Dissolved Oxygen Analyses

Standards and Assessment Section

Russ Frydenborg, Garry Payne, and Ken Weaver

Presentation Contents

- Background/History on DO Issues
- Statewide DO/Nutrient Study
- Results of DO Study
- Exploring Approaches for DO criteria revisions
  - **Freshwater**
  - **Marine Waters**
- Deviation from Background DO Concept

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."

History of Existing DO Criteria

- Florida's existing DO criteria, based on EPA 1976 "Redbook" recommendations, were last revised in 1979
- Much discussion for criteria involved northern salmonids and "well-rounded" game populations
- 1986 EPA guidance recognizes that there are a number of natural conditions that can result in DO levels below the recommended criteria and acknowledged that in these cases, the default criteria would not be appropriate

EPA 1986 DO Criteria Guidance

"Naturally-occurring dissolved oxygen concentrations may occasionally fall below target criteria levels due to a combination of low flow, high temperature, and natural oxygen demand. These naturally-occurring conditions represent a normal situation in which the productivity of fish or other aquatic organisms may not be the maximum possible under ideal circumstances, but which represent the maximum productivity under the particular set of natural conditions. (USEPA. 1986. Ambient Water Quality Criteria for Dissolved Oxygen. EPA 440/5-86-003).

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EPA 1986 DO Criteria Guidance (cont.)

Under these circumstances the numerical criteria should be considered unattainable, but ***naturally-occurring conditions which fail to meet criteria should not be interpreted as violations of criteria****. Although further reductions in dissolved oxygen may be inadvisable, effects of any* ***reductions should be compared to natural ambient conditions*** *and not to ideal conditions." (USEPA 1986).*

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EPA Guidance

- Additionally, EPA's recommended Marine DO criterion was qualified with the following statement:

  "The committee would like to stress that, due to a lack of fundamental information on the DO requirements of marine and estuarine organisms, these requirements are tentative and should be changed when additional data indicate that they are inadequate" (Federal Water Pollution Control Administration 1968).

Issues with Existing Florida DO Criteria

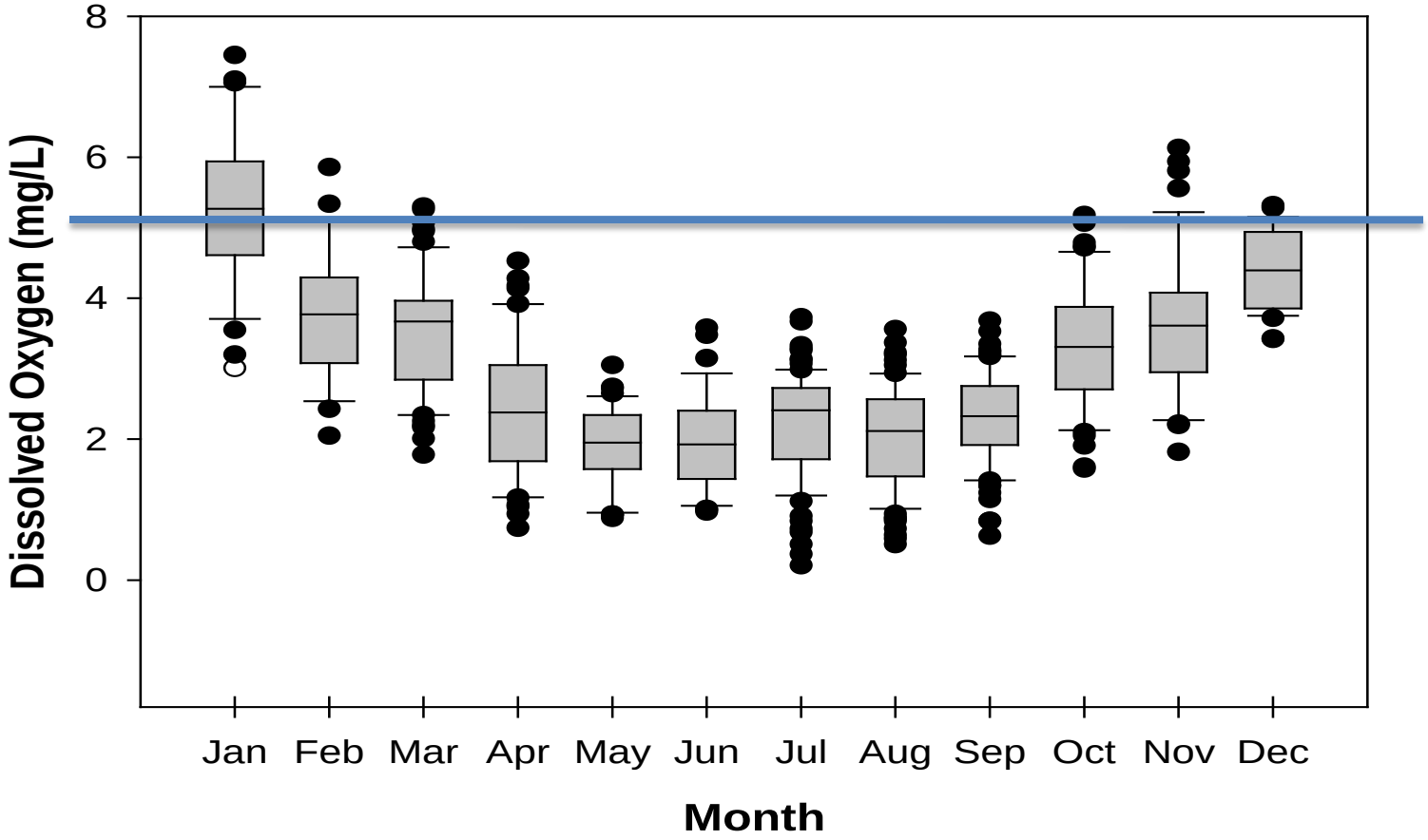
- Many Florida waters naturally exhibit low DO levels
  - Groundwater typically <20% saturation
  - High temperatures, dense canopy/shading
  - Low water velocities, stratification
  - Abundant natural organic input (leaf litter)
- Original DER (*Department of Environmental Regulation*) DO language failed to include an acceptable departure from natural conditions

Issues With Existing Florida DO Criteria (cont.)

- The repercussions of this error did not become readily apparent until the implementation of the TMDL Program
- Without a specific natural background clause for DO, numerous natural waters were identified as impaired for DO and placed on the Clean Water Act (CWA) 303(d) list
  - Results in unnecessary resource expenditures
- Naturally low DO conditions currently addressed through Site Specific Alternative Criteria (SSAC)
  - Burdensome process, time consuming

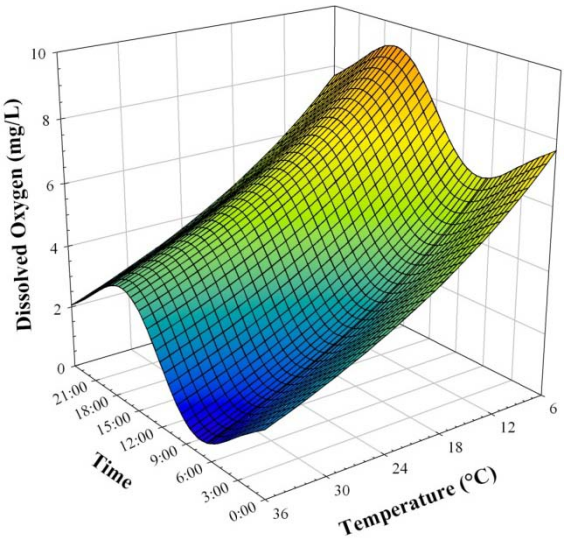

Econfina River:
Example of Minimally Disturbed Stream with healthy macroinvertebrate community (SCI > 40). Daily average DO during summer is 2.1 mg/L

Reference System (Econfina) Daily Minimum DO



Site Specific Alternative Criteria (SSAC)

- DEP has approved 14 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

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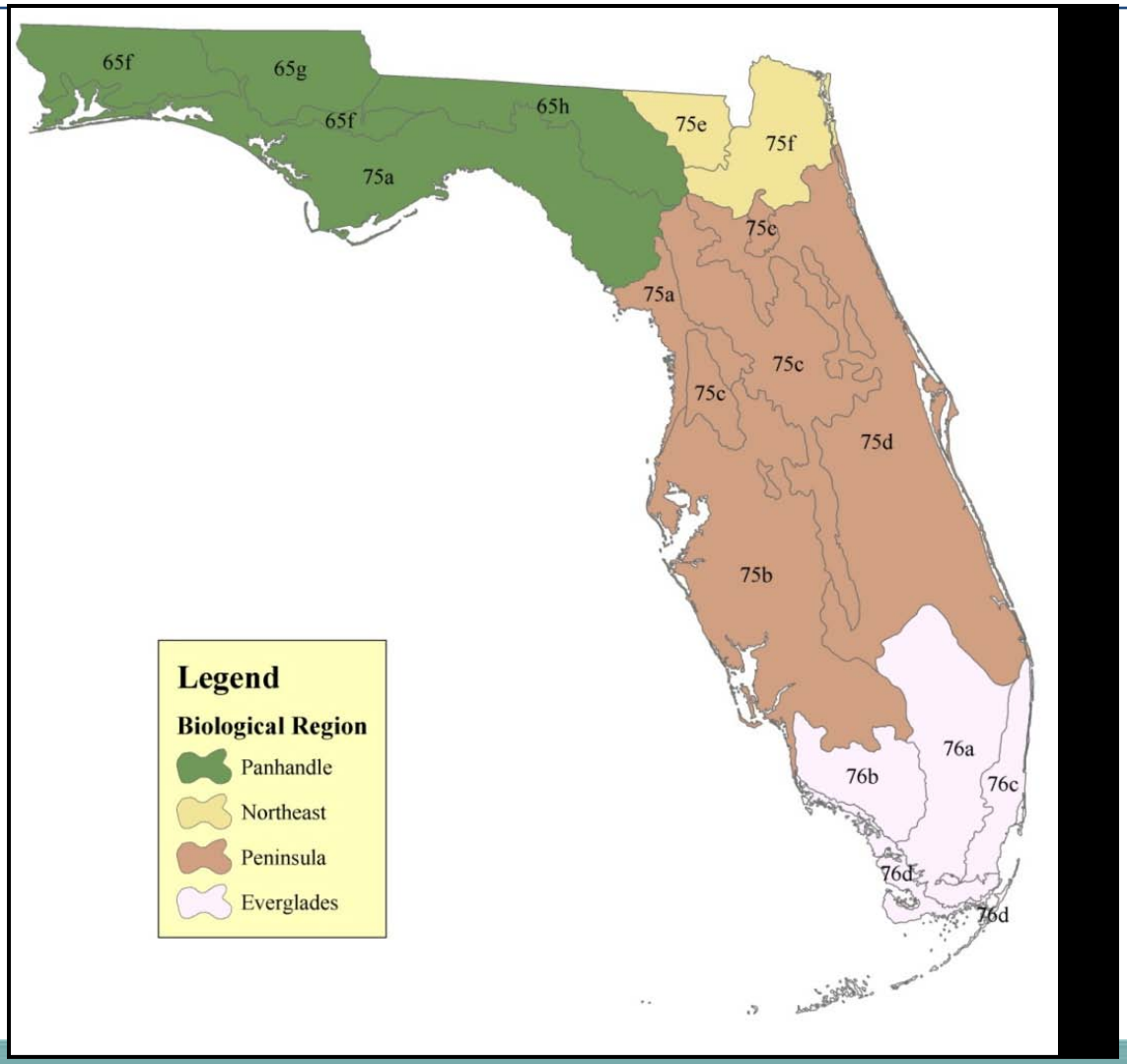
Statewide DO / Nutrient Study

- 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

Sites Sampled Across Florida Bioregions



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Statewide DO / Nutrient Study (cont.)

Quarterly Monitoring consisted of:

- 3-day Sonde deployments (DO, specific conductance, pH, temperature)
- Vertical profile measurements (at deploy & retrieval)
- WQ sampling (nutrients, color, chlorophyll, Total Organic Carbon, turbidity)
- Biological sampling (2 quarters) (Habitat, Stream Condition Index, periphyton/phytoplankton)

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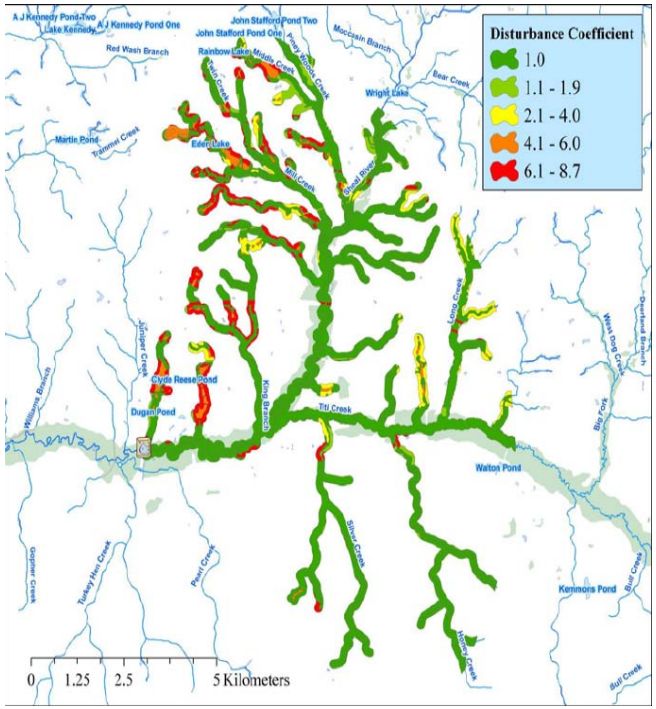
DO Study Site Selection

- Reference and non-reference sites sampled to assess effect of human disturbance on DO regime
- Reference site selection initially based on Landscape Development Intensity Index (Brown and Vivas 2005), with *post hoc* criteria to minimize confounding factors, including conductivity, habitat, hydrology, and nitrate

Landscape Development Intensity Index



A Quantitative Measure of the Intensity of Human Landscape Uses

$$LDI = \Sigma (LDC * \%LU)$$

Where,
LDI = Landscape Development Intensity
LDC = Disturbance Coefficient associated with the particular land use
%LU = Percent area of the wetland drainage basin occupied by the land use category

(Brown and Vivas, 2005)

LDI Coefficients

Category	Coefficient
Natural System	1
Pine Plantation	1.6
Pasture	3.4
Row Crops	4.5
Residential (low)	6.8
Residential (high)	7.6
Commercial	8.0
Industrial	8.3
Commercial (high)	9.2
Business District	10.0

Based on non-renewable Energy inputs, Odom's "Embodied Energy" concept.

Ranking of land use comes from the literature reviews primarily Harper (1994) and Beaulac and Reckhow (1982)

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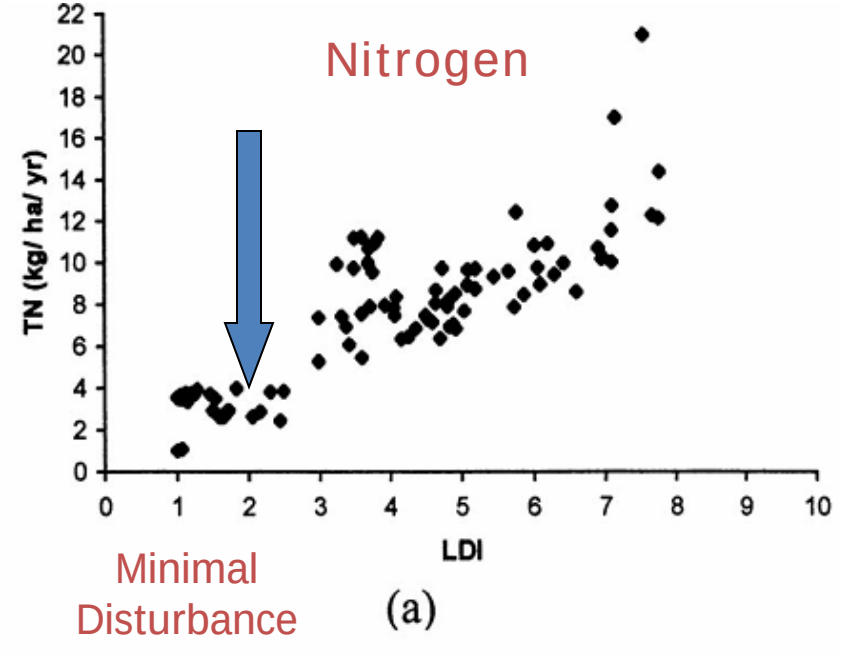
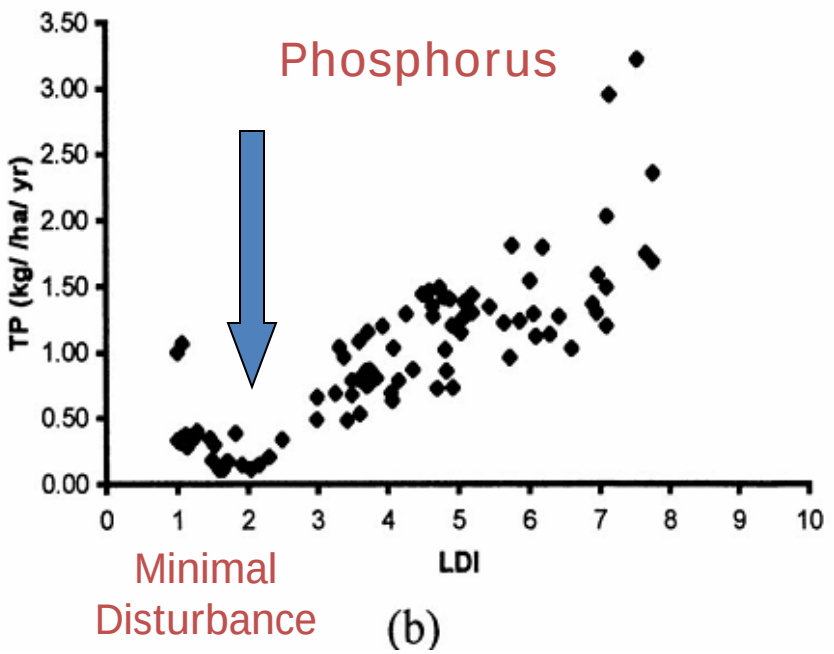
Relationship Between LDI and Nutrient Loading (Brown and Vivas 2005)





Background on Stream Condition Index

- Measures invertebrate response to human disturbance, with 10 metrics:
  - Total Taxa, Clinger Taxa, Long Lived Taxa, Percent Suspension Feeders, Sensitive Taxa, Tanytarsini, Very Tolerant (inverse), Ephemeroptera Taxa, Trichoptera Taxa, Percent Dominant (inverse)
- Calibrated via EPA Biological Condition Gradient Approach and Reference Site Distribution
- EPA concurs that an average score of 40 or higher is biologically healthy, and consistent with meeting the designated use of a healthy, well balanced aquatic community (Federal Register /Vol. 75, No. 233, page 75775)

GENERAL RESULTS OF STATEWIDE DO/NUTRIENT STUDY

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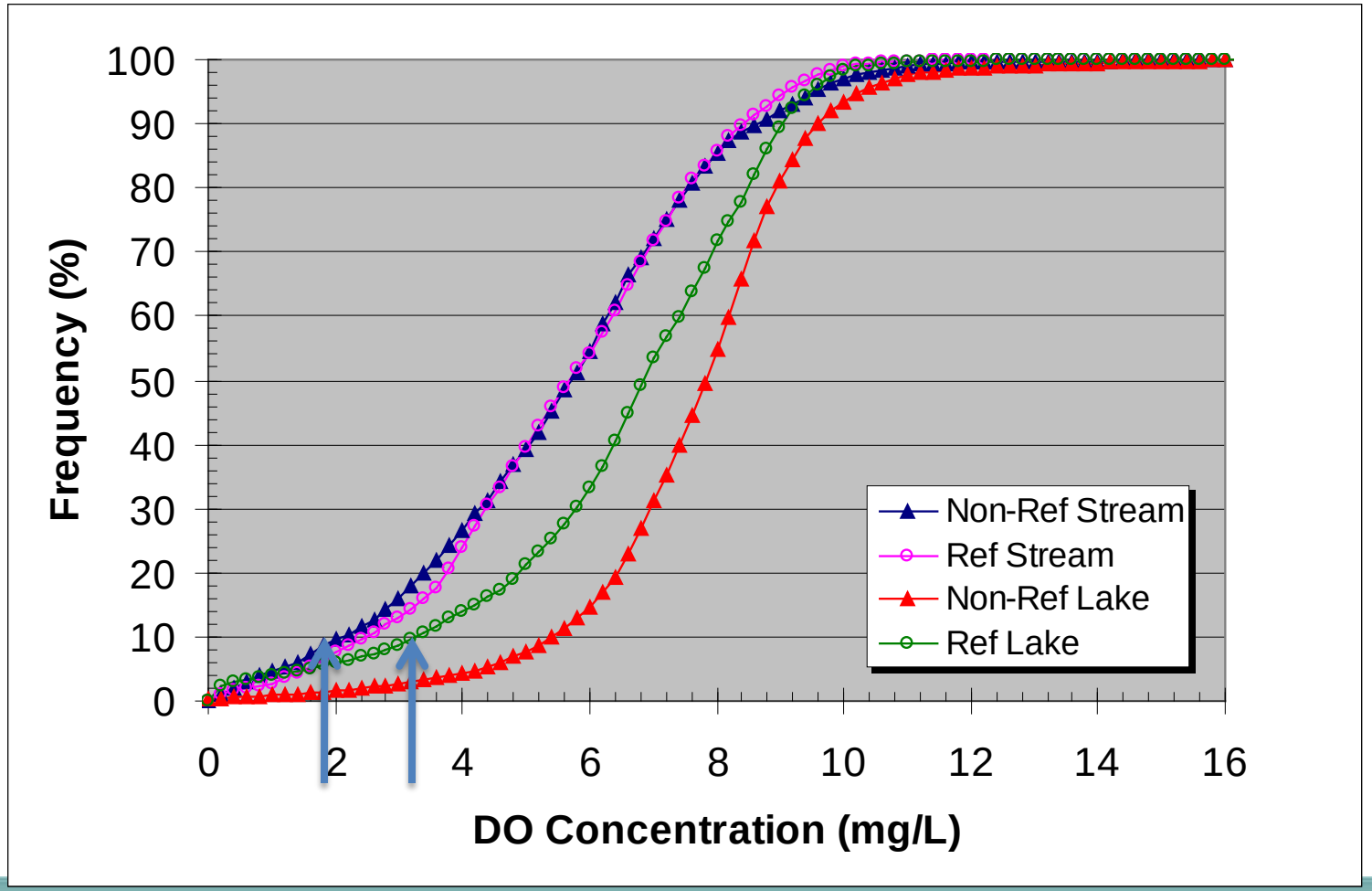
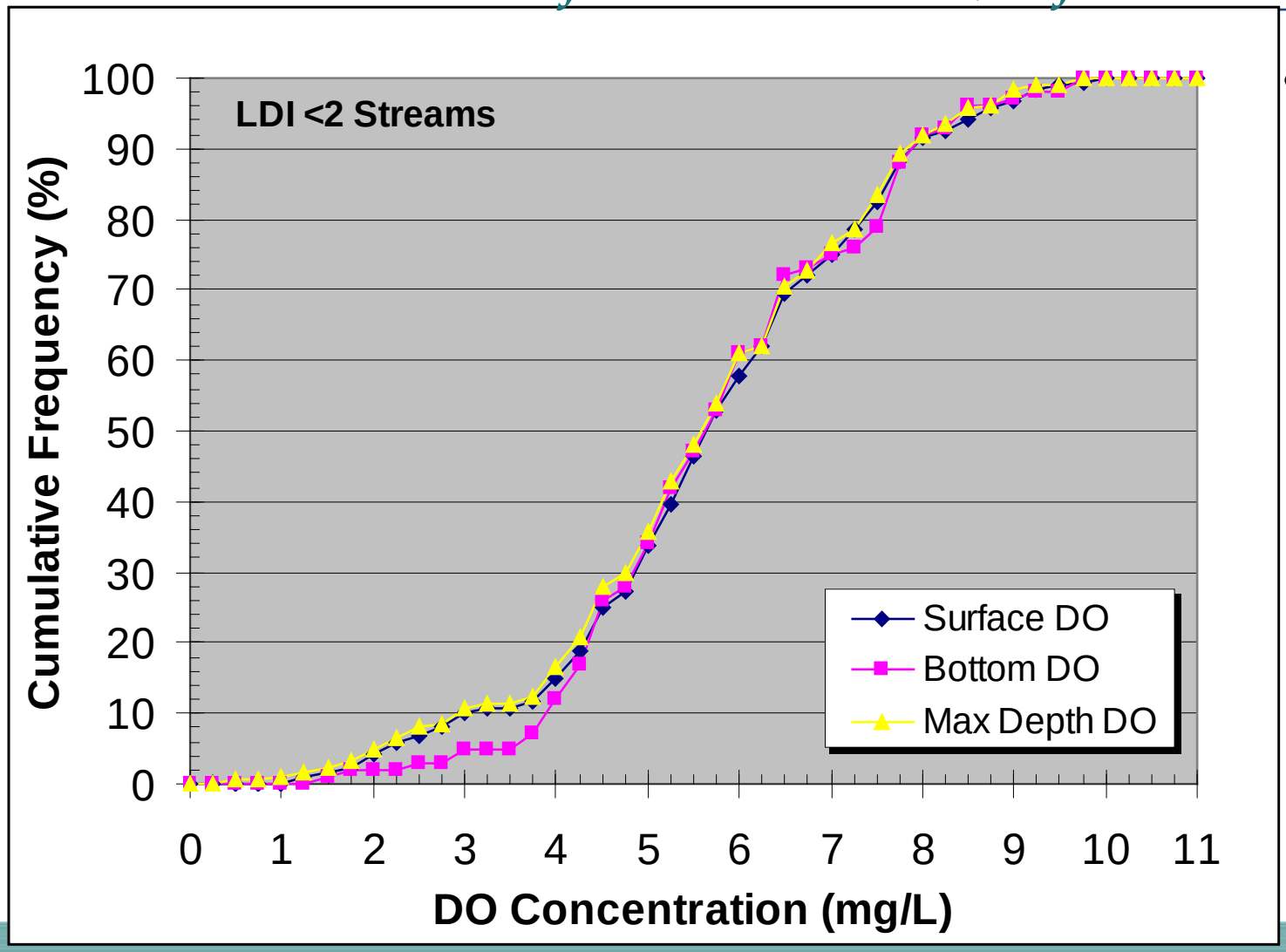
DO/Nutrient Study
Data Distributions, Stream and Lake Diel DO Concentration

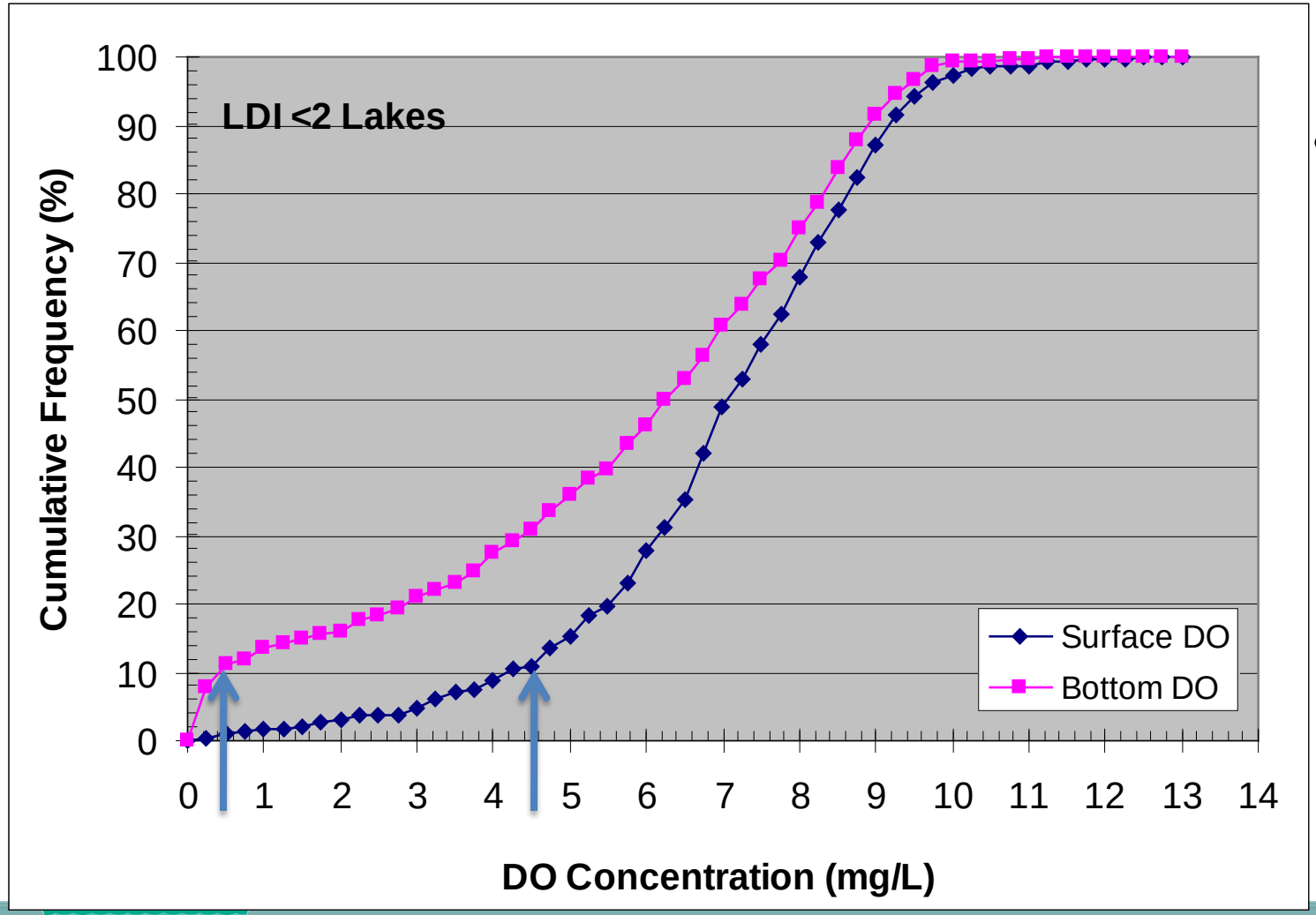


DO/Nutrient Study
Vertical Profile DO Data (Ref. Streams)



- 70 % of reference streams have one vertical measurement.

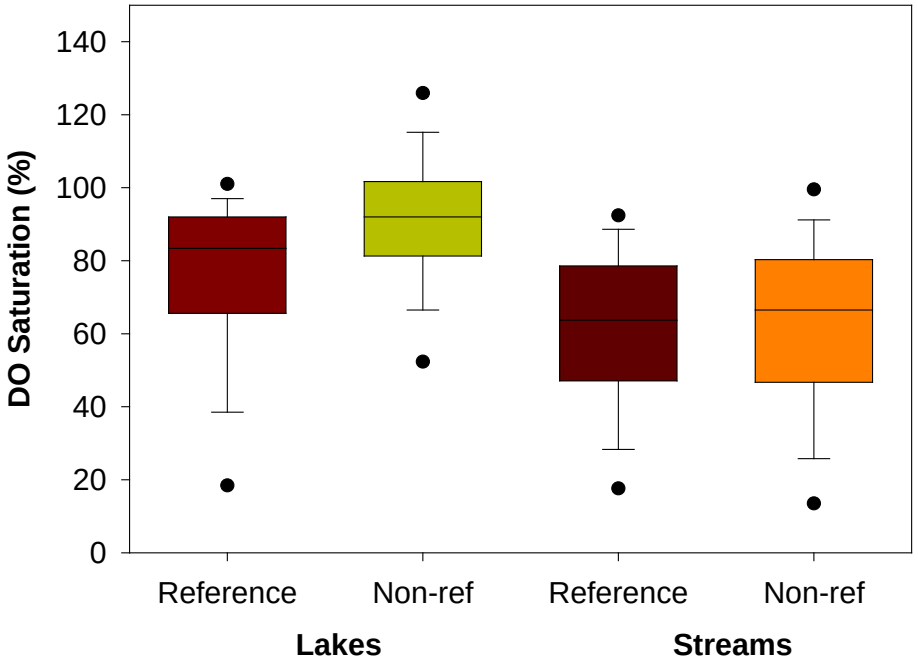
DO/Nutrient Study
Vertical Profile DO Data (Ref. Lakes)



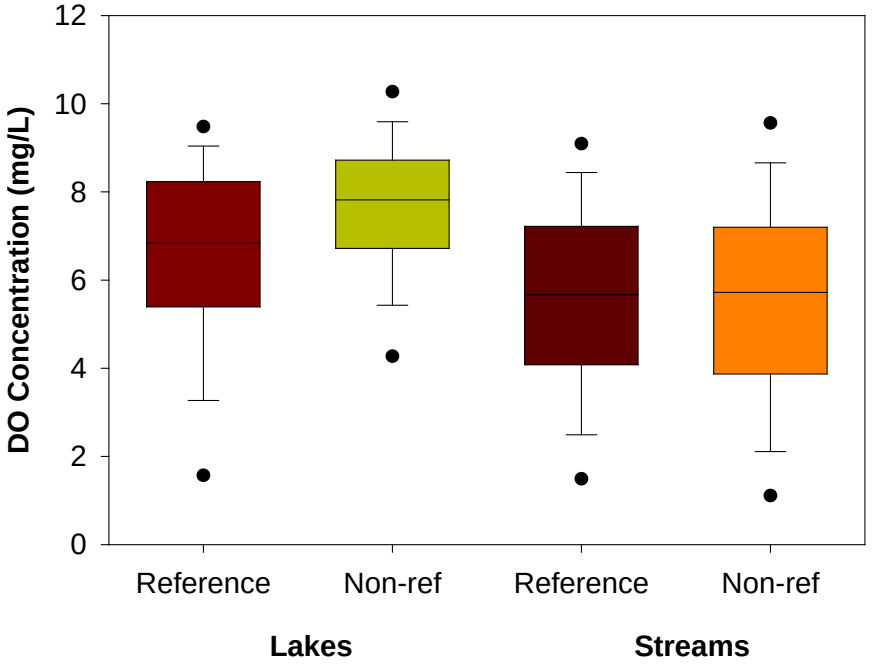
- At lower 10th percentile, difference between surface and bottom is 4.0 mg/L.

DO/Nutrient Study
Box Plot Comparisons

DO % Saturation



DO Concentration



Evaluation of Existing DO Criteria

Waterbody Class I	Bioregion	Reference	Count	Average DO Conc	Average Min DO Conc	Average Max DO Conc	Average % Excursions	Average Daily Range
Lake	Northeast	Non-reference	4	8.64	6.23	12.16	0.87	4.00
Lake	Northeast	Reference	16	6.98	5.58	8.03	6.46	1.27
Lake	Panhandle	Non-reference	56	7.41	5.64	9.33	13.41	2.38
Lake	Panhandle	Reference	112	6.20	5.08	7.32	27.08	1.36
Lake	Peninsula	Non-reference	210	7.79	6.47	9.29	4.78	1.72
Lake	Peninsula	Reference	196	6.71	5.25	8.19	18.49	1.62
Lake	State	Non-reference	270	7.72	6.29	9.34	6.51	1.89
Lake	State	Reference	324	6.55	5.21	7.88	20.87	1.52
Stream	Northeast	Non-reference	31	5.24	3.62	7.63	45.21	2.54
Stream	Northeast	Reference	67	5.74	4.99	6.79	35.99	0.69
Stream	Panhandle	Non-reference	42	6.35	5.16	8.07	25.70	1.93
Stream	Panhandle	Reference	107	6.32	5.45	7.43	28.69	1.06
Stream	Peninsula	Non-reference	238	5.45	4.23	7.38	40.00	2.13
Stream	Peninsula	Reference	134	4.83	4.11	6.02	50.62	0.93
Stream	State	Non-reference	311	5.55	4.29	7.50	38.58	2.14
Stream	State	Reference	308	5.55	4.77	6.68	39.82	0.92

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Evaluation of Existing DO Criteria

Waterbody Class I	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 Study Overall Findings

- Large percent of reference sites do not meet current criteria
  - Generally, more reference sites fall below 5.0 mg/L than non-reference sites
  - Greater percent of reference sites have more than 10% of measurements below 5.0 mg/L compared to non-reference sites.
- Existing DO criteria of 5.0 mg/L all times and all places is inaccurate for minimally disturbed reference conditions
- Need to develop more accurate DO criteria to avoid issues with inappropriate criteria (e.g., listing reference waters as impaired, developing large number of SSACs).

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EXPLORING APPROACHES FOR DO CRITERIA REVISIONS - FRESHWATERS

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Potential Approaches for DO Criteria

- Reference Site Approach
  - Percentile of reference site distribution
- Cause-Effect Approach (SCI response to DO)
  - DO needed to protect most sensitive community (stream macroinvertebrates)
  - As conservative measure, apply stream criteria to lakes

Potential Reference Site Approach

- Select all sites that are <2 on LDI and > 40 on SCI and calculate lower 10th percentile of Sonde deployment data:
  - Statewide 3.4 mg/L
  - Northeast 3.2 mg/L
  - Panhandle 4.5 mg/L
  - Peninsula 2.5 mg/L
- Waters should not be below these values more than 10% of the time

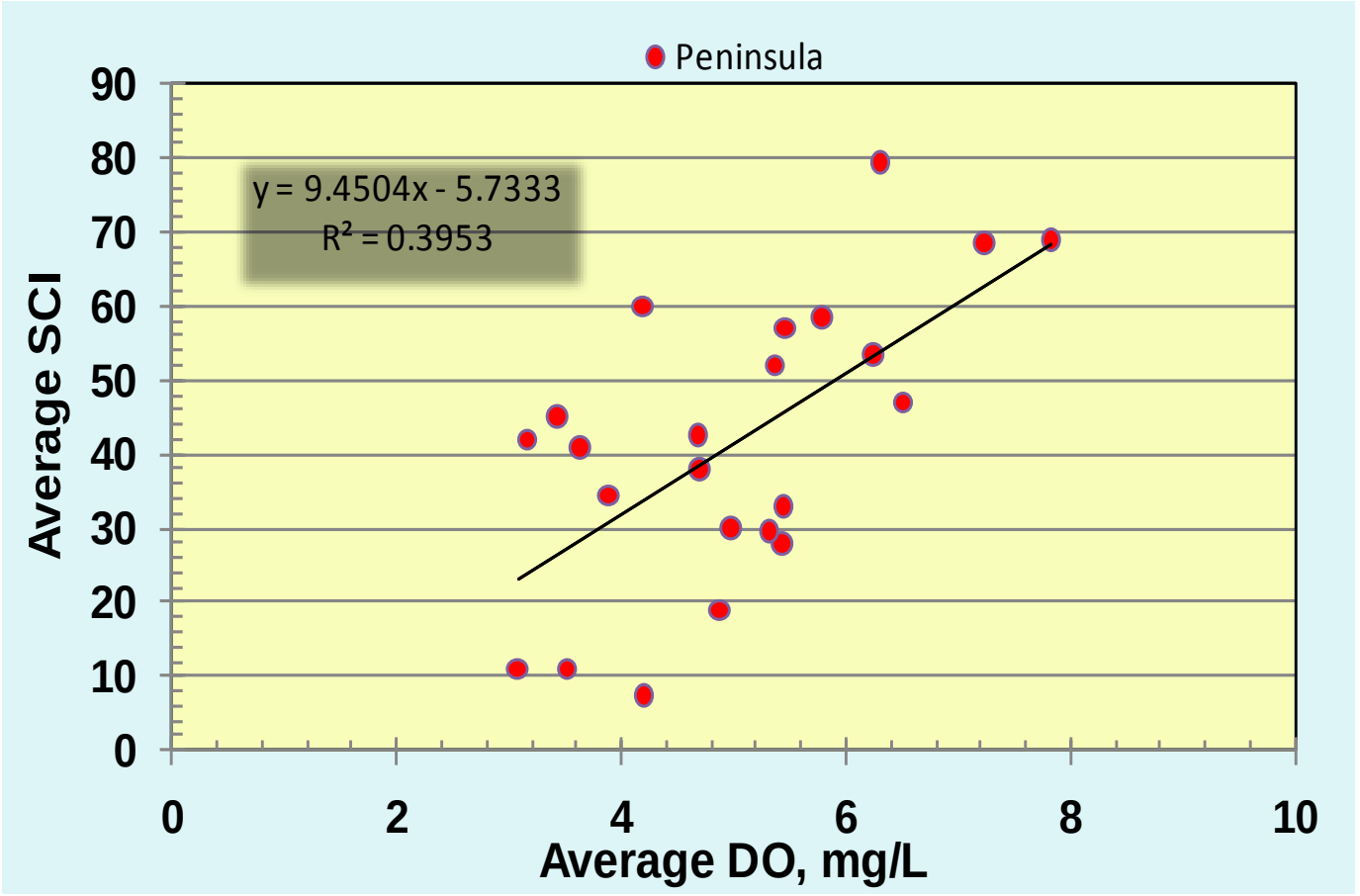
Cause-Effect Approach to DO

- 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, establishing DO at levels protective of stream invertebrate community response (SCI) also protects all freshwaters

Process to Relate SCI vs. DO

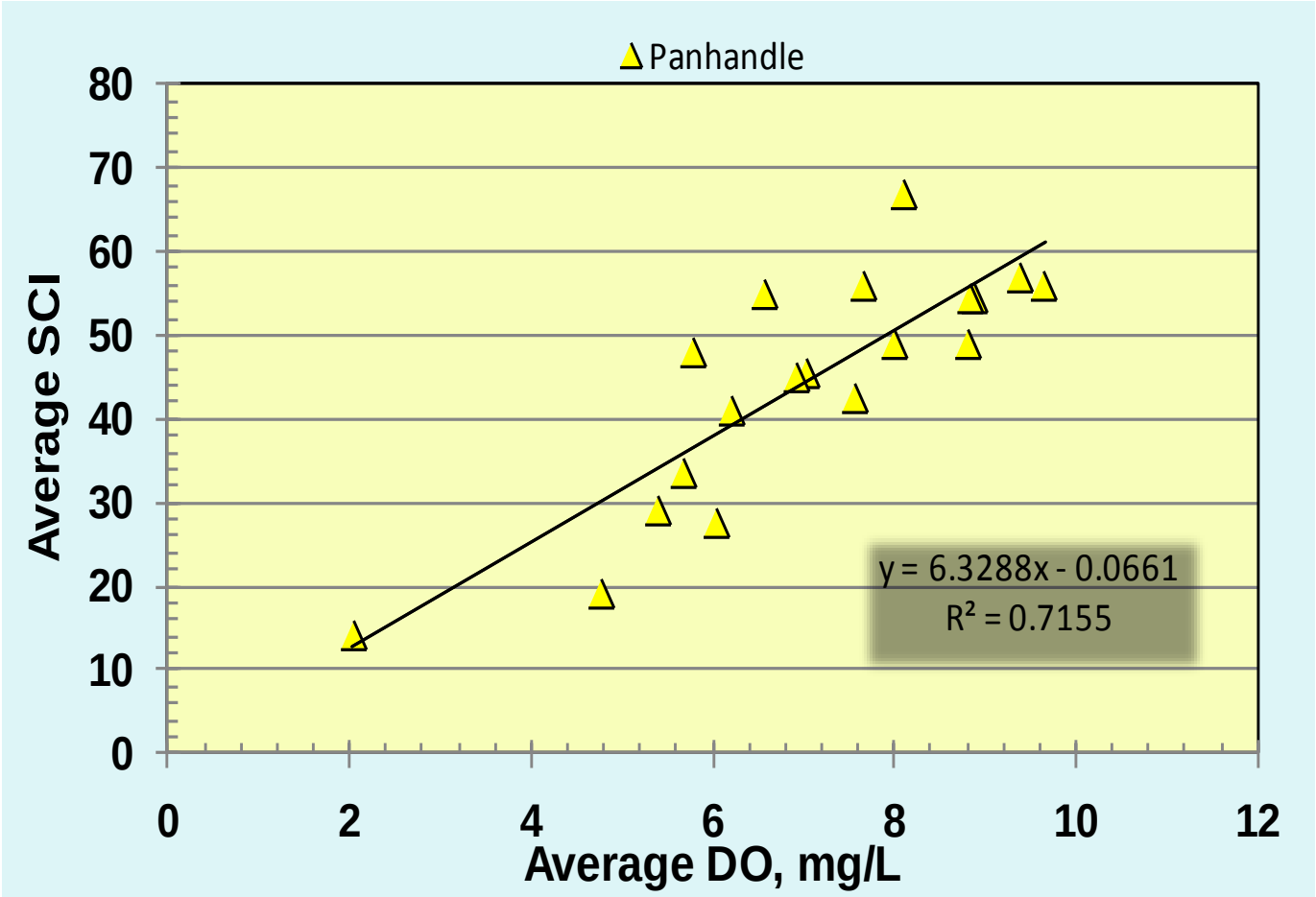
- Bioregions analyzed both separately and together
- DO study stream data screened data to minimize effect of confounding variables
  - LDI < 2,
  - Conductivity < 250 umhos/cm,
  - Habitat Assessment > 110,
  - Nitrate < 0.35 mg/L

SCI vs. Annual Average DO Peninsula



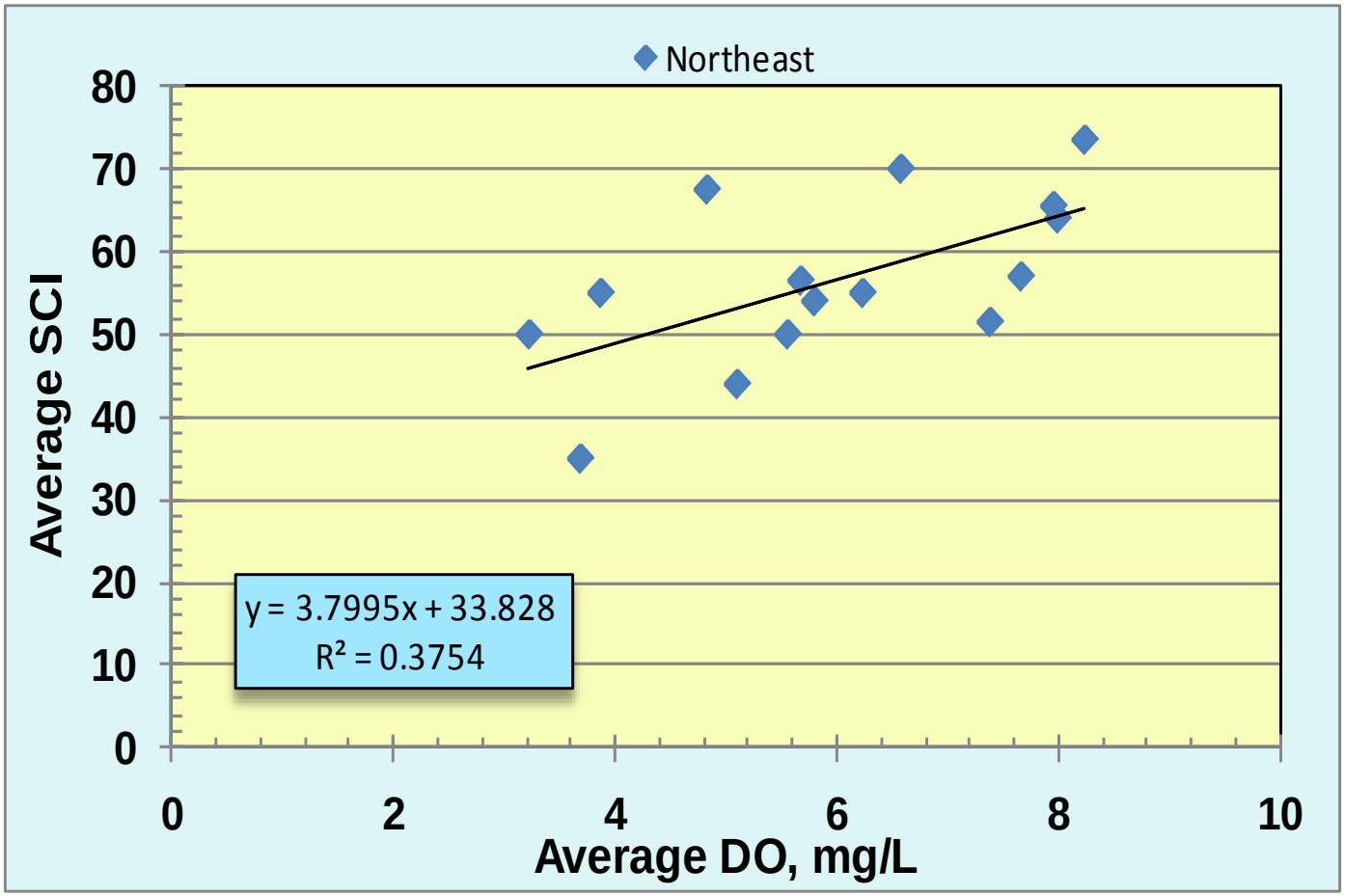
Annual average SCI score vs. annual average DO concentration

SCI vs. Annual Average DO Panhandle



Annual average SCI score vs. annual average DO concentration

SCI vs. Annual Average DO Northeast

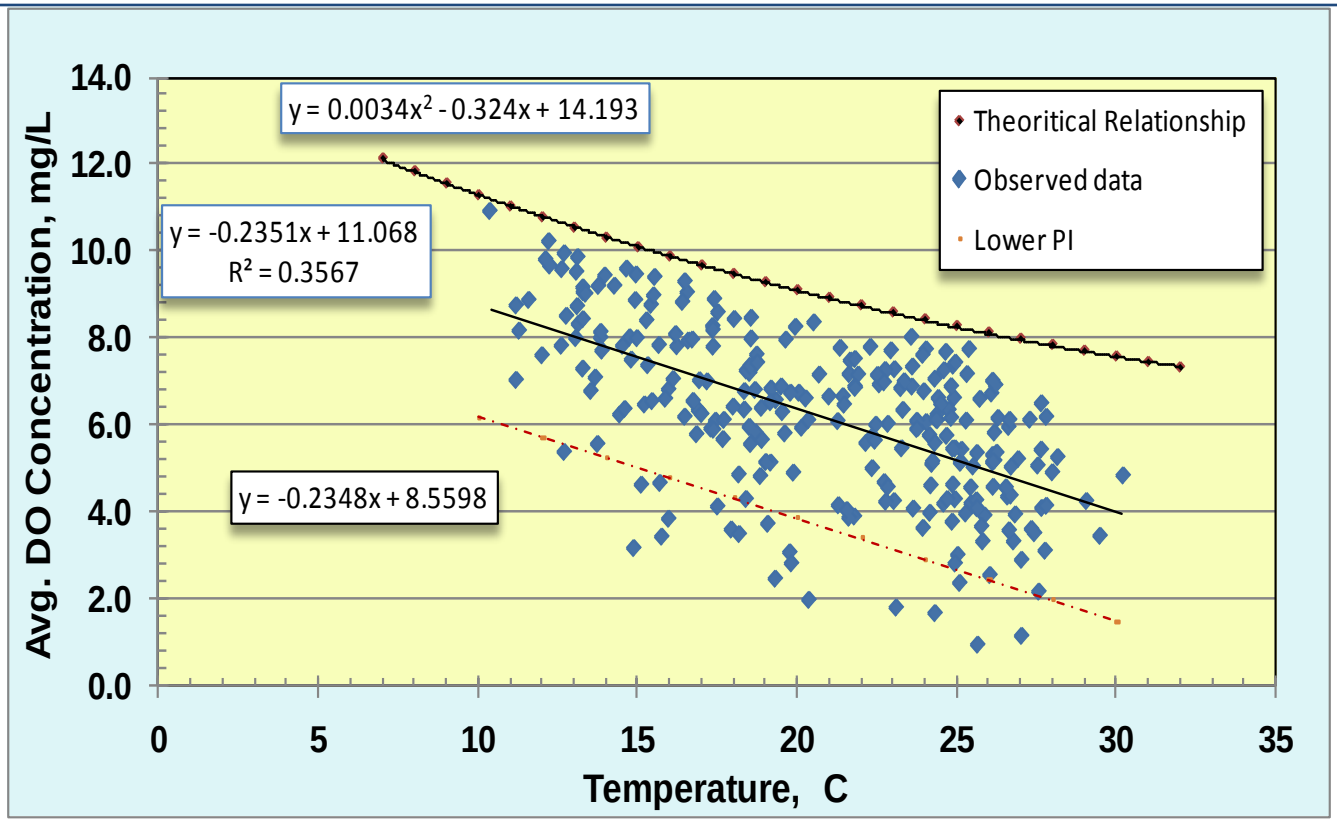


Annual average SCI score vs. annual average DO concentration

Temperature and DO

- Ideal Gas Law dictates that the concentration of DO in water is inversely related to temperature
- In aquatic ecosystems, factors other than temperature influence the DO concentration (e.g., re-aeration, photosynthetic activity, respiration, and natural oxygen demand)
- However, temperature dependent or % saturation based criteria would improve accuracy

Temperature, Average DO, and >40 SCI



Deployment Average Temp vs. Deployment average DO and lower 90% prediction interval along with the theoretical DO VS temperature relationship for sites passing SCI

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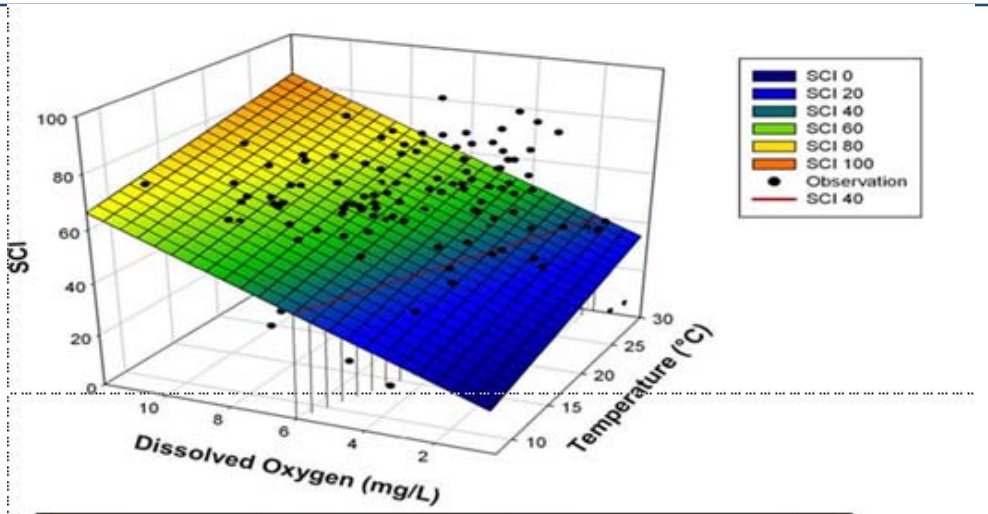
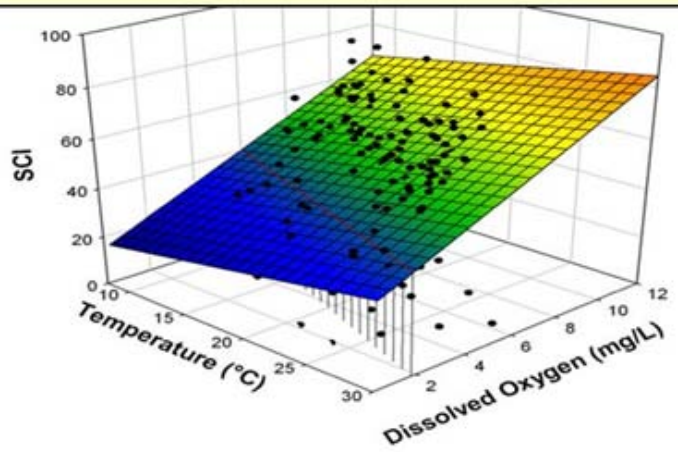
Multiple Linear Regression

Surface diagram of multiple-regression conducted between SCI and DO and water temperature.



$$SCI = 4.60 * DO + 0.58 * Temp + 10.71$$



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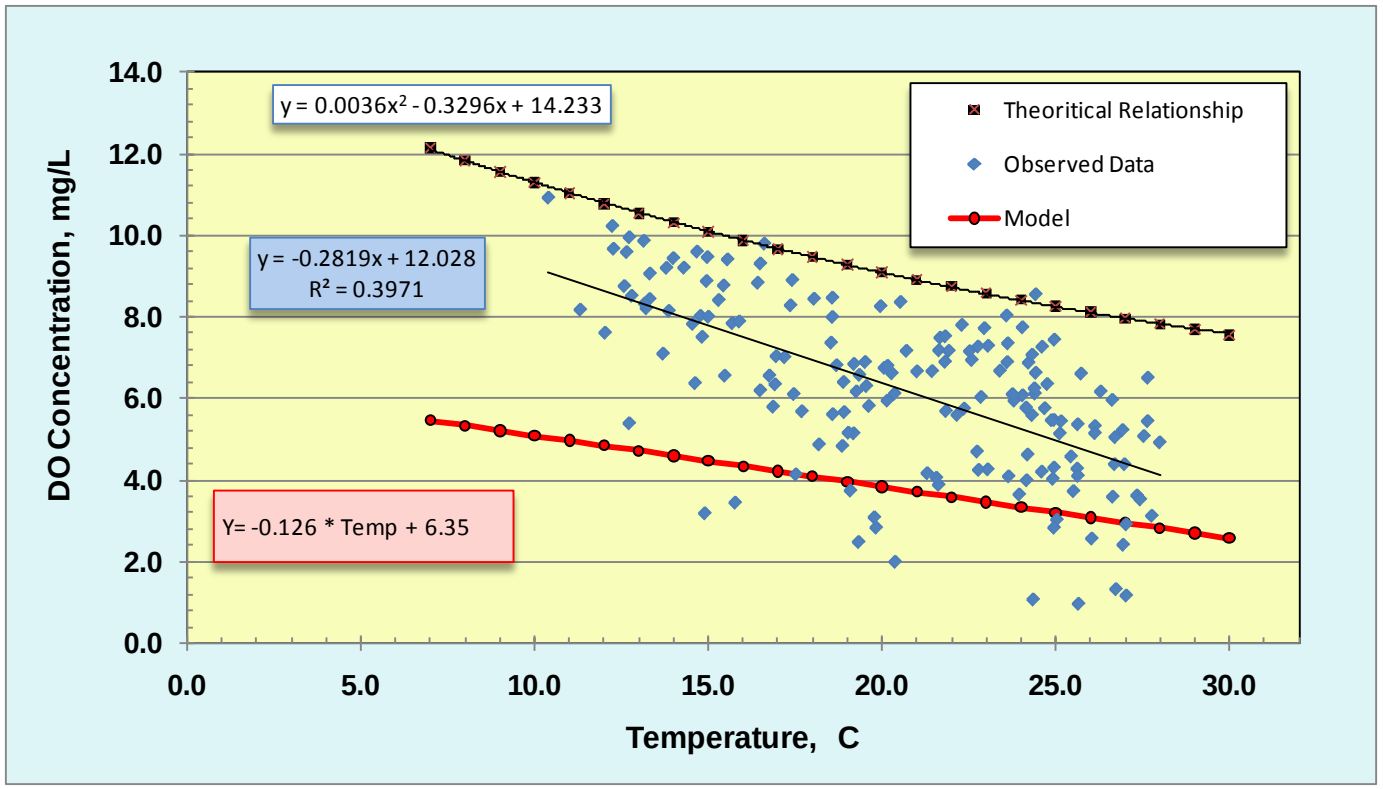
Multiple Linear Regression



Solving the equation resulting from the multiple regression equation of SCI vs. DO and water temperature using an SCI score of 40, as shown by the red line, and referred to as “model”

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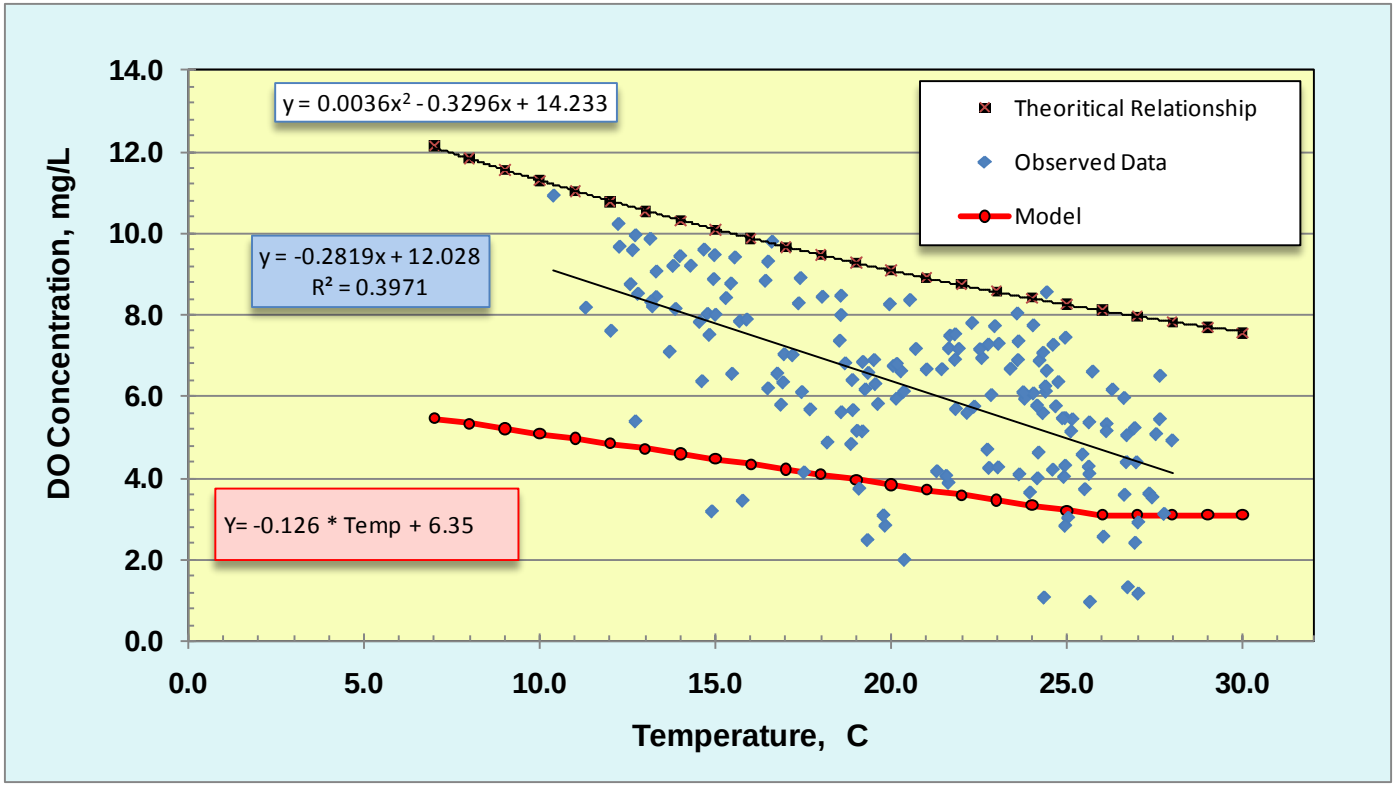
Multiple Linear Regression



Truncating the model at the 10th percentile of deployment minima DO concentrations for LDI < 2 sites passing SCI

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DO/Temperature Combinations, Described by Model, that Pass SCI, Statewide

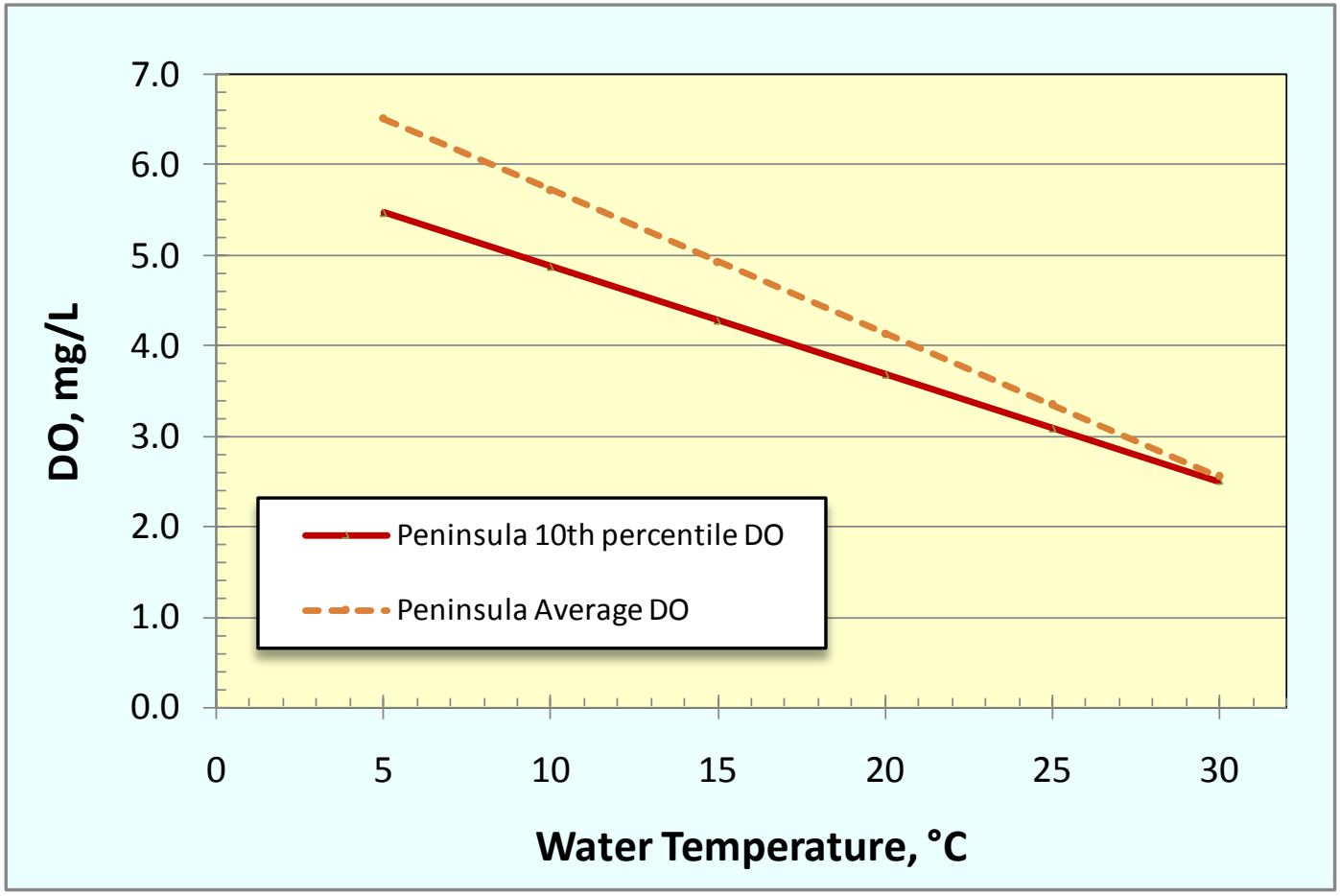
Temperature, °C	DO Criterion, mg/L
5	5.74
10	5.11
15	4.48
20	3.85
25	3.30*
30	3.30*

* Truncated at lower 10th percentile.

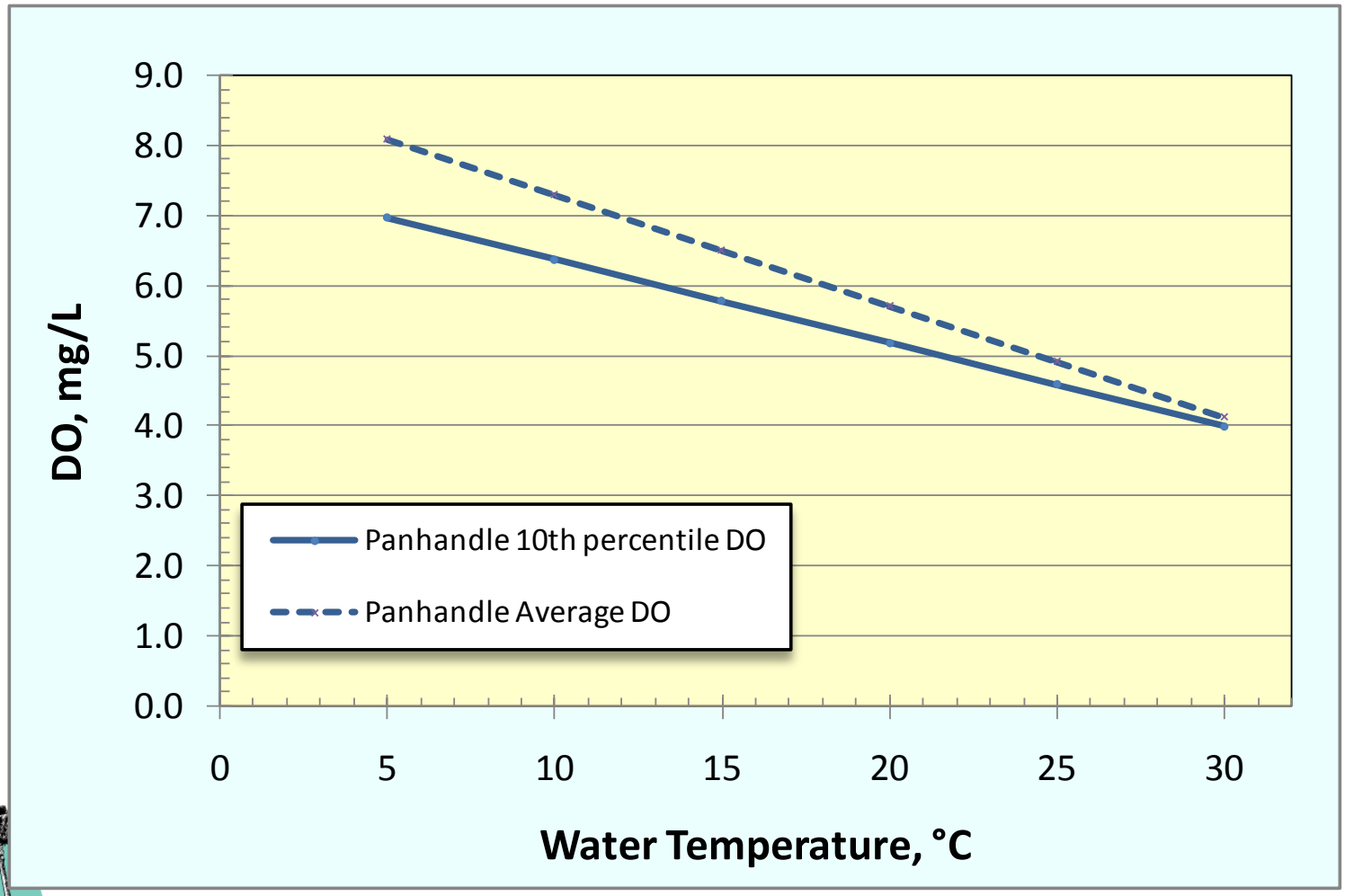
Inverse Prediction DO Model (Pollman)

- Curt Pollman constructed multiple linear regression models to predict SCI using DO, temperature, and bioregion as independent variables
  - 10^{th} percentile DO (R^2 =0.44; adjusted R^2 =0.42)
  - Average DO (R^2 =0.42; adjusted R^2 =0.41)
  - Bioregion was significant in both models
- Used inverse prediction to derive the DO required to produce an SCI value equal to 40

Minimum DO Predicted to Yield SCI Values = 40 for Undisturbed Florida Streams (Peninsula)



Minimum DO Predicted to Yield SCI Values = 40 for Undisturbed Florida Streams (Panhandle)



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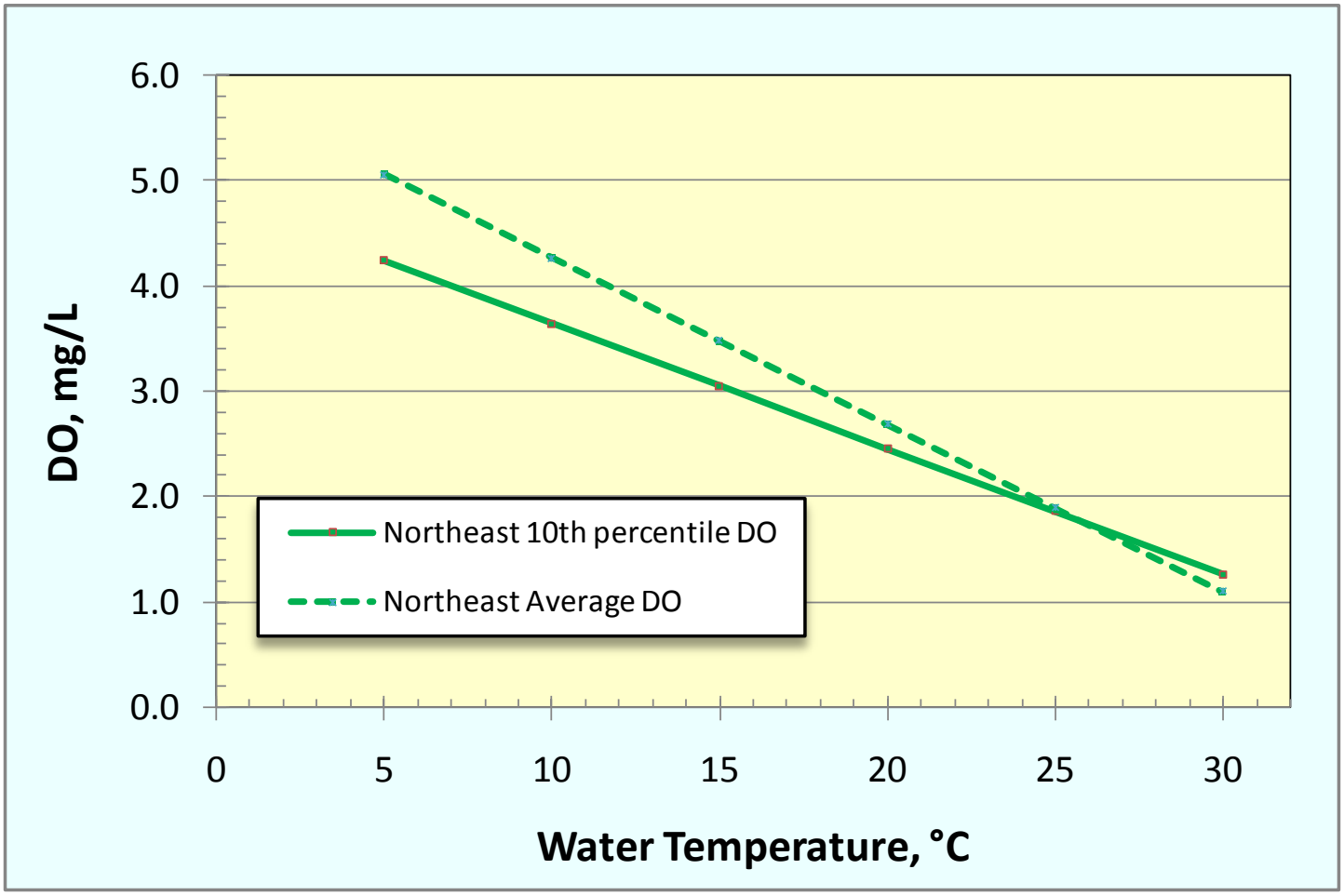
Minimum DO Predicted to Yield SCI Values = 40 for Undisturbed Florida Streams (Northeast)



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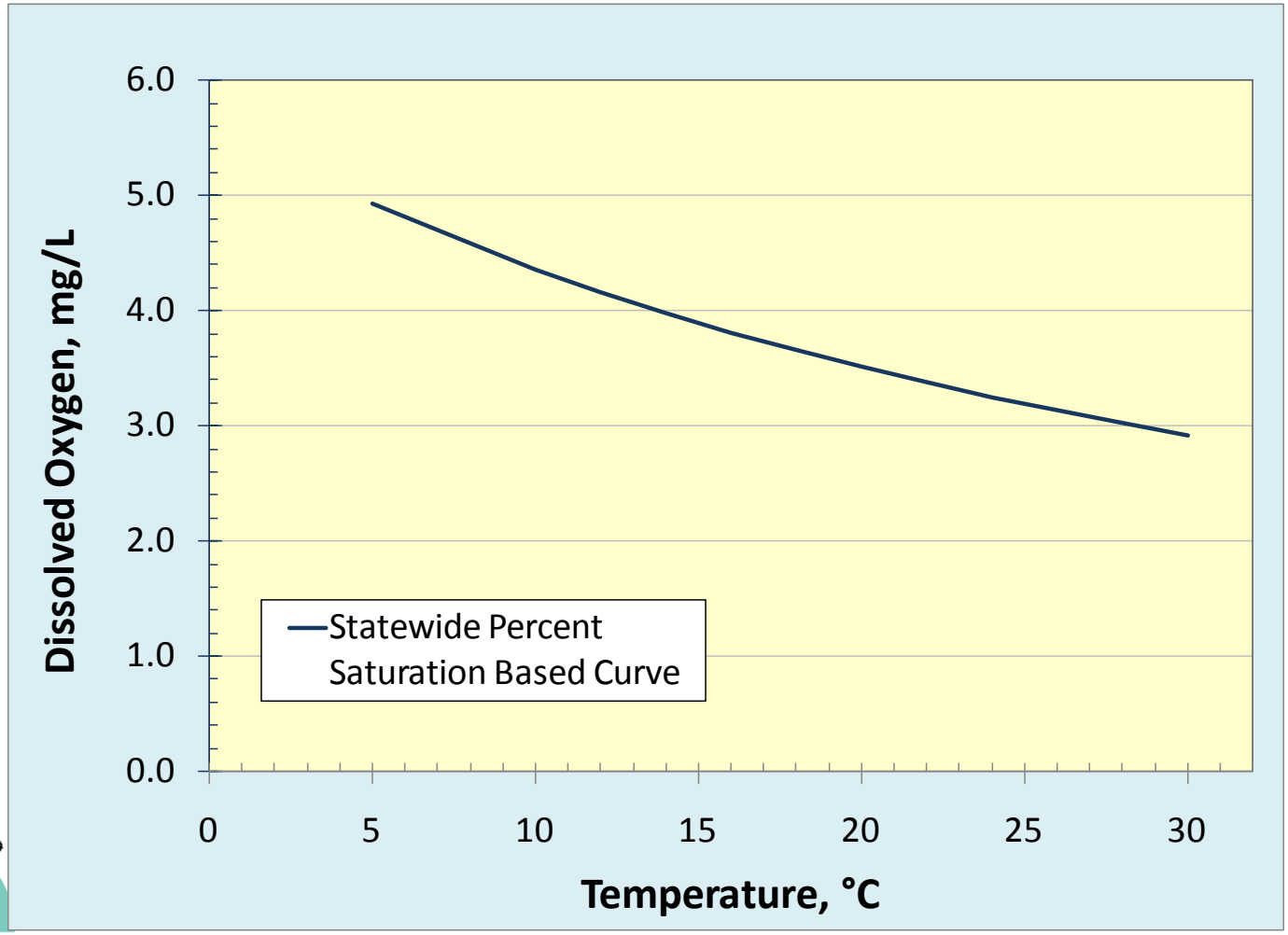
Inverse Prediction DO Model (Pollman)

- Because DO saturation is a function of temperature, the critical value of $DO_{\%sat}$ can be used to construct a temperature-dependent curve of minimum or critical DO concentrations
- Pollman constructed a statewide DO saturation based model
  - Statewide (R^2 =0.218; adjusted R^2 =0.211)
- Derived a minimum DO curve by inverse prediction of the $DO_{\%sat}$ value that yields SCI = 40

Percent Saturation Derived Minimum DO as a Function of Temperature Predicted to Yield SCI Values = 40 for Undisturbed Florida Streams



Freshwater Conclusions

- Empirical evidence indicates that current DO criteria are inaccurate, and that revising the criteria is an appropriate management decision
- Temperature-dependent or % saturation based criteria would improve accuracy

EXPLORING APPROACHES FOR DO CRITERIA REVISIONS –MARINE WATERS

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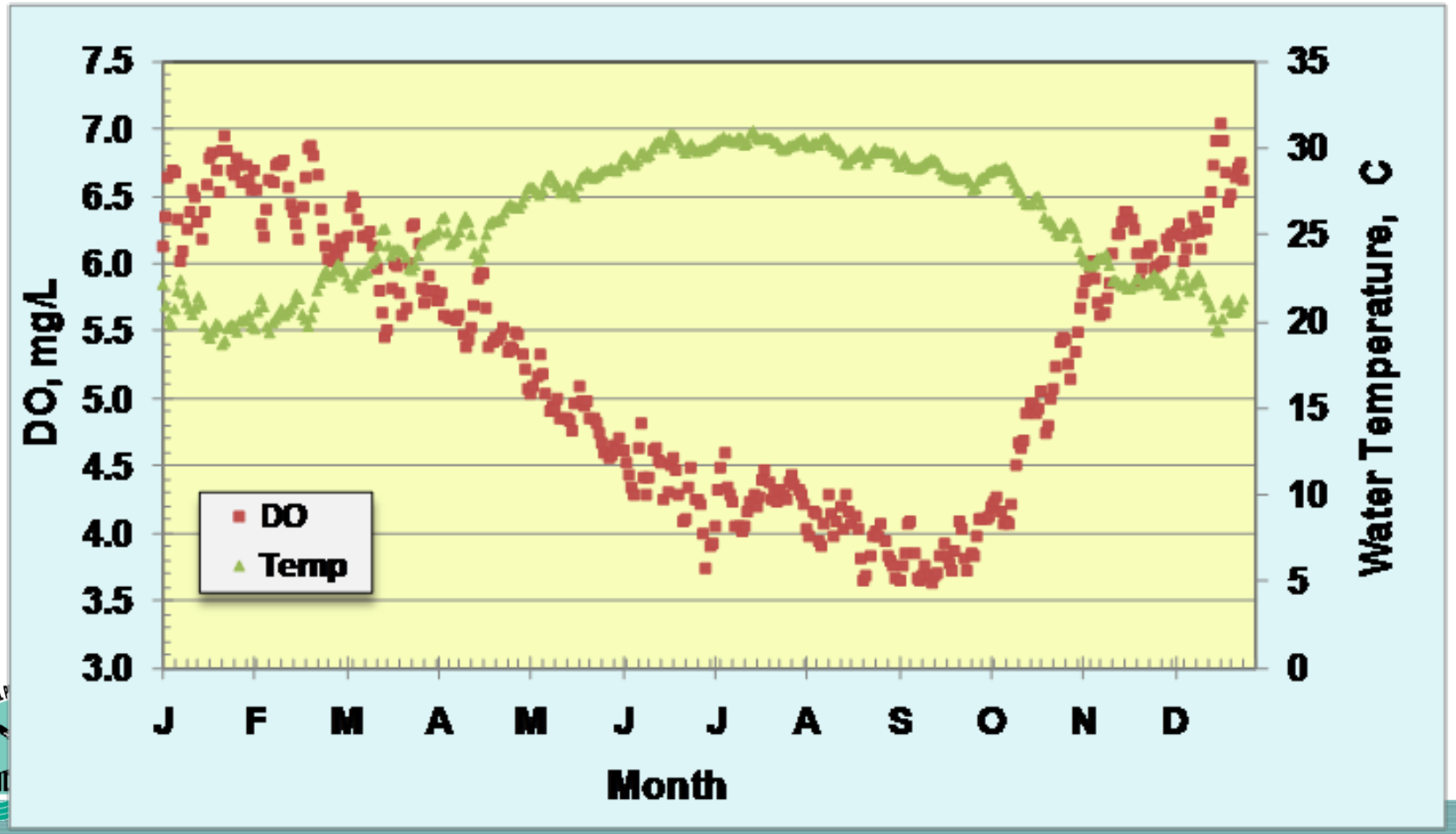
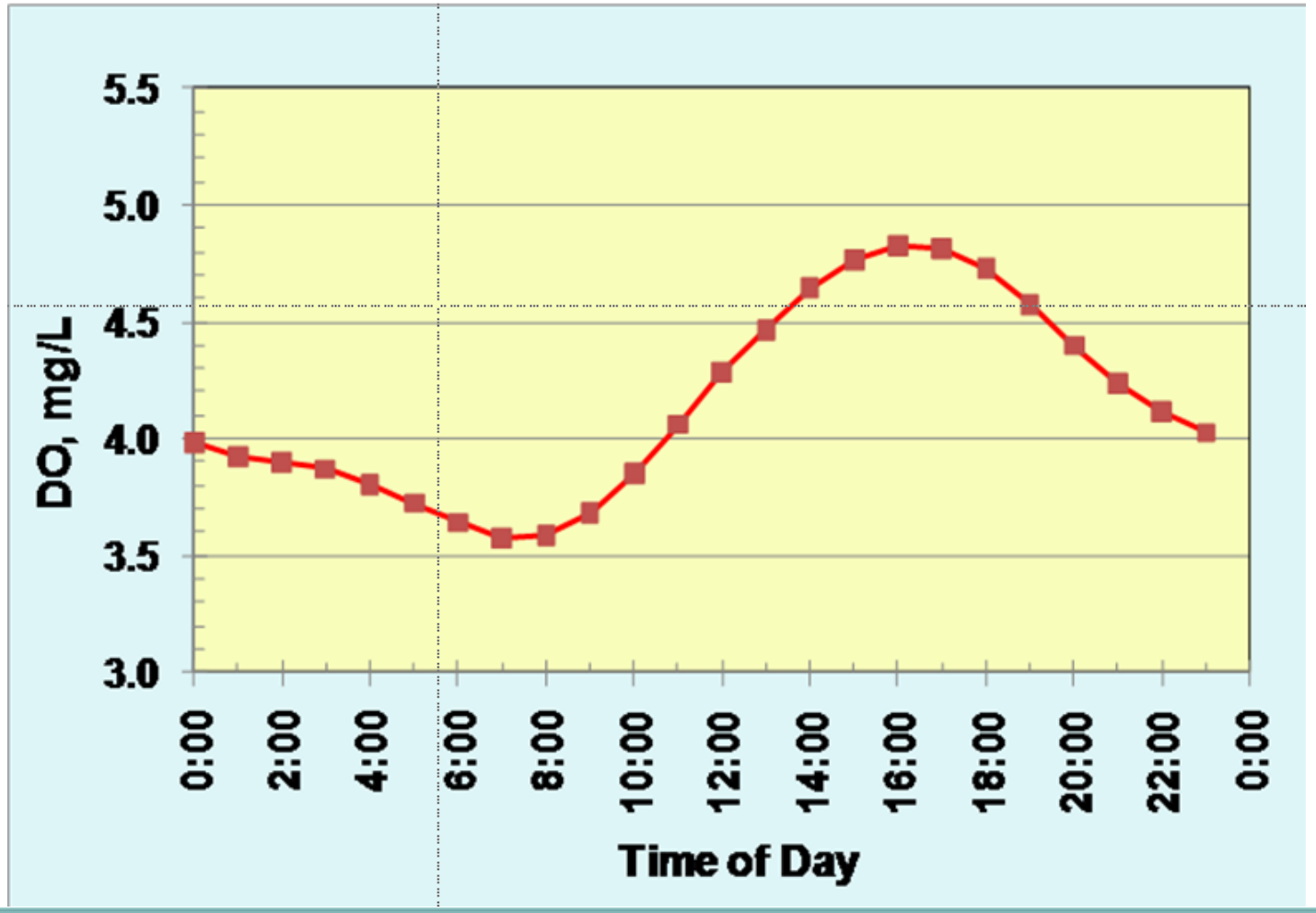
DO Levels Commonly Found in Florida Marine Systems

Average daily mean DO concentrations and water temperatures for Faka-Union Bay.

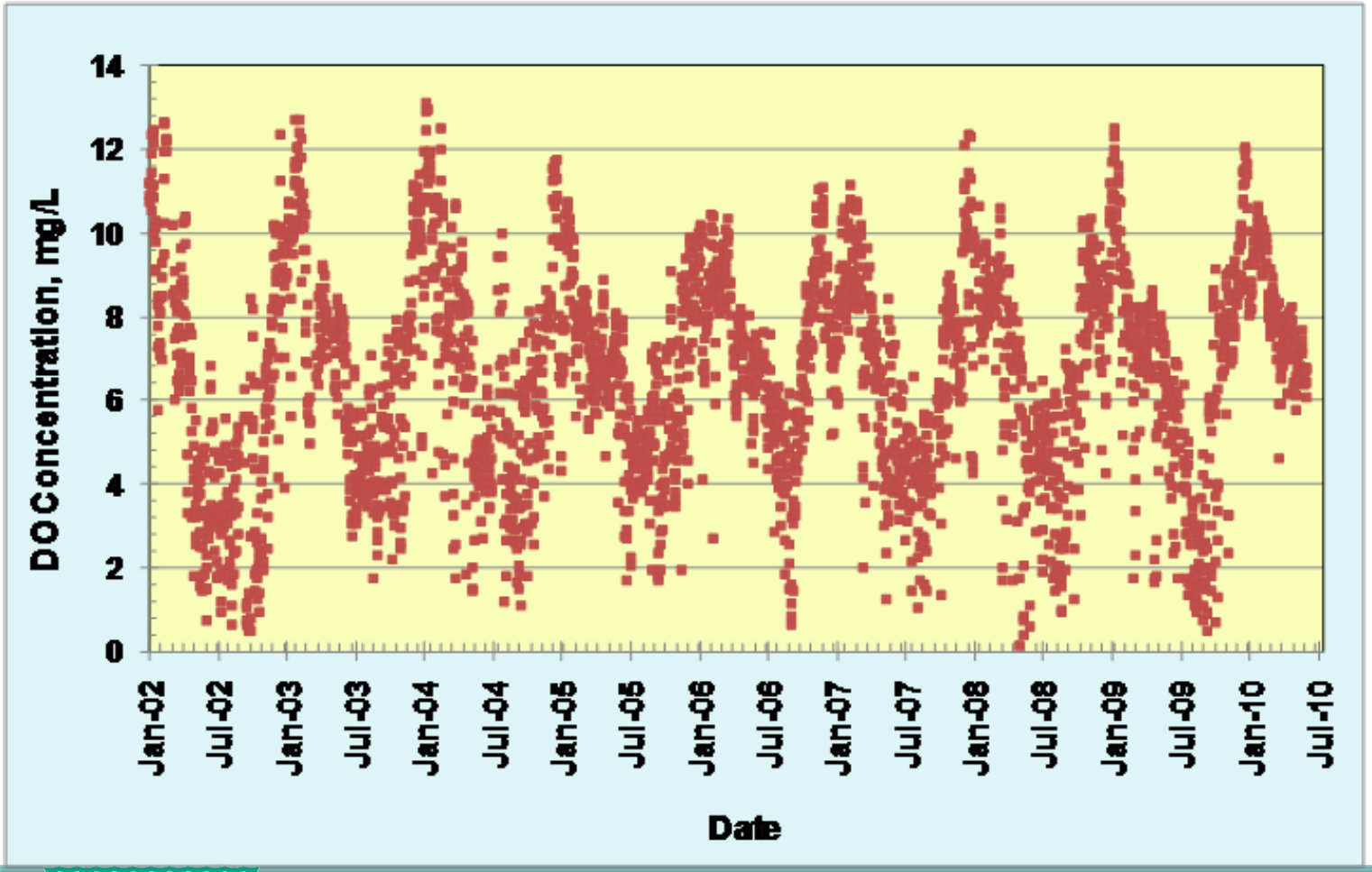


DO Levels Commonly Found in Florida Marine Systems

Average diel fluctuation in DO concentrations for Faka-Union Bay during the summer months (June through September).



DO Levels Commonly Found in Florida Marine Systems

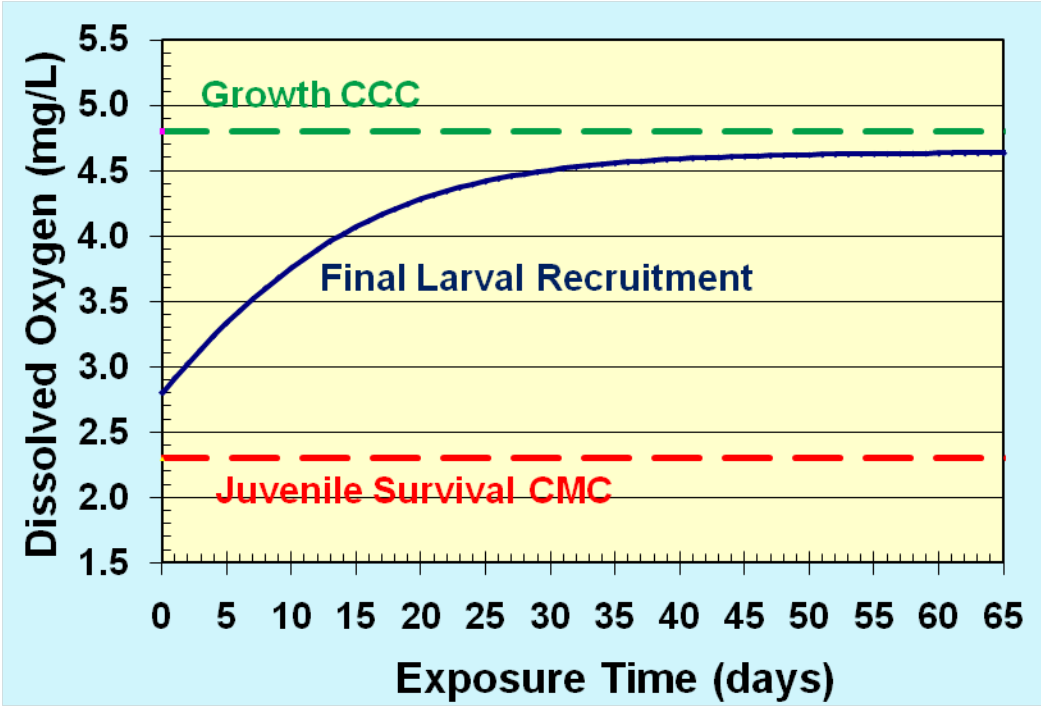


Daily average DO concentrations for East Bay (Apalachicola) from January 2002 through June 2010.

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.



EPA Virginian Province Approach

The aquatic life based approach utilized for the Virginian Province (EPA 2000) defines three DO concentration levels as follows:

1. The criterion minimum concentration (CMC), defined as a DO concentration below which any exposure for a 24-hour period would result in unacceptable acute effects. (Set at 2.3 mg/L for the Virginian Province)

2. The Criterion Continuous Concentration (CCC), which is defined as a mean daily DO concentration above which continuous exposure is not expected to result in unacceptable chronic effects. (Set at 4.8 mg/L for the Virginian Province)

3. The Final Recruitment Curve (FRC) establishes the duration of exposures at DO concentrations between the CCC and CMC

Calculation of CMC and CCC

- The CMC and CCC are calculated using a modified version of the standard procedure for the derivation of a final acute value (FAV) for toxic pollutants presented in Stephen *et al.* (1985)
- Standard method modified to account for the fact that organisms respond to DO in an opposite manner than that to toxicants rather than high levels

$$S^2 = \frac{\sum((\ln GMAV)^2) - ((\sum(\ln GMAV))^2 / 4)}{\sum(P) - ((\sum\sqrt{P})^2)/4)}$$

$$S = \sqrt{S^2} \qquad P = R/(n+1)$$

$$L = (\sum(\ln GMAV) - S(\sum(\sqrt{P})))/4$$

$$A = S(\sqrt{0.95}) + L$$

$$FAV = e^A$$

Where:
R = rank of sensitivity
GMAV = Genus mean acute value
FAV = Final Acute Value

23 Florida Species Used to Derive DO CMC

GMAV Rank	Species	Common name	SMAV	GMAV	LC_5/LC_{50}
1	*Spisula solidissima*	Atlantic surfclam	0.43	0.43	1.63
2	*Prionotus carolinus*	northern sea robin	0.55	0.55	1.45
3	*Eurypanopeus depressus*	flat mud crab	0.57	0.57	
4	*Leiostomus xanthurus*	Spot	0.70	0.70	1.16
5	*Scopthalmus aquosus*	windowpane flounder	0.81	0.81	1.48
6	*Palaemonetes pugio*	daggerblade grass shrimp	0.72	0.86	
	Palaemonetes vulgaris	marsh grass shrimp	1.02		1.45
7	*Crassostrea virginica*	eastern oyster	0.88	0.88	
8	*Ampelisca abdita*	Amphipod	0.90	0.90	
9	*Callinectes sapidus*	blue crab	1.00	1.00	
10	*Brevoortia tyrannus*	Atlantic menhaden	1.12	1.12	1.53
11	*Stenotomus chrysops*	scup	1.25	1.25	
12	*Paralichthys dentatus*	summer flounder	1.32	1.32	1.19
13	*Mugil cephalus*	Striped Mullet	1.38	1.38	
14	*Americamysis bahia*	mysid shrimp	1.40	1.40	1.16
15	*Farfantepenaeus duorarum*	pink shrimp	1.41	1.41	
16	*Sciaenops ocellatus*	red drum	1.45	1.45	
17	*Morone saxatilis*	striped bass	1.58	1.58	1.23
18	*Lagodon rhomboides*	Pinfish	1.61	1.61	1.17
19	*Syngnathus fuscus*	pipe fish	1.63	1.63	
20	*Trachinotus carolinus*	pompano	1.74	1.74	
21	*Cynoscion nebulosus*	spotted seatrout	1.88	1.88	
22	*Menidia beryllina*	inland silversides	1.94	1.94	
23	*Harengula jaguana*	scaled sardines	2.17	2.17	

- The CMC was calculated based on the acute effects data for 23 genera
- Genera mean acute values (LC_{50}) 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 LC_5 to LC_{50} ratio (1.35)
- Resulting CMC is 2.9 mg/L.

Criterion Continuous Concentration (CCC)

- A threshold above which long-term, continuous exposures of low DO should not cause unacceptable chronic (sublethal) effects
- Growth is generally more sensitive than survival to low DO
- Data are highly limited for other endpoints (e.g., reproductive effects)
- The use of larval/juvenile growth endpoints provides a conservative estimate of potential chronic effects.

Florida species Used to Derive DO CCC

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

Larval Recruitment Curve

- EPA (2000) developed a model that estimates the period (in days) a given DO concentration between the CCC and CMC can be tolerated without causing unacceptable effects on total larval survival for the entire recruitment season
- A 5% cumulative seasonal larval recruitment reduction is considered acceptable
  - This level should be insignificant relative to recruitment in the absence of hypoxia
  - Intended to minimize the effect of hypoxia on the ultimate fate of juveniles

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Model Parameters

- Length of spawning period
- Larval development time
- Natural attrition rate
- Percent population exposed to hypoxic event (e.g., vertical distribution)

	A	B	C	D	E	F	G	H	I	J	K	L
1		D.O. Response					Population Parameters					
2		Life Stage 1		Life Stage 2								
3	Organism	ER_{SURV} Po	ER_{SURV} k	ER_{SURV} Po	ER_{SURV} k	ER_{devel} Augment % for Increased Larval Development	R Length of Recruitment Season (days)	D Duration of Larval Development (days)	N_0 Initial Cohort Size	*a* Attrition Rate (%/day)	*p* Percentage Population Exposed to Hypoxic Event	% **Impairment to Model**
4	*Cancer* (rock crab)	0.0100	0.0450	not used		100%	65	35	100	5%	50%	**5**
5	*Dyspanopeus* (mud crab)	0.0100	0.0489	0.1000	0.0220	100%	66	21	100	5%	50%	**5**
6	*Eurypanopeus* (mud crab)	0.0001	0.0655	not used		100%	66	21	100	5%	50%	**5**
7	*Homarus* (lobster)	0.0500	0.0300	not used		100%	95	35	100	5%	50%	**5**
8	*Libinia* (spider crab)	0.0100	0.0470	not used		100%	66	21	100	5%	50%	**5**
9	*Menidia* (silverside)	0.0010	0.0880	not used		100%	42	14	100	5%	50%	**5**
10	*Morone* (striped bass)	0.0100	0.0380	not used		100%	49	28	100	5%	50%	**5**
11	*Palaemonetes* (grass shrimp)	0.0500	0.0520	not used		100%	100	12	100	5%	50%	**5**
12	*Scianops* (red drum)	0.0100	0.0500	not used		100%	49	21	100	5%	50%	**5**
13												

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

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10 Florida Species Used to Derive Final Recruitment Curve

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

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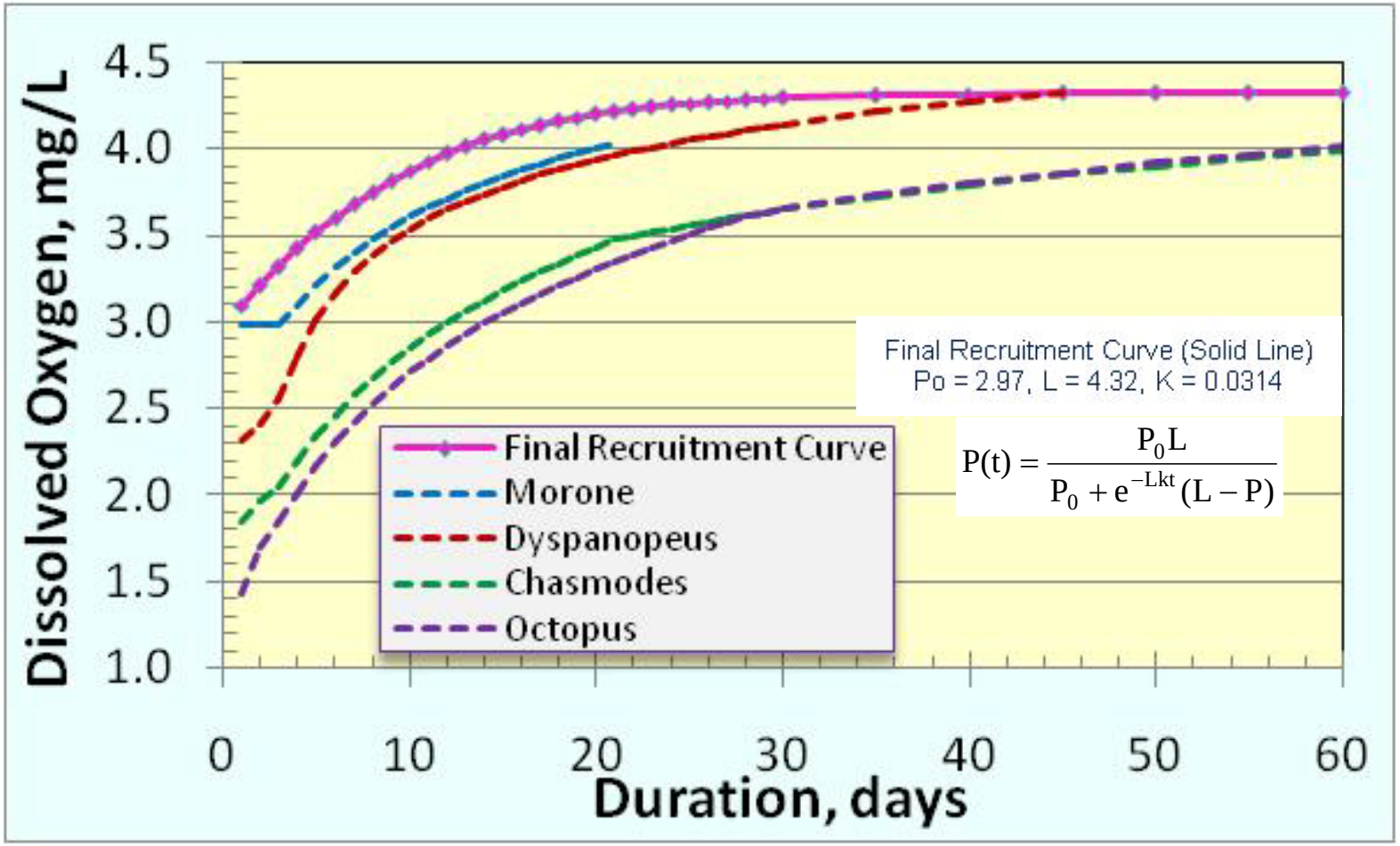
Recruitment Model Output for Florida Species



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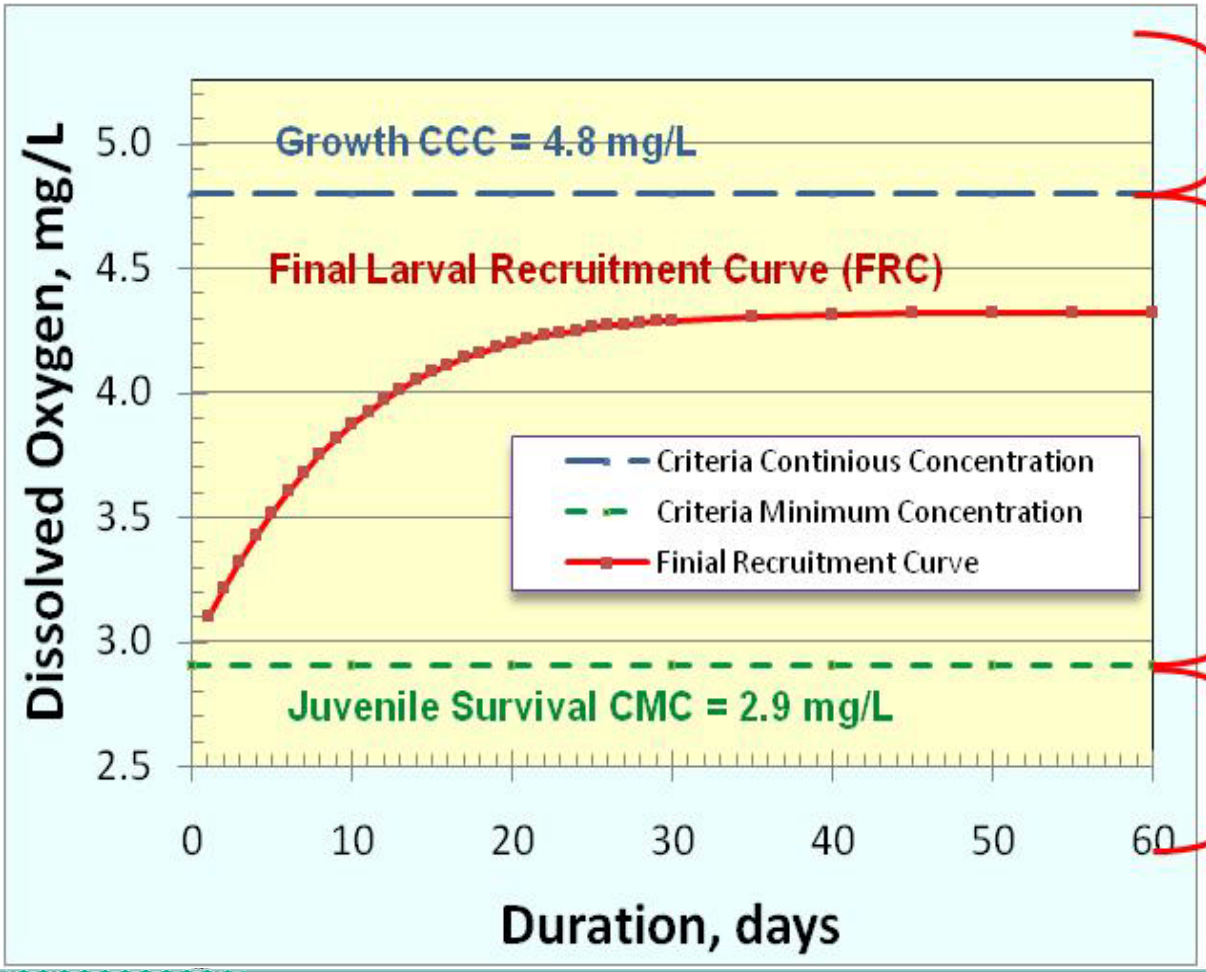
Florida Marine DO Criteria Based on EPA's Virginian Province Approach



Above 4.8 mg/L, no impacts expected.

Between 2.9 and 4.8 mg/L exposure duration based on larval survival response.

Below 2.9 mg/L, adverse acute impacts possible

Marine DO Conclusions

- EPA's Virginian Province Approach provides defensible DO dose-response relationship
- Some sensitive taxa used in the model may not occur in many naturally low DO Florida estuaries
  - Some waterbodies may still require SSACs to appropriately characterize natural DO regime

DEVIATION FROM BACKGROUND DO CONCEPT

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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)

DO Deviation: Marine (cont.)

- EPA indicated that the Virginian Province Approach was an acceptable method for determining adverse impacts on resident biota
- EPA Region IV approved this concept for Georgia Water Quality Standards in March 2010

DO Deviation from Background Conclusions

- Inclusion of similar language in Florida standards would reduce the number of minimally disturbed waterbodies that are incorrectly placed on the 303(d) list and provide a more easily implementable TMDL target

Next Steps

- DEP assembling a peer review committee to evaluate the science behind potential DO criteria revisions
- Accepting suggestions for peer-review committee (academics preferred).
- Evaluate DO requirements of listed species (e.g., sturgeon)

Questions and Comments

russel.frydenborg@dep.state.fl.us

kenneth.weaver@dep.state.fl.us

grover.payne@dep.state.fl.us