# EXPLORATORY EXERCISE:

## Dissolved Oxygen Assessment Methodologies in Rivers and Streams

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# Challenge

- Even though continuous monitoring is capable of better capturing true variability, the magnitude and durations of exposures that affect aquatic life are still largely unknown

- So, how do we make reasonable assessments using continuous data?

  - Start by learning and comparing current practices

# Exercise

- Applied different assessment methodologies and results on a 9+ year continuous DO dataset

- Randomly reviewed and included state standards and assessment methodologies, not a comprehensive review

# Presentation Takeaways

- Variety of DO criteria thresholds, durations, and assessment methodologies

- For one long-term, continuous dataset examined, season sampled yielded more variable assessment results than assessment methodology

# State DO Standards

- Different criteria depending on waterbody classification (eg. warm vs cold water)

- Different criteria depending on season (eg. spawning)

**Durations**

- Instantaneous Minimum DO value (no time period specified)

- 16-hour min

- Daily min

- Daily mean

- 3-day min

- 3-day rolling mean of mins

- 3-day rolling mean

- 4-day min or mean (unclear)

- 7-day mean of mins

- 7-day min of means

- 7-day mean

- 7-day rolling mean

- 30-day mean
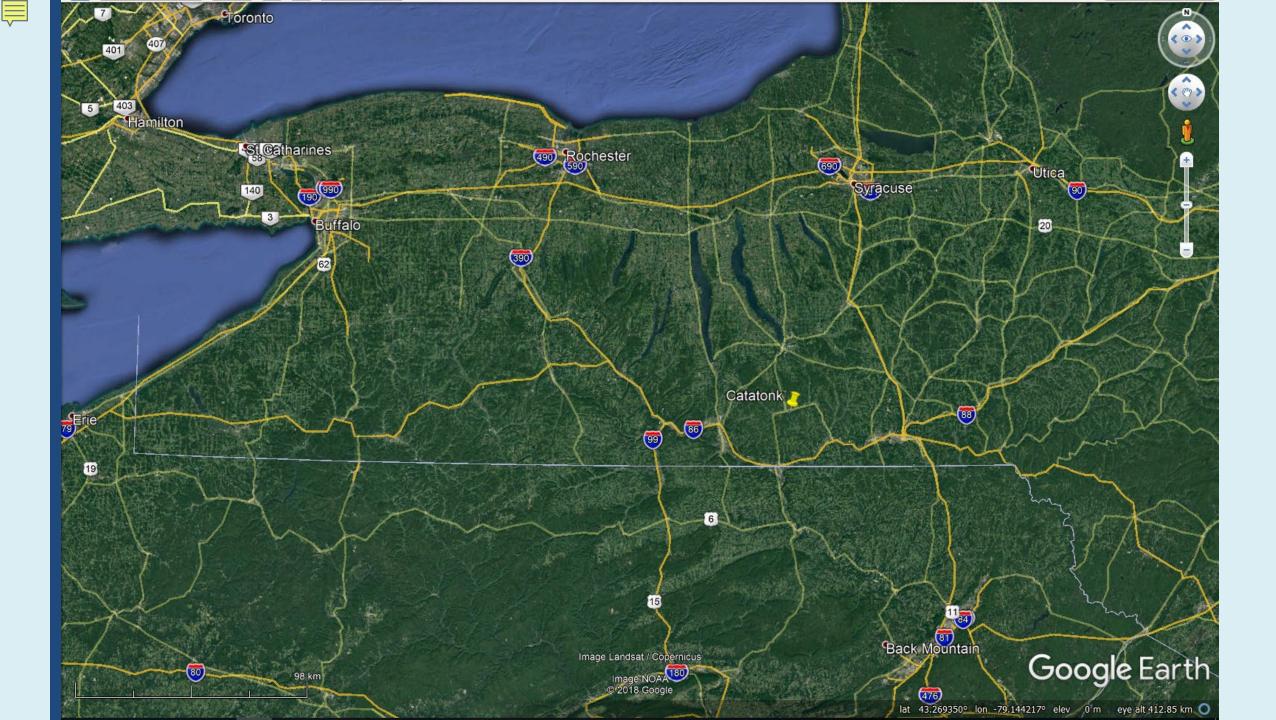
- 30-day rolling mean

- 30-day rolling mean of mins

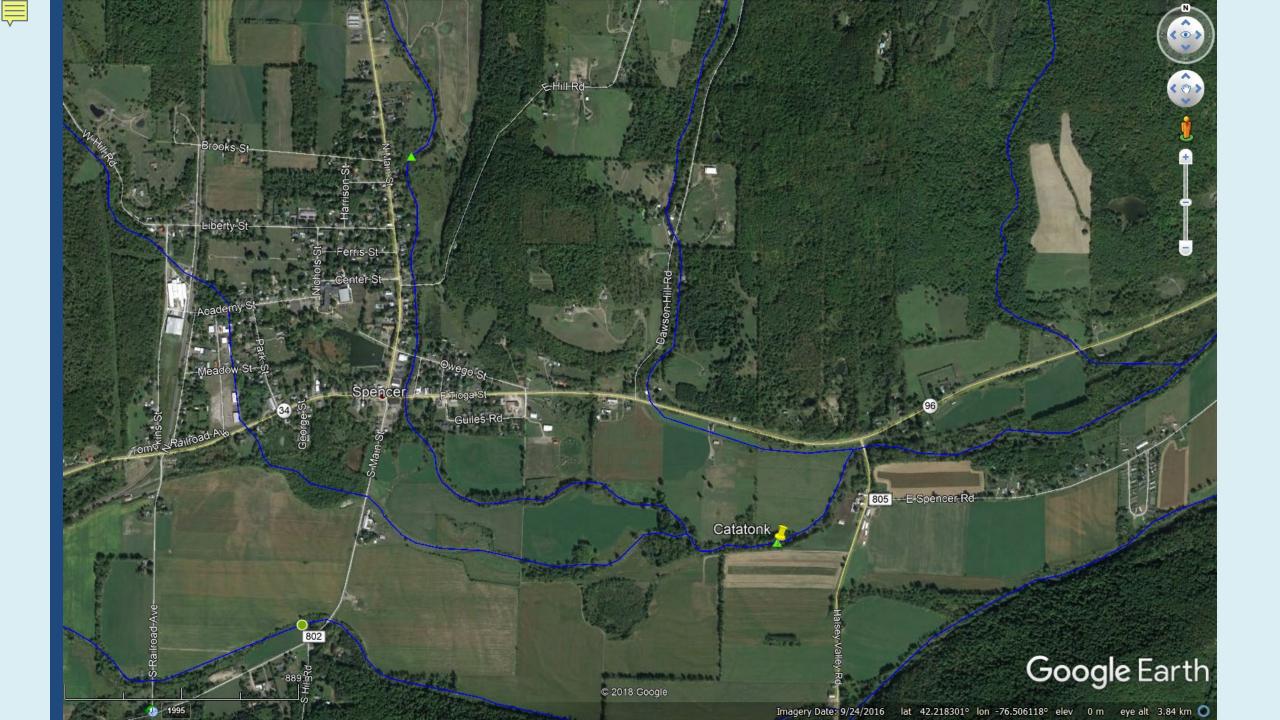# CONTINUOUS DATA ASSESSMENT METHODOLOGIES

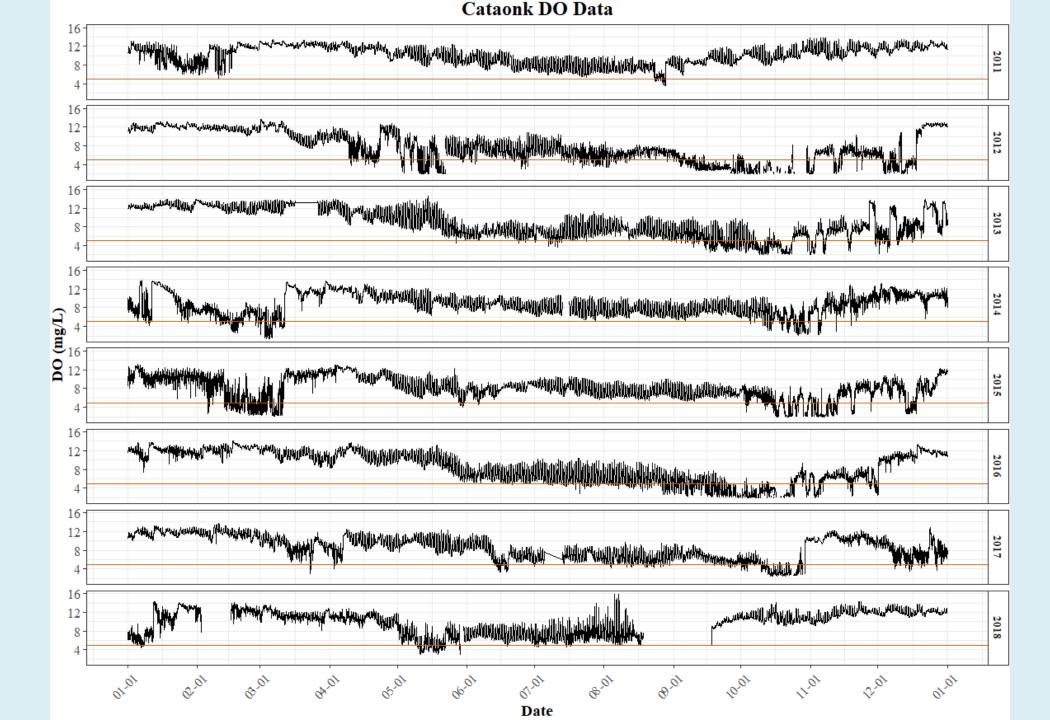Must be considered in larger context of monitoring program, goals, and data requirements

# Additional Context Often Provided in Assessment Methodologies

- Minimum Data Requirements
  - *Hours required to have a daily sample; days, seasons, or years to make an assessment*
  - *Do you need all 7 days to assess against a 7-day mean standard, etc?*

- Definition (duration) of One Sample and Violation
  - *Is one sample one timestamp, one day, one 7-day period, etc?*
  - *Number of rolling average violations needed to be impaired*

- Defining Critical Periods of Deployment
  - *To make an assessment, monitor during spawning seasons or during time periods when DO is expected to be lowest*

- Overwhelming evidence factor
  - *Ability to base assessment decision on magnitude of exceedance (often stated for discrete data as well)*

Cataonk DO Data

# Exercise limitations (at least some of them..)

- Used the same threshold values for all assessments

(Minimum threshold = 5 mg/L, Mean threshold = 5.5 mg/L)

 – Unrealistic in areas with different seasonal standards

- Does not examine other datasets (eg biology, nutrients, flow) which would often be evaluated concurrently

- Does not directly evaluate data within the monitoring context (critical seasons, magnitude of violation, etc)

- Does not evaluate diel swings

 – Thresholds might exist in nutrient assessment protocols or implementation plans that are not examined here

- It only examines one site

**DISCLAIMER:** Does not evaluate if methodologies are protective of Aquatic Life Use or indicate that EPA endorses a particular methodology

# Calculated metrics and methodologies – Percent Exceedance (>10% = impaired)

- Calculations
  - *Percent of <u>all</u> points (15 minutes) that were below 5 mg/L*
  - *Percent of <u>daily</u> means and <u>daily</u> mins (ignoring missing data) below threshold (5.5 or 5 mg/L)*

- For rolling calculations (eg 30 day mean), each day represents the mean of the previous x days. If the end day of that mean is below the threshold, the end 'day' is in violation

- Metrics
  - *Roll30dmean_dmean = rolling 30 day mean of daily means*
  - *Roll30dmean_dmin = rolling 30 day mean of daily mins*
  - *Roll7dmean_dmean = rolling 7 day mean of daily means*
  - *Roll7dmin_dmeans = rolling 7 day min of daily means*
  - *Roll7dmean_dmin = rolling 7 day mean of daily mins*
  - *Roll3dmean_dmean = rolling 3 day mean of daily means*
  - *Roll3dmean_dmin = rolling 3 day mean of daily mins*
  - *Roll3dmin_dmin = rolling 3 day minimum*
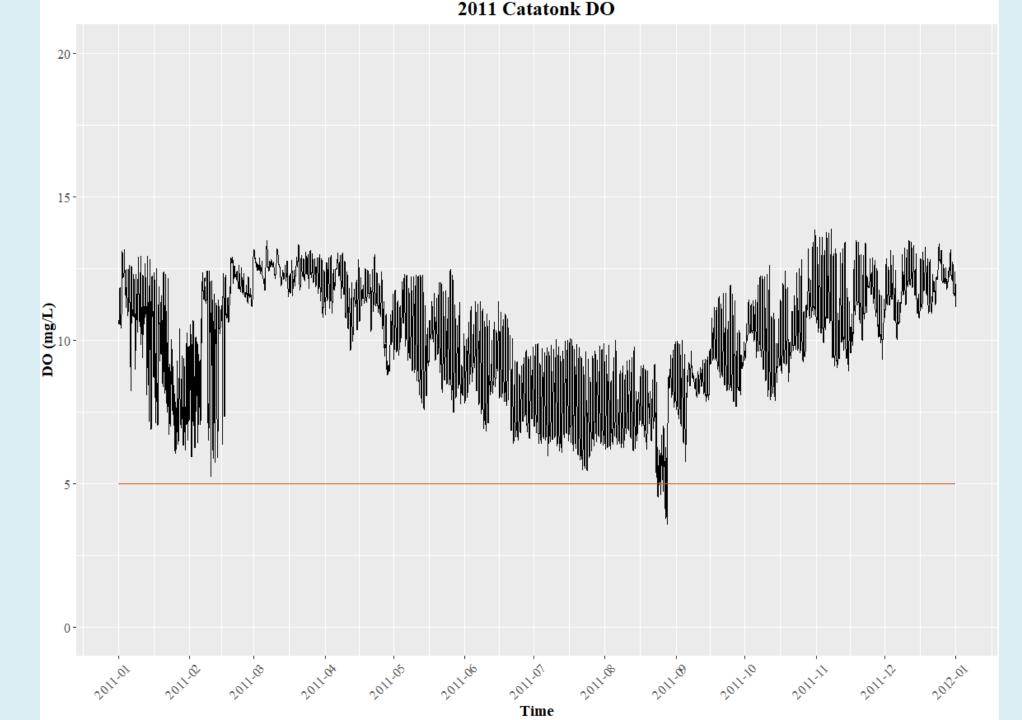  - *Dailymean*
  - *Dailymin*

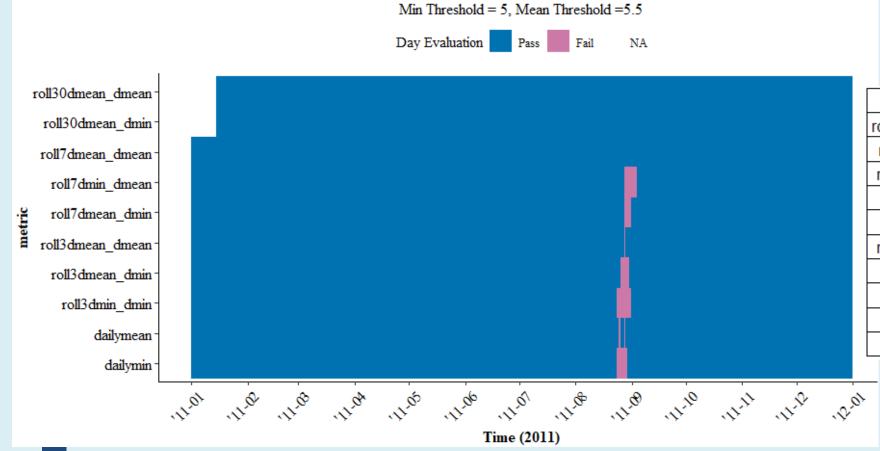# Calculated Metrics and Methodologies – Impairment Criteria

- Binomial Distribution Probability to daily min/means
  - Year (365 samples) in violation if >45 days are below threshold
  - Month in violation if >6 days are below threshold

- 10% of 10%
  - If >10% of data were less than the threshold **in a day** that was one day in *violation (for 15 minute data, >0.1\*4\*24=9.6 points (2.4 hr) in violation),*
  - Then, if 10% of all days were in violation, it was impaired

- 10% of daily means skipping 3 days if there is a violation (quasi 4-day chronic)
  - Once first mean violation occurs, skip violations for following 3 days, then continue evaluating daily means for violations

- >1% of all year (rolling) violates DO min = impairment.   Independent of number of samples.
  - Always calculated over entire year.  Assumes all missing data meets standards.
  - If one, 7-day mean is in violation, site is impaired (7/365 >1%)

# Calculated Metrics and Methodologies – Impairment Criteria

- If 2 or more 3- or 30- day rolling averages violated

- If one violation event was below DO minimum for more than 4 hours

- Percentiles: impaired if
  - *UCL of 1st %-ile of all data < standard*
  - *UCL of 10%ile of daily means < standard*

- Grab sample simulation
  - Randomly picked one value, biweekly, between 9a and 4p.  Repeated 10,000 times
  - For each iteration out of 10,000, calculated if the year would be in violation of 10% rule.
  - Final number is the percent of iterations where the year would be impaired

- Hypermetric distribution probability assessment (and others) not calculated

**2011 Catatonk DO**
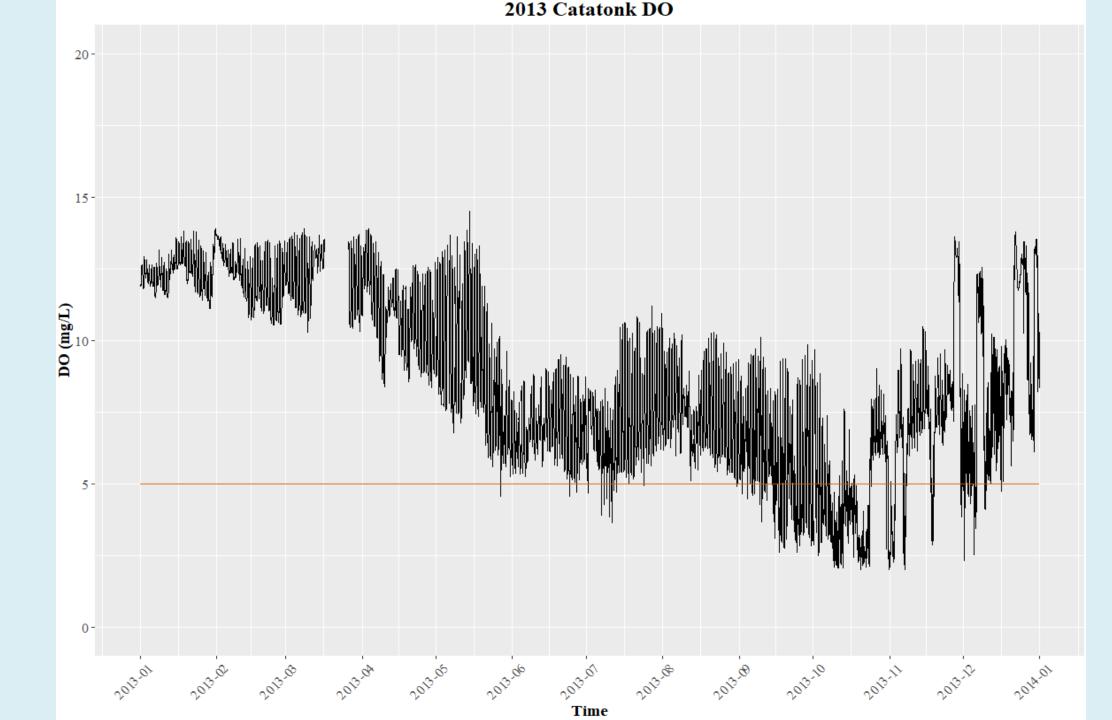
# Catatonk 2011



| Site | DO Mins UCL 1st %ile DO Value | DO Means UCL 10th %ile DO Value |
|---|---|---|
| Catatonk 2011 | 5.7 | 7.8 |

| metric | perexyear | daysex |
|---|---|---|
| roll30dmean_dmean | 0.0 | 0 |
| roll30dmean_dmin | 0.0 | 0 |
| roll7dmean_dmean | 0.0 | 0 |
| roll7dmin_dmean | 1.9 | 7 |
| roll7dmean_dmin | 1.1 | 4 |
| roll3dmean_dmean | 0.3 | 1 |
| roll3dmean_dmin | 1.4 | 5 |
| roll3dmin_dmin | 2.2 | 8 |
| dailymean | 0.5 | 2 |
| dailymin | 1.6 | 6 |

Grab Samples = 0%

| Site | % points violate | % daily min | % daily mean | binomial dmins | binomial dmeans | 10% of 10% | > 1% yr | roll30dmean _dmin | roll7dmean _dmean | roll7dmin_ dmean | roll7dmean _dmin | roll3dmean _dmean | roll3dmean _dmin | roll3dmin _dmin | > 1 7day mean | mean (skip 3 days) | >1 3 or 30 day rollmean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2011 | 0.34 | 1.6 | 0.5 | P | P | P | P | 0 | 0 | 1.9 | 1.1 | 0.3 | 1.4 | 2.2 | P | 0.27 | P |
| Aug 2011 | 3.94 | 19.4 | 6.5 | P | P | F | P | 0 | 0 | 12.9 | 12.9 | 3.2 | 16.1 | 25.8 | P | 3.23 | P |
| Oct 2011 | 0 | 0 | 0 | P | P | P | P | 0 | 0 | 0 | 0 | 0 | 0 | 0 | P | 0 | P |

2013 Catatonk DO

# 2013 Oct



Min Threshold = 5, Mean Threshold =5.5, Number of Samples =31

Day Evaluation ▪ Pass ▪ Fail
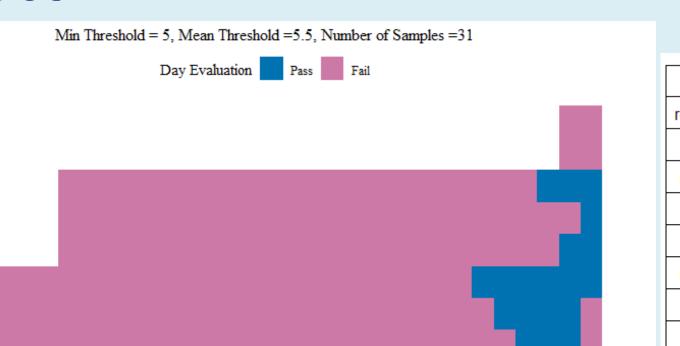
| Year | DO Mins UCL 1st %ile DO Value | DO Means UCL 10th %ile DO Value |
|---|---|---|
| 2013 Oct | 2.2 | 3.2 |

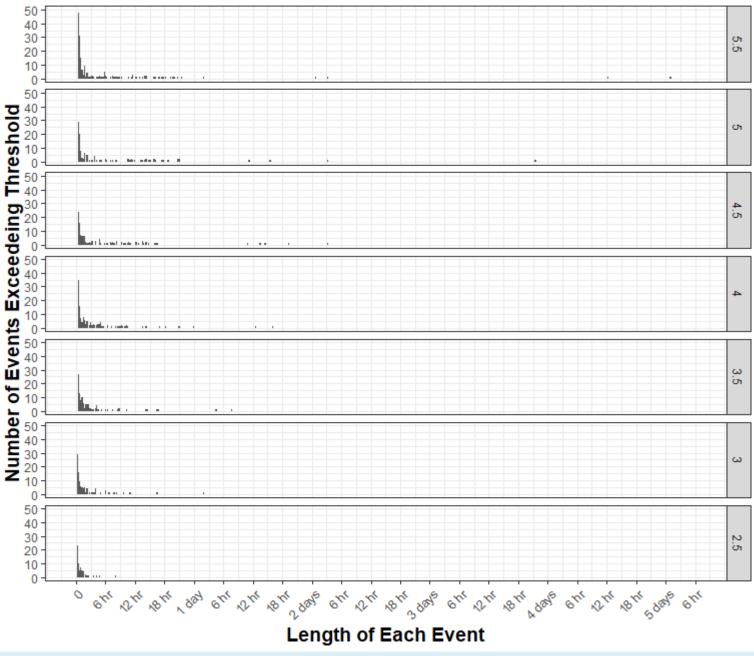| metric | perex | daysex |
|---|---|---|
| roll30dmean_dmean | | 2 |
| roll30dmean_dmin | | 2 |
| roll7dmean_dmean | 71.0 | 22 |
| roll7dmin_dmean | 77.4 | 24 |
| roll7dmean_dmin | 74.2 | 23 |
| roll3dmean_dmean | 71.0 | 22 |
| roll3dmean_dmin | 80.6 | 25 |
| roll3dmin_dmin | 83.9 | 26 |
| dailymean | 71.0 | 22 |
| dailymin | 83.9 | 26 |

| Site | % points violate | % daily min | % daily mean | binomial dmins | binomial dmeans | 10% of 10% (VA) | PA (>1% yr) | roll30dmean_dmin | roll7dmean_dmean | roll7dmin_dmean | roll7dmean_dmin | roll3dmean_dmean | roll3dmean_dmin | roll3dmin_dmin | > 1 7day mean | mean (skip 3 days) | >1 3 or 30 day rollmean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2013 | 10.02 | 27.9 | 10.1 | F | P | F | F | 24.9 | 10.4 | 17.5 | 26.6 | 9.6 | 27.4 | 37.8 | F | 3.65 | F |
| Aug 2013 | 0.1 | 0 | 0 | P | P | P | P | 0 | 0 | 0 | 0 | 0 | 0 | 0 | P | 0 | P |
| Oct 2013 | 63.87 | 83.9 | 71 | F | F | F | F | 71 | 77.4 | 74.2 | 71 | 80.6 | 83.9 | F | 19.35 | F |

## DO Events Below Thresholds
### Catatonk 2013, 15 min timestamps

| Threshold | Events | Max Duration (Days) |
|-----------|--------|---------------------|
| 5.5 | 407 | 5.04 |
| 5 | 257 | 3.90 |
| 4.5 | 218 | 2.14 |
| 4 | 224 | 1.67 |
| 3.5 | 185 | 1.32 |
| 3 | 98 | 1.08 |
| 2.5 | 63 | 0.33 |

Events with Duration > 4 days

| Time | MinDO | Thresh | Days |
|------|-------|--------|------|
| 2013-10-07 15:00:00 | 2.0 | 5.5 | 5.041667 |
| 2013-10-15 19:00:00 | 2.1 | 5.5 | 4.510417 |

| Time Period | >4 hour below min |
|-------------|-------------------|
| Catatonk 2013 | Impaired |
| Catatonk Aug 2013 | Not Impaired |
| Catatonk Oct 2013 | Impaired |

# Percent of days impaired – red if >10%

| Daily Min | Year | August | October |
|---|---|---|---|
| **2011** | 1.6 | 19.4 | 0 |
| **2012** | 46.7 | 48.4 | 100 |
| **2013** | 28.7 | 0 | 83.9 |
| **2014** | 16.3 | 0 | 71 |
| **2015** | 24.7 | 3.2 | 77.4 |
| **2016** | 36.9 | 96.8 | 93.5 |
| **2017** | 24.9 | 71 | 93.5 |
| **2018** | 10.2 | 21.1 | 0 |

| Daily Mean | Year | August | October |
|---|---|---|---|
| **2011** | 0.5 | 6.5 | 0 |
| **2012** | 24.5 | 0 | 100 |
| **2013** | 10.4 | 0 | 71 |
| **2014** | 6.1 | 0 | 29 |
| **2015** | 14.5 | 0 | 41.9 |
| **2016** | 18.3 | 12.9 | 83.9 |
| **2017** | 7.8 | 0 | 71 |
| **2018** | 3.1 | 0 | 0 |