Dissolved Oxygen

New Hampshire Water Quality Standards Advisory Committee,

April 9, 2020

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NH Dept. of Environmental Services

Ideas in dissolved oxygen we will touch on in the next few minutes…

1. Insight into what New Hampshire considers as an acceptable level of “Production Impairment”.
2. Concentration and Percent Saturation Equivalency - Relationship between DO concentration and DO Percent Saturation in existing Great Bay Estuary Data.
3. Existing Dissolved Oxygen Regime - Existing Dataset Approach to Setting Acceptable Condition Criteria.

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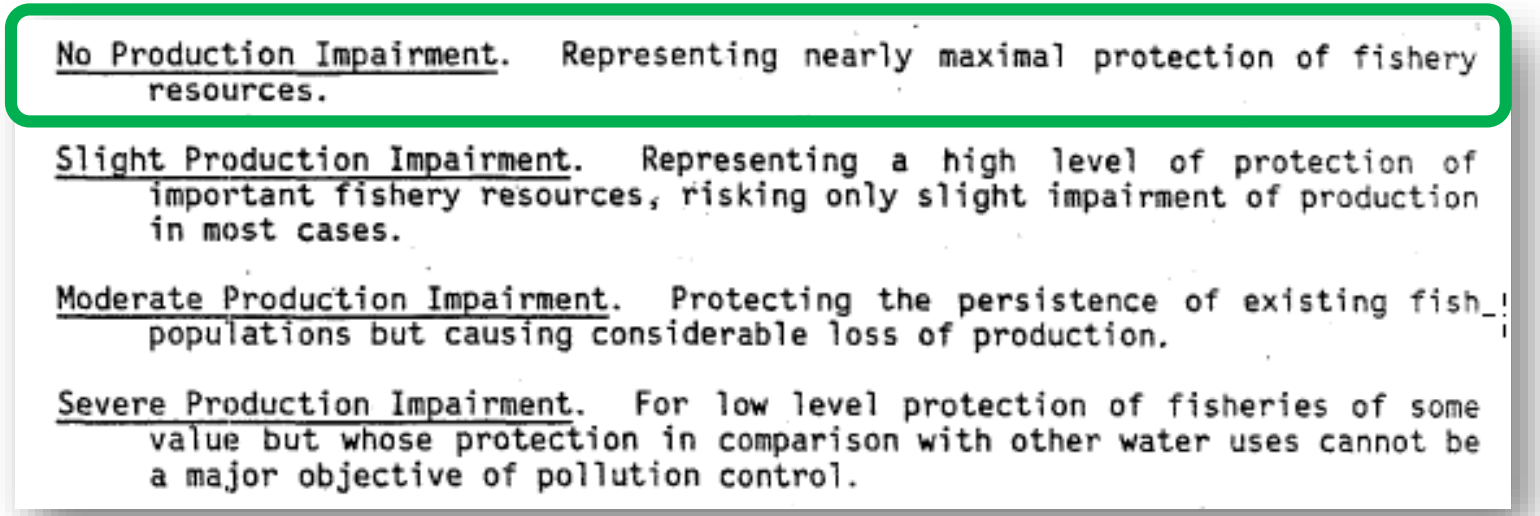
Origin of the existing 5 mg/L?



No Production Impairment. Representing nearly maximal protection of fishery resources.

Slight Production Impairment. Representing a high level of protection of important fishery resources, risking only slight impairment of production in most cases.

Moderate Production Impairment. Protecting the persistence of existing fish populations but causing considerable loss of production.

Severe Production Impairment. For low level protection of fisheries of some value but whose protection in comparison with other water uses cannot be a major objective of pollution control.

EPA 1986 Dissolved Oxygen 304(a) Guidance (page 30).

New Hampshire has always considered that “No Production Impairment” as the dissolved oxygen attainment goal.

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

[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.

Page 34, EPA 1986

- From the EPA 1986 Dissolved Oxygen 304(a) Guidance.
- New Hampshire used both the extended period average values and the instantaneous minima.
- Note that Class A waters were set at 6 mg/L instantaneous.

depend on innumerable other factors. If slight production impairment or a small but undefinable risk of moderate production impairment is unacceptable, then continuous exposure conditions should use the no production impairment values as means and the slight production impairment values as minima.

Page 34, EPA 1986

Page 31

1. Salmonid Waters

   a. Embryo and Larval Stages

      - No Production Impairment = 11* (8)
      - Slight Production Impairment = 9* (6)
      - Moderate Production Impairment = 8* (5)
      - Severe Production Impairment = 7* (4)
      - Limit to Avoid Acute Mortality = 6* (3)

   (* Note: These are water column concentrations recommended to achieve the required intergravel dissolved oxygen concentrations shown in parentheses. The 3 mg/l difference is discussed in the criteria document.)

   b. Other Life Stages

      - No Production Impairment = 8
      - Slight Production Impairment = 6
      - Moderate Production Impairment = 5
      - Severe Production Impairment = 4
      - Limit to Avoid Acute Mortality = 3

2. Nonsalmonid Waters

   a. Early Life Stages

      - No Production Impairment = 6.5
      - Slight Production Impairment = 5.5
      - Moderate Production Impairment = 5
      - Severe Production Impairment = 4.5
      - Limit to Avoid Acute Mortality = 4

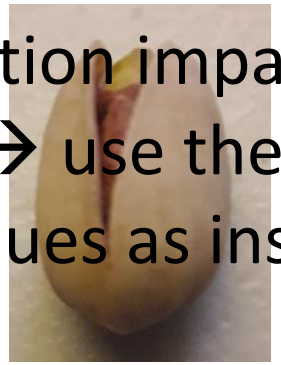
   b. Other Life Stages

      - No Production Impairment = 6
      - Slight Production Impairment = 5
      - Moderate Production Impairment = 4
      - Severe Production Impairment = 3.5
      - Limit to Avoid Acute Mortality = 3

3. Invertebrates

      - No Production Impairment = 8
      - Some Production Impairment = 5
      - Acute Mortality Limit = 4

If slight production impairment is unacceptable → use the slight impairment values as instantaneous minima



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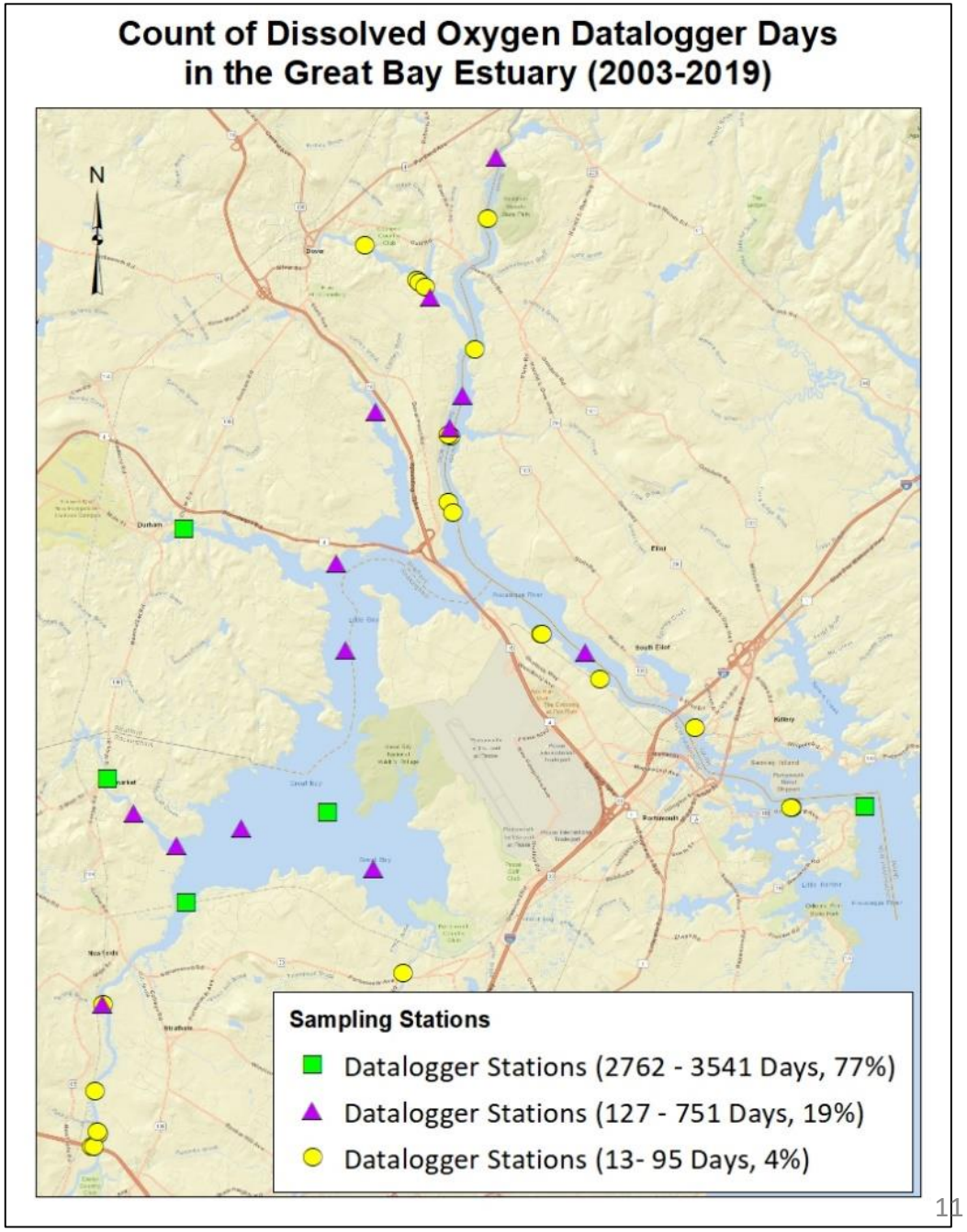
What is acceptable?

- New Hampshire has always considered that “No Production Impairment” as the dissolved oxygen attainment goal.
- Since the existing dissolved oxygen criteria were adopted, the Great Bay Estuary has been designated as a Estuary of National Significance following a New Hampshire initiative and formal request by the Governor.
- These pieces shall inform the acceptable level of dissolved oxygen alteration in our estuarine waters.

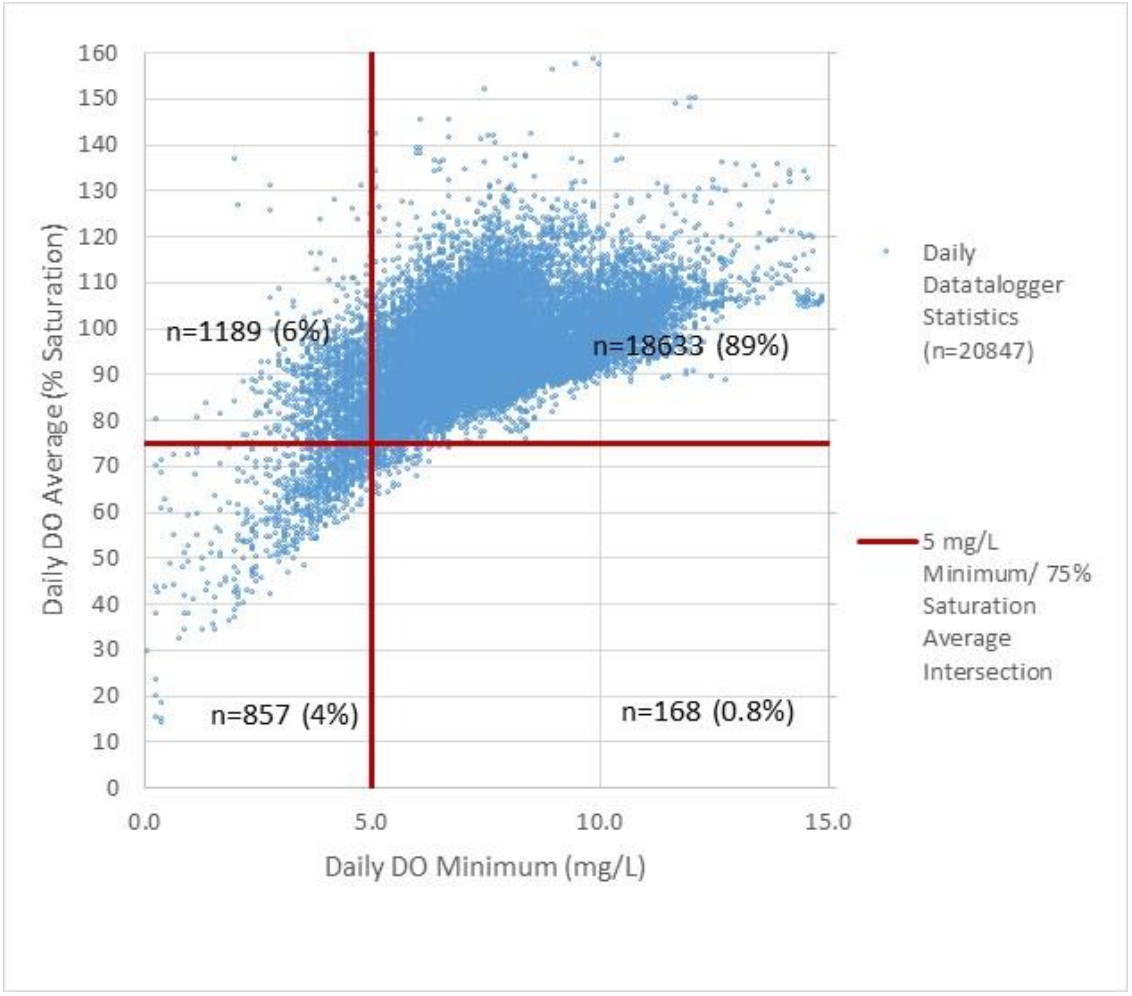
1. Insight into what New Hampshire considers as an acceptable level of “Production Impairment”.
2. Concentration and Percent Saturation Equivalency - Relationship between DO concentration and DO Percent Saturation in existing Great Bay Estuary Data.
3. Existing Dissolved Oxygen Regime - Existing Dataset Approach to Setting Acceptable Condition Criteria.

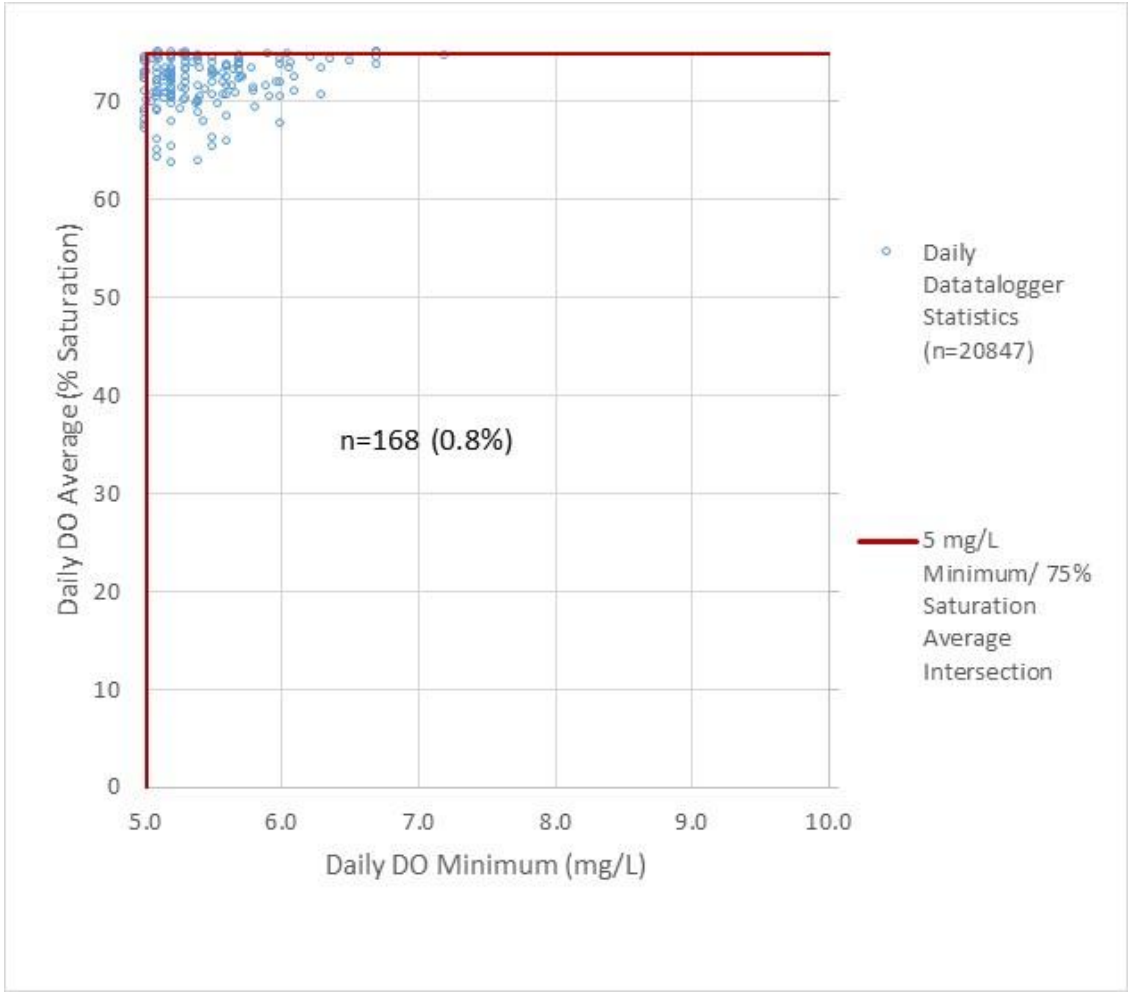
Great Bay Estuary

- 42 Datalogger sites.
- ~21,000 Complete days that have DO conc, %sat, & water temperature.
- Functionally a spatial and temporal census.



Equivalency in marine water – 5 mg/L to 75% Saturation?
How often are we below 75% average saturation and above 5 mg/L?

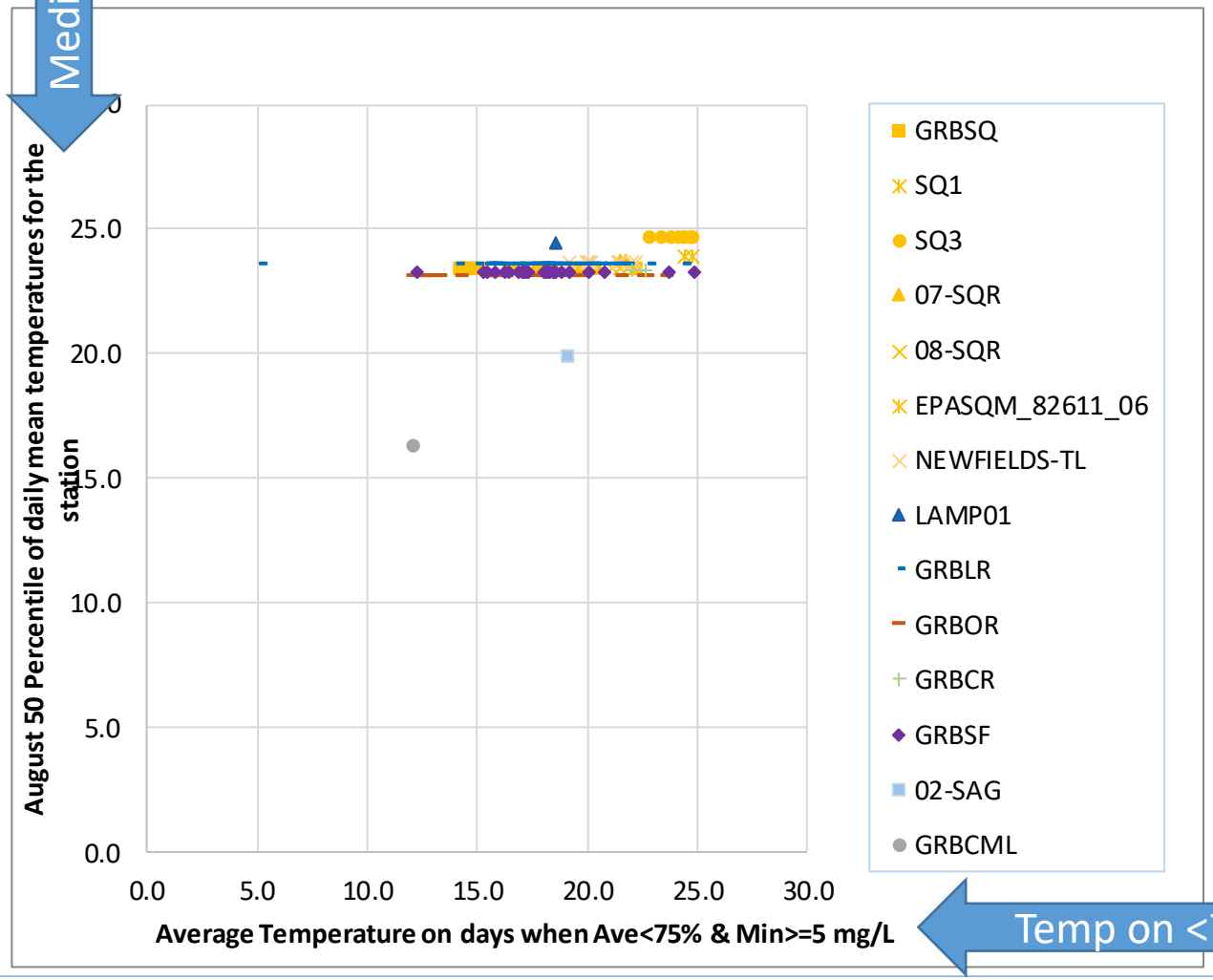




While there are a small days wherein DO is below 75% average saturation and above 5 mg/L, the minimum DO on those days is by no measure high (median = 5.3 mg/L) while 24-hour %Sat is not very low (72%).

Do those days of below 75% average saturation and above 5 mg/L occur under cold conditions (marine waters)?

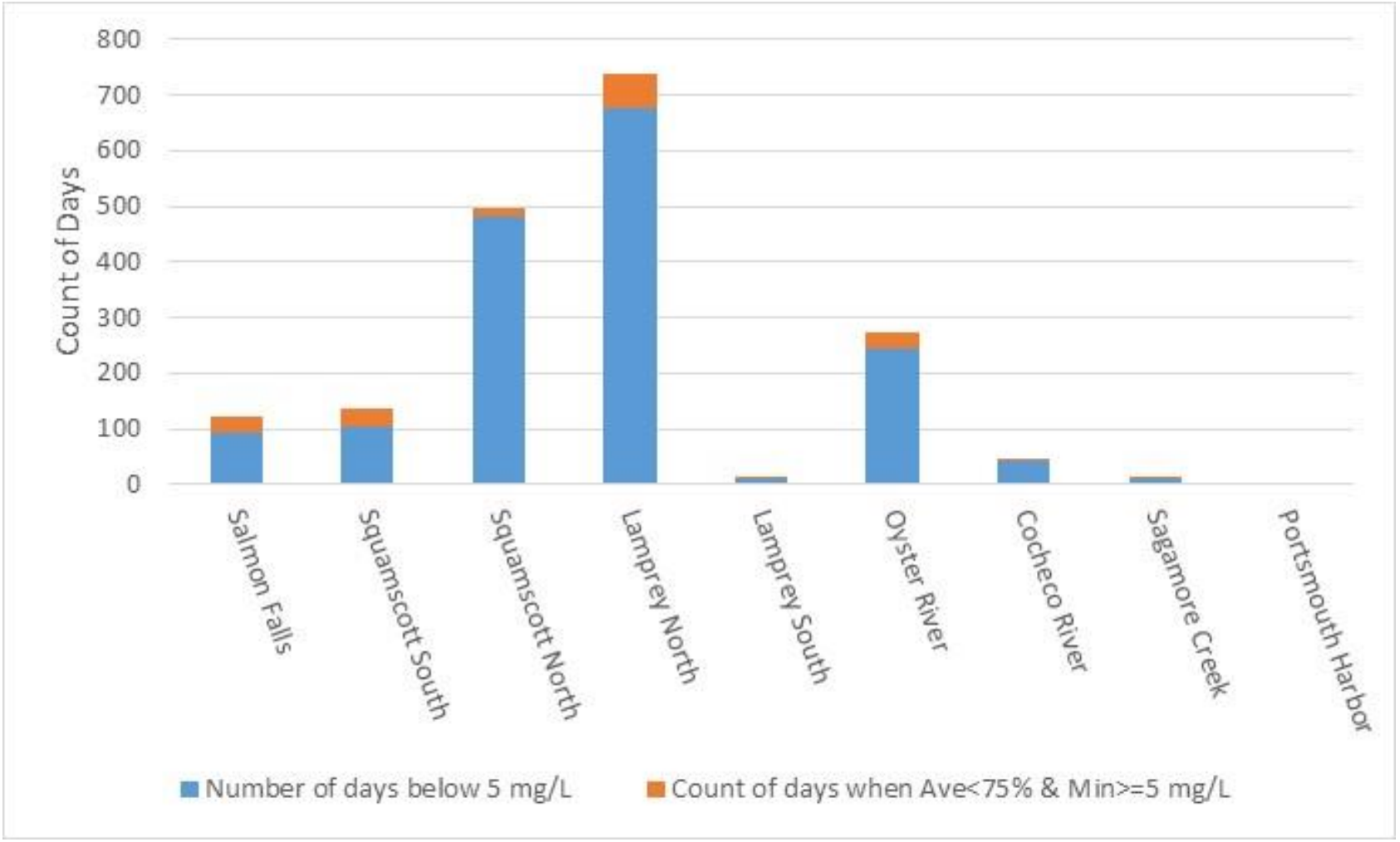
Median August Temp



Temp on <75% ave days

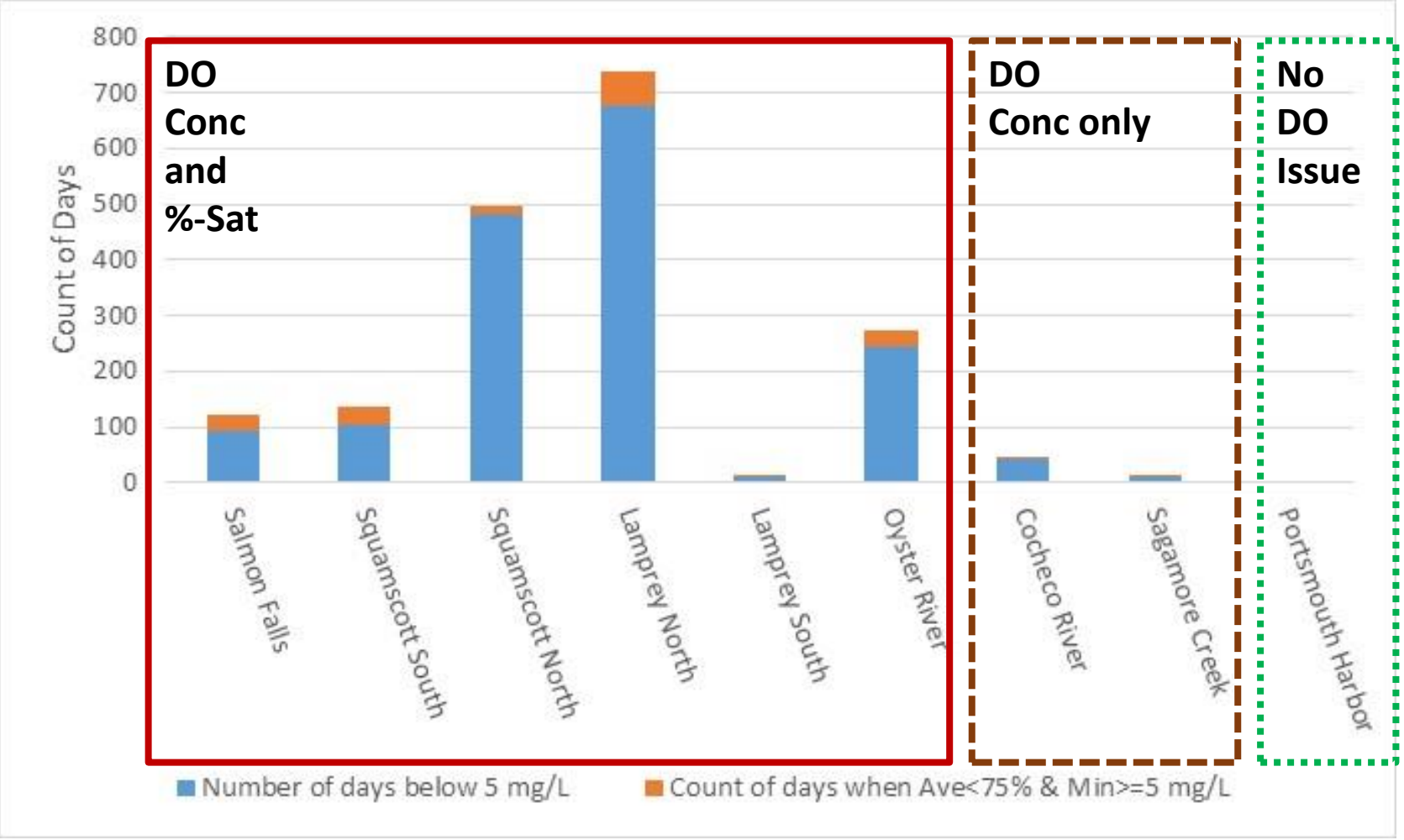
While there are a small number of days wherein DO is below 75% average saturation and above 5 mg/L, the temperature on those days is not low (median = 18.4 C).

Do those days of below 75% average saturation and above 5 mg/L occur at waterbodies that otherwise show no low DO (marine waters)?



- For the waterbodies, the days <5 mg/L far outweigh days when Ave<75% & Min>=5 mg/L.

Do those days of below 75% average saturation and above 5 mg/L occur at waterbodies that otherwise show no low DO (marine waters)?



- For the waterbodies, the days <5 mg/L far outweigh days when Ave<75% & Min>=5 mg/L.
- The concern that %Sat is driving DO impairments is unfounded.

Do those days of below 75% average saturation and above 5 mg/L occur at sites that otherwise show no low DO?

Two Views

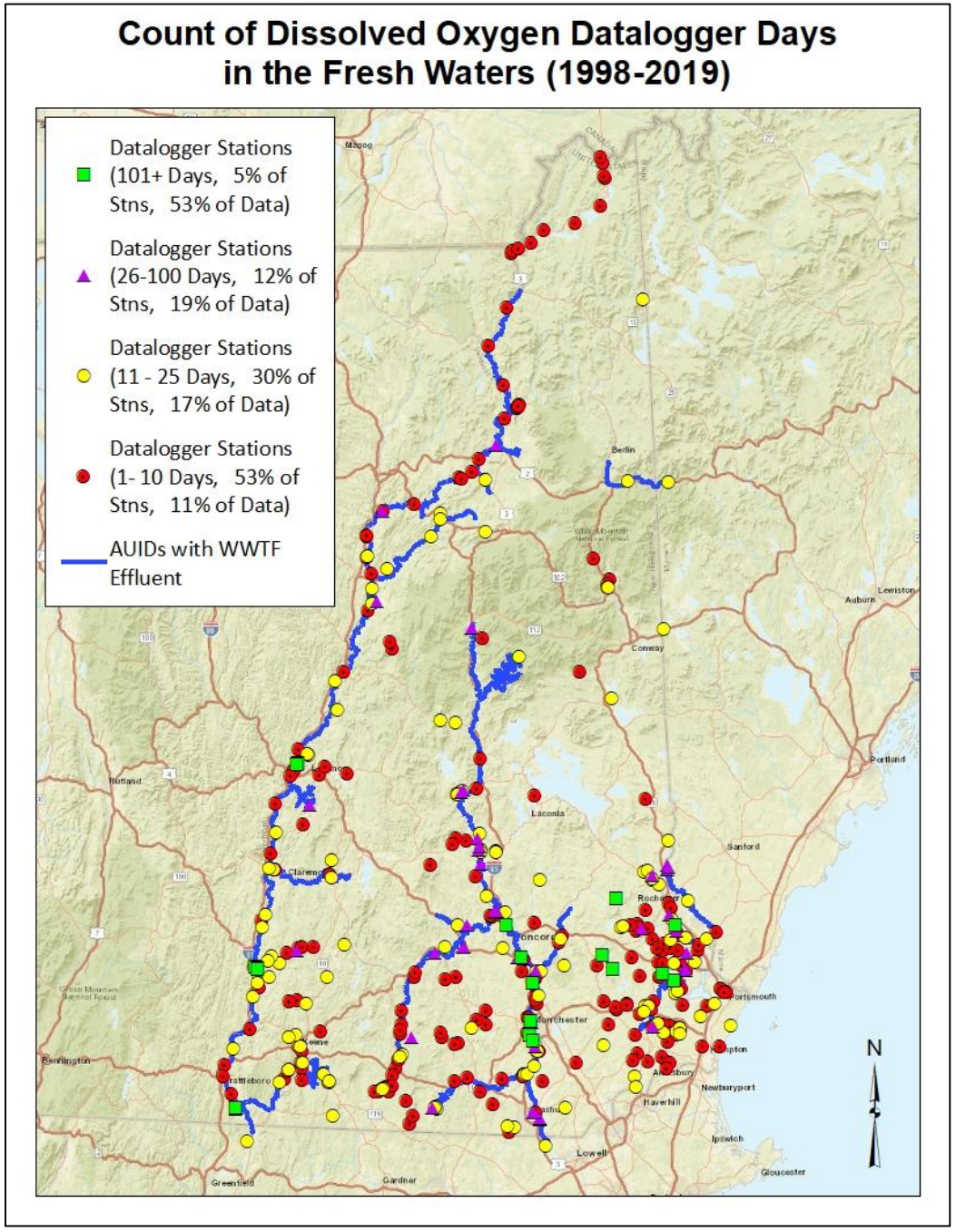
- By itself, the 5 mg/L criteria appears to be protective of the 75% daily average in the marine waters.
- By itself, the 75% daily average does not trigger DO impairment assessments that are not otherwise triggered by DO concentration in the marine waters.

Conclusion

- While altering New Hampshire's 75% daily average at will have little impact on environmental protection and DO assessment, it will have a big impact on the CWA review process.

Freshwaters

- 401 Datalogger sites.
- 10,490 Complete days that have DO conc, %sat, & water temperature.
- Majority of the data is in developed areas and on rivers receiving WWTF effluent.
- Few sites have more that a single short-term deployment (median = 10 days).
- Whereas the estuarine dataloggers are nearly a census (space an time), freshwater dataloggers are much more likely to be placed where problems are suspected for a limited amount of time. Analysis cannot be completed at this time.



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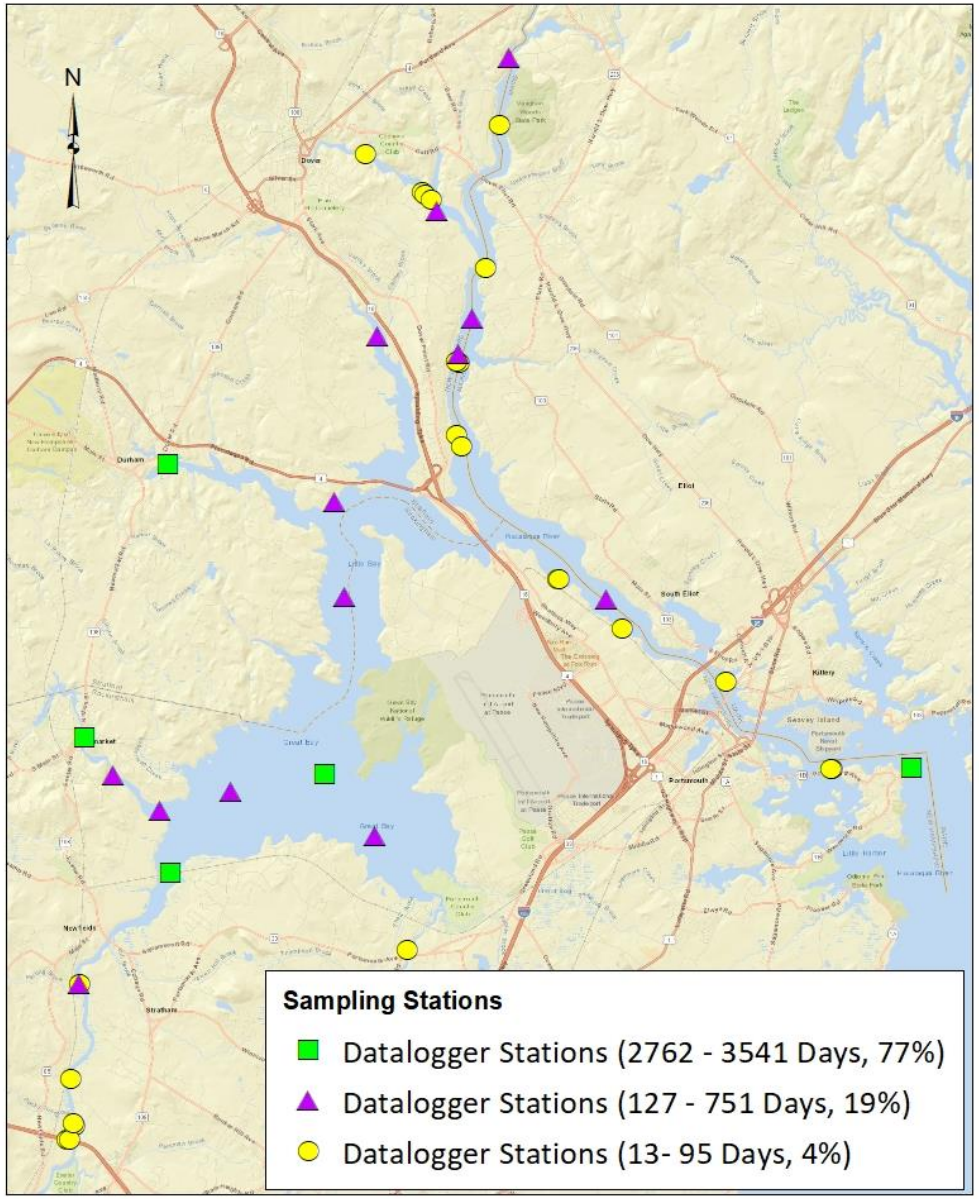
Existing Conditions – Broad Statistics

Determine typical dissolved oxygen concentrations throughout the estuary using existing datalogger monitoring.

- Annual and Summer Tendencies
- Spatial Variability
- Baseline Period - 2002-2018 (*+limited 2019*)
- Concept – criteria from existing “baseline”
  - Straight statistics no response
  - ~~Reference water approach~~
  - All waters approach

Count of Dissolved Oxygen Datalogger Days in the Great Bay Estuary (2003-2019)



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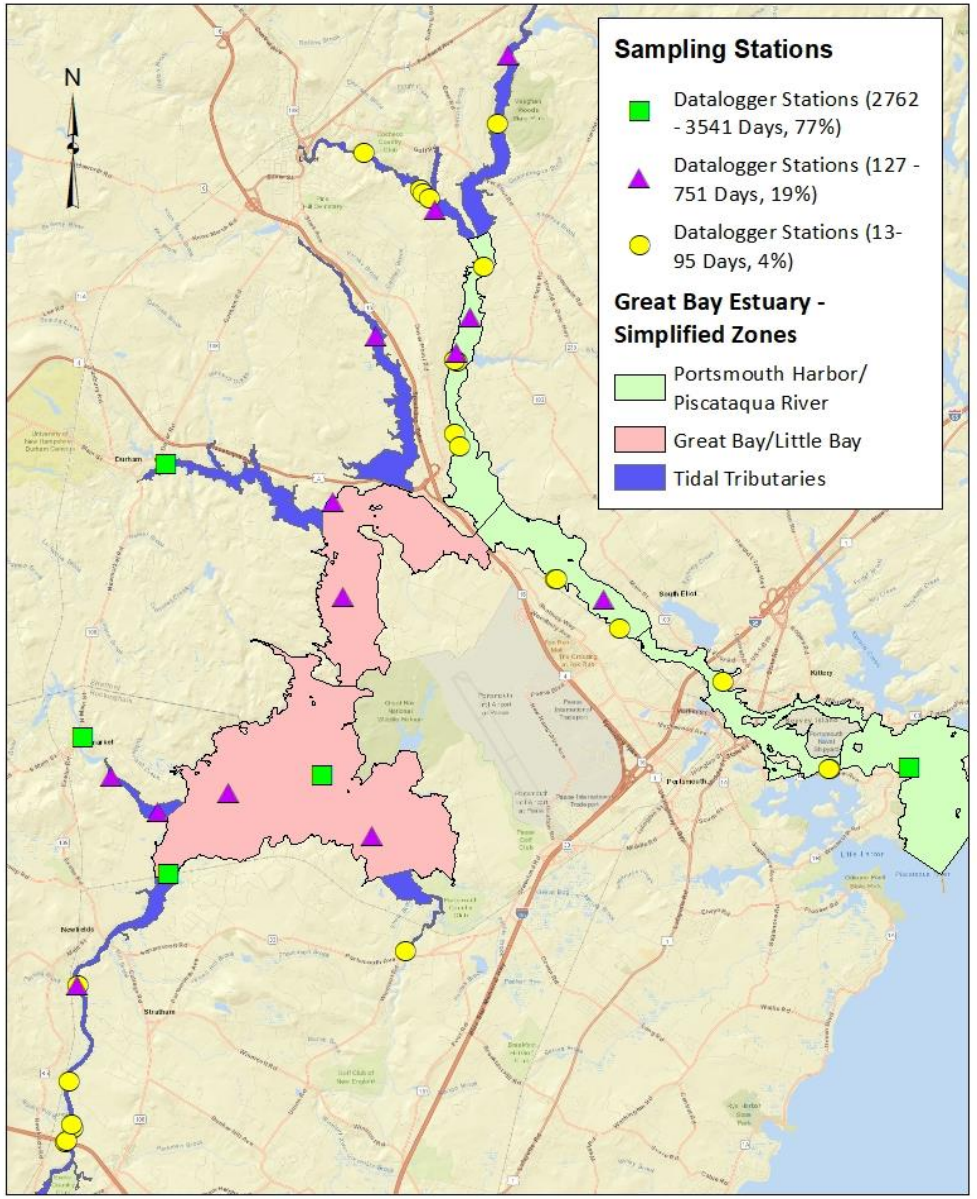
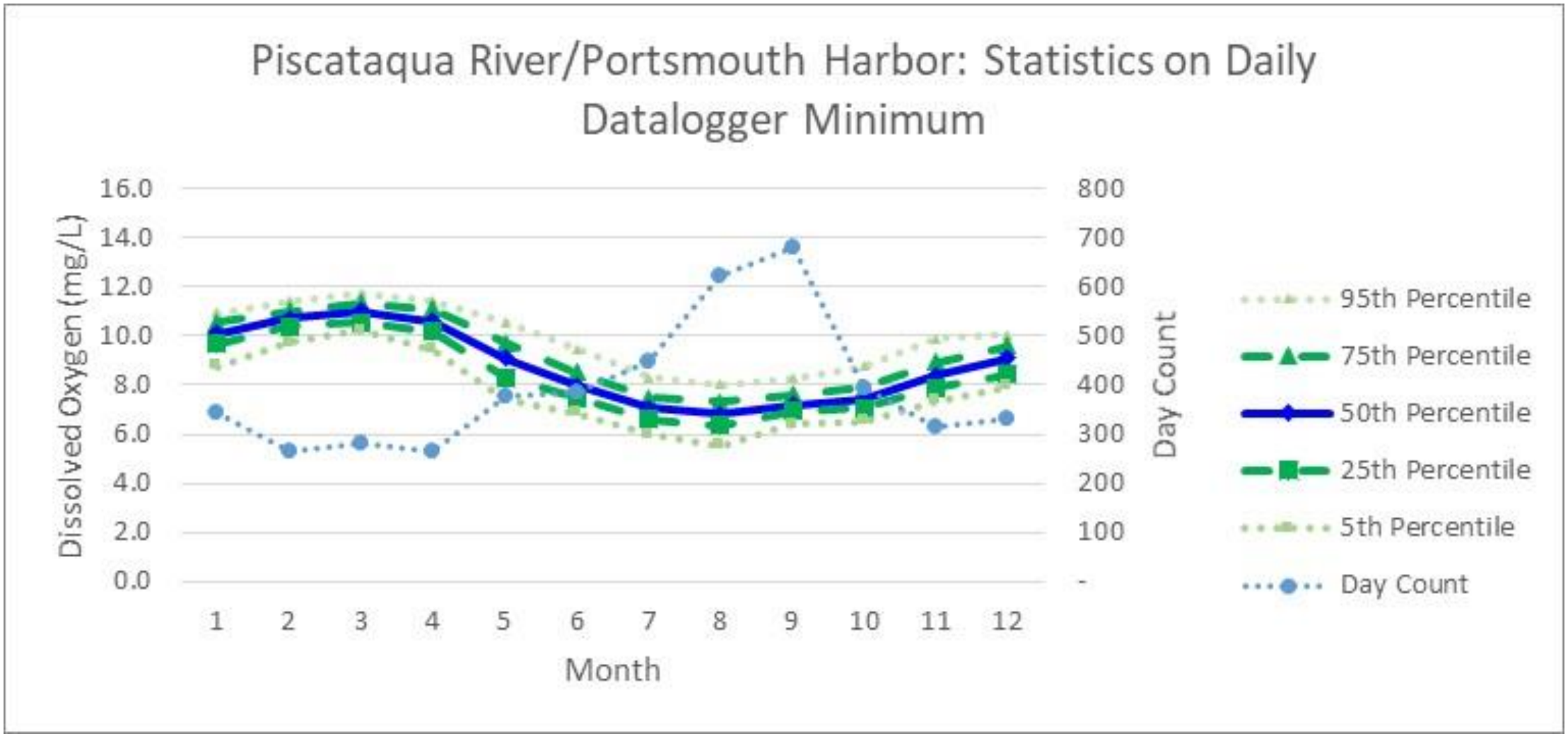
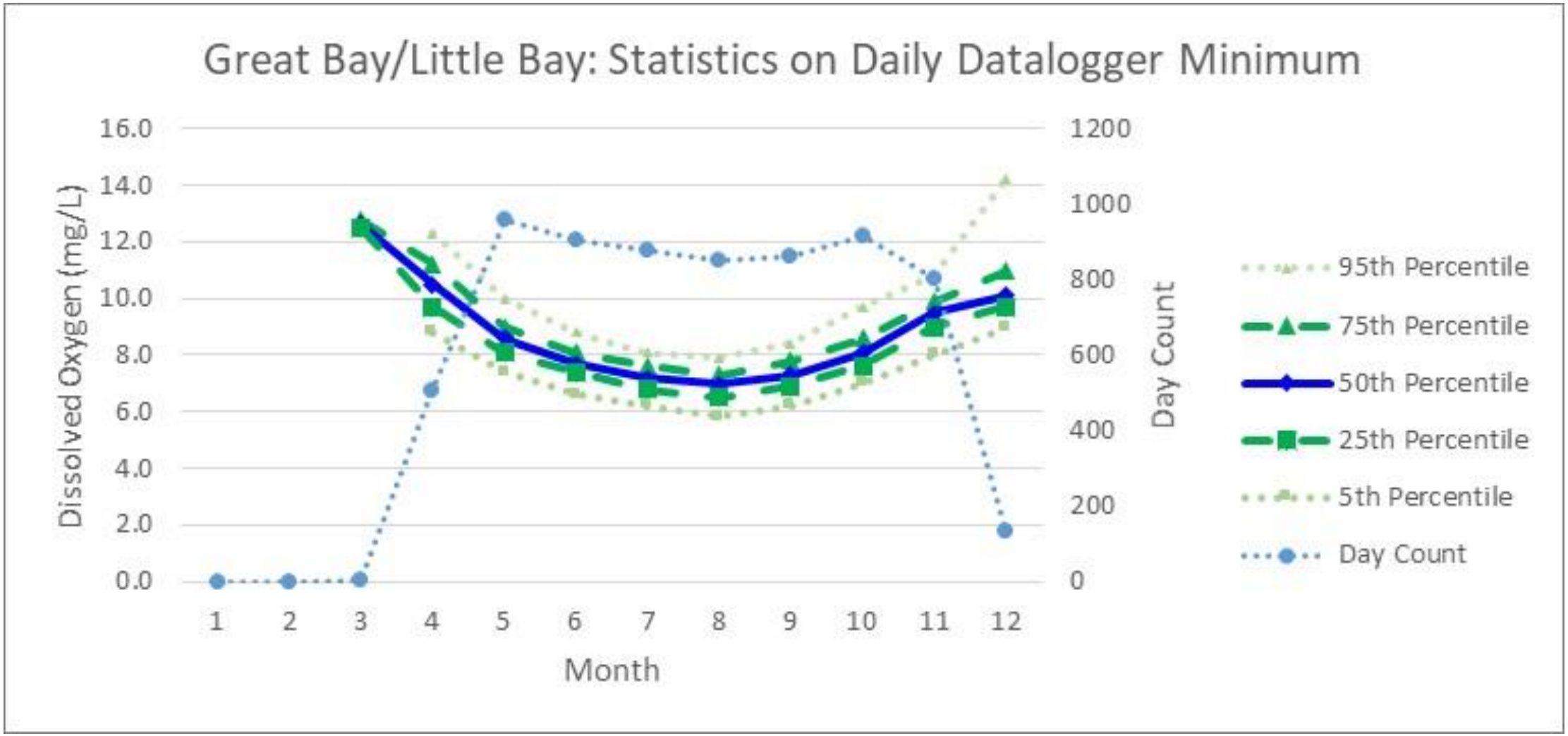



Piscataqua River/Portsmouth Harbor: Statistics on Daily Datalogger Minimum
Dissolved Oxygen (mg/L)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
800
700
600
500
400
300
200
100
-
Day Count
1
2
3
4
5
6
7
8
9
10
11
12
Month
95th Percentile
75th Percentile
50th Percentile
25th Percentile
5th Percentile
Day Count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Dissolved Oxygen (mg/L)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1200
1000
800
600
400
200
0
Day Count
1
2
3
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10
11
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Month
95th Percentile
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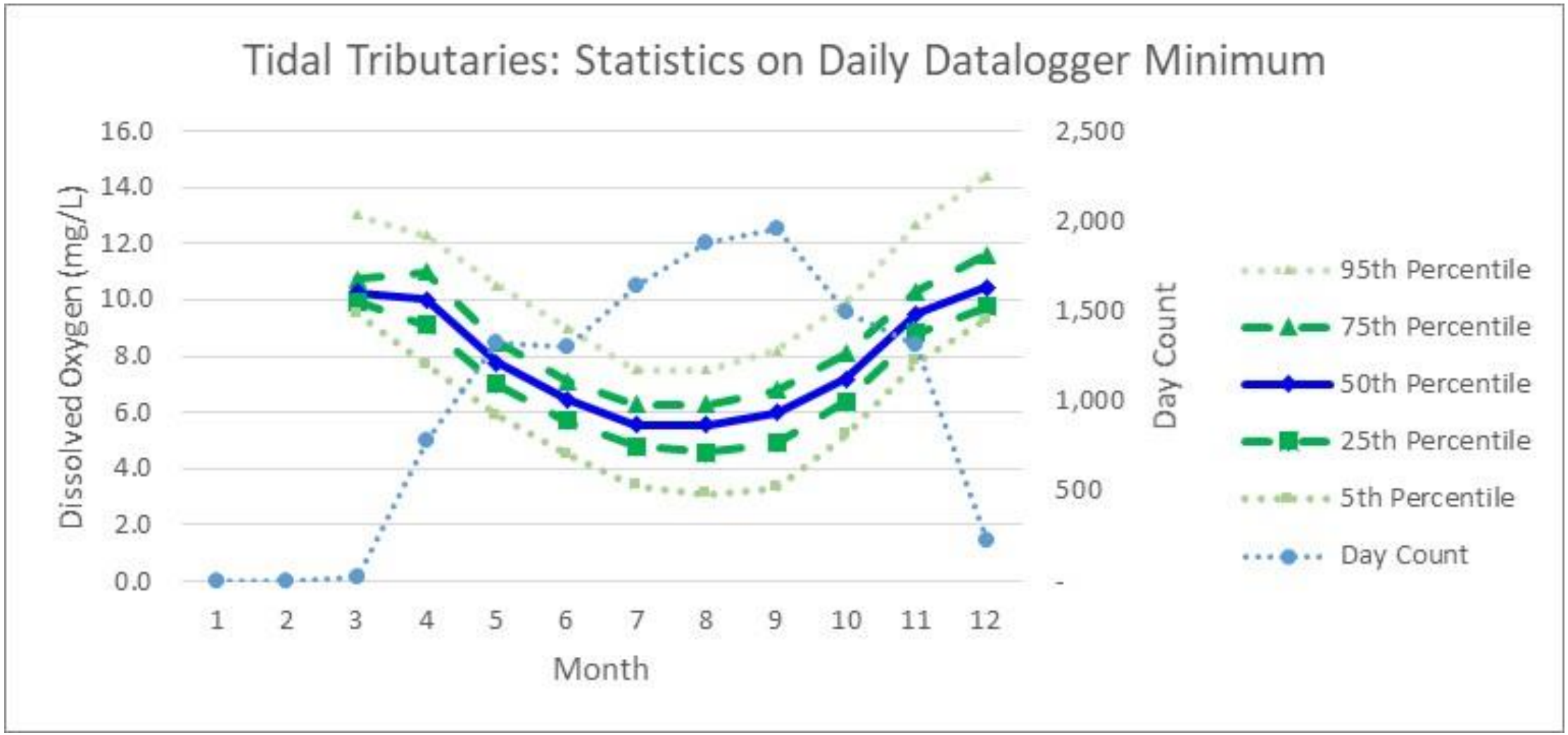
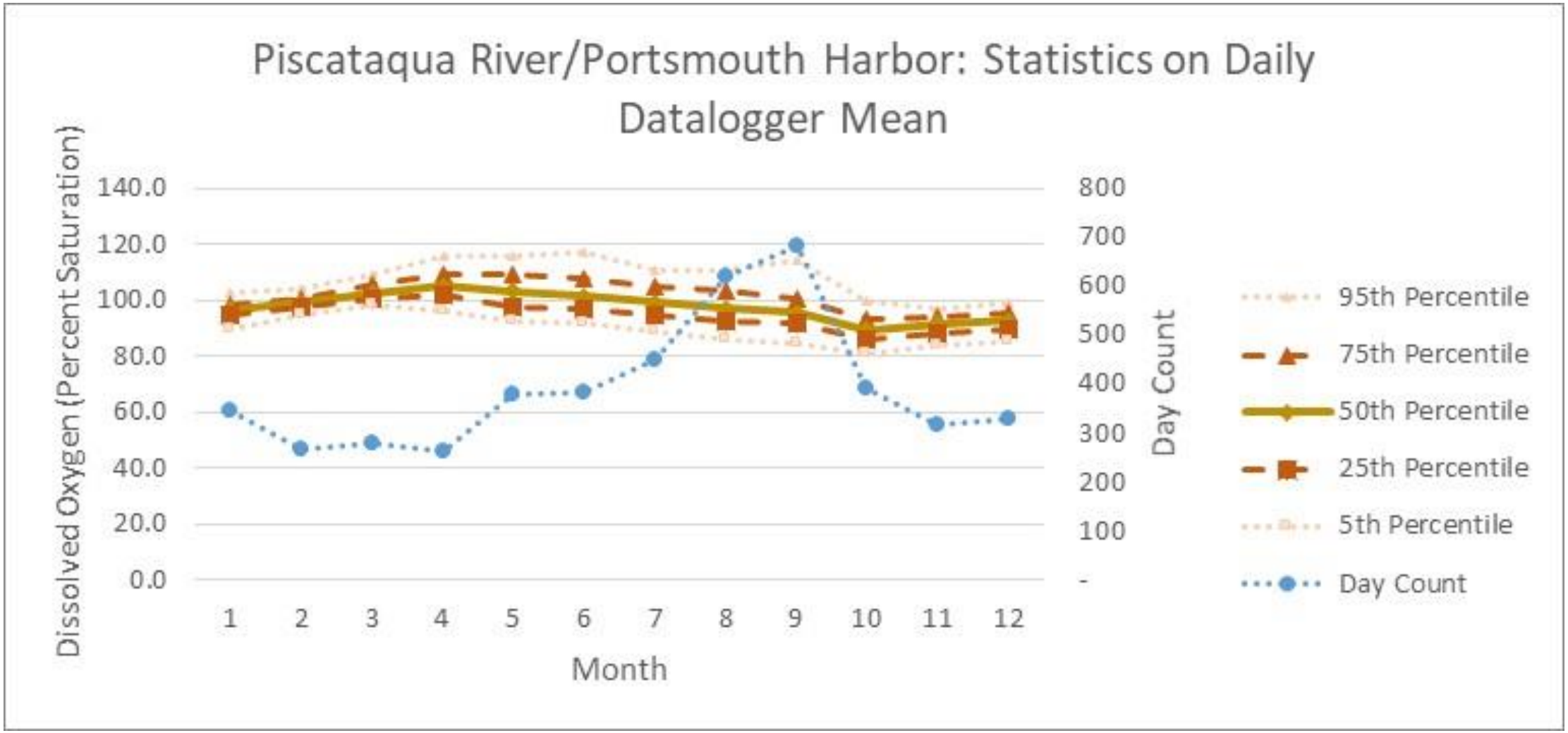
50th Percentile
25th Percentile
5th Percentile
Day Count


Tidal Tributaries: Statistics on Daily Datalogger Minimum
Dissolved Oxygen (mg/L)
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
1
2
3
4
5
6
7
8
9
10
11
12
Month
2,500
2,000
1,500
1,000
500
-
Day Count
95th Percentile
75th Percentile
50th Percentile
25th Percentile
5th Percentile
Day Count

What s the likelihood that Percent Saturation is below the 75% average saturation out of the critical season?


Piscataqua River/Portsmouth Harbor: Statistics on Daily Datalogger Mean
Dissolved Oxygen (Percent Saturation)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
800
700
600
500
400
300
200
100
-
Day Count
1
2
3
4
5
6
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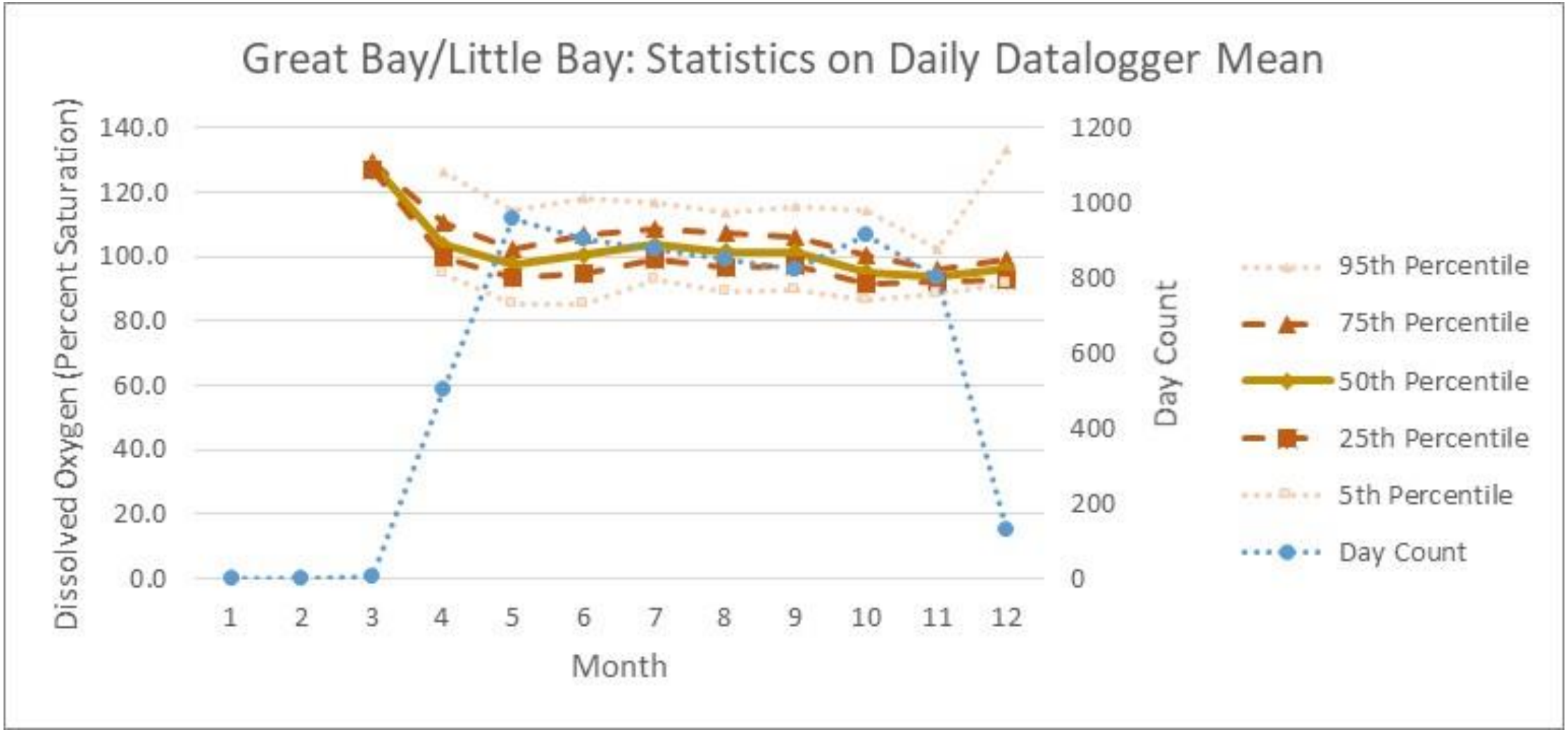
10
11
12
Month
95th Percentile
75th Percentile
50th Percentile
25th Percentile
5th Percentile
Day Count


Great Bay/Little Bay: Statistics on Daily Datalogger Mean
Dissolved Oxygen (Percent Saturation)
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
1200
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800
600
400
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0
Day Count
1
2
3
4
5
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9
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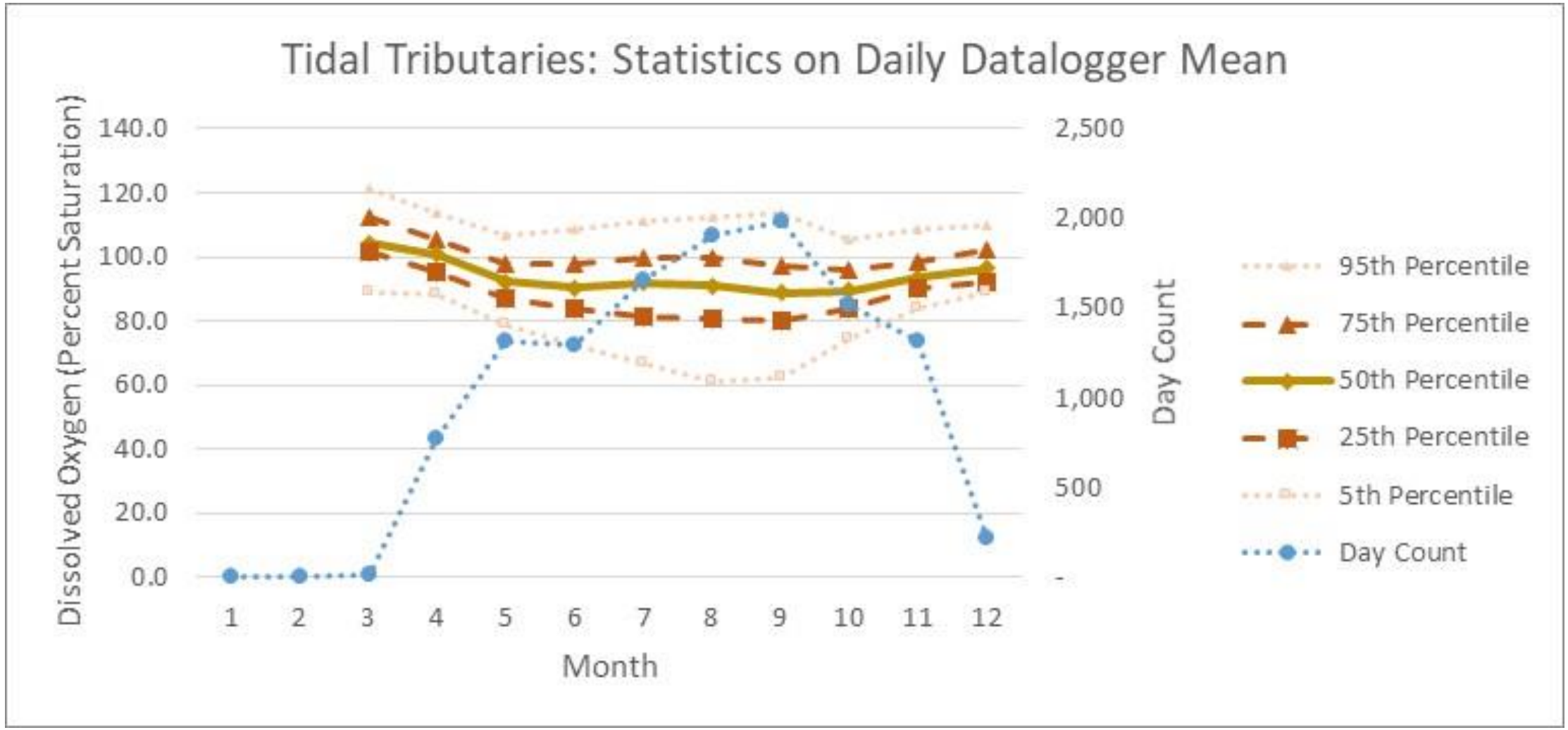
Day Count


Tidal Tributaries: Statistics on Daily Datalogger Mean
Dissolved Oxygen (Percent Saturation)
140.0
120.0
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20.0
0.0
2,500
2,000
1,500
1,000
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-
Day Count
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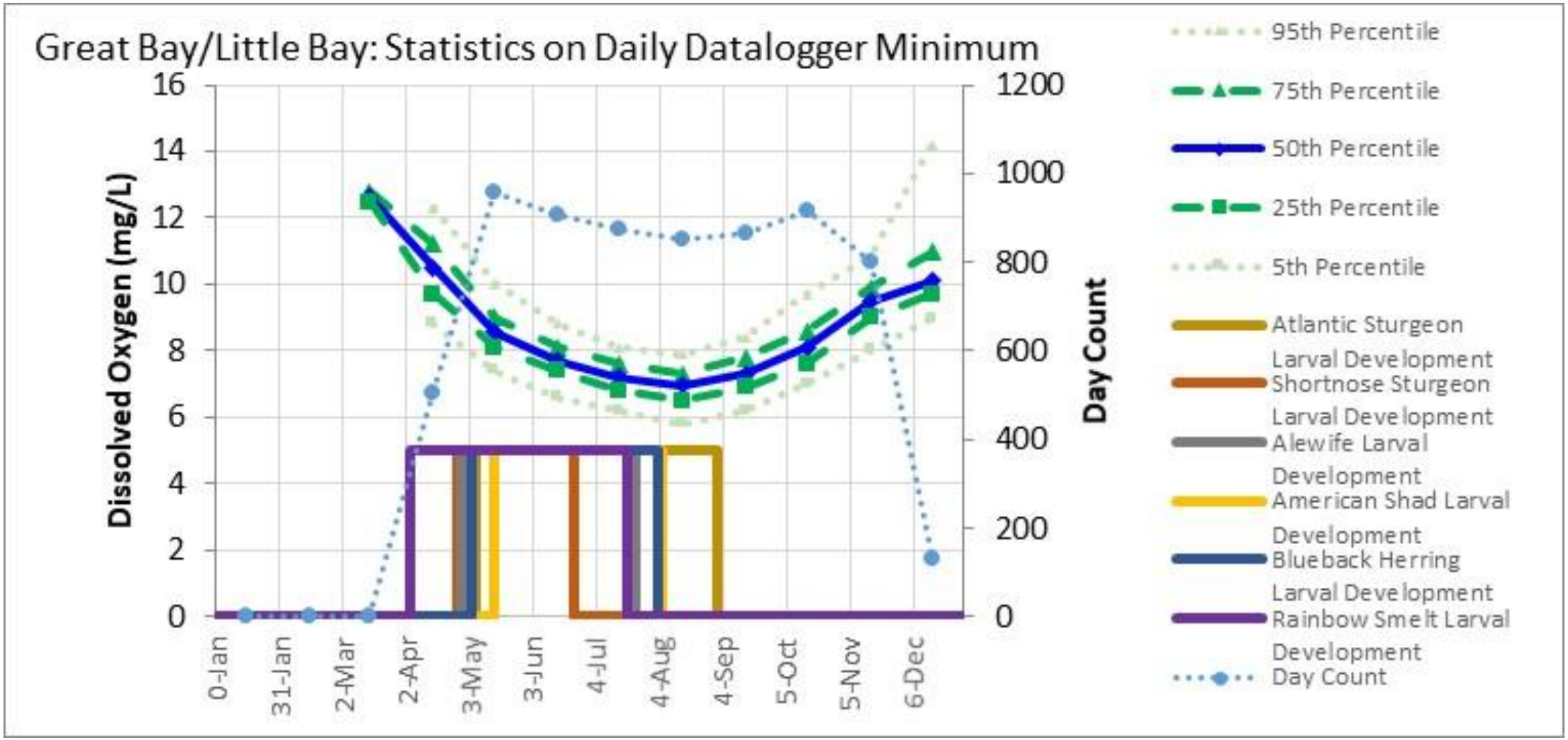
25th Percentile
5th Percentile
Day Count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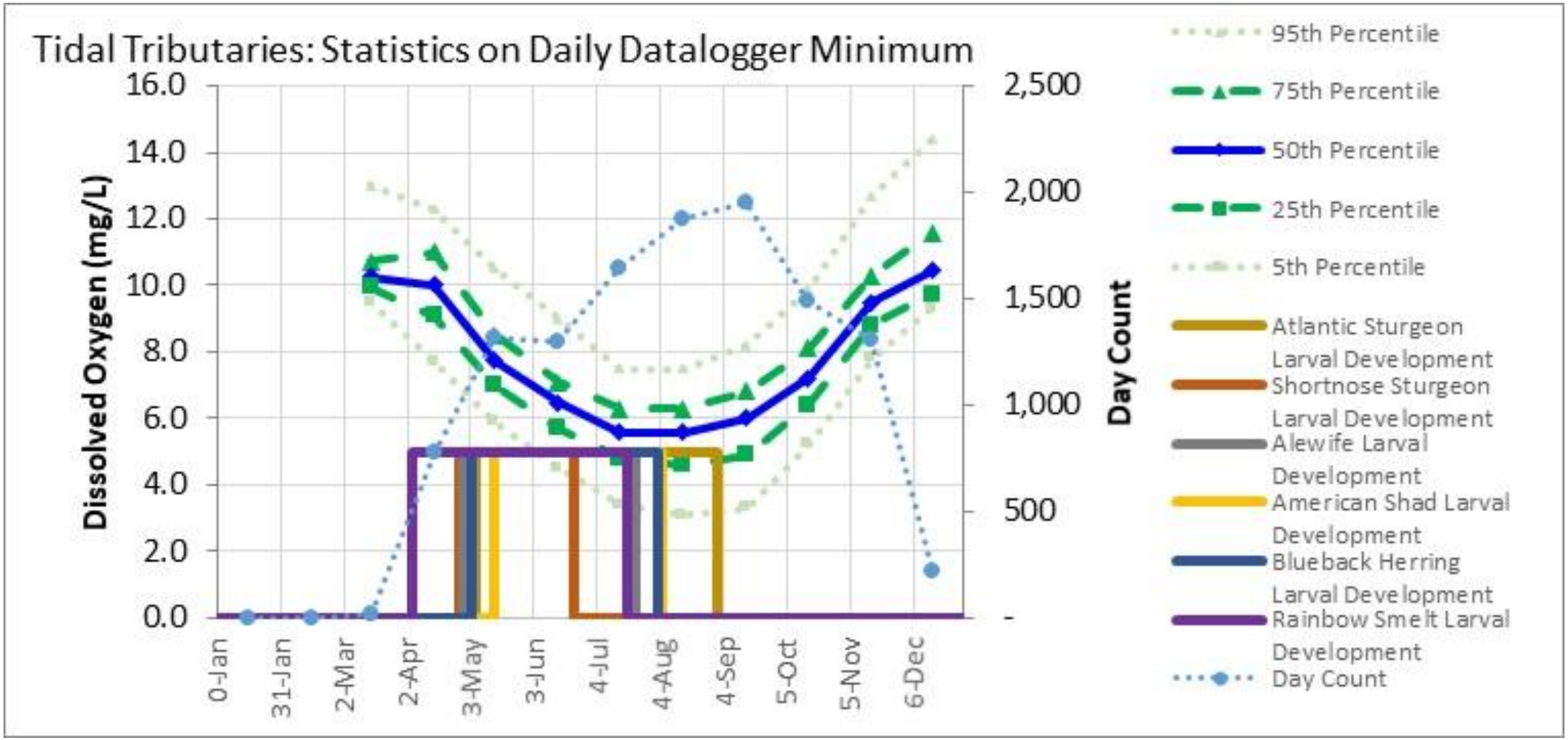
16
14
12
10
8
6
4
2
0
1200
1000
800
600
400
200
0
Day Count
0-Jan
31-Jan
2-Mar
2-Apr
3-May
3-Jun
4-Jul
4-Aug
4-Sep
5-Oct
5-Nov
6-Dec
95th Percentile
75th Percentile
50th Percentile
25th Percentile
5th Percentile
Atlantic Sturgeon Larval Development
Shortnose Sturgeon Larval Development
Alewife Larval Development
American Shad Larval Development
Blueback Herring Larval Development
Rainbow Smelt Larval Development
Day Count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12.0
10.0
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4.0
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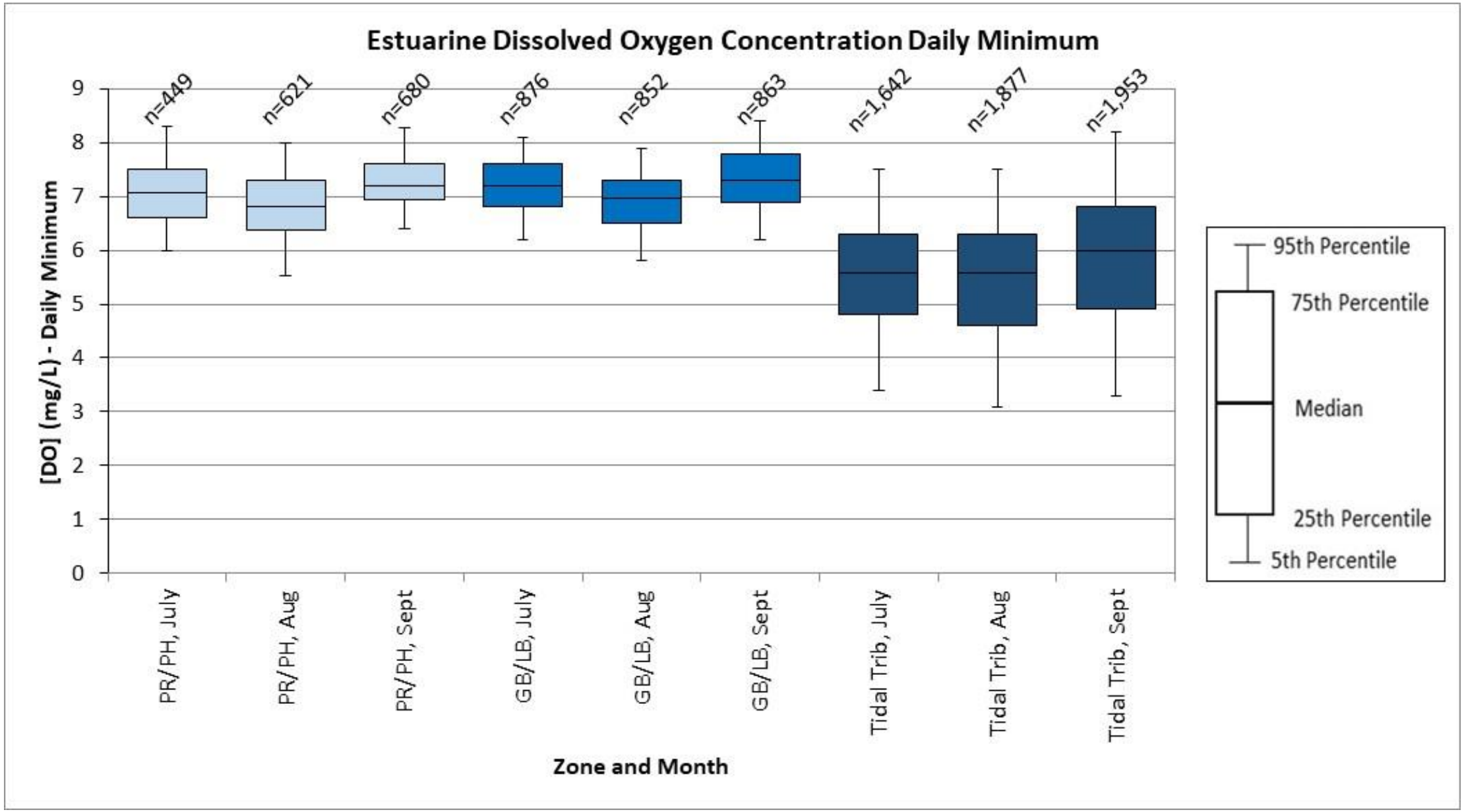
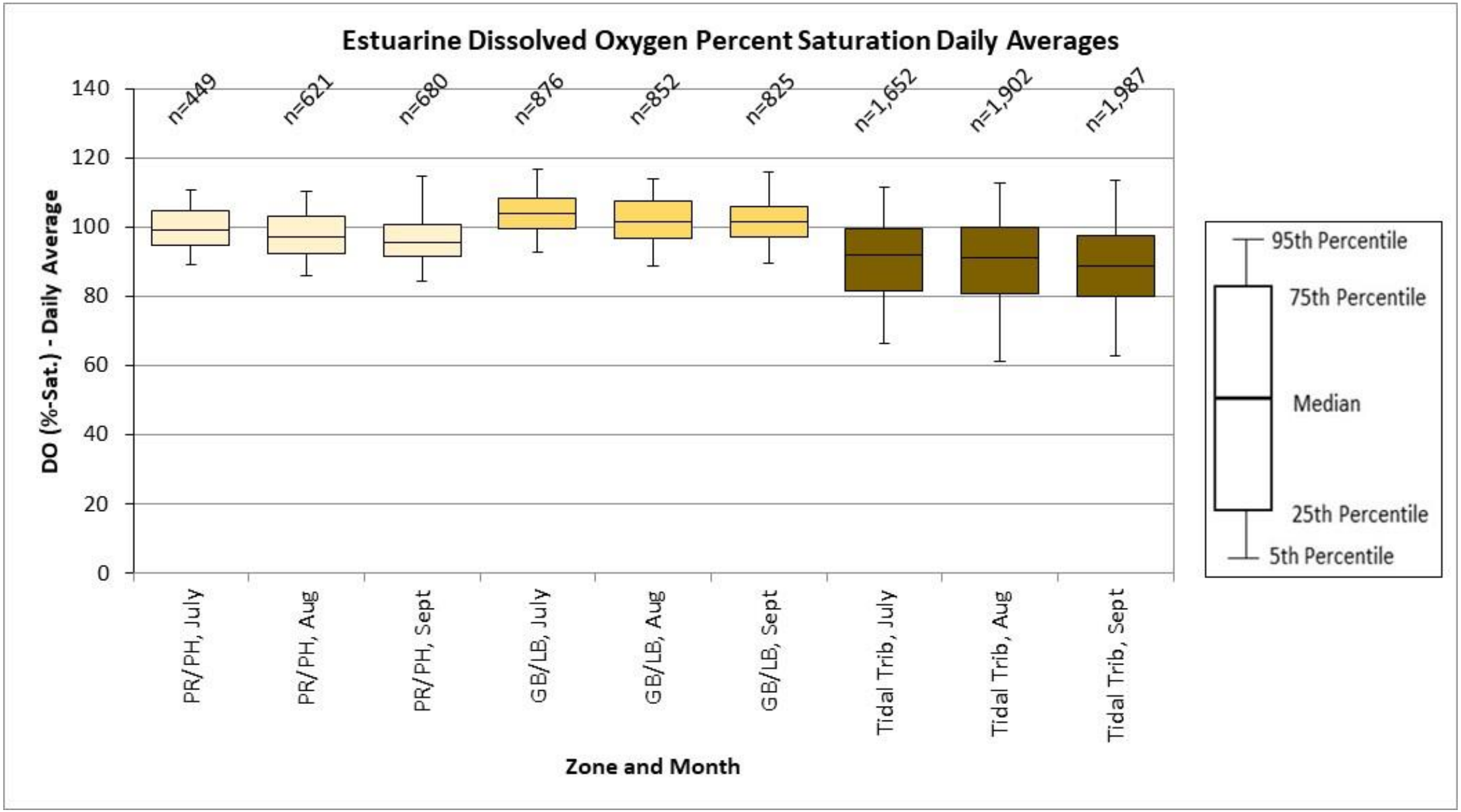
0.0
2,500
2,000
1,500
1,000
500
-
Day Count
0-Jan
31-Jan
2-Mar
2-Apr
3-May
3-Jun
4-Jul
4-Aug
4-Sep
5-Oct
5-Nov
6-Dec
95th Percentile
75th Percentile
50th Percentile
25th Percentile
5th Percentile
Atlantic Sturgeon Larval Development
Shortnose Sturgeon Larval Development
Alewife Larval Development
American Shad Larval Development
Blueback Herring Larval Development
Rainbow Smelt Larval Development
Day Count

Focus on the Summer Months


Estuarine Dissolved Oxygen Concentration Daily Minimum
[DO] (mg/L) - Daily Minimum
0
1
2
3
4
5
6
7
8
9
n=449
n=621
n=680
n=876
n=852
n=863
n=1,642
n=1,877
n=1,953
PR/PH, July
PR/PH, Aug
PR/PH, Sept
GB/LB, July
GB/LB, Aug
GB/LB, Sept
Tidal Trib, July
Tidal Trib, Aug
Tidal Trib, Sept
Zone and Month
95th Percentile
75th Percentile
Median
25th Percentile
5th Percentile


Estuarine Dissolved Oxygen Percent Saturation Daily Averages
DO (%-Sat.) - Daily Average
140
120
100
80
60
40
20
0
n=449
n=621
n=680
n=876
n=852
n=825
n=1,652
n=1,902
n=1,987
PR/PH, July
PR/PH, Aug
PR/PH, Sept
GB/LB, July
GB/LB, Aug
GB/LB, Sept
Tidal Trib, July
Tidal Trib, Aug
Tidal Trib, Sept
Zone and Month
95th Percentile
75th Percentile
Median
25th Percentile
5th Percentile

If we were to set estuarine DO criteria based on protecting the baseline condition…

- Concentration Instantaneous Minimum could be something like;
  - Piscataqua River/Portsmouth Harbor ~ 6.5 mg/L (August 25th percentile)
  - Great Bay/Little Bay ~ 6.5 mg/L (August 25th percentile)
  - Tidal Tributaries ~ 4.5 mg/L (August 25th percentile)
- **HOWEVER,** this would erroneously be making the assumption that the existing conditions are already protecting a balanced, integrated and adaptive biological community.

Discussion?