



*Florida Department of
Environmental Protection*

Potential Revisions to Dissolved Oxygen Criteria

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Florida's Current DO Criteria

62-302.530, Florida Administrative Code

Freshwater (Class III):

- “Shall not be less than 5.0 mg/L.”
- “Normal daily and seasonal fluctuations above this level shall be maintained.”

Marine Water (Class II and III):

- “Shall not average less than 5.0 mg/L in a 24-hour period and shall never be less than 4.0 mg/L”
- “Normal daily and seasonal fluctuations above these levels shall be maintained.”





Issues with Existing Florida DO Criteria

- Many Florida waters naturally exhibit low DO levels
 - Groundwater typically <20% saturation
 - High temperatures, dense canopy/shading
 - Low water velocities, stratification
 - Abundant natural organic input (leaf litter)
- Original DER (*Department of Environmental Regulation*) DO language did not include an acceptable departure from natural conditions

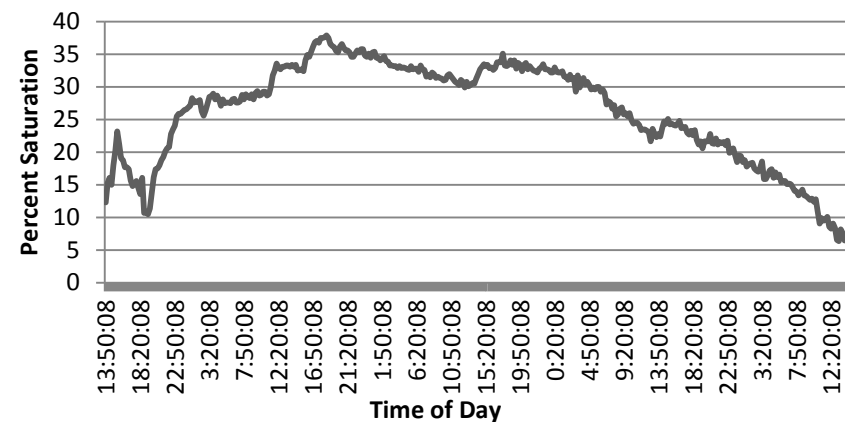




Examples of Naturally Low DO



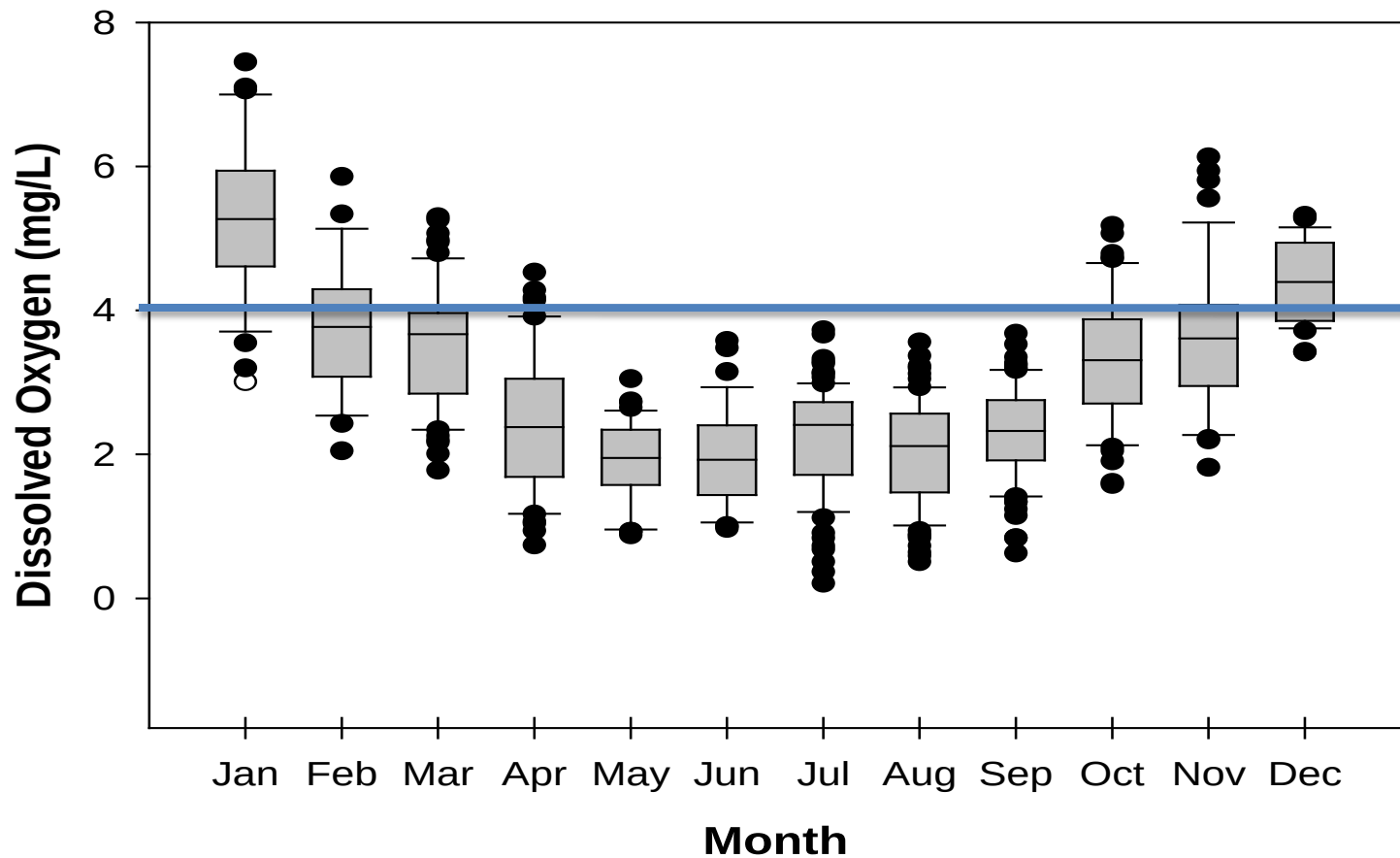
**Aucilla River
4-Day DO Sonde Deployment**



Statistic	DO (%)	DO (mg/L)
Average	26.35	2.10
Std. Dev.	7.64	0.61
Median	28.25	2.28
Maximum	37.90	3.00
Minimum	6.40	0.51



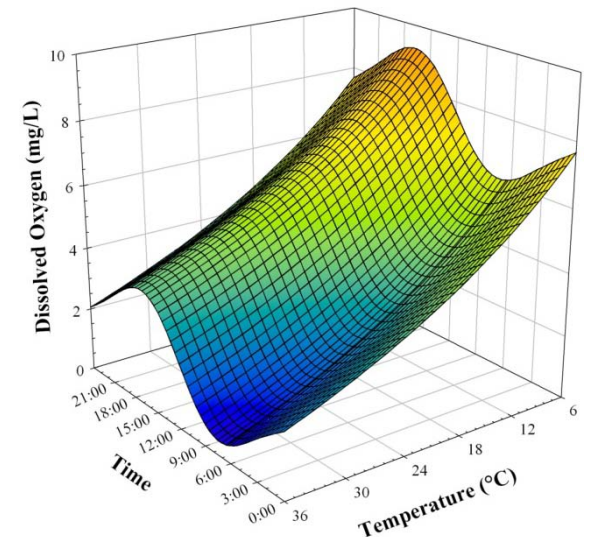
Reference Estuary System (Econfina) Daily Minimum DO





Site Specific Alternative Criteria (SSAC)

- DEP has approved 13 DO SSACs based on natural or existing conditions
- Eleven freshwater
 - Range: 0.1 - 4.0 mg/L
 - Median approximately 3.0 mg/L
 - Some include averaging periods
 - Some include seasonal components
 - Everglades algorithm uses time and temperature
- Lower St. Johns River
 - Based on modification of EPA (2000) Virginian Province DO criteria (Type II SSAC)





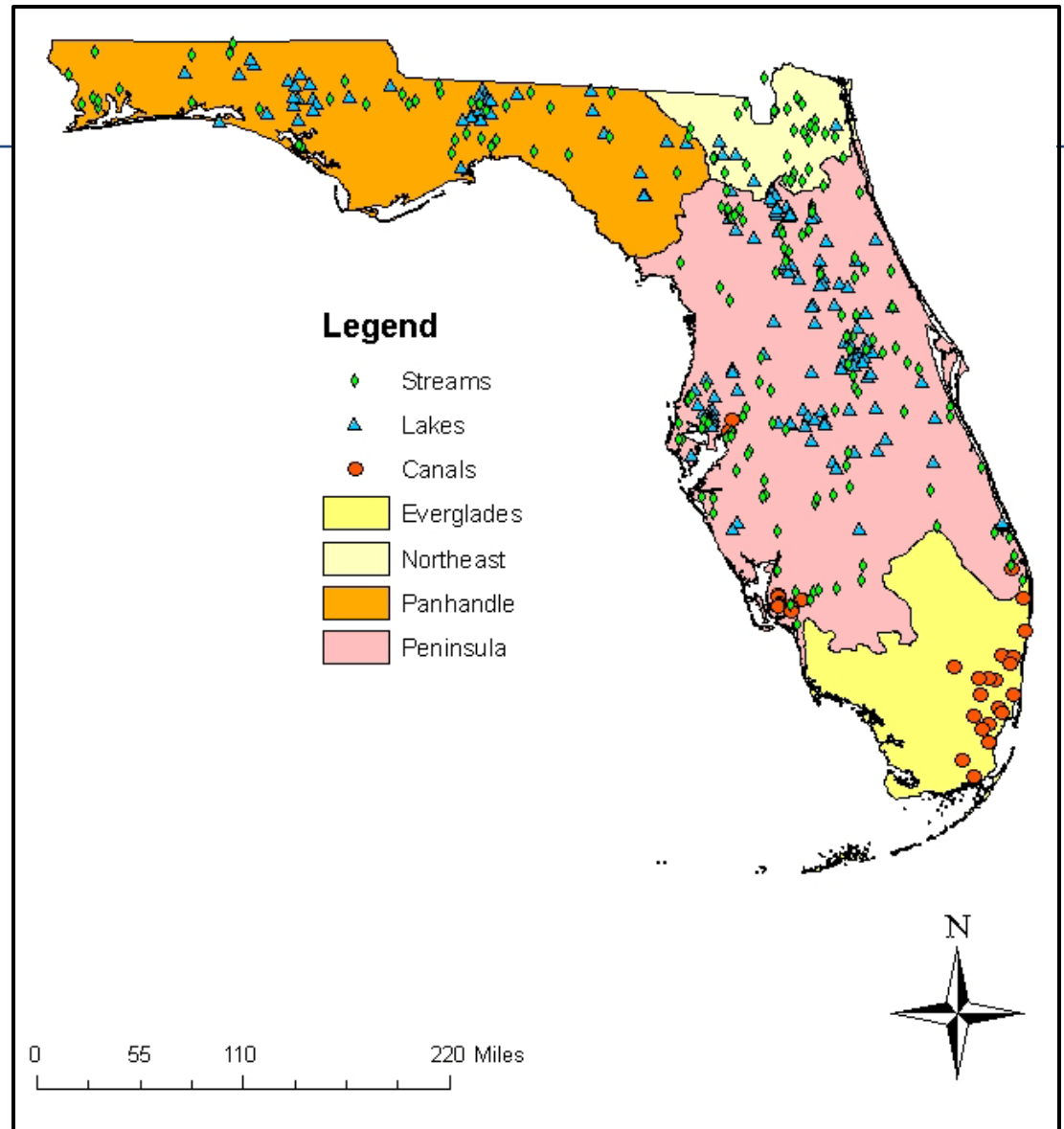
Statewide DO / Nutrient Study

- Extensive statewide DO / Nutrient study was conducted to collect data to support the development of revised DO (and nutrient) criteria for Florida's freshwaters
 - Natural diel and seasonal oxygen regimes
 - Biological response to DO
- Study consisted of:
 - Quarterly sampling at 342 freshwater sites (both reference and non-reference) across Florida for one year
 - 150 lake sites , 160 stream sites, 32 canal sites
 - Minimally disturbed reference sites selected based on LDI <2, augmented by BPJ



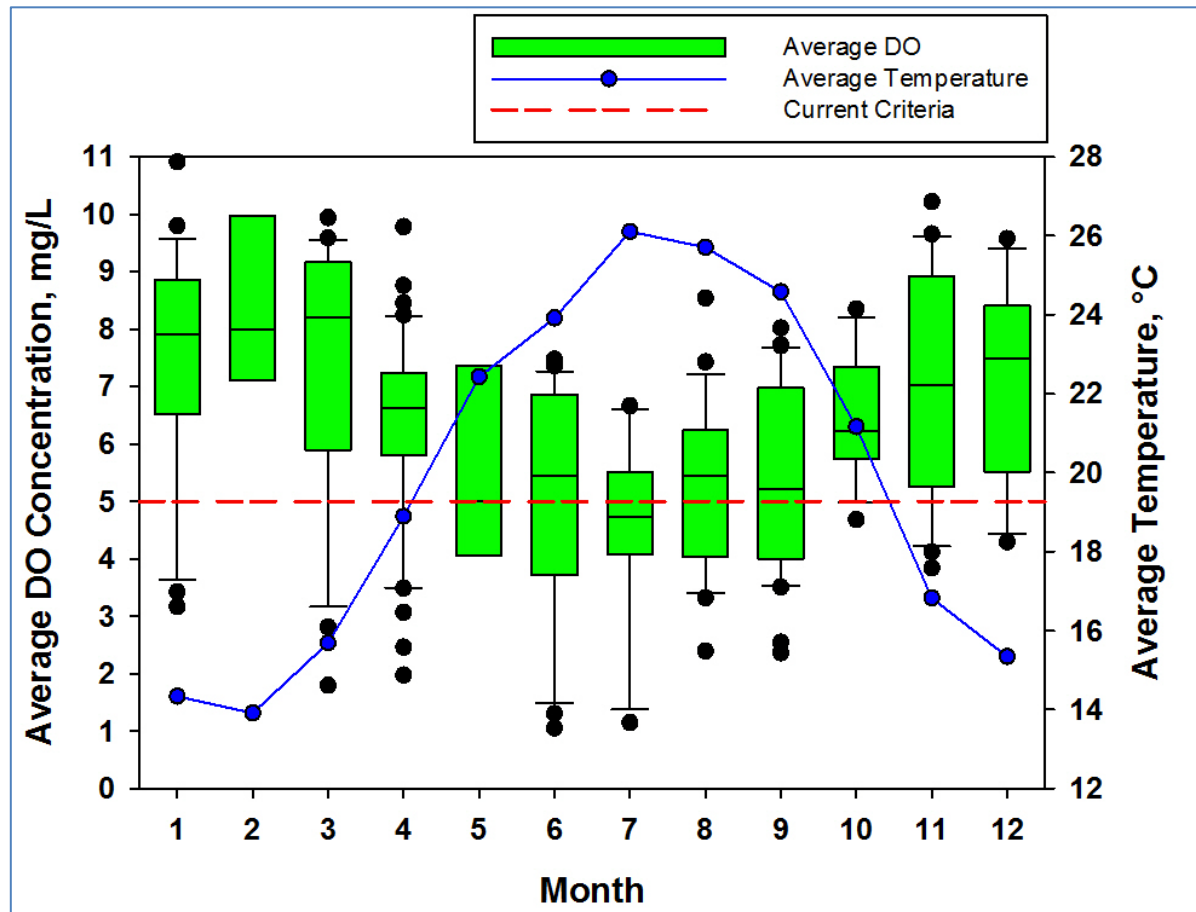


Sites Sampled Across Florida Bioregions





DO and Temperature at Reference Sites





Evaluation of Existing DO Criteria

Waterbody Type	Reference	Count	Average DO Conc	Average % Excursions	% of sites with >10% Excursions
Lake	Non-reference	69	7.72	6.5	17.4
Lake	Reference	82	6.55	20.9	52.4
Stream	Non-reference	84	5.55	38.6	67.9
Stream	Reference	81	5.55	39.8	70.4

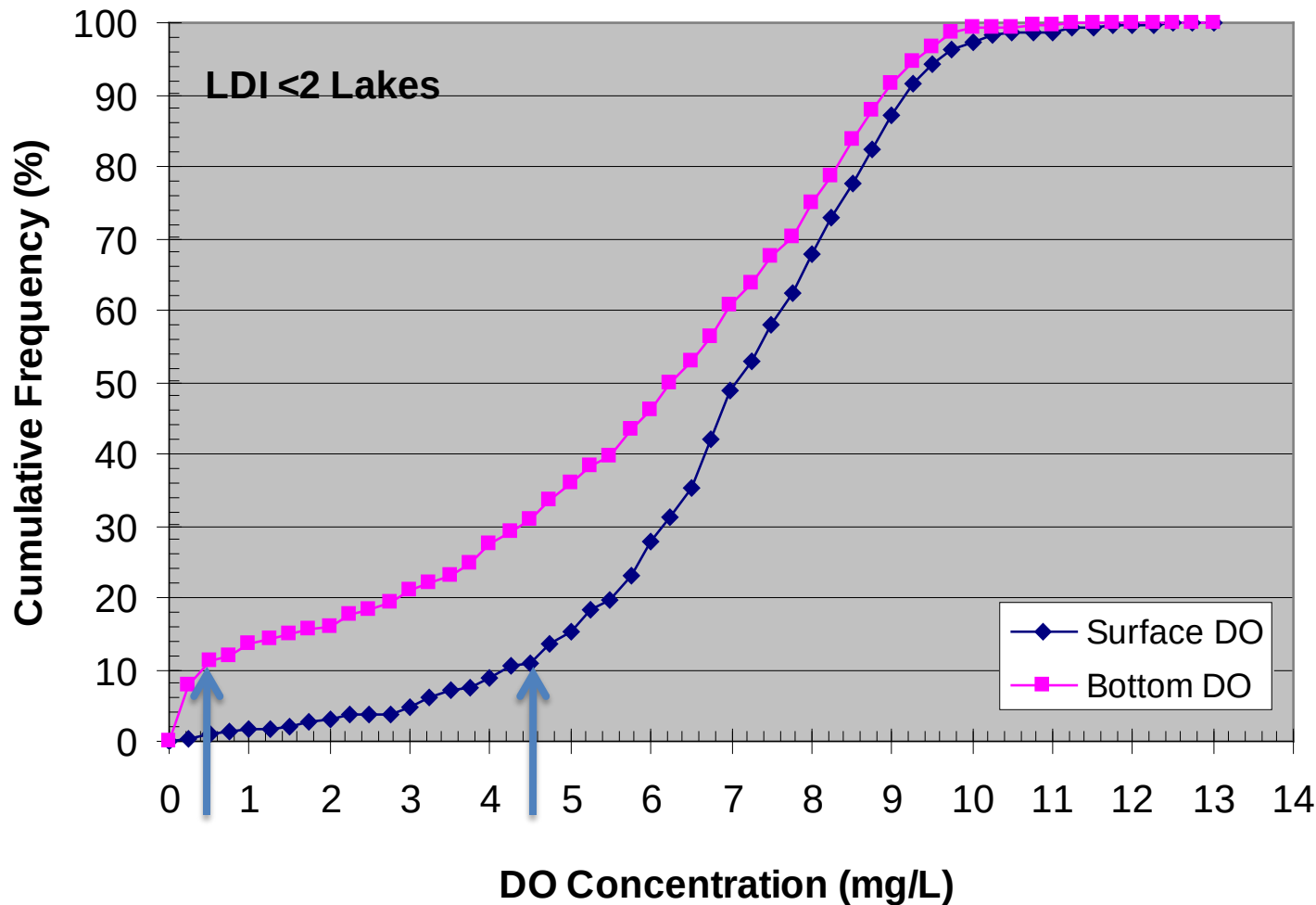
- Large percent of reference ($LDI < 2$) sites do not meet current criteria (52% of lakes and 70% of streams)
- In general, greater percent of reference sites have more than 10% of measurements below 5.0 mg/L than non-reference sites.





DO/Nutrient Study

Vertical Profile DO Data (Reference Lakes)



- At lower 10th percentile, difference between surface and bottom is 4.0 mg/L.



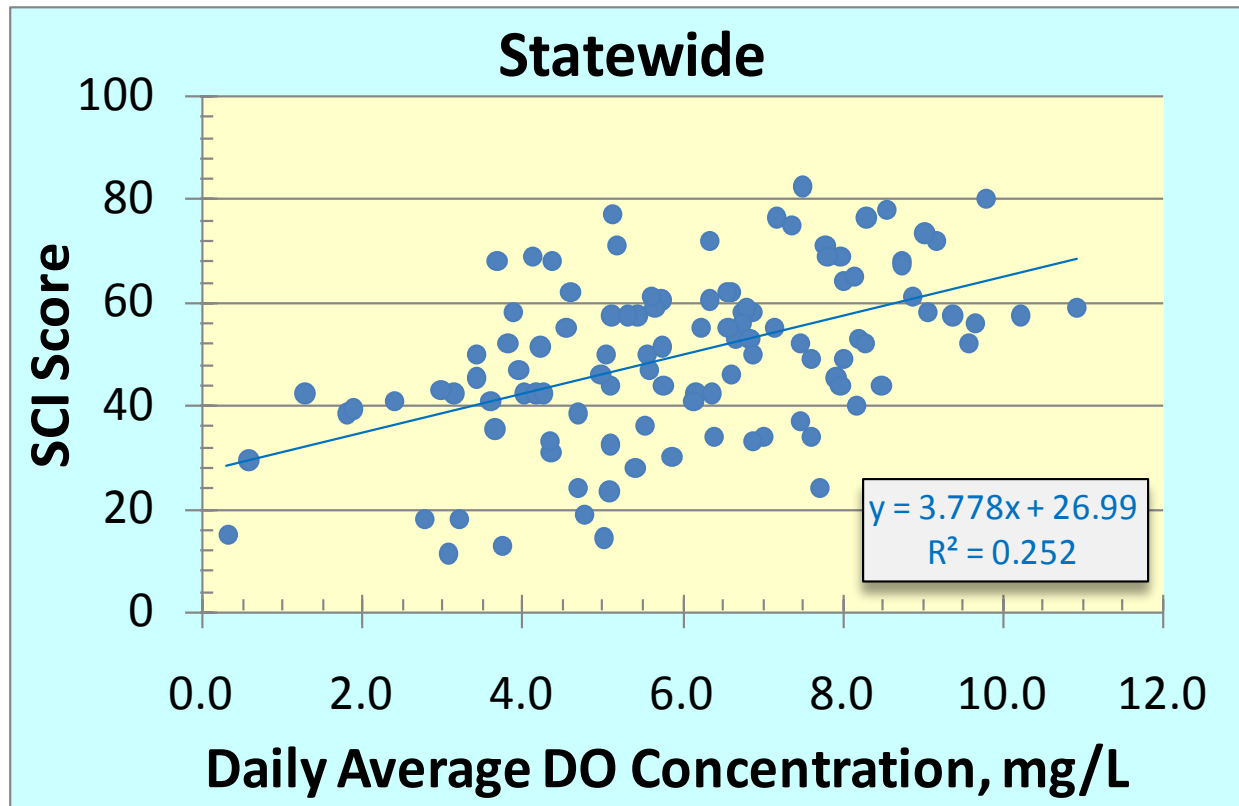
Approach for Freshwater DO Criteria

- Cause-Effect Approach (SCI response to DO)
 - DEP preferred approach
 - DO needed to protect most sensitive community (stream macroinvertebrates)
 - As conservative measure, apply stream criteria to lakes



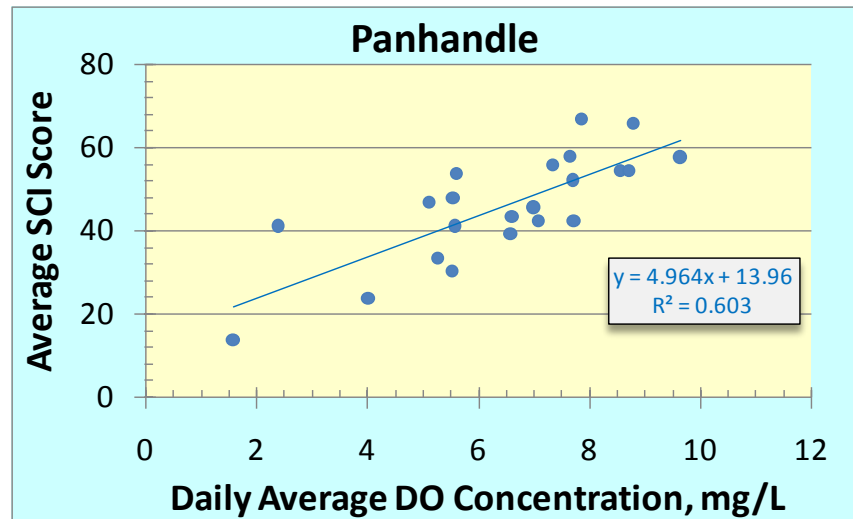
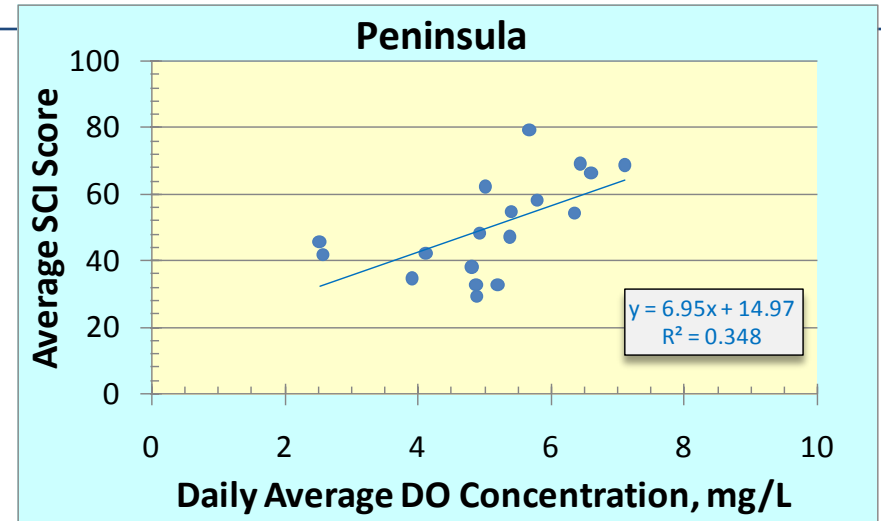
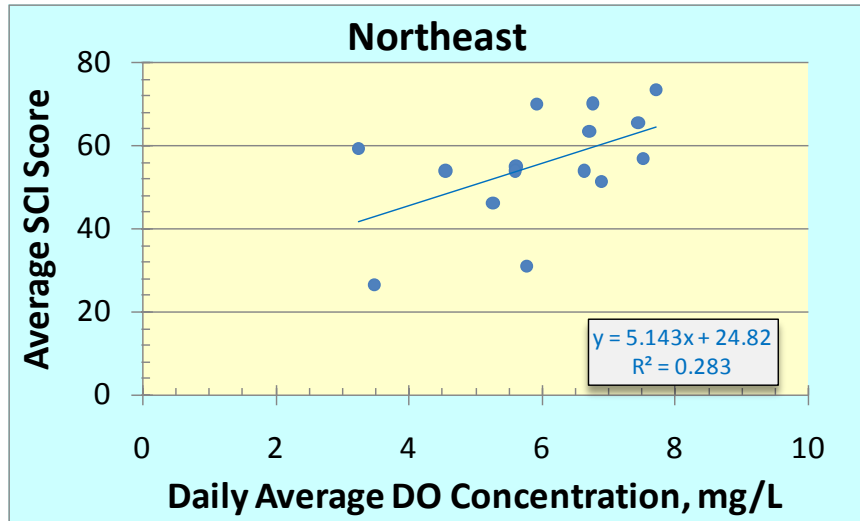


SCI vs. DO Concentration Statewide





Average SCI vs. DO by Region





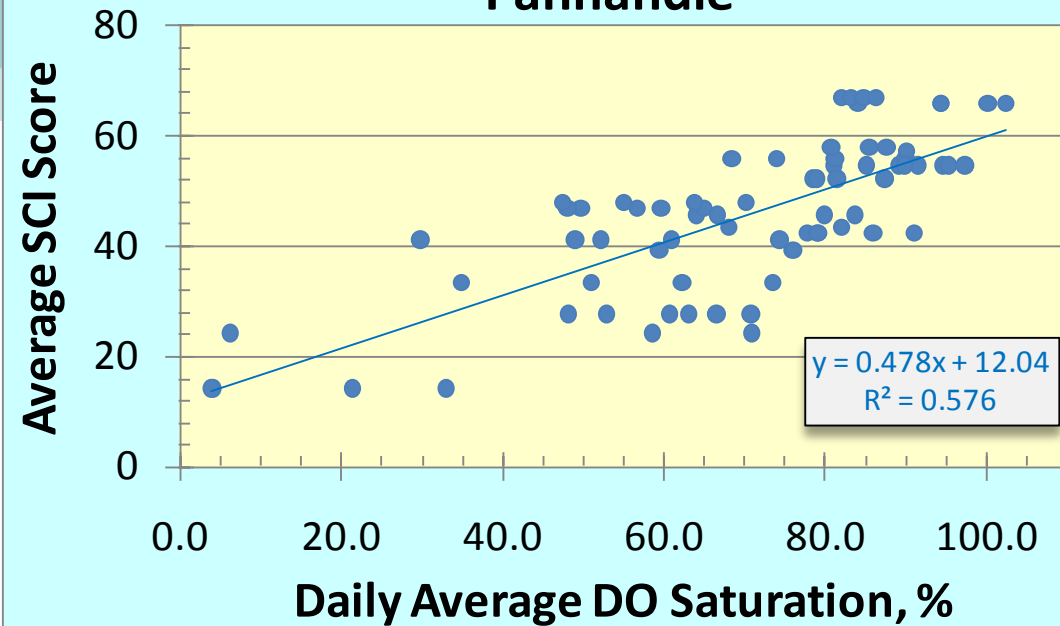
Regional DO/SCI Differences

- Effect of bioregion on DO vs SCI relationship was analyzed
- Stepwise regression showed Panhandle Bioregion to be significantly different from Northeast and Peninsula, and that
- Northeast and Peninsula could be combined

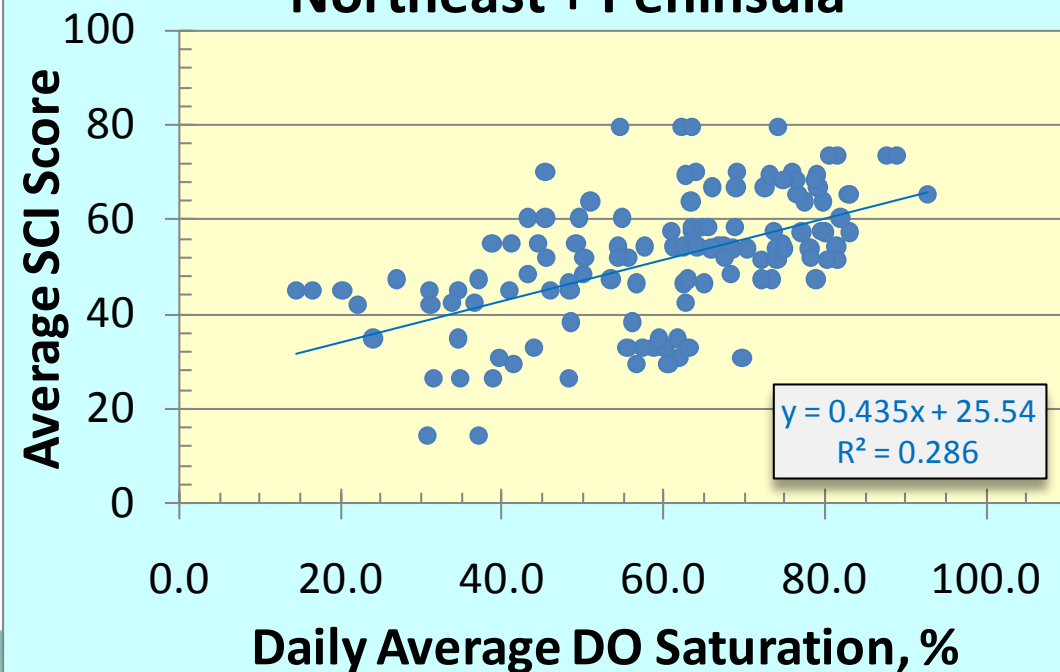




Panhandle



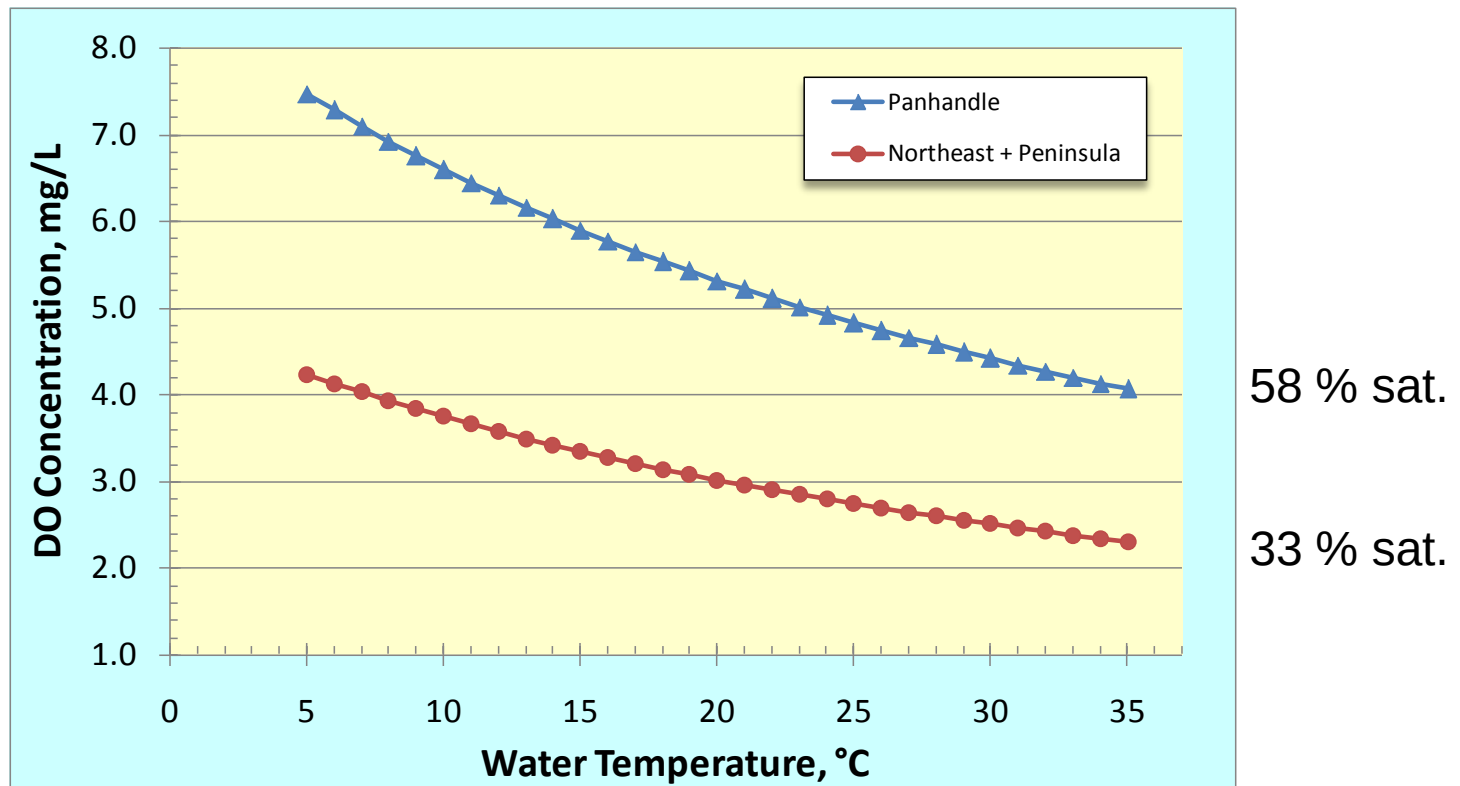
Northeast + Peninsula



Regional relationships between average SCI score and average daily DO percent saturation



DO criteria derived by solving the linear regression equations for the average SCI versus daily average percent DO saturation for an SCI score of 40





Proposed percent DO saturation criteria

The daily average percent DO saturation shall not be below 58.5 percent in the Panhandle bioregion or 33.2 percent in the Northeast and Peninsula bioregions.

Temperature, °C	Panhandle DO Criterion, mg/L	Northeast and Peninsula DO Criterion, mg/L
5	7.47	4.24
10	6.60	3.75
15	5.90	3.35
20	5.32	3.02
25	4.83	2.74
30	4.42	2.51

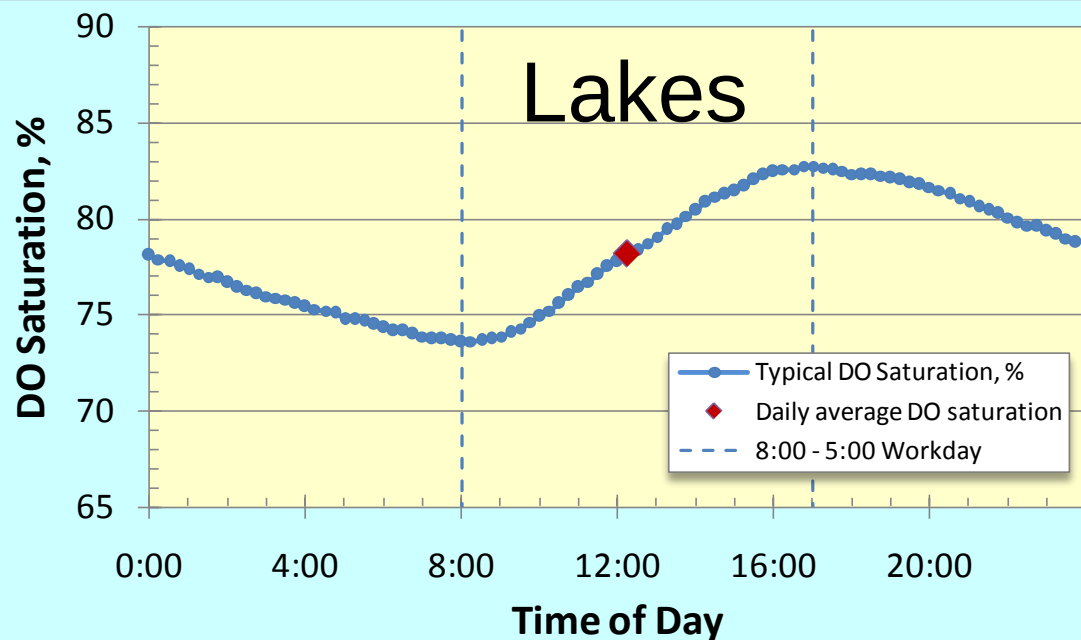
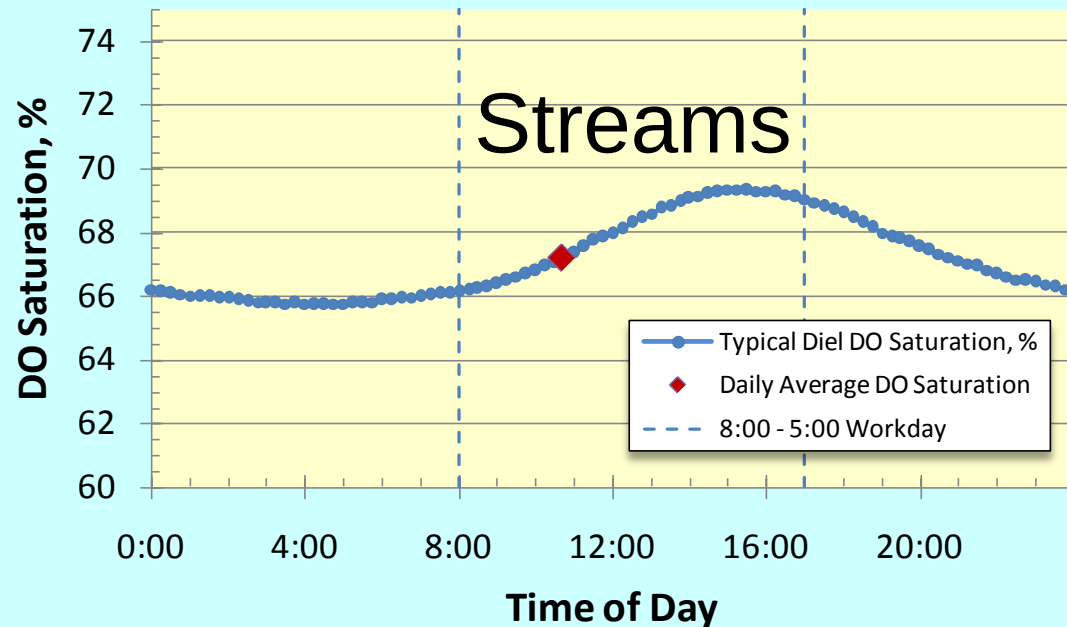




Cause-Effect Approach to DO

- Evidence that:
 - Stream invertebrates are more sensitive to low DO than stream fish [Davis (1975), Estes (2010)]
 - Stream invertebrates are more sensitive to low DO than lake or wetland invertebrates or fish [Fox et al. (1937), Hobbs and Hall (1974)]
- Therefore, DO at levels protective of stream invertebrate community response (SCI) also protects all freshwaters, including lakes
 - Applied to upper 2 m of water column



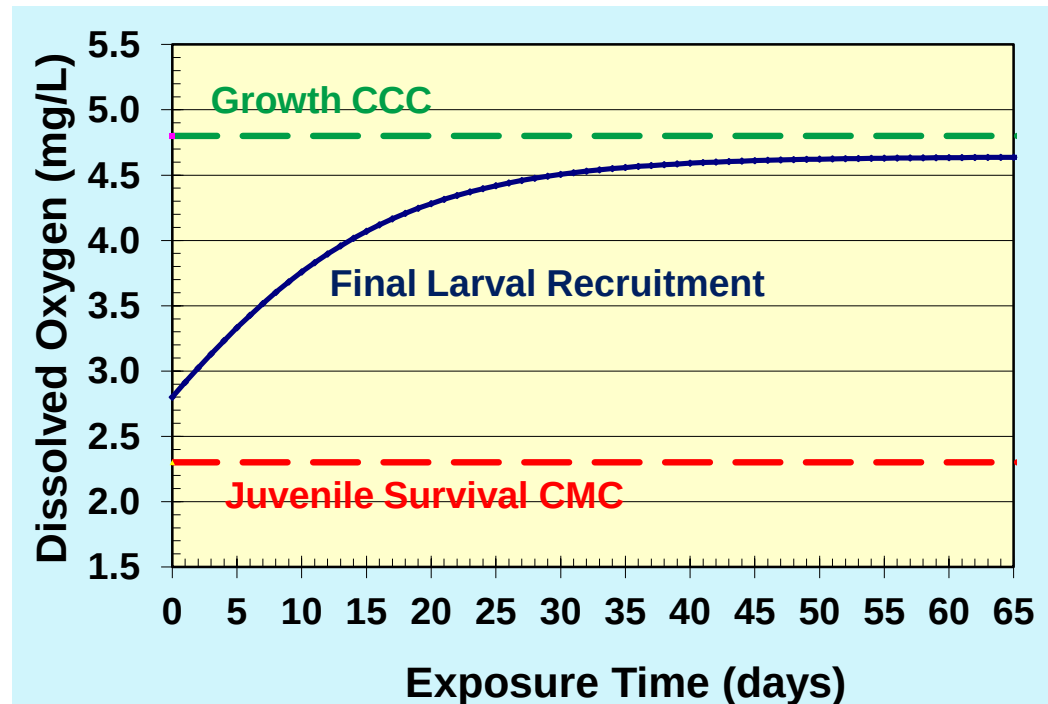


*Evaluate
Effect of
Sampling
Time
During
IWR
Assessment*



Methods to Revise Florida's Marine DO Criteria

- Based on EPA's Virginian Province Approach (EPA 2000) which uses measured response of sensitive organisms to low DO levels to establish allowable exposure durations.
- Three components to criteria:
 - Criteria Minimum Concentration (CMC)
 - Criteria Continuous Concentration (CCC)
 - Final larval recruitment/survival Curve.





23 Florida Species Used to Derive DO CMC

GMAV Rank	Species	Common name	SMAV	GMAV	LC ₅ /LC ₅₀
1	<i>Spisula solidissima</i>	Atlantic surfclam	0.43	0.43	1.63
2	<i>Prionotus carolinus</i>	northern sea robin	0.55	0.55	1.45
3	<i>Eurypanopeus depressus</i>	flat mud crab	0.57	0.57	
4	<i>Leiostomus xanthurus</i>	Spot	0.70	0.70	1.16
5	<i>Scophthalmus aquosus</i>	windowpane flounder	0.81	0.81	1.48
6	<i>Palaemonetes pugio</i>	daggerblade grass shrimp	0.72	0.86	
	<i>Palaemonetes vulgaris</i>	marsh grass shrimp	1.02		1.45
7	<i>Crassostrea virginica</i>	eastern oyster	0.88	0.88	
8	<i>Ampelisca abdita</i>	Amphipod	0.90	0.90	
9	<i>Callinectes sapidus</i>	blue crab	1.00	1.00	
10	<i>Brevoortia tyrannus</i>	Atlantic menhaden	1.12	1.12	1.53
11	<i>Stenotomus chrysops</i>	scup	1.25	1.25	
12	<i>Paralichthys dentatus</i>	summer flounder	1.32	1.32	1.19
13	<i>Mugil cephalus</i>	Striped Mullet	1.38	1.38	
14	<i>Americamysis bahia</i>	mysid shrimp	1.40	1.40	1.16
15	<i>Farfantepenaeus duorarum</i>	pink shrimp	1.41	1.41	
16	<i>Sciaenops ocellatus</i>	red drum	1.45	1.45	
17	<i>Morone saxatilis</i>	striped bass	1.58	1.58	1.23
18	<i>Lagodon rhomboides</i>	Pinfish	1.61	1.61	1.17
19	<i>Syngnathus fuscus</i>	pipe fish	1.63	1.63	
20	<i>Trachinotus carolinus</i>	pompano	1.74	1.74	
21	<i>Cynoscion nebulosus</i>	spotted seatrout	1.88	1.88	
22	<i>Menidia beryllina</i>	inland silversides	1.94	1.94	
23	<i>Harengula jaguana</i>	scaled sardines	2.17	2.17	

- The CMC was calculated based on the acute effects data for 23 genera
- Genera mean acute values (LC₅₀) of the test organisms ranged from 0.43 to 2.17 mg/L
- CMC was calculated as the FAV (95th percentile genus GMAV) multiplied by the mean LC₅ to LC₅₀ ratio (1.35)
- Resulting CMC is 2.8 mg/L.



Florida species Used to Derive DO CCC

Sensitivity Rank	Species	Common name	SMCV	GMCV
1	<i>Brevoortia tyrannus</i>	Atlantic menhaden	1.50	1.50
2	<i>Leiostomus xanthurus</i>	spot	1.50	1.50
3	<i>Americamysis bahia</i>	mysid	2.67	2.67
4	<i>Cyprinodon variegatus</i>	sheepshead minnow	2.74	2.74
5	<i>Morone saxatilis</i>	striped bass	2.80	2.80
6	<i>Cancer irroratus</i>	Atlantic rock crab	2.87	2.87
7	<i>Palaemonetes vulgaris</i>	marsh grass shrimp	3.15	3.15
8	<i>Mercenaria mercenaria</i>	northern quahog	3.17	3.17
9	<i>Menidia menidia</i>	Atlantic silverside	3.30	3.30
10	<i>Paralichthys dentatus</i>	summer flounder	3.97	3.33
10a	<i>Paralichthys lethostigma</i>	southern flounder	2.79	3.33
11	<i>Labinia dubia</i>	longnose spider crab	4.67	4.67
12	<i>Dyspanopeus sayi</i>	say mud crab	4.67	4.67

- Derivation was based on (larval and juvenile) growth bioassay data for 12 species
- Genera mean chronic values of the test organisms ranged from 1.50 to 4.67 mg/L
- CCC was calculated as the FCV (95th percentile genus GMCV)
- Resulting CCC is 4.9 mg/L.



Final Recruitment Curve (FRC)

- FRC fit using the larval dose-response curves for the four most sensitive genera: *Morone*, *Dyspanopeus*, *Chasmodes*, and *Octopus*
- Line of best fit through the points generated by the output of the recruitment model
- The equation is a standard mathematical expression for inhibited growth. The equation is:

$$P(t) = \frac{P_0 L}{P_0 + e^{-Lkt} (L - P)}$$

Where: $P(t)$ = is the DO concentration at time t

P_0 = is the y-intercept

L = the upper DO limit

k = a rate constant, and

t = time in days over which $P(t)$ may be tolerated





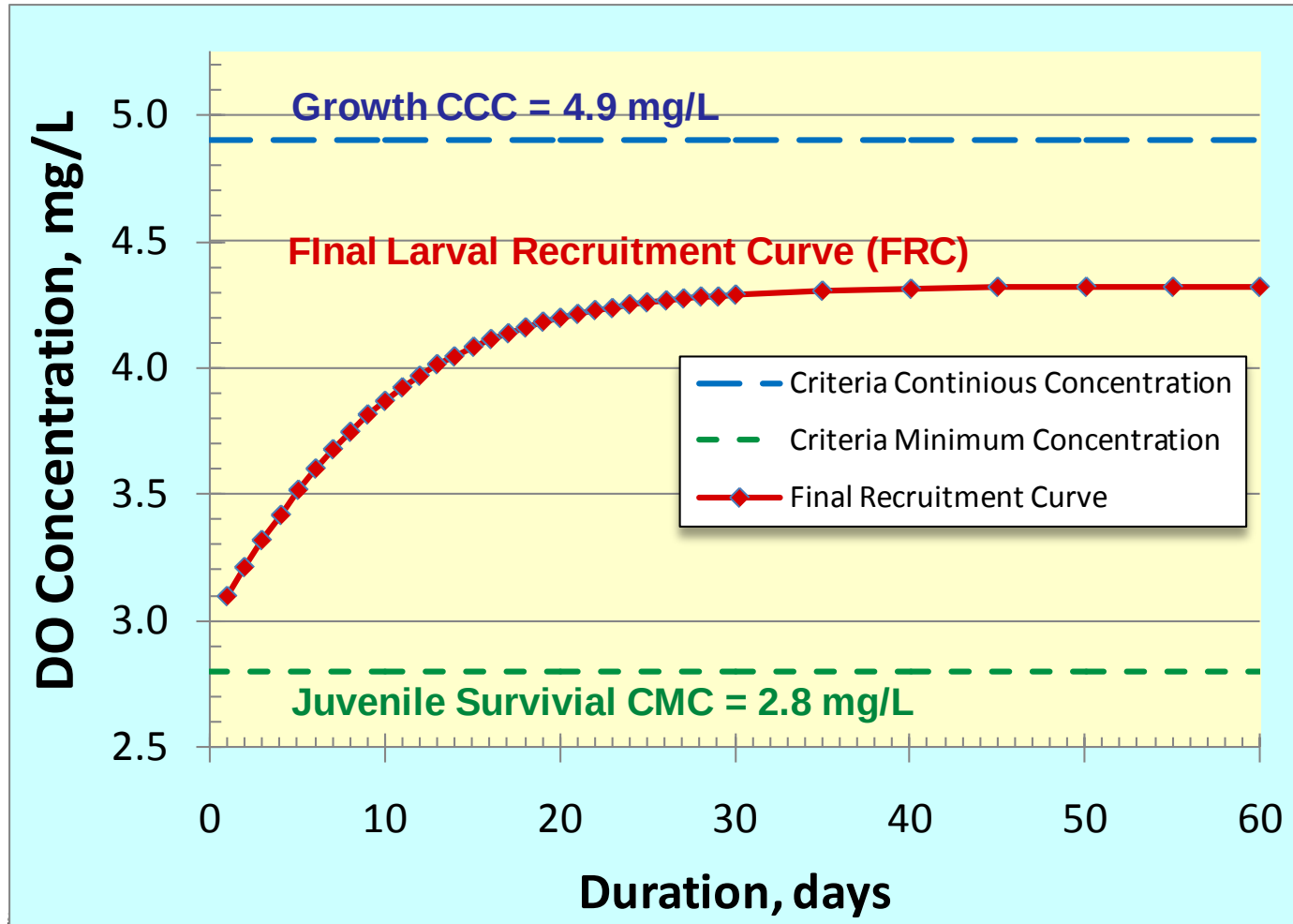
10 Florida Species Used to Derive Final Recruitment Curve

Species	Common	SMAV	GMAV	Recruitment Days	Development Days
<i>Palaemonetes</i>	grass shrimp	0.72	0.86	100	12
<i>Sciaenops ocellatus</i>	red drum	1.76	1.76	90	21
<i>Dyspanopeus sayi</i>	Say mud crab	1.80	1.80	66	21
<i>Menidia beryllina</i>	inland silversides	1.94	1.94	42	14
<i>Libinia dubia</i>	longnose spider crab	2.05	2.05	66	21
<i>Eurypanopeus depressus</i>	flat mud crab	2.11	2.11	66	21
<i>Cancer irroratus</i>	rock crab	2.15	2.15	65	35
<i>Morone saxatilis</i>	striped bass	2.41	2.41	49	28
<i>Chasmodes bosquianus</i>	striped blenny	2.50	2.50	210	21
<i>Octopus burryi</i>	Burry's octopus	2.54	2.54	300	28





Virginian Province Approach Applied to Data for Florida Species



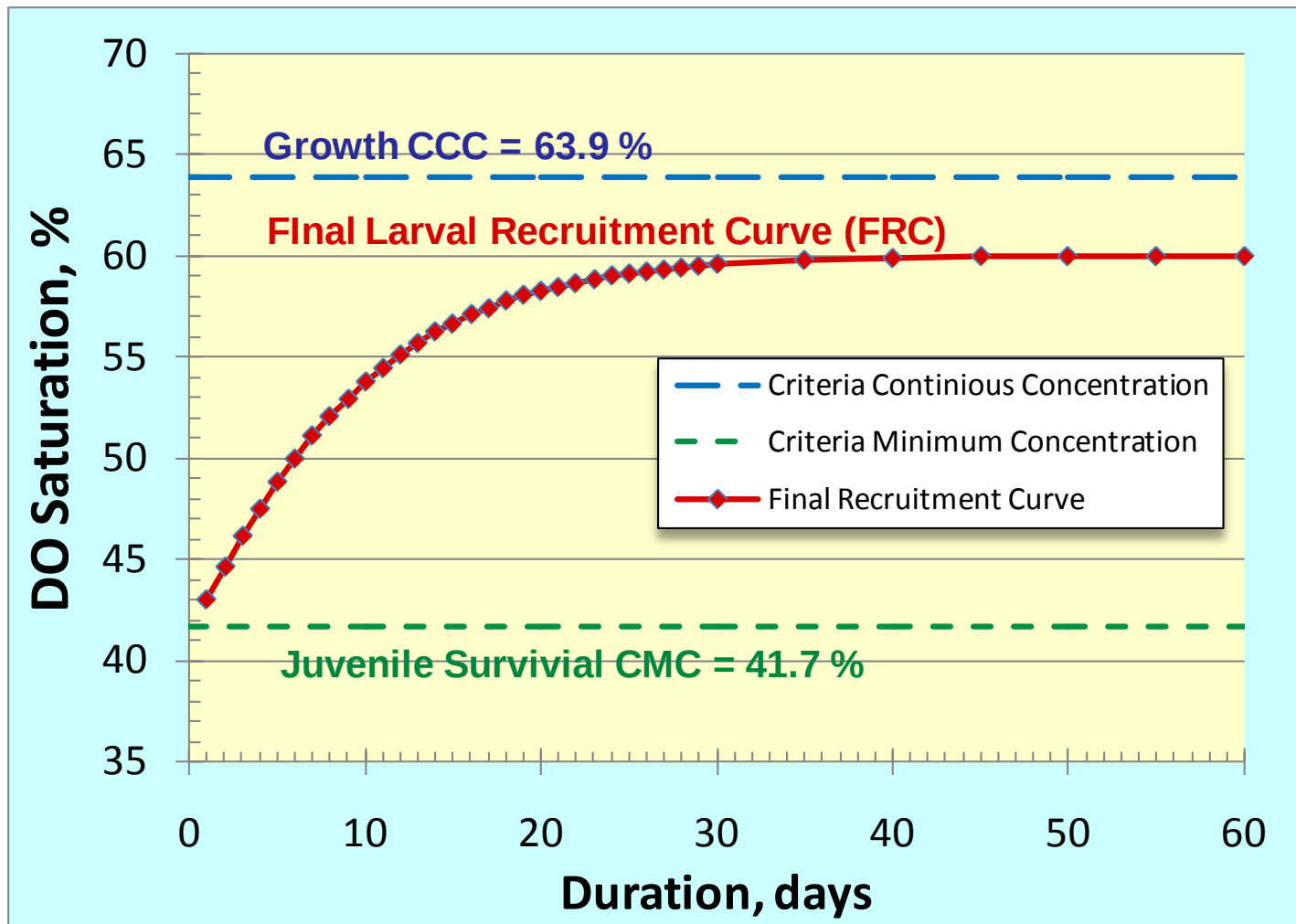
No adverse effects expected

Exposure duration based on larval recruitment model

Adverse effects likely

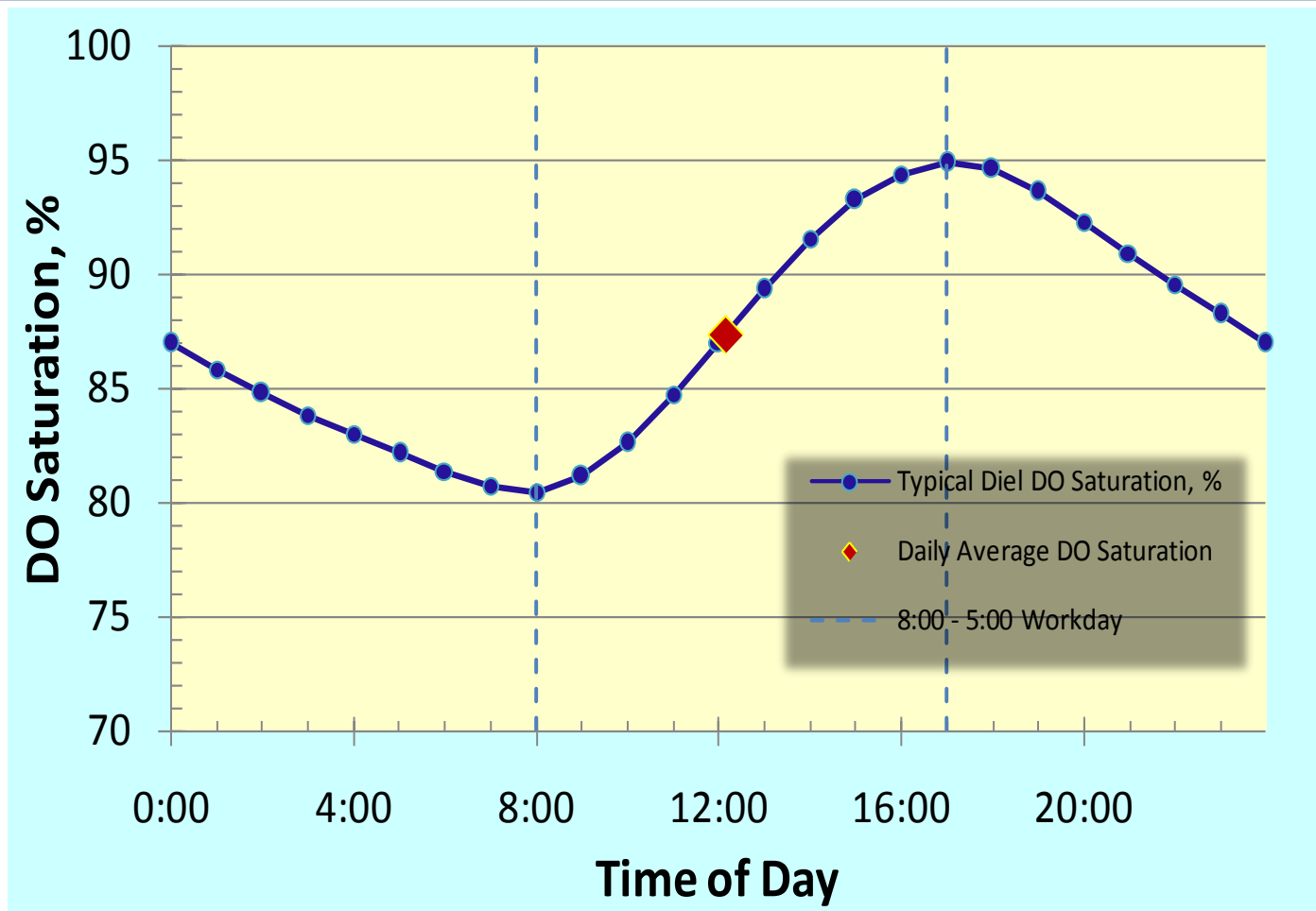


% Saturation-based Marine DO Criteria



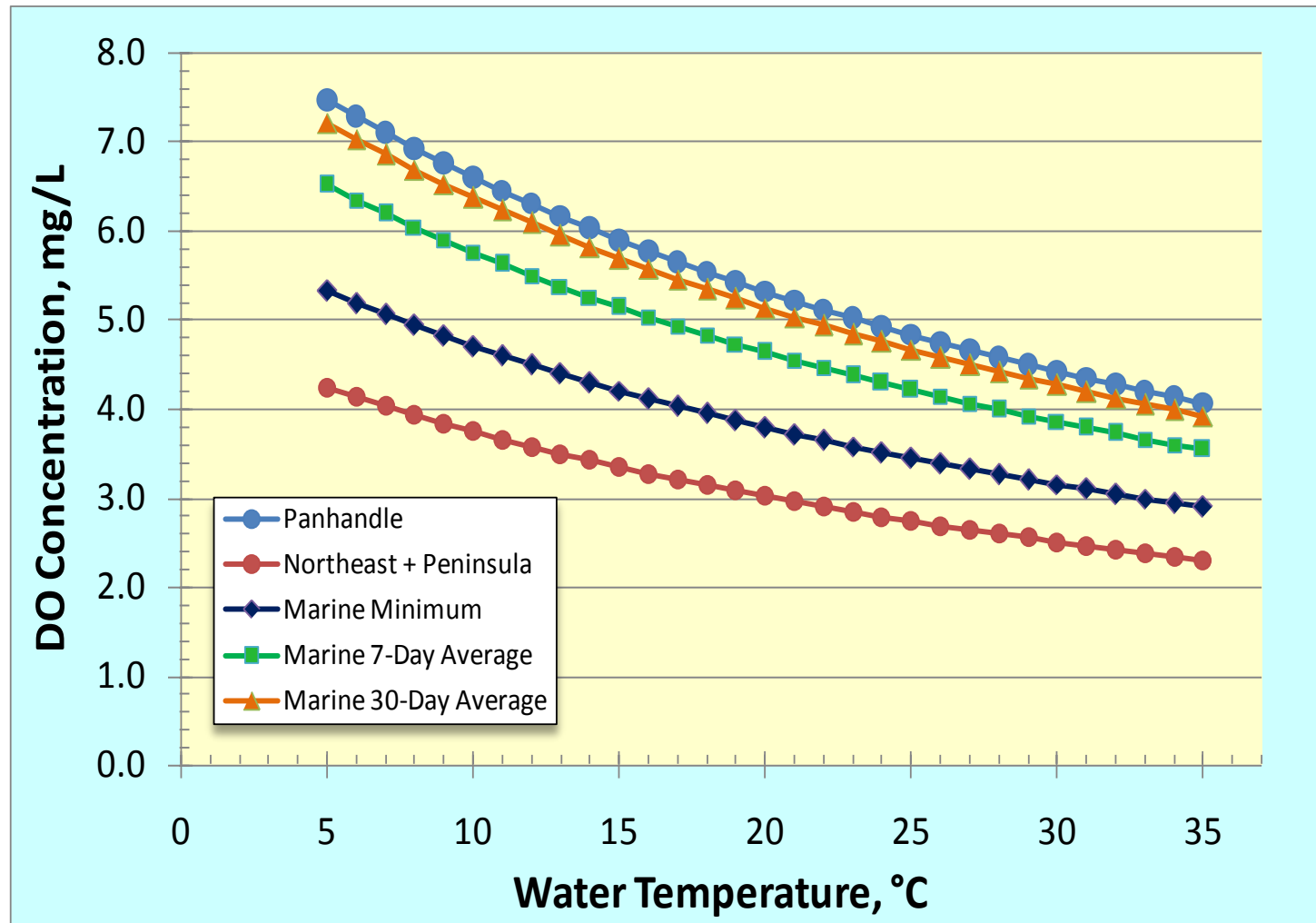


Evaluate Effect of Sampling Time During TMDL Assessment





Proposed DO Saturation Criteria for Florida's Fresh and Marine Waters





DO Deviation: Freshwater

- ***“Where natural conditions alone create dissolved oxygen concentrations less than 110% of the applicable criteria means or minima, or both, the minimum acceptable concentration is 90% of the natural concentration” (EPA 1986, Ambient Water Quality for DO)***
- **EPA Region IV approved this concept for Georgia Water Quality Standards in March 2010**





DO Deviation: Marine

- *“Dissolved Oxygen: A daily average of 5.0 mg/L and no less than 4.0 mg/L at all times. If it is determined that the natural condition in the waterbody is less than the values stated above, then **the criteria will revert to the natural condition and the water quality standard will allow for a 0.1 mg/L deficit from the natural dissolved oxygen value. Up to 10% deficit will be allowed** if it is demonstrated that resident aquatic species shall not be adversely affected” (EPA 1980, Ambient Water Quality for DO)*

