Dissolved Oxygen Subcommittee:

First Meeting

10/13/16

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

Agenda

- Review Current Criteria
- And History
- Other states WQS
- Issues
- Where to begin?

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Current NH DO Criteria

- **Except as naturally occurs:**
  - **RSA 485-A:8,II: $\geq$ 75% saturation in Class B**
  - **Env-Wq 1703.07**

Class	Daily Average % Saturation	Minimum 7 day mean (mg/L)	Instantaneous Minimum (mg/L)
A	75%		6.0
B [1]	75%		5.0
A or B [2]	75%	9.5	8.0

1. For lakes, ponds impoundments and reservoirs, criteria applies within the epilimnion or within the top 25% of depth if not thermally stratified.

2. Applies to cold water fish spawning per areas identified by NHFGD whose early life stages are not directly exposed to the water column from 10/1 to 5/14 (but may be extended to 6/30)

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NH DO Saturation History for Class A and B

Year	Class A[1]	Class B [1]
1947	–	"near saturation for dissolved oxygen", [near=] "at least seventy-five percentum" [B-1 & B-2]
1970	≥ 75% Sat	≥ 75% Sat
1976	≥ 75% Sat,	≥ 75% Sat
1990	≥ 75% Sat for 16 hours per day,	References RSA 485-A:8 (need to check 1990 RSA)
1996	≥ 75% Sat for 16 hours per day	≥ 75% Sat daily average
1999 (current)	≥ 75% Sat daily average	≥ 75% Sat daily average

1. The criteria apply except as naturally occurs

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NH DO Concentration History for Class A and B

Year	Class A[1]	Class B [1]
1947	just saturation	just saturation
1970[2]	just saturation	just saturation
1976	≥ 6 mg/L in cold water fisheries	≥ 6 mg/L in coldwater fisheries
1990	≥ 6 mg/L	References RSA 485-A:8 (need to check 1990 RSA)
1996[2]	≥ 6 mg/L Cold water fishery spawning areas, Oct 1 to May 14 ≥ 9.5 mg/L (7 day ave.) ≥ 8 mg/L (inst. Min.)	≥ 5 mg/L Cold water fishery spawning areas, Oct 1 to May 14 ≥ 9.5 mg/L (7 day ave.) ≥ 8 mg/L (inst. Min.)
1999[3] (current)	as 1996	as 1996

1. The criteria apply except as naturally occurs.
2. Class C said ≥ 5 mg/L.
3. Stratification in Class B waters addressed.

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EPA Criteria (1986)

Table 8. Water quality criteria for ambient dissolved oxygen concentration.

	Coldwater Criteria		Warmwater Criteria	
	Early Life Stages[1,2]	Other Life Stages	Early Life Stages[2]	Other Life Stages
30 Day Mean	NA[3]	6.5	NA	5.5
7 Day Mean	9.5 (6.5)	NA	6.0	NA
7 Day Mean Minimum	NA	5.0	NA	4.0
1 Day Minimum[4,5]	8.0 (5.0)	4.0	5.0	3.0

(See next slide for Notes for this table)

EPA Criteria (1986)

Notes for Table 8 – EPA DO Criteria

[1] These are water column concentrations recommended to achieve the required intergravel dissolved oxygen concentrations shown in parentheses. The 3 mg/l differential is discussed in the criteria document. For species that have early life stages exposed directly to the water column, the figures in parentheses apply.

[2] Includes all embryonic and larval stages and all juvenile forms to 30-days following hatching.

[3] NA (not applicable).

[4] For highly manipulatable discharges, further restrictions apply (see page 37)

[5] All minima should be considered as instantaneous concentrations to be achieved at all times.

DO WQC for Other States (as of 6/2015)

State	% Sat range	Min DO range (mg/L)	Remarks
NH	Daily Ave =75%	7 day ave =9.5 Min =5, 6, 8	Depends on Class, Life stage, CWF, waterbody type
CT	----	Chronic Min =4.8 Acute Min =3 Min =5	Depends on Class
MA	----	Min $\geq$ 16 hrs /day =5 Min =3-6	Depends on Class, CWF/WWF
ME	Min =60%-75%	30 day ave =6.5 7 day ave =9.5 Min =5-8	Depends on Class, Life Stage
RI	Daily Ave =65% - 75%	7 day ave =6.5-9.5 Min =5 - 8	Depends on CWF/WWF, Life Stage
VT	Min =60% - 95%	Min =5-7	Depends on Class, Life stage, CWF/WWF

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Issues for DO Sub-Committee to Consider

- Species
  - Coldwater/Warmwater, Life Stage
- Magnitude
- Duration
- Return Frequency
- Calendar
- Space
- Natural levels
- Assessment feasibility

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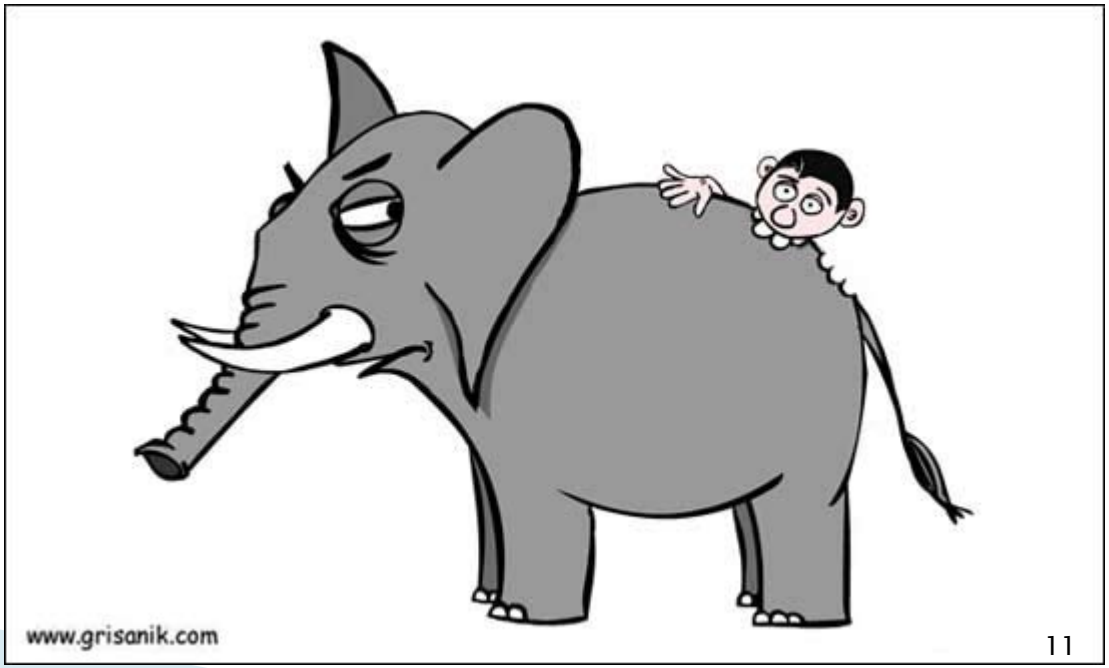
DO Subcommittee

Topics:

- Dissolved Oxygen Saturation – Value, Current Status as a criteria, and new science
- Dissolved Oxygen Concentration
  - Current status in NH
  - Applicability of 2000 Marine Criteria document for areas south of Cape Cod
  - Tidal river versus well mixed estuary
  - Species sensitivity to DO
  - Monitoring and criteria implementation
- Discussion of options for rule versus statute changes

How to begin?

- Is dissolved oxygen a good predictor of aquatic life use?
- Saturation or concentration? Or both?
- Salt water or freshwater?
- Guidance approach or NH data analysis?



Why worry about DO?

- Minimum DO concentrations necessary to avoid mortality in both adult and larval stages of fishes.
- Sub-lethal effects of varying DO conditions = stress responses
  - avoidance,
  - decreased swimming performance,
  - reduction in metabolic rate,
  - reduced growth, and
  - changes in behavior that may increase risk of predation.
- Low DO concentrations have been shown to prevent spawning, and reduce fecundity of female fish in lab experiments.
- Increase fish susceptibility to disease and increase the toxicity of certain chemicals and pollutants.
- Early life stages of fish, such as embryonic and larval stages, are generally more sensitive to low DO concentrations than adult life stages.
- Salmonids generally require higher concentrations of DO than fish that inhabit warmwater ecosystems, but some warm and cool species of fish (shad, herring, pike, sculpins, smallmouth bass) more sensitive than other warm water species.

DO Saturation

- Current impairments
- List of questions
- Discussion

DO sat -- impairments

DO Impairment Matrix	ESTUARY	OCEAN	IMPOUNDMENT	LAKE/ POND	RIVER/ STREAM	Grand Total
Both NS	5		12	42	76	135
Just DO Conc NS	3		6	2	43	54
Just DO sat NS			4	93	19	116
Total AUs	70	26	1,232	1,557	5,940	8,825

Impairment to one or more in (CHLa, TP, Fish, Macros)	IMPOUNDMENT	LAKE/ POND	RIVER/ STREAM	Grand Total
No	3	69	18	90
Yes	1	24	1	26
Grand Total	4	93	19	116

34 of the lake/pond DO sat impairments are an artifact of the previous way that beaches were separated from lakes

DO Saturation Questions:

- Is DO saturation a good predictor of aquatic life health?
- Is it necessary to have a water quality standard for percent saturation of dissolved oxygen to protect aquatic life uses?
- The 75% average saturation criteria is a dynamic approach yielding reduced allowable average degradation to 5 mg/L as the temperature increases to 25°C. Does the percent saturation criteria help to avoid disruption of the biological continuum?

More Sat questions

- What types of water would have naturally low DO saturation (or concentration)? Do we have data to substantiate that? (FL approach?)
- What about high saturation numbers?
- What is natural? Where is natural?
- Put criteria in statute versus rule?
- Should the marine and freshwater systems be addressed differently in the DO criteria? Should the low salinity tidal river be treated more like the ocean salinity marine water or more like the freshwater?

Next Steps

- Schedule
- Agenda for next meeting
- Who else?

Florida

FDEP selected DO percent saturation rather than concentration because:

- a) the daily average DO saturation provided the best correlation with Stream Condition Index scores, and
- b) saturation automatically accounts for the inherent relationship between temperature and DO.

FDEP developed different regional criteria to account for the observed regional differences in measured DO levels and biological expectations, and used the confidence interval to add a protective safety factor accounting for the uncertainty in the relationships and the naturally expected diel fluctuations in the DO levels.

Florida

Table 6. DO concentrations resulting from proposed percent DO saturation criteria for a range of water temperatures typically expected in Florida Panhandle West, Peninsula, and Northeast + Big Bend bioregion streams.

Temp, °C	NE + Pan East Criteria, 34% Sat	Peninsula Criteria, 38% Sat	Pan West Criteria, 67% Sat
8	4.0	4.5	7.9
10	3.8	4.3	7.6
12	3.7	4.1	7.2
14	3.5	3.9	6.9
16	3.4	3.8	6.6
18	3.2	3.6	6.3
20	3.1	3.5	6.1
22	3.0	3.3	5.9
24	2.9	3.2	5.6
26	2.8	3.1	5.4
28	2.7	3.0	5.2
30	2.6	2.9	5.1

DO concentration

- Is DO concentration a good predictor of aquatic life health?
- Class A waters – where to determine compliance
- Issues with Cape Cod to Cape Hatteras guidance
- To be meaningful, any criteria must be implementable via common and reasonable sampling methods. While dataloggers provide a complete picture of the diel cycles, they are not the common sampling method. How would we balance criteria with normal sampling protocols?

Cape Cod to Cape Hatteras

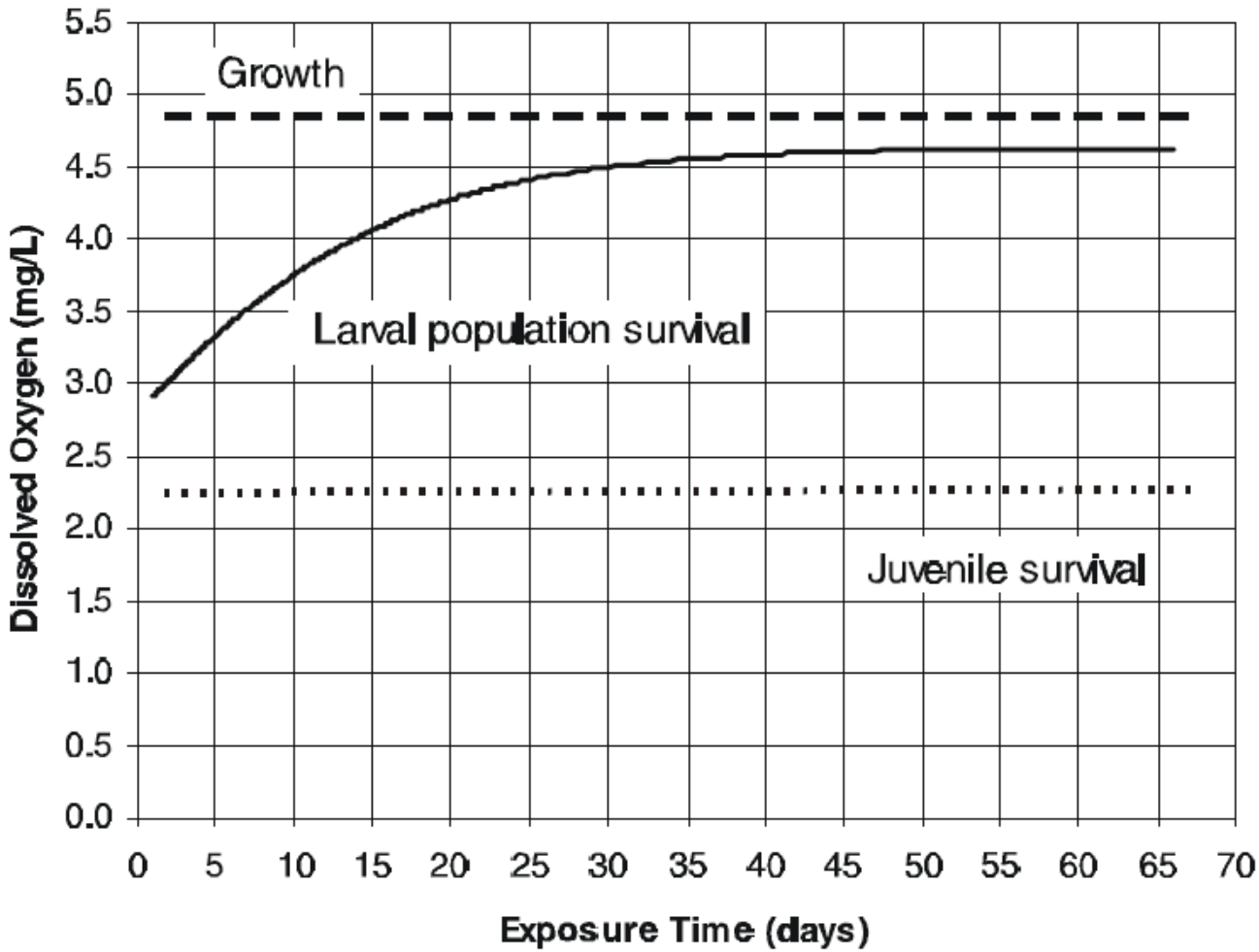


Table 6. Summary of Virginian Province saltwater dissolved oxygen criteria.

Endpoint	Persistent Exposure (24 h or greater continuous low DO conditions)	Episodic and Cyclic Exposure (less than 24 h duration of low DO conditions)
Juvenile and Adult Survival (minimum allowable conditions)	(1) *a limit for continuous exposure* DO = 2.3 mg/L (criterion minimum concentration, CMC)	(4) *a limit based on the hourly duration of exposure* DO = 0.370*ln(t) + 1.095 where: DO = allowable concentration (mg/L) t = exposure duration (hours)
Growth Effects (maximum conditions required)	(2) *a limit for continuous exposure* DO = 4.8 mg/L (criterion continuous concentration, CCC)	(5) *a limit based on the intensity and hourly duration of exposure* Cumulative cyclic adjusted percent daily reduction in growth must not exceed 25% $\sum_{1}^{n} \frac{t_i * 1.56 * Gred_i}{24} < 25\%$ and $Gred_i = -23.1 * DO_i + 138.1$ where: $Gred_i$ = growth reduction (%) DO_i = allowable concentration (mg/L) t_i = exposure interval duration (hours) i = exposure interval
Larval Recruitment Effects[a] (specific allowable conditions)	(3) *a limit based on the number of days a continuous exposure can occur* Cumulative fraction of allowable days above a given daily mean DO must not exceed 1.0 $\sum \frac{t_i(actual)}{t_i(allowed)} < 1.0$ and $DO_i = \frac{13.0}{(2.80 + 1.84e^{-0.10 tsubi})}$ where: DO_i = allowable concentration (mg/L) t_i = exposure interval duration (days) i = exposure interval	(6) *a limit based on the number of days an intensity and hourly duration pattern of exposure can occur* Maximum daily cohort mortality for any hourly duration interval of a DO minimum must not exceed a corresponding allowable days of occurrence where: Allowable number of days is a function of maximum daily cohort mortality (%) Maximum daily cohort mortality (%) is a function of DO minimum for any exposure interval (mg/L) and the duration of the interval (hours)

[a] Model integrating survival effects to maintain minimally impaired larval populations.

Background material

- PA approach should be copied and handed out. Did this get approved?

- Other document with technical approach to setting DO criteria.

Next Steps

- Schedule
- Agenda for next meeting
- Who else?