DO Relative Stress Index

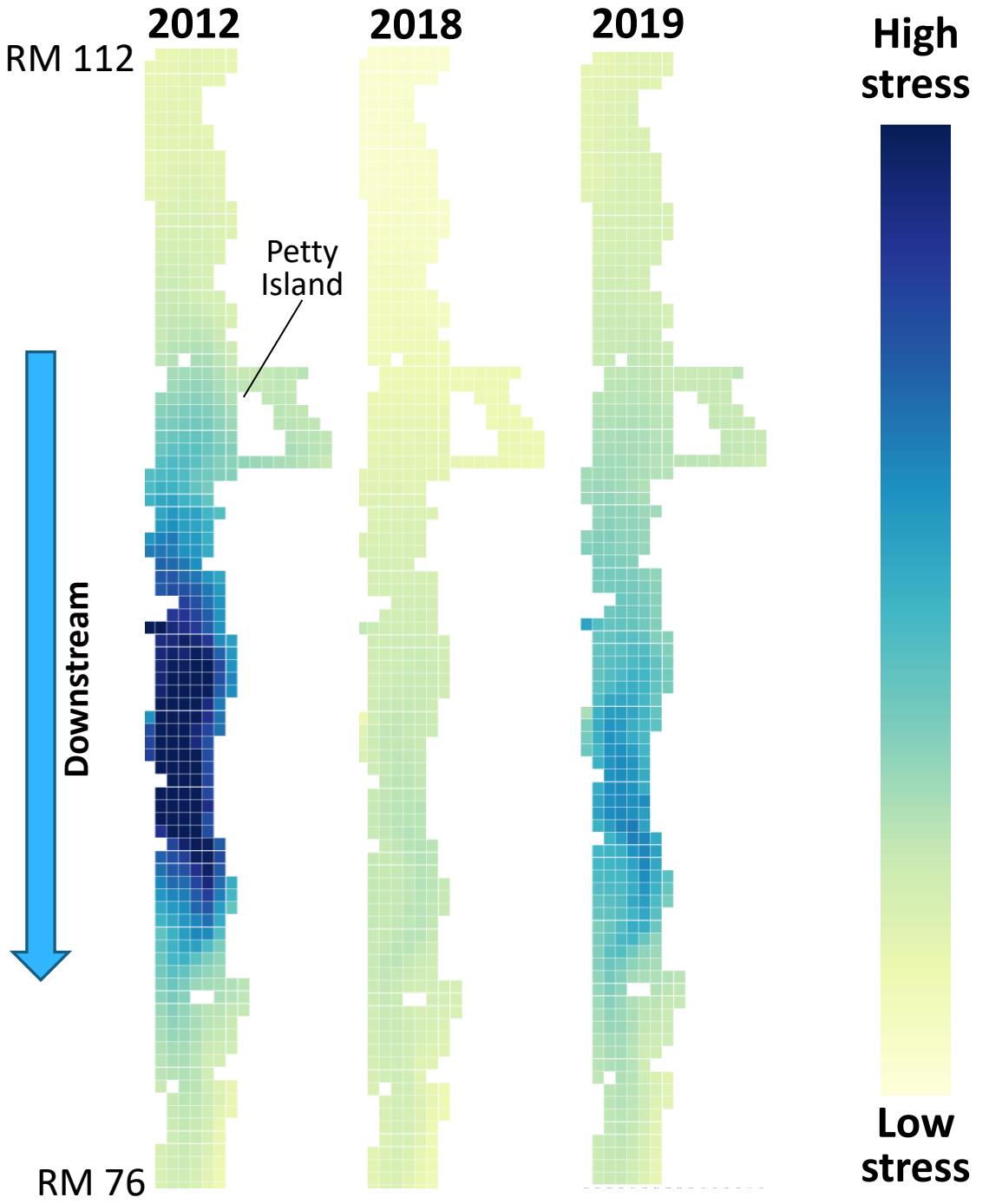
A tool to compare output from different model scenarios

Delaware River Basin Commission
DELAWARE • NEW JERSEY
PENNSYLVANIA • NEW YORK
UNITED STATES OF AMERICA

DO Relative Stress Index

1. Considers **relative stress** to aquatic life from low-DO events during different model scenarios
2. Considers **magnitude, frequency, and duration** of low-DO events, which are not captured in direct model output
3. NEW: Reflects rapidly increasing "stress" as DO decreases

   (e.g., 3.5 → 4 mg/L DO reduces stress more than 4.5 → 5 mg/L DO)



DO Relative Stress Index

1. Considers **relative stress** to aquatic life from low-DO events during different model scenarios
2. Considers **magnitude, frequency, and duration** of low-DO events, which are not captured in direct model output
3. NEW: Reflects rapidly increasing "stress" as DO decreases

   (e.g., 3.5 → 4 mg/L DO reduces stress more than 4.5 → 5 mg/L DO)

…DOES NOT represent physical reality

1. Extension of area-under-curve calculation for DO time series
2. It cannot be measured—it compares, rather than quantifies, stress
3. The DO Relative Stress Index characterizes stress to aquatic life, but it is not a model of fish mortality or metabolism

Delaware River Basin Commission
DELAWARE • NEW JERSEY
PENNSYLVANIA • NEW YORK
UNITED STATES OF AMERICA

DO Relative Stress Index: Calculation overview

Step 1. Compute the difference between modeled DO values and an index threshold during the critical propagation season (5/1–10/15).

Step 2. Calculate a “severity exponent” for each DO value to account for rapidly increasing relative stress as DO decreases.

Step 3. Apply the severity exponent to each difference.

Step 4. Take the area under the curve and normalize.

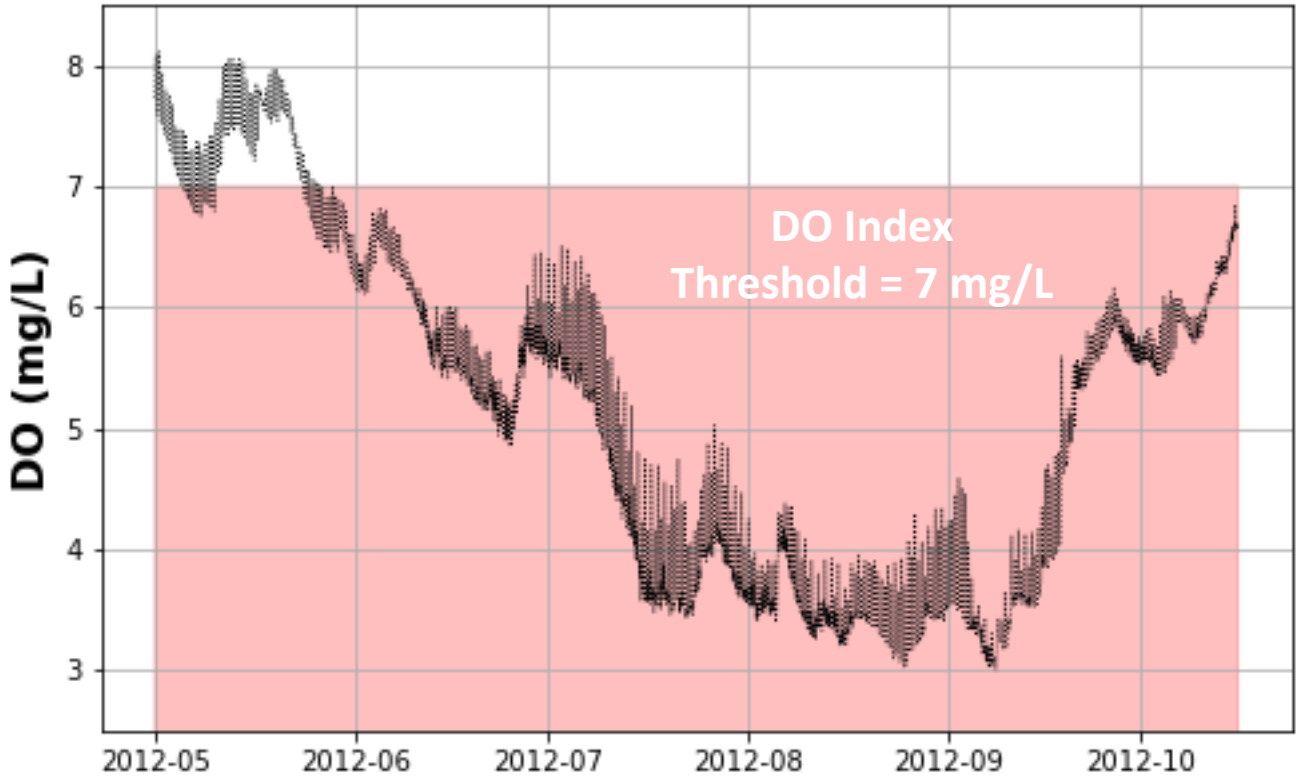
Delaware River Basin Commission
DELAWARE • NEW JERSEY
PENNSYLVANIA • NEW YORK
UNITED STATES OF AMERICA

Step 1. Compare modeled DO during the critical propagation period to an index threshold (7 mg/L)

DO Index Threshold = 7 mg/L

- A high index threshold allows comparison of model results across a wide range of DO outcomes
- 7 mg/L = top of suitable DO range ("Optimal", based on literature review)

Modeled DO for one cell, May 1 – Oct 15



Note: This cell (33, 131, 5) is among those with the lowest DO in the 2012 model!

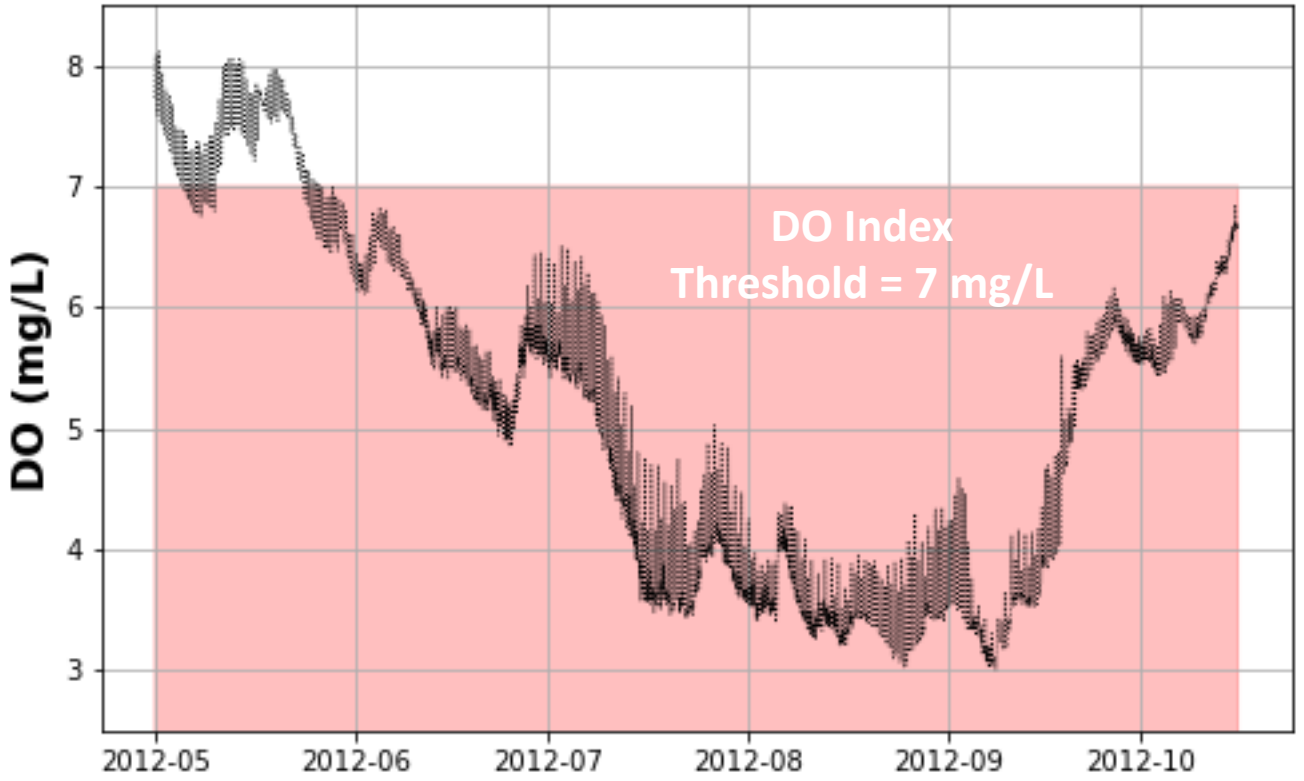
Step 1. Compare modeled DO during the critical propagation period to an index threshold (7 mg/L)

$$Diff(t) = 0 \quad if\ DO \geq 7\ mg/L$$

$$Diff(t) = 7 - DO + 1 \quad if\ DO < 7\ mg/L$$

So that when we apply an exponent, the number always gets bigger!

Modeled DO for one cell, May 1 – Oct 15



Note: This cell (33, 131, 5) is among those with the lowest DO in the 2012 model!

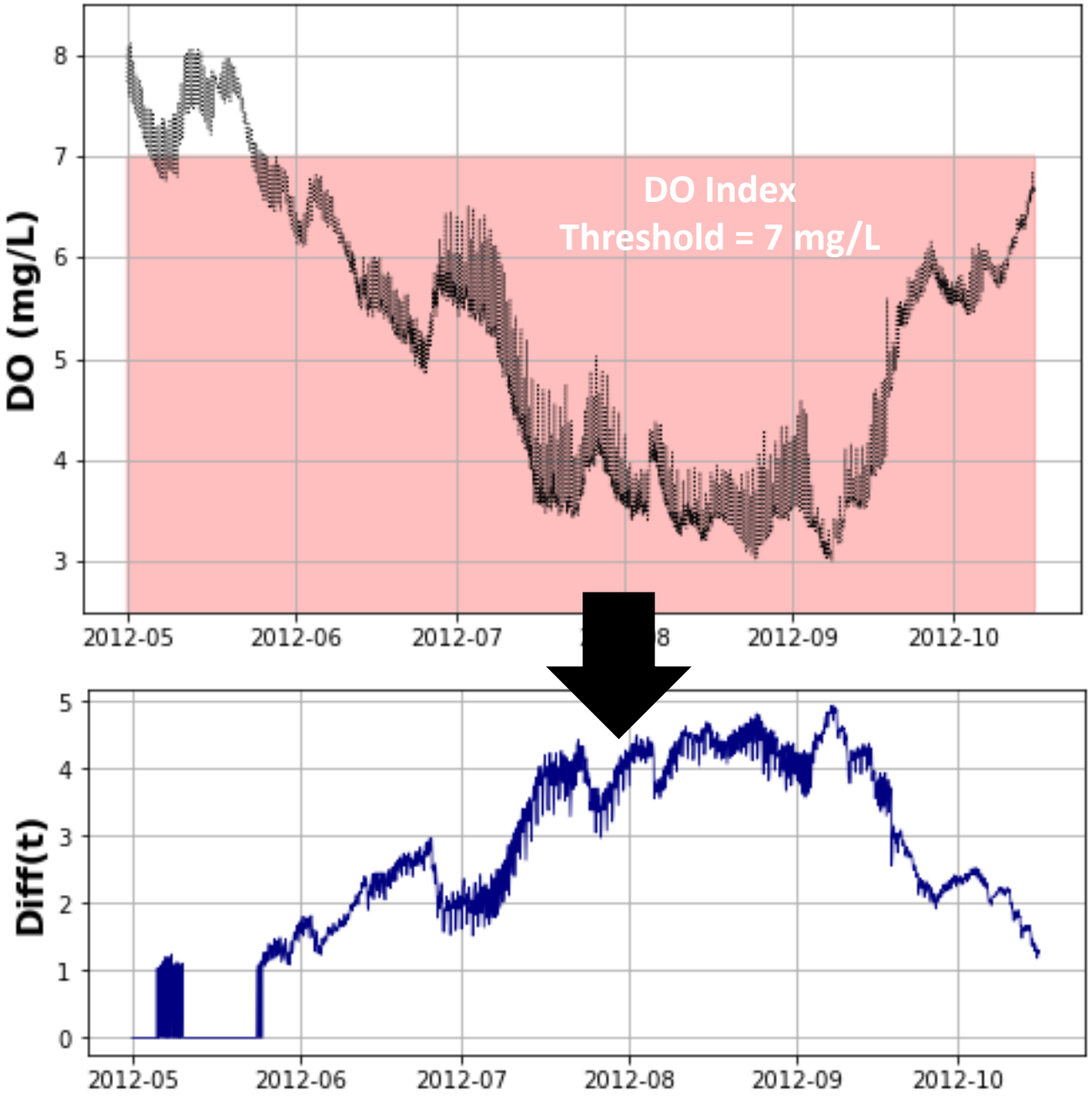
Step 1. Compare modeled DO during the critical propagation period to an index threshold (7 mg/L)

$$Diff(t) = 0 \quad if\ DO \geq 7\ mg/L$$

$$Diff(t) = 7 - DO + 1 \quad if\ DO < 7\ mg/L$$

So that when we apply an exponent, the number always gets bigger!

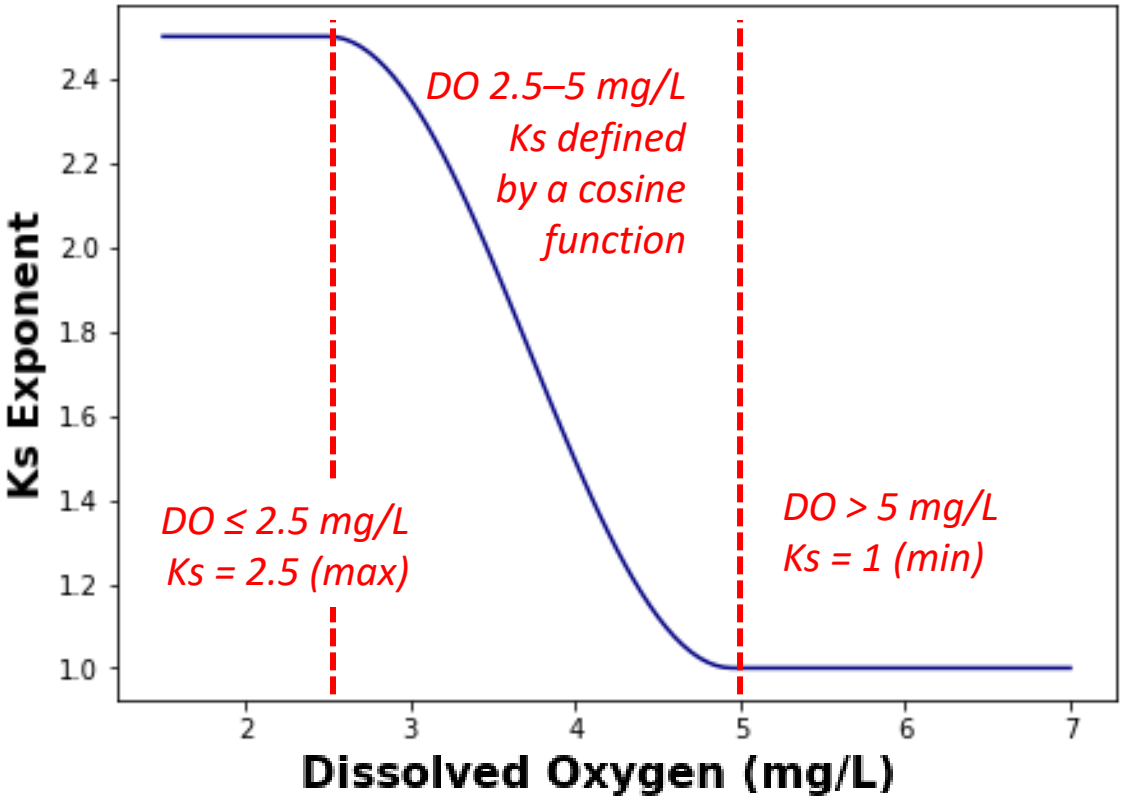
Modeled DO for one cell, May 1 – Oct 15



Step 2. Calculate Ks, the "severity exponent," to represent exponentially higher relative stress as DO decreases

$$Stress = Diff(t)^{Ks(t)}$$

Ks(t) is determined based on the DO value



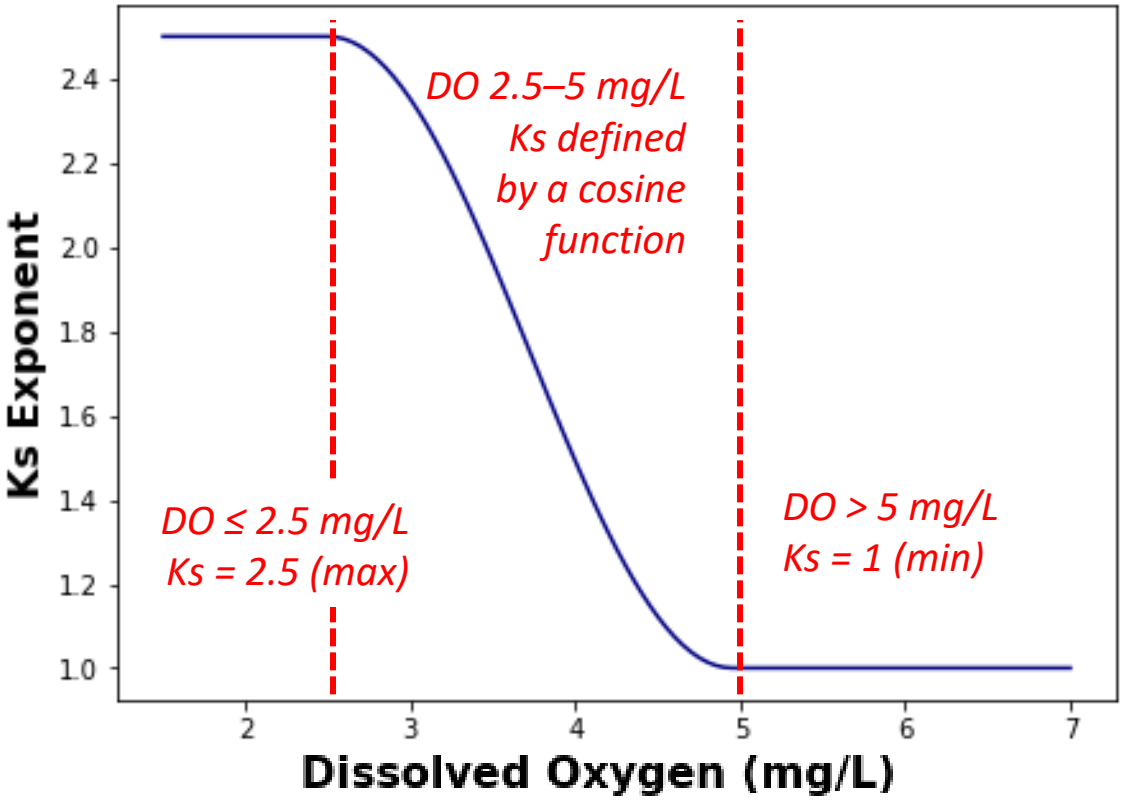
Literature review informed choice of Ks exponent increasing from 5 to 2.5 mg/L DO:

- With 6-hr exposure at 22.5°C, **YOY (<30 days old)** Shortnose sturgeon had:
  - **100% mortality ≤2.5 mg/L DO**
  - **0% mortality >4 mg/L DO**

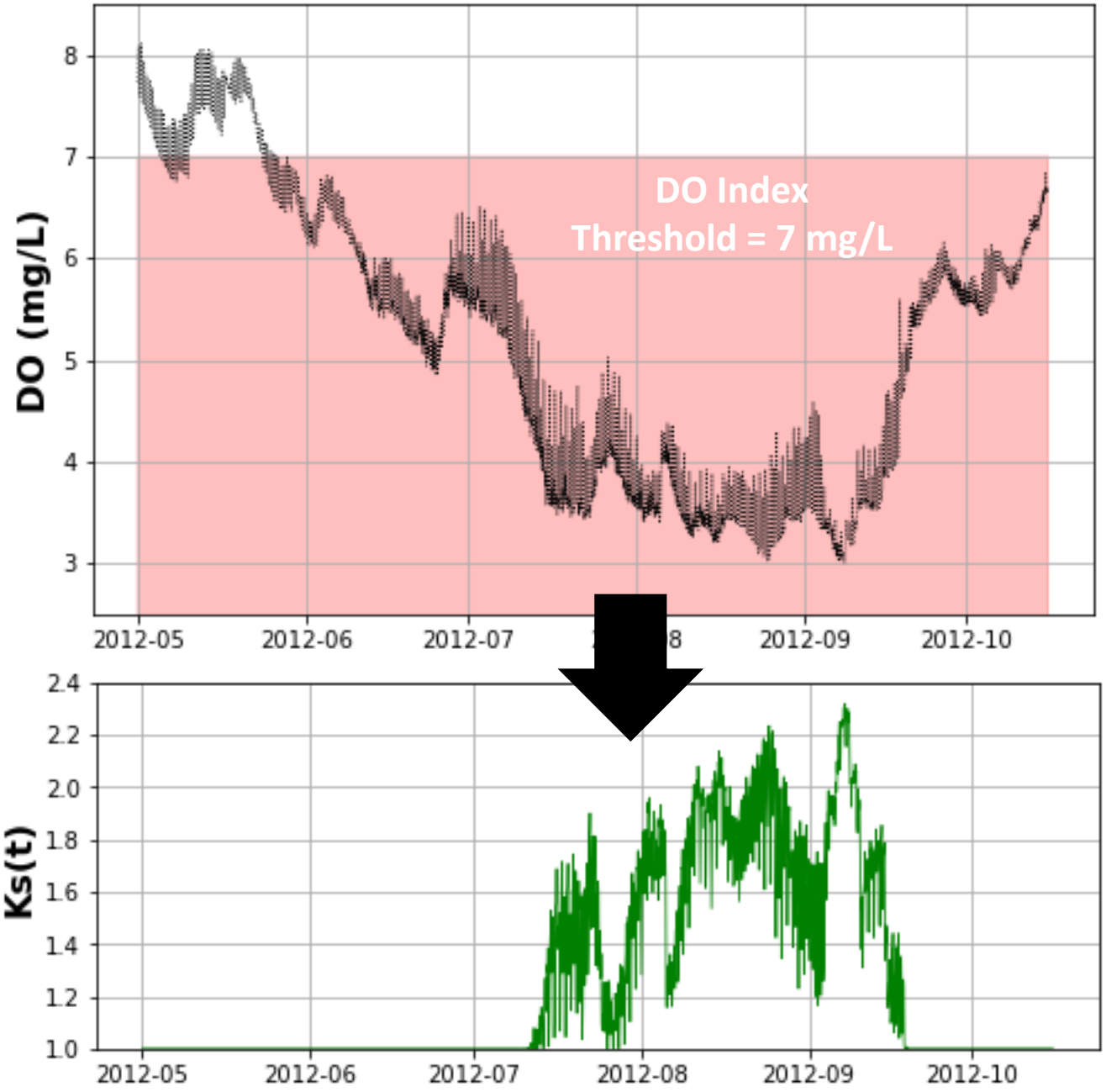
  (*Jenkins et al. 1993*)

- **YOY** Atlantic sturgeon showed **non-lethal effects at 4.3–4.7 mg/L DO** at 22–27°C (*Secor and Niklitschek 2001*)

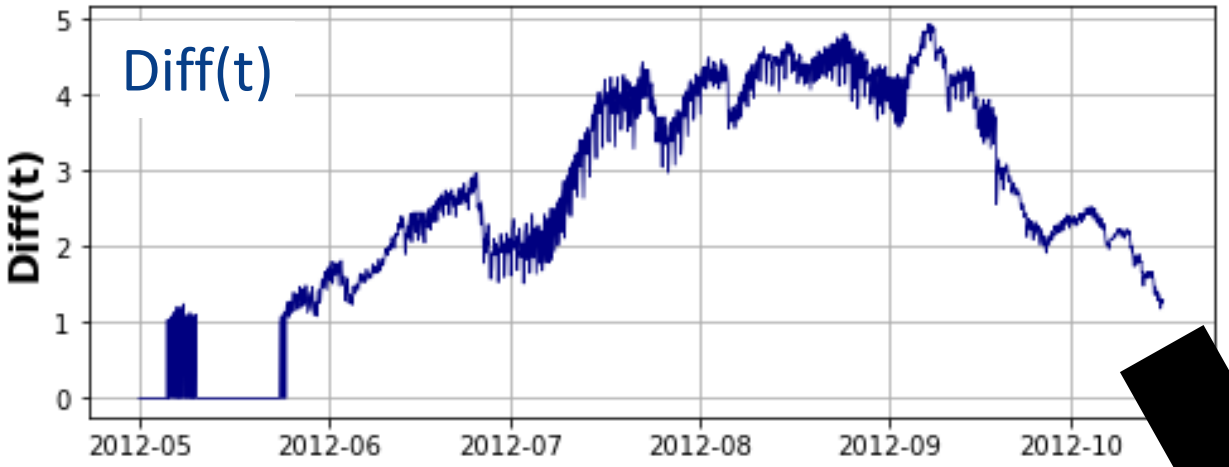
Step 2. Calculate Ks, the "severity exponent," to represent exponentially higher relative stress as DO decreases

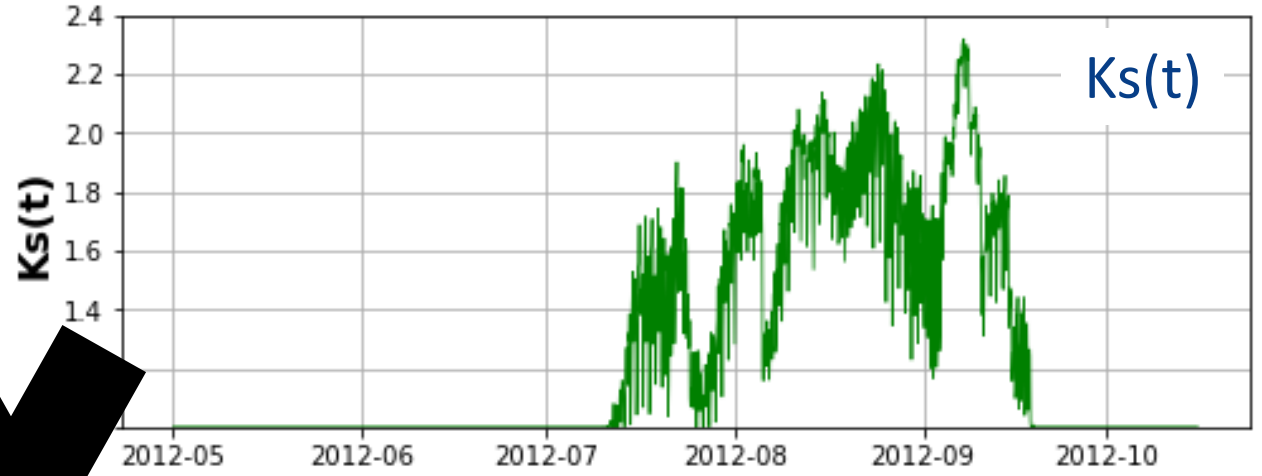


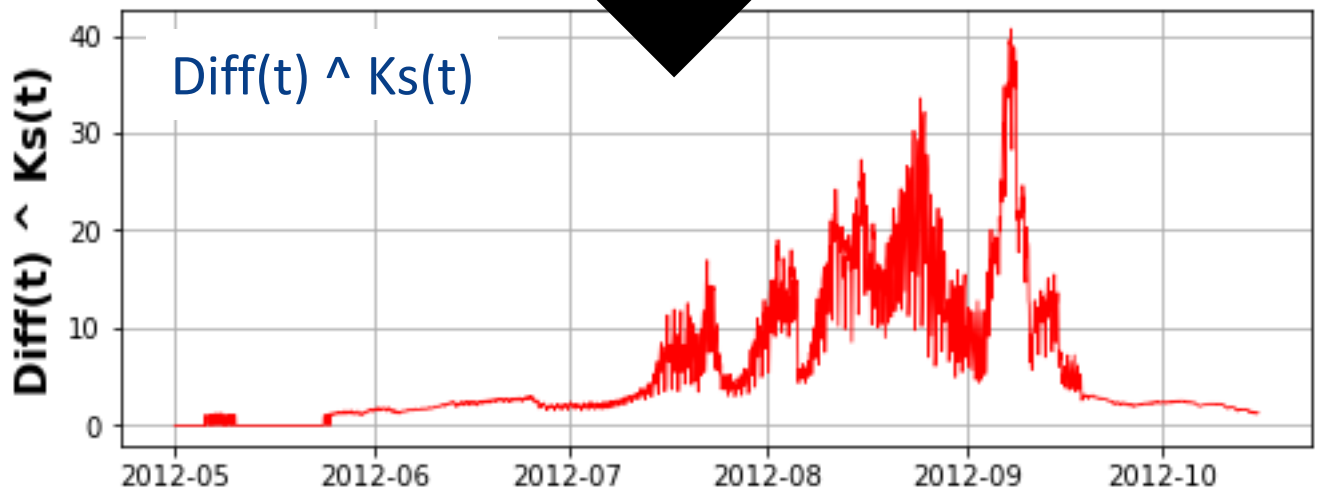
Modeled DO for one cell, May 1 – Oct 15

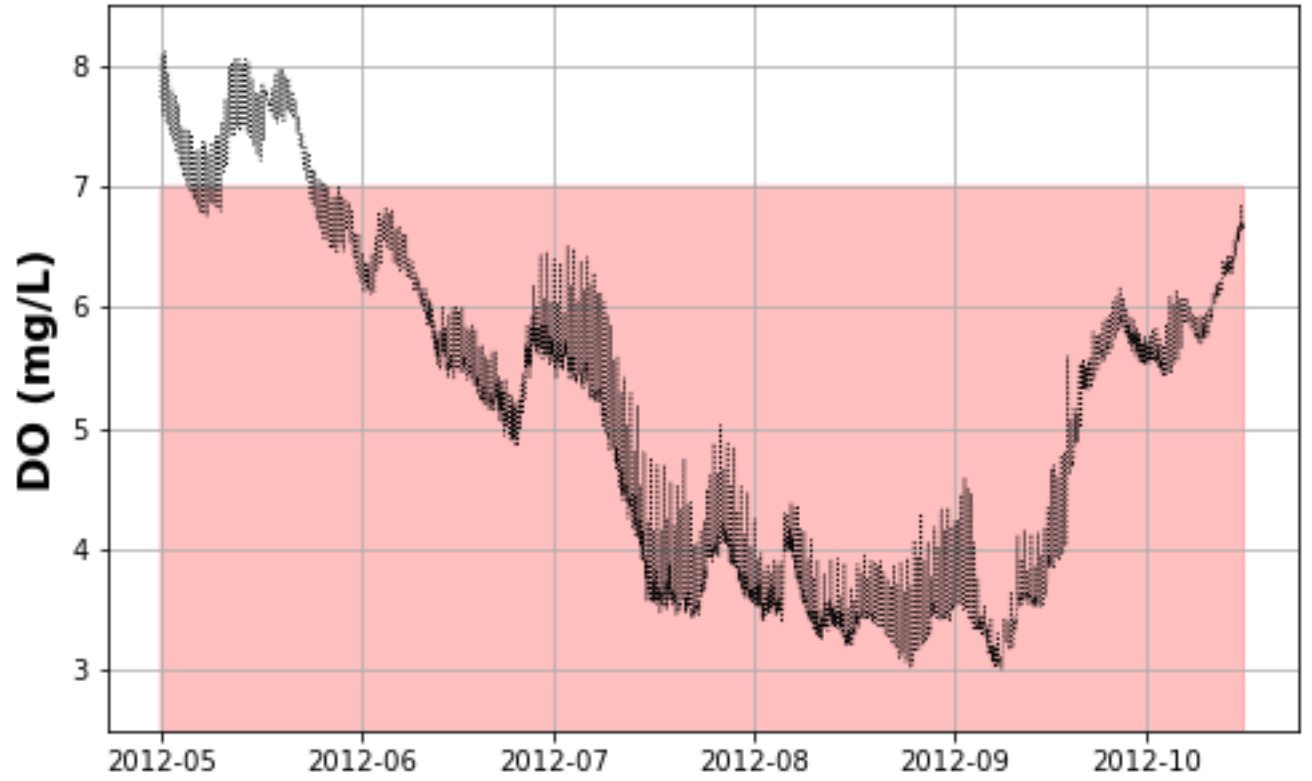


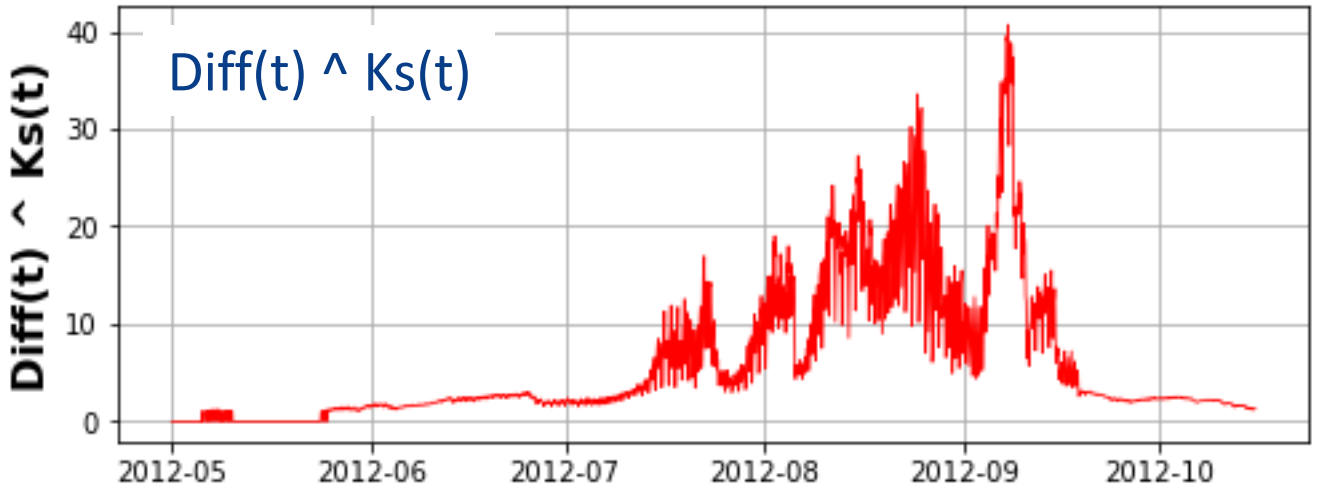
Step 3. Apply the Ks exponent to the Diff(t) curve



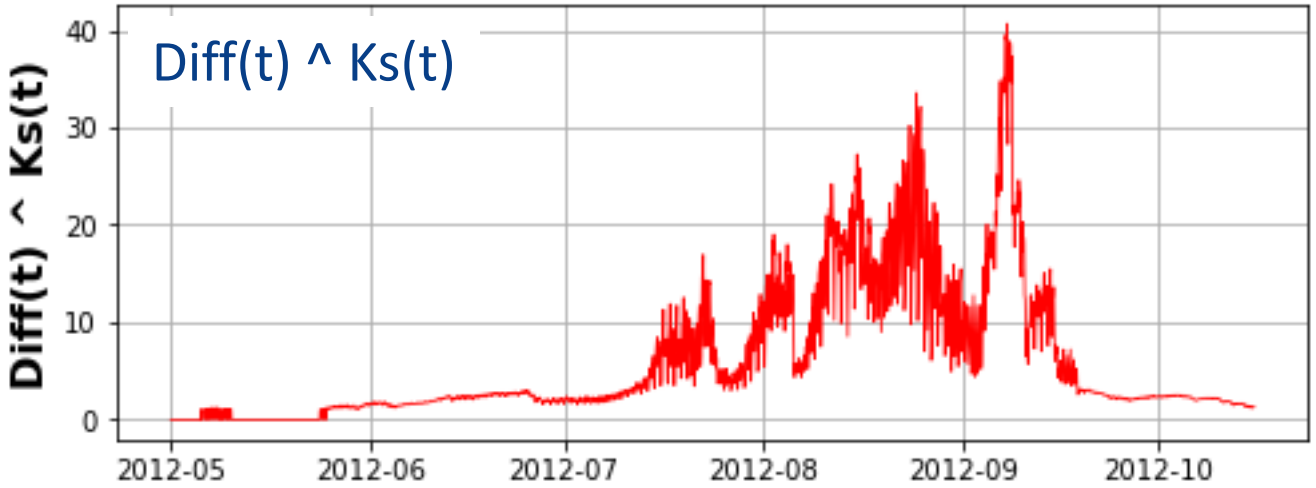





DO (mg/L)
8
7
6
5
4
3
2012-05
2012-06
2012-07
2012-08
2012-09
2012-10


Diff(t) ^ Ks(t)
40
30
20
10
0
2012-05
2012-06
2012-07
2012-08
2012-09
2012-10

Step 4. Calculate the area under the curve & normalize



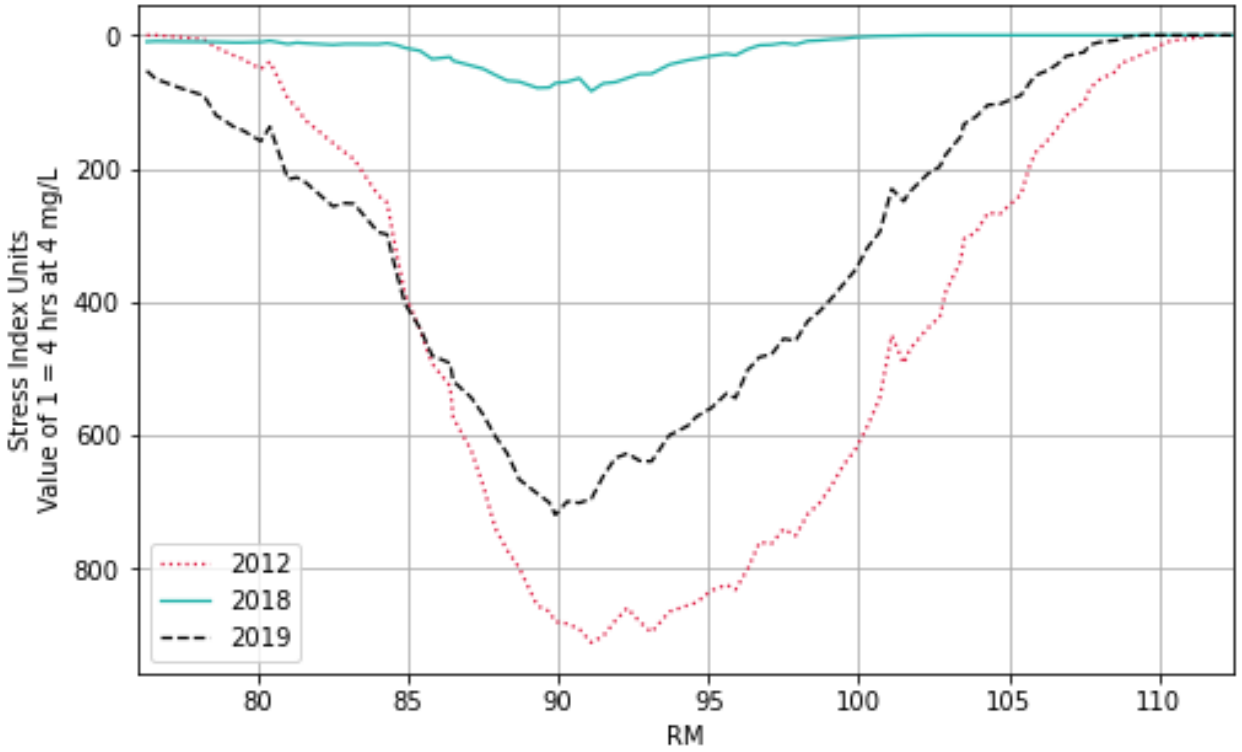
$$RSI_{DO} = \frac{\int_{t=5/1}^{10/15} Diff(t)^{Ks(t)} dt}{Norm}$$

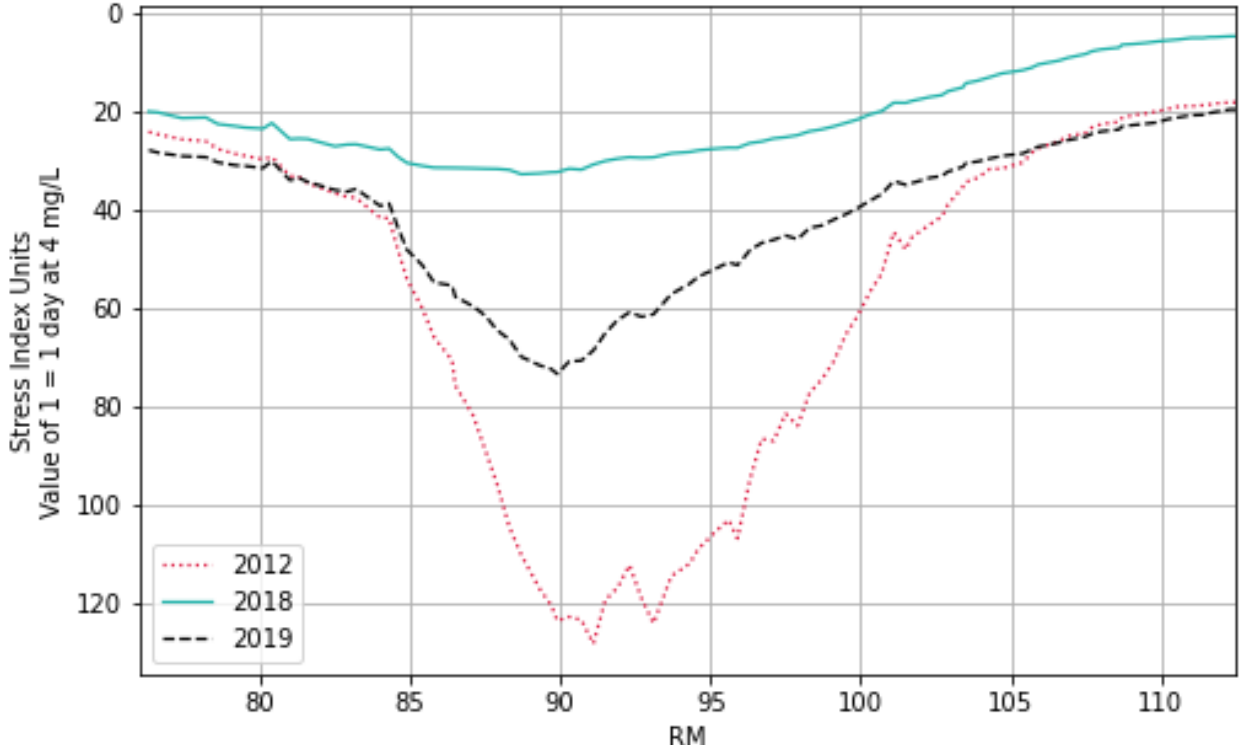
Norm = Stress of 1 day at 4 mg/L
Diff = 7 – 4 + 1 = 4, *Ks* = 1.49
$Norm = Diff^{Ks} = 4^{1.49} =$ **7.89**

Relative stress index for this cell = 128.2

Recall: This cell (33, 131, 5) is among those with the lowest DO in the 2012 model!

Median DO Relative Stress Index (RSI) at each J-value for calibrated model results





Previous iteration:

- DO index threshold = 5 mg/L
- No Ks exponent
- Normalization = 4 hrs at 4 mg/L

Updated calculation:

- Relative stress preserved: ’12 > ’19 > ’18
- Difference btwn 2019 & 2012 amplified
- Wider spatial range has RSI>0

Average RSI at each IJ-location (2012)