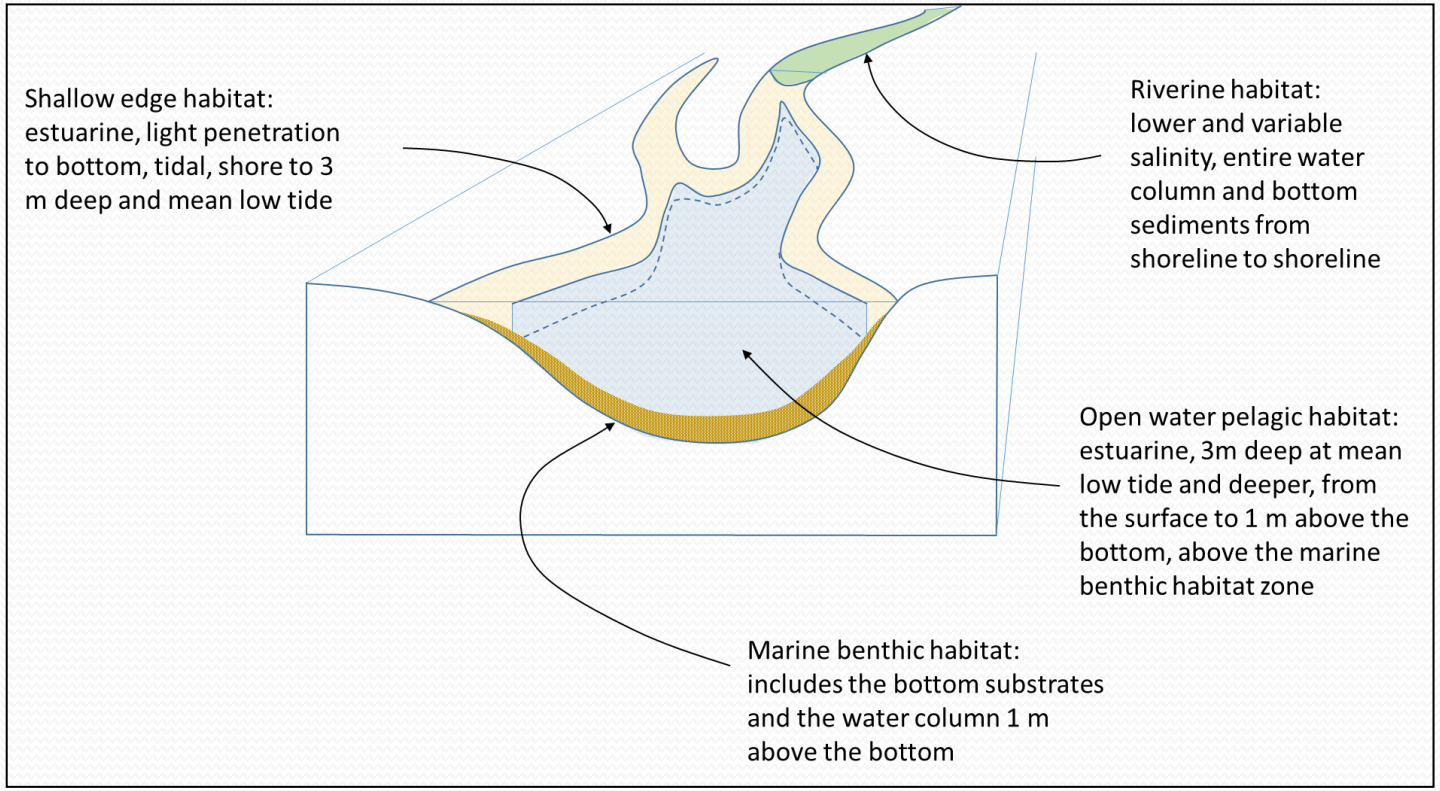
- The draft DO criteria are intended to apply to all coastal waters of Massachusetts
- No 'least-disturbed reference' areas have been defined
- Site-specific criteria might apply where sturgeon are known to spawn (e.g., the Merrimack River)



Spatial Extent of Sampling: Habitat

Sampling the marine benthic habitat (0.5 to 1 m off the bottom) is critical to identify DO exposures

Other habitats may also be sampled, as needed to characterize the entire system



Coastal DO Data Collection Methods

At a location:

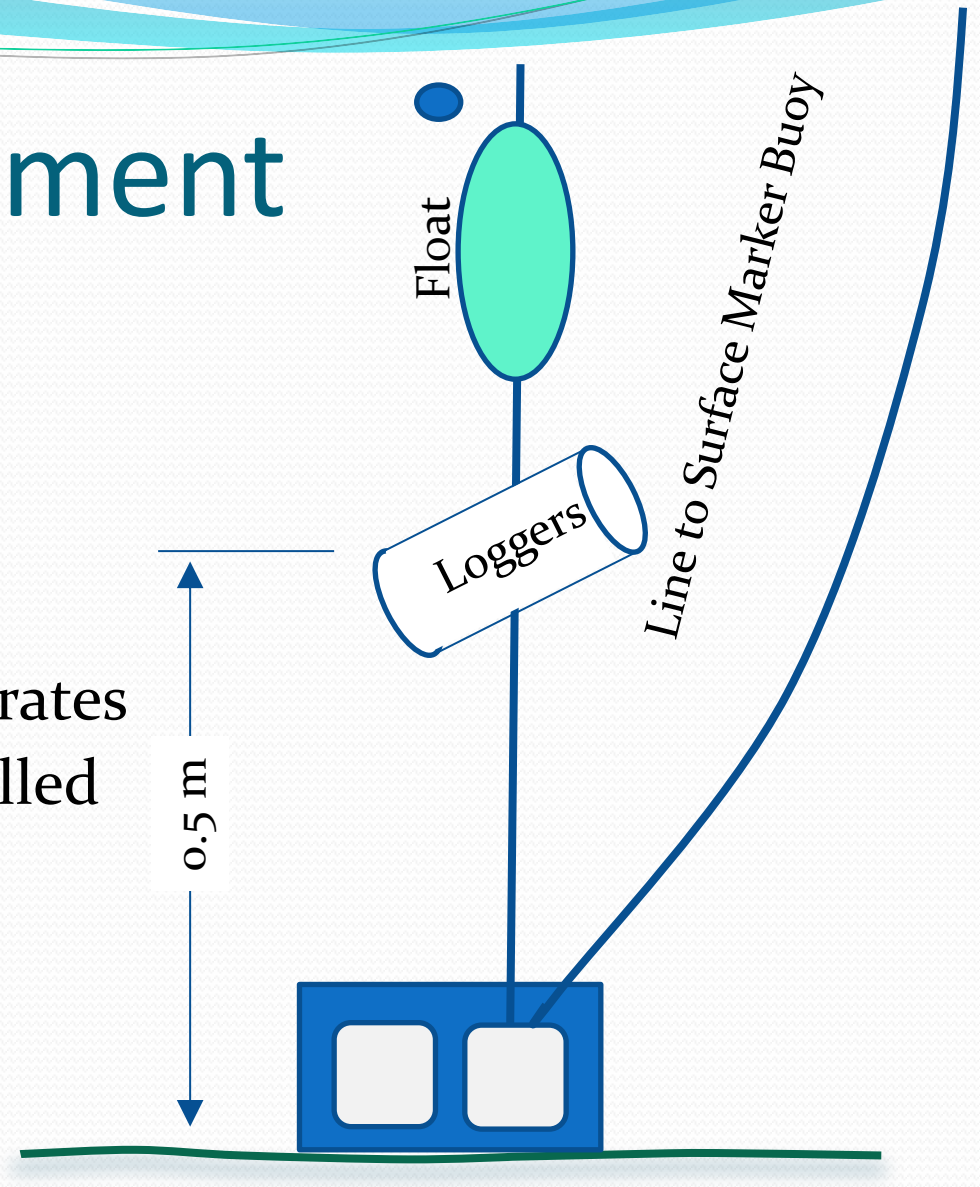
- Grab
- Depth Integrated Profiles
- Continuous Equipment Types
  - Economic
  - Super-station
- Continuous Deployment Options (preferred)
  - Seasonal Deployment
  - Daily, Weekly, etc. Deployment

Grab (Instantaneous) Method

- Used instead of continuous monitoring due to
  - Simpler and common equipment
  - Manageable application schedule
  - Exploration and screening of multiple locations
- Single sampling event with a submersible probe or sampler
  - Multiple sampling visits per location are necessary to capture variability
- Identify sampling location
- Sample near the bottom (0.5 to 1 m off the bottom)
- Keep a record of calibration and maintenance

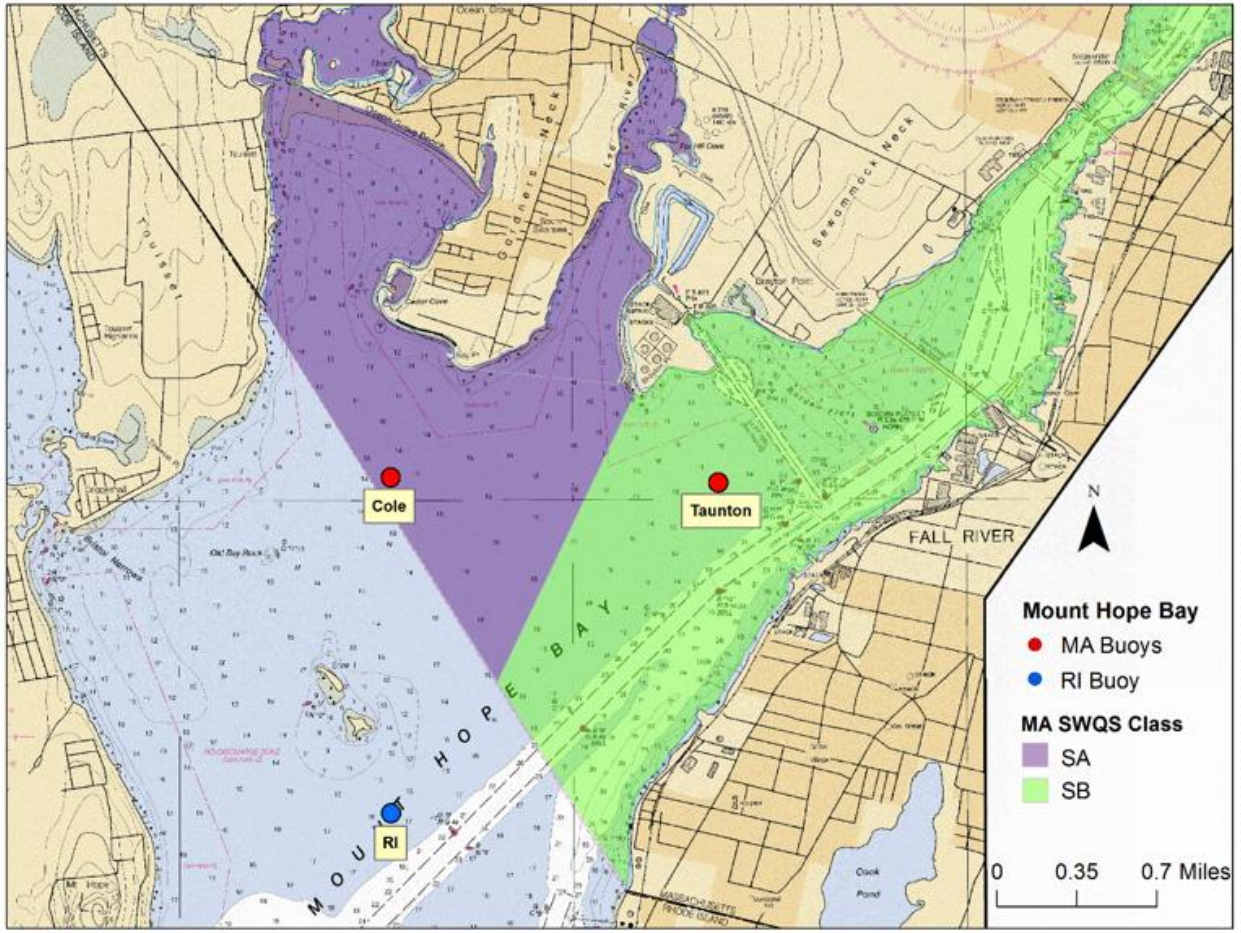
'Economic' Sampling Equipment

- Must be accurately calibrated to a standard
- Must be regularly maintained
- Must have Standard Operating Procedures
  - Deployed in an identifiable location
  - Recording within 0.5 to 1.0 m of bottom substrates
  - Data consistently recorded and quality controlled
- Data Loggers
  - Tough, accurate, economical
  - Consider deployment, anchoring, retrieval, download, and maintenance



Sampling Equipment: Buoys

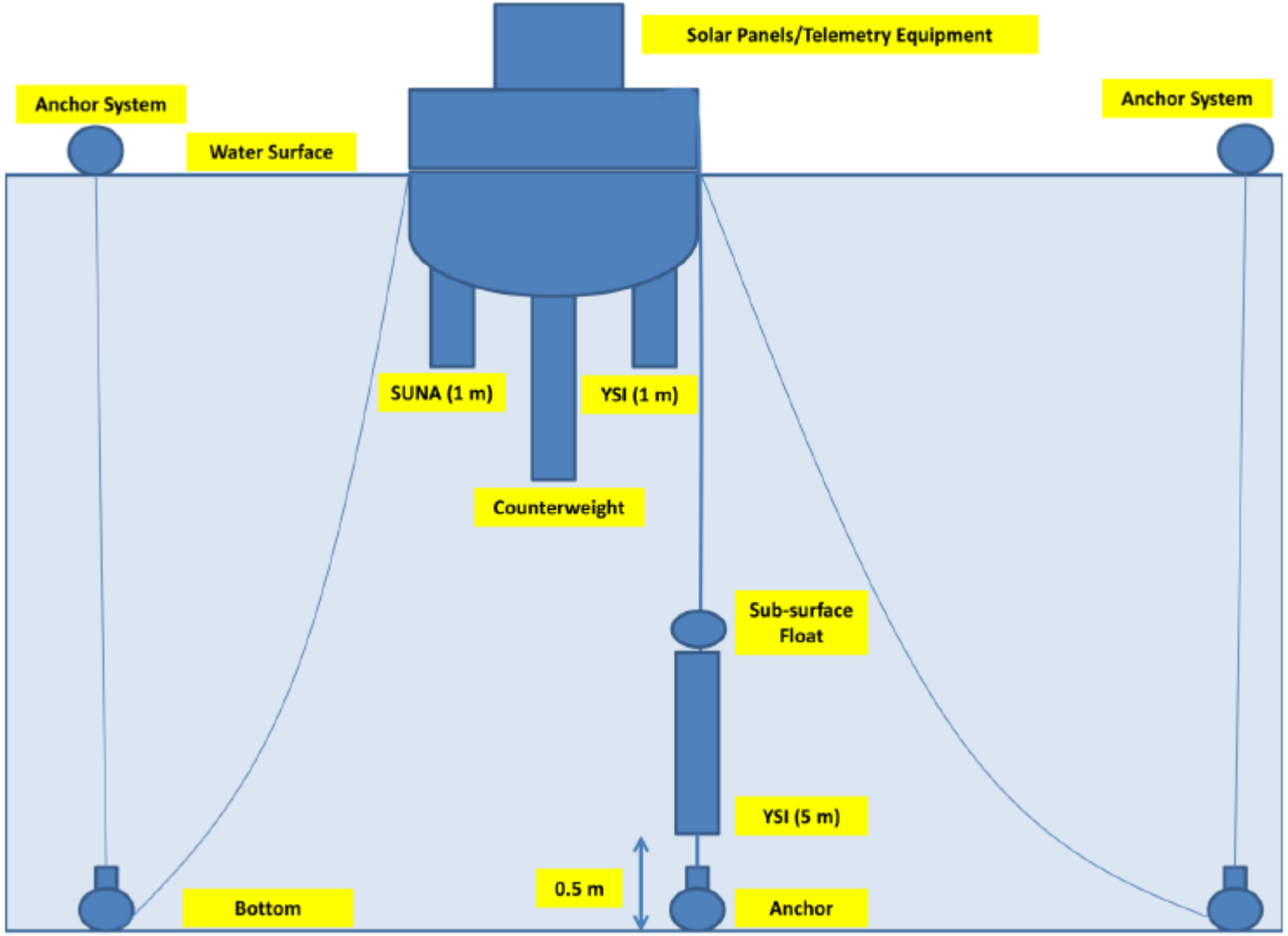
- Multiple sampling locations are recommended to characterize DO conditions in coastal and marine MA waters
- MassDEP maintains two buoys to address water quality data gaps in Mount Hope Bay
- Buoys measure DO concentrations every 15 minutes at two depths:
  - 1 m below the surface
  - 0.5 m from the bottom



Sampling Equipment

'Super-station' buoy

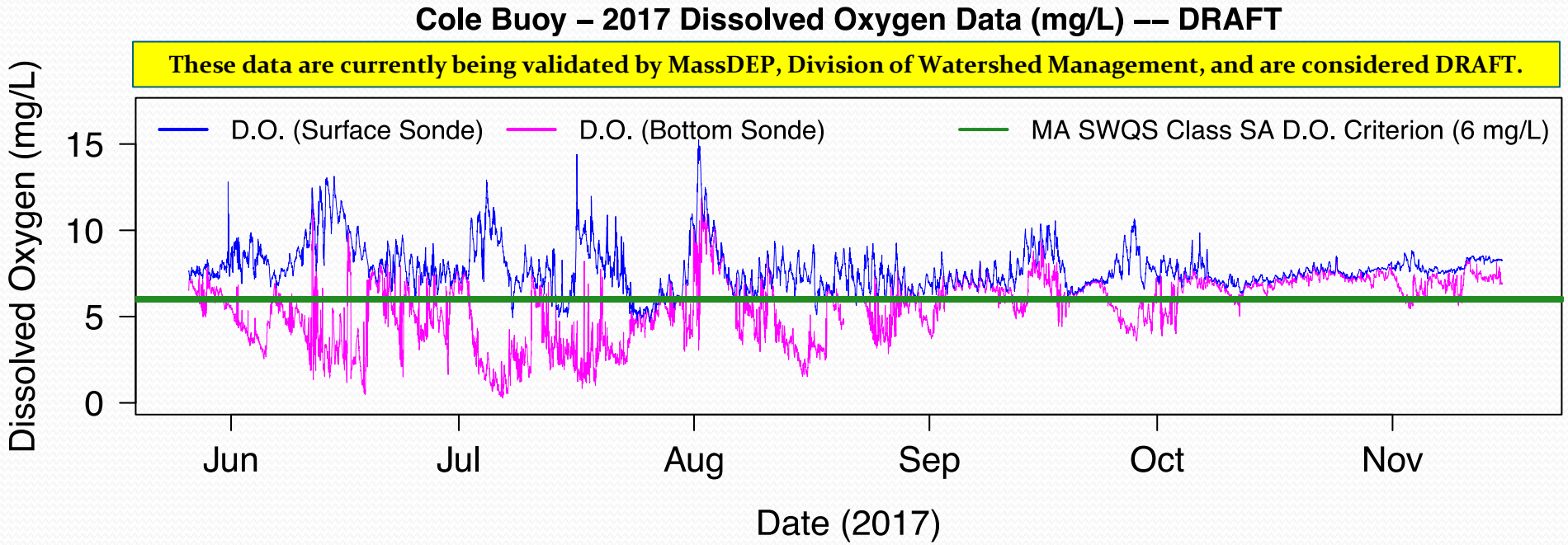
Bottom samples are collected within 0.5 m of the bottom substrate



MassDEP Buoy Schematic

Spatial Extent of Sampling: Current Continuous Data Collection - Cole

- DO levels are typically higher at the surface than at the bottom.
- Sampling the marine benthic habitat is critical to identify DO exposures.

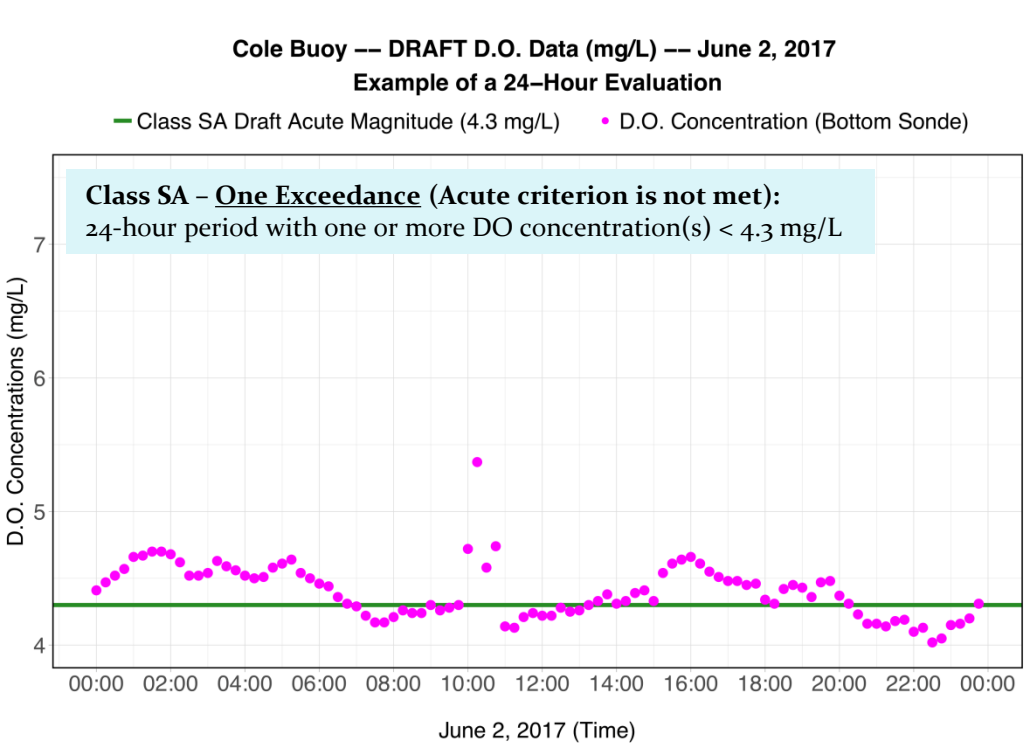


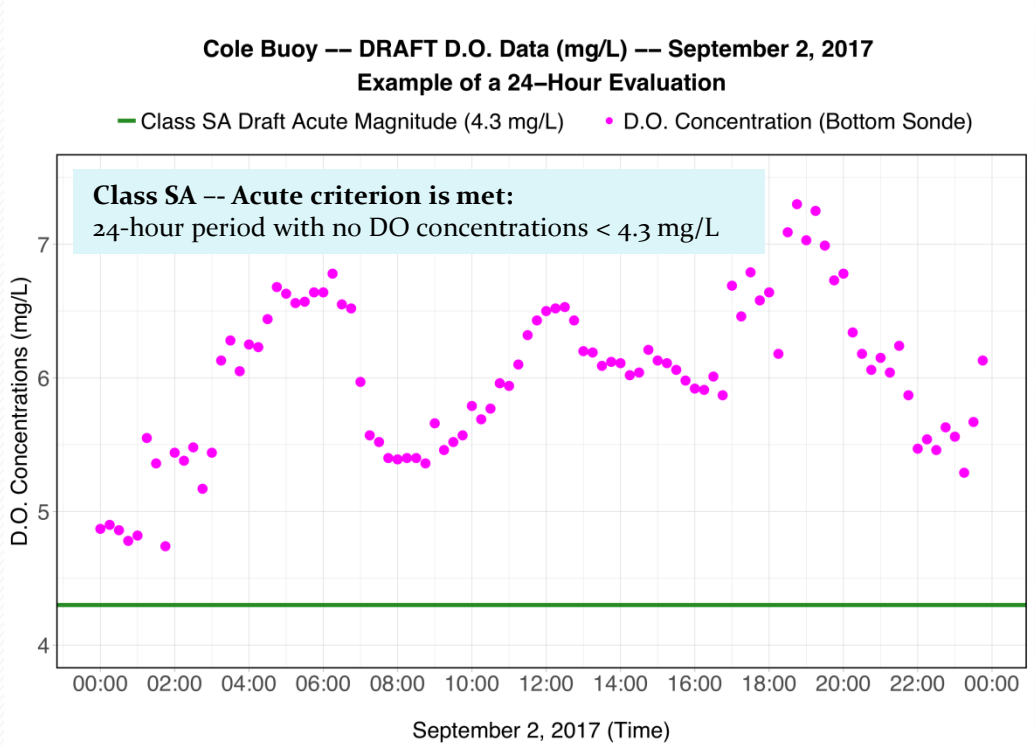
MA Coastal and Marine DO Criteria Review: Phase III Draft Criteria Application

Examples: 2017 Continuous Data vs. Draft Acute DO Criteria

- **Magnitude:** Class SA criterion = 4.3 mg/L
  Class SB criterion = 3.3 mg/L
- **Duration**:
  - 24-hours
  - Exceedance (criterion is not met) = each 24-hour period with one or more DO concentration(s) less than the criterion
- **Frequency**
  - No more than one exceedance in an index period or no more than one exceedance over three consecutive index periods

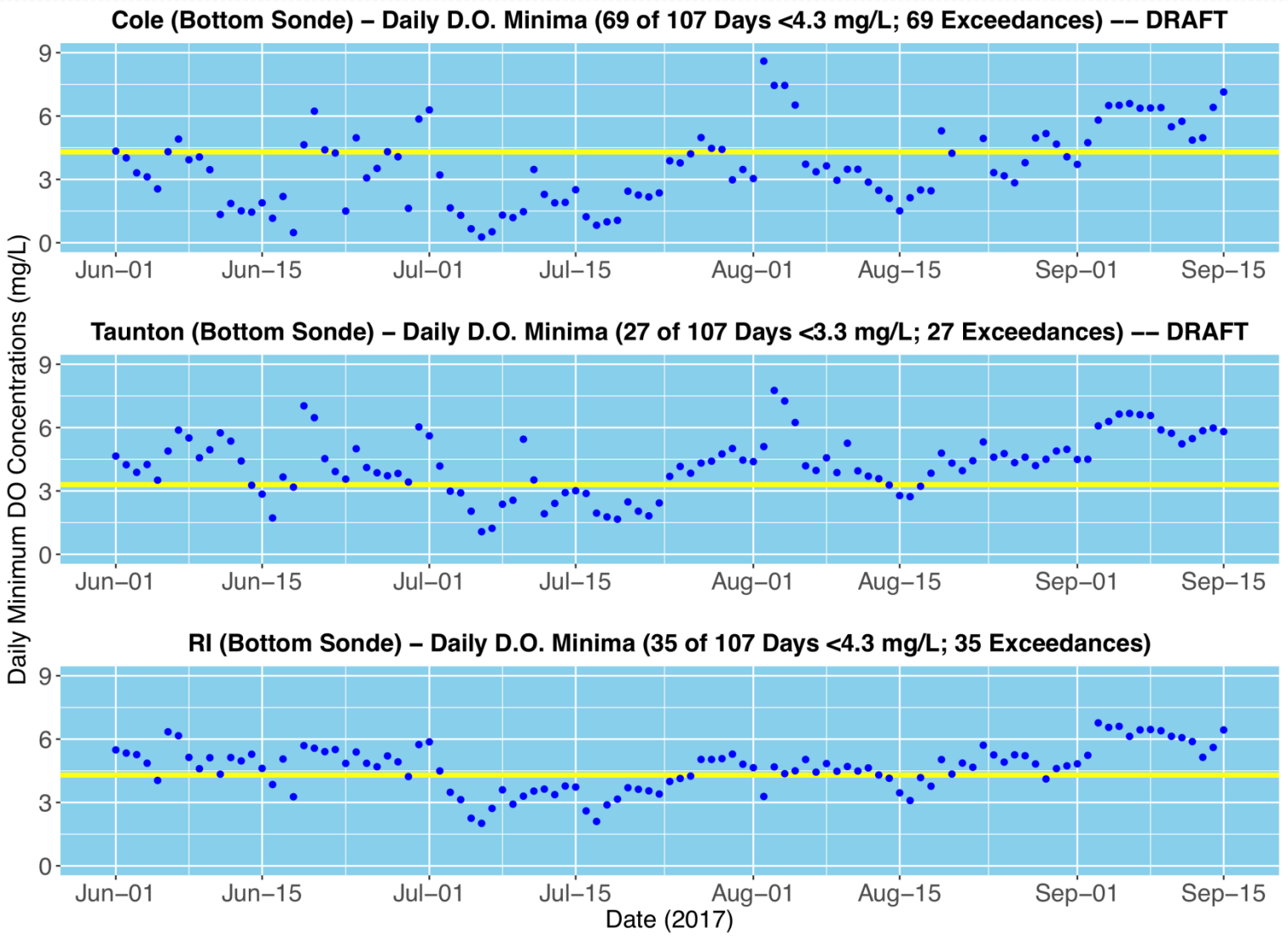
These data are currently being validated by MassDEP, Division of Watershed Management, and are considered DRAFT.





Examples: 2017 Continuous Data vs. Draft Acute DO Criteria

MA data are currently being validated by MassDEP, Division of Watershed Management, and are considered DRAFT.



The index period, June 1st to Sep 15th, is 107 days. Blue points on each plot represent daily minimum DO concentrations during the index period. These concentrations are compared to draft acute DO criteria (Class SA or Class SB), shown as yellow lines. Total exceedances are the number of days with minimum DO concentrations less than draft acute DO criteria.

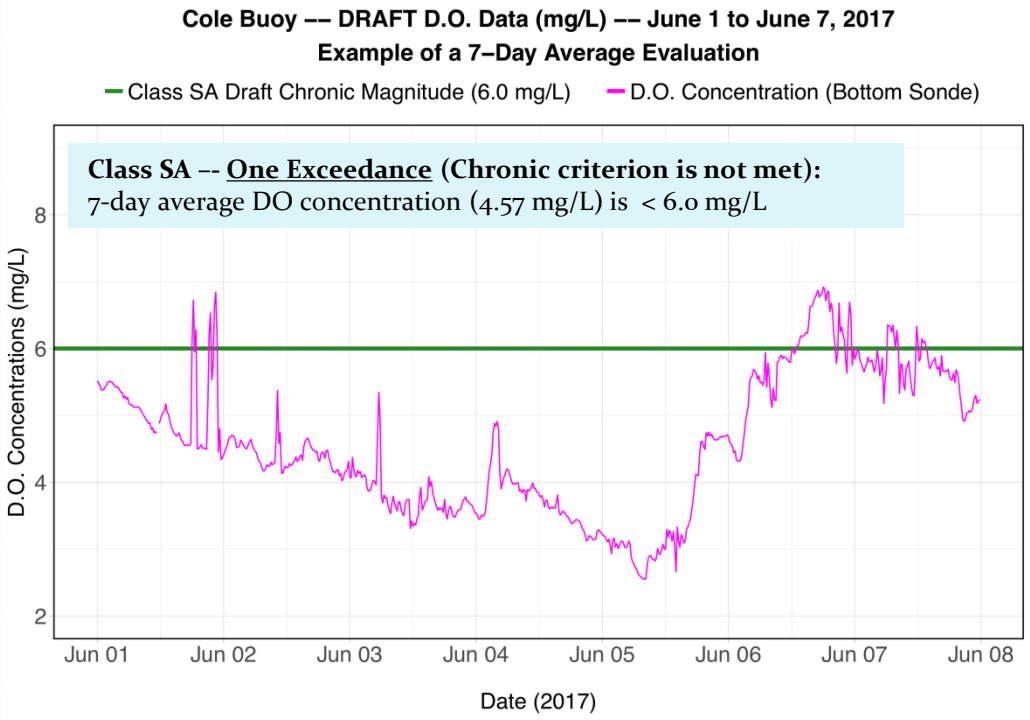
Draft Acute DO Criteria: Continuous Data

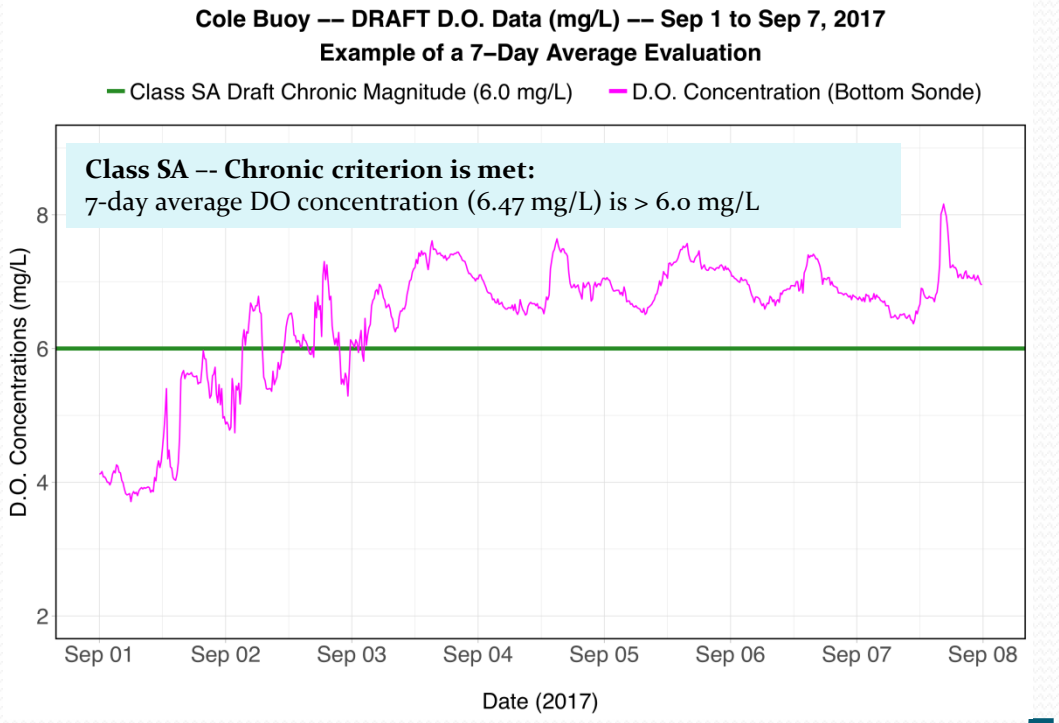
- **Magnitude:**
  - Class SA = 4.3 mg/L
  - Class SB = 3.3 mg/L
- **Duration**:
  - 24-hours
  - Exceedance: each 24-hour period with DO concentration < acute criteria
- **Frequency**:
  - No more than one exceedance in an index period or no more than one exceedance over three consecutive index periods

Examples: 2017 Continuous Data vs. Draft Chronic DO Criteria

- **Magnitude:** Class SA criterion = 6.0 mg/L
  Class SB criterion = 5.0 mg/L
- **Duration**:
  - 7-days
  - Exceedance (criterion is not met): 7-day rolling DO concentration average less than the criterion
- **Frequency**
  - No more than a 10% exceedance in an index period or no more than a 10% exceedance over three consecutive index periods

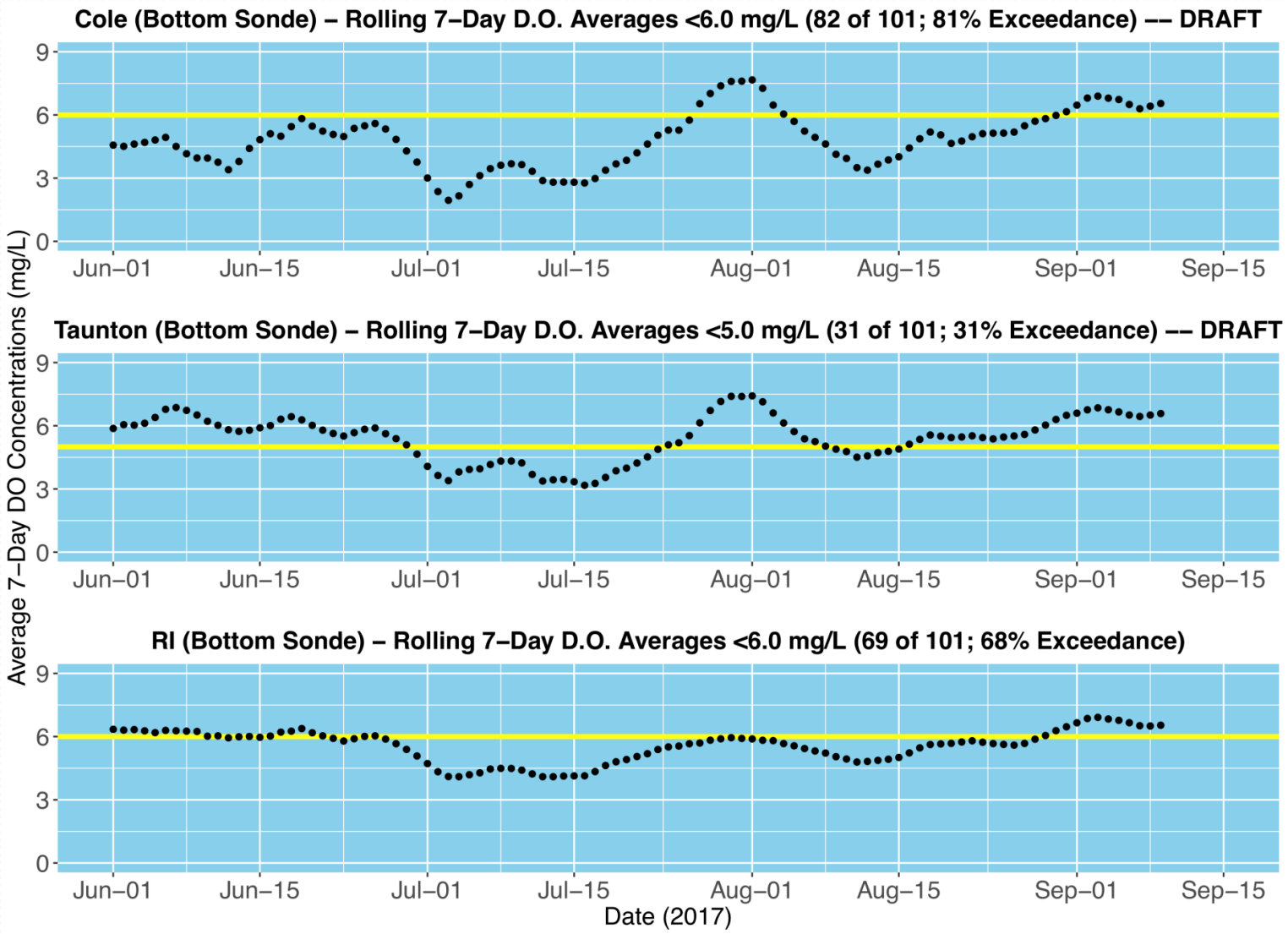
These data are currently being validated by MassDEP, Division of Watershed Management, and are considered DRAFT.





Examples: 2017 Continuous Data vs. Draft Chronic DO Criteria

MA data are currently being validated by MassDEP, Division of Watershed Management, and are considered DRAFT.



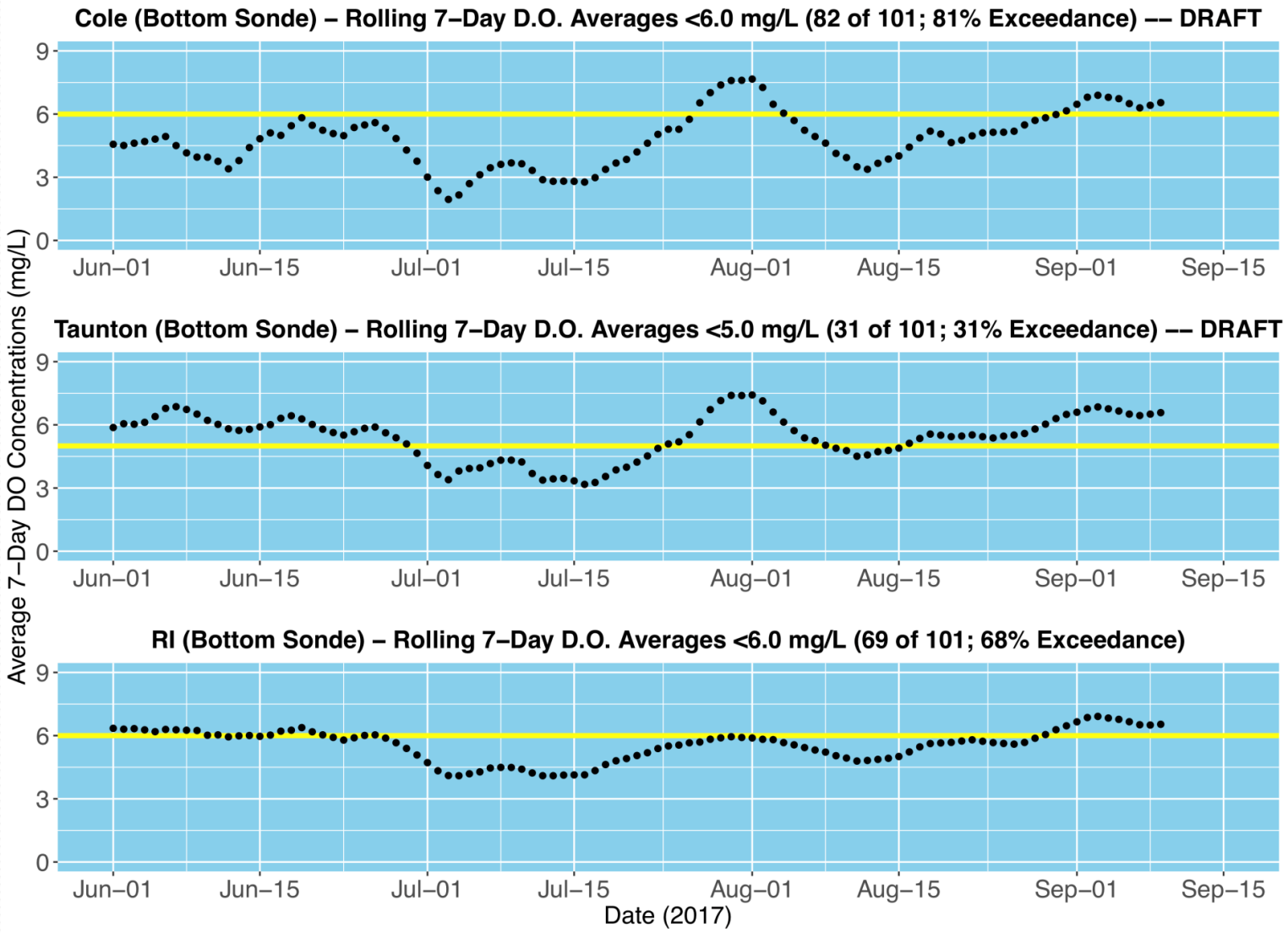
The index period, June 1st to Sep 15th, is 107 days. Black points on each plot represent 101 rolling 7-day DO concentration averages during the index period. These 7-day averages are compared to draft chronic DO criteria (Class SA or Class SB), shown as yellow lines. Exceedance percentages are the proportion of 7-day DO concentration averages less than draft chronic DO criteria.

Draft Chronic DO Criteria: Continuous Data

- **Magnitude:**
  - Class SA = 6.0 mg/L
  - Class SB = 5.0 mg/L
- **Duration**:
  - 7-days
  - Exceedance: 7-day rolling DO concentration average < chronic criteria
- **Frequency**:
  - No more than a 10% exceedance in an index period or no more than a 10% exceedance over three consecutive index periods

Example: Continuous vs. Instantaneous Data

MA data are currently being validated by MassDEP, Division of Watershed Management, and are considered DRAFT.



Example exceedance calculations for draft chronic criteria using continuous data vs. simulated grab sample data.

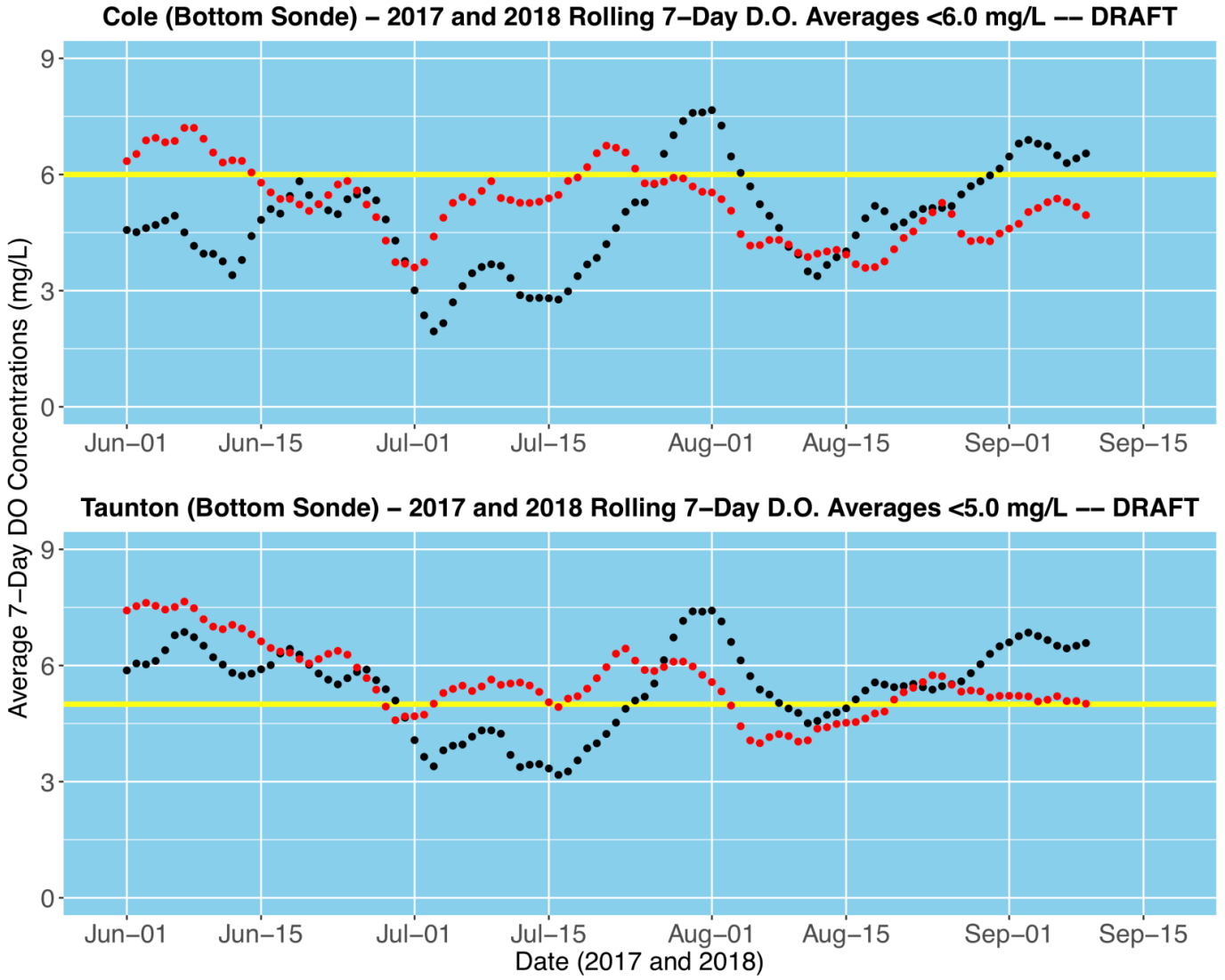
For simulated grab data, one sample between 7 am and 4 pm was randomly selected from each week of the index period (16 weeks). Next, the exceedance rate of these 16 samples was calculated. The overall procedure was repeated 1,000 times to calculate the mean exceedance using random weekly grab samples.

Example Exceedance Comparisons (2017 Data) for Draft Chronic Criteria

Site (Bottom Sonde)	Continuous	Weekly Grab
Cole	81%	74%
Taunton	31%	37%
RI	68%	60%

Example: 2017 and 2018 Continuous Data vs. Draft Chronic DO Criteria

These data are currently being validated by MassDEP, Division of Watershed Management, and are considered DRAFT.



Example exceedance calculations for draft chronic criteria using continuous data from two different years (2017 and 2018) during the index period.

Cole (Bottom Sonde) vs. Class SA Draft Chronic DO Criterion (6 mg/L)

Exceedance (2017) : 81%
Exceedance (2018) : 80%

Taunton (Bottom Sonde) vs. Class SB Draft Chronic DO Criterion (5 mg/L)

Exceedance (2017) : 31%
Exceedance (2018) : 23%

MA Coastal and Marine DO Criteria Review: Summary

Summary: Draft MA Marine DO Criteria

- MassDEP: A multi-year review of coastal and marine DO criteria
- A Technical Advisory Committee provided expert guidance
- To derive draft criteria, a Modified Virginian Province Approach was selected
- Sturgeon were identified as the most sensitive species; both the draft acute and chronic criteria provide protection for these endangered species
- The draft DO criteria apply to all coastal and marine waters in Massachusetts

Summary: Draft MA Marine DO Criteria

SWQS Class and Designated Use	Criteria Magnitude	Criteria Duration (within an index period, June 1 to Sep 15)	Criteria Frequency	Protection Provided
SA (Excellent Habitat)	**6.0 mg/L** (Chronic)	**Continuous Data: 7-days** Exceedance: 7–day average DO <6.0 mg/L **Grab Data: Instantaneous** Exceedance: DO <6.0 mg/L	**No more than a 10% exceedance in an index period or no more than a 10% exceedance over three consecutive index periods**	Spawning/Growth/Survival of aquatic organisms including NMFS recommendation for increased protection of sturgeon
	4.3 mg/L (Acute)	**Continuous Data: 24-hours** Exceedance: 24-hour period with DO concentration <4.3 mg/L **Grab Data: Instantaneous** Exceedance: DO <4.3 mg/L	**No more than one exceedance in an index period or no more than one exceedance over three consecutive index periods**	Survival of aquatic organisms including increased protection of sturgeon
SB (Habitat)	**5.0 mg/L** (Chronic)	**Continuous Data: 7-days** Exceedance: 7–day average DO <5.0 mg/L **Grab Data: Instantaneous** Exceedance: DO <5.0 mg/L	**No more than a 10% exceedance in an index period or no more than a 10% exceedance over three consecutive index periods**	Foraging/Growth/Survival of aquatic organisms including sturgeon
	3.3 mg/L (Acute)	**Continuous Data: 24-hours** Exceedance: 24-hour period with DO concentration <3.3 mg/L **Grab Data: Instantaneous** Exceedance: DO <3.3 mg/L	**No more than one exceedance in an index period or no more than one exceedance over three consecutive index periods**	Survival of aquatic organisms including sturgeon

Next Steps

- Collect stakeholder feedback
- Consultants submit Draft Marine DO Criteria Review Report to MassDEP by June 30th
  - Internal MassDEP review
  - External review
- Consider future adoption of Marine DO criteria in the MA Surface Water Quality Standards (SWQS)
  - Adoption of revised criteria would include a rule-making process to promulgate regulations
  - A public comment period would be a part of any such future rule-making process
- Application of adopted criteria in the MA SWQS
  - MassDEP uses ambient water quality data to assess whether waters are meeting their designated uses
  - Permittees must meet criteria in the MA SWQS when discharging to surface waters
  - Criteria exceedances at the described frequencies indicate water quality standards violations

Questions or Comments?

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