Data Assessment Follow Ups from previous meeting

Eutrophication Model Expert Panel Meeting

July 25 & 26, 2017

Delaware River Basin Commission

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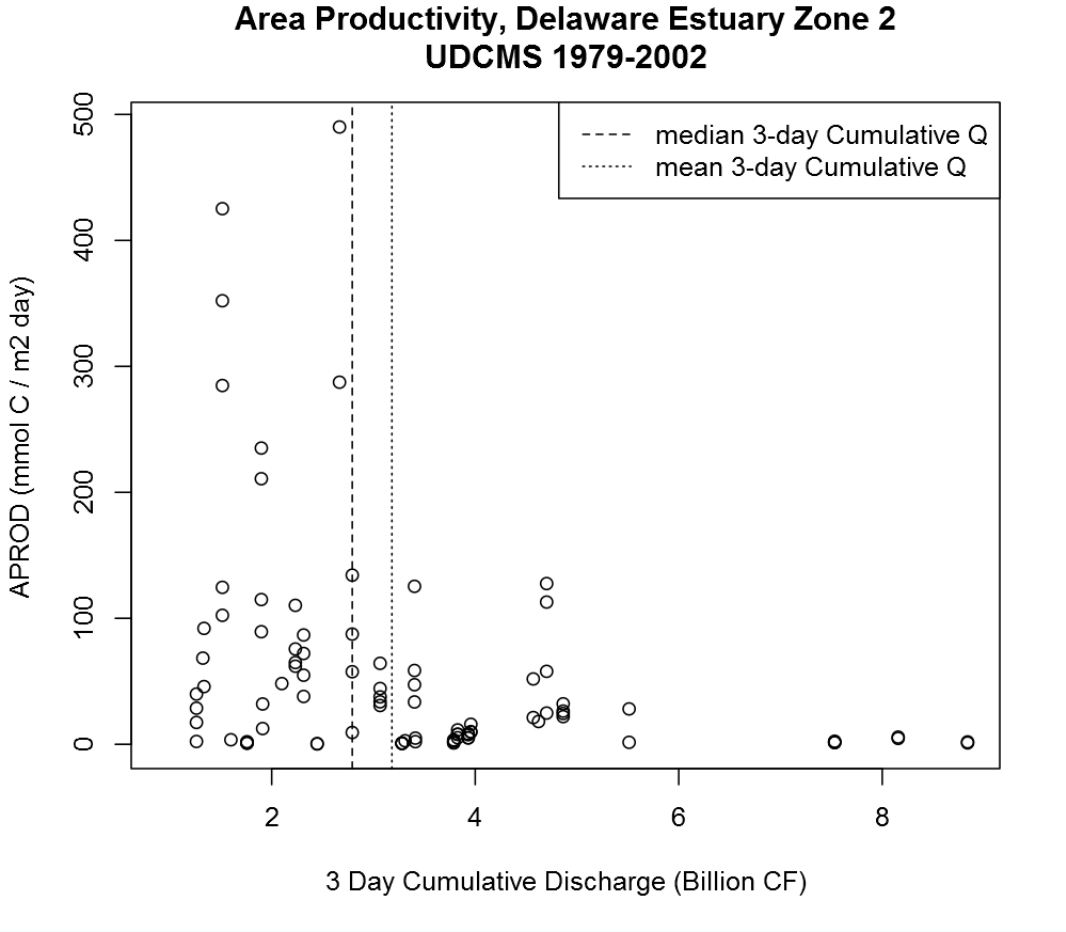
From November 2016 Expert Panel Meeting

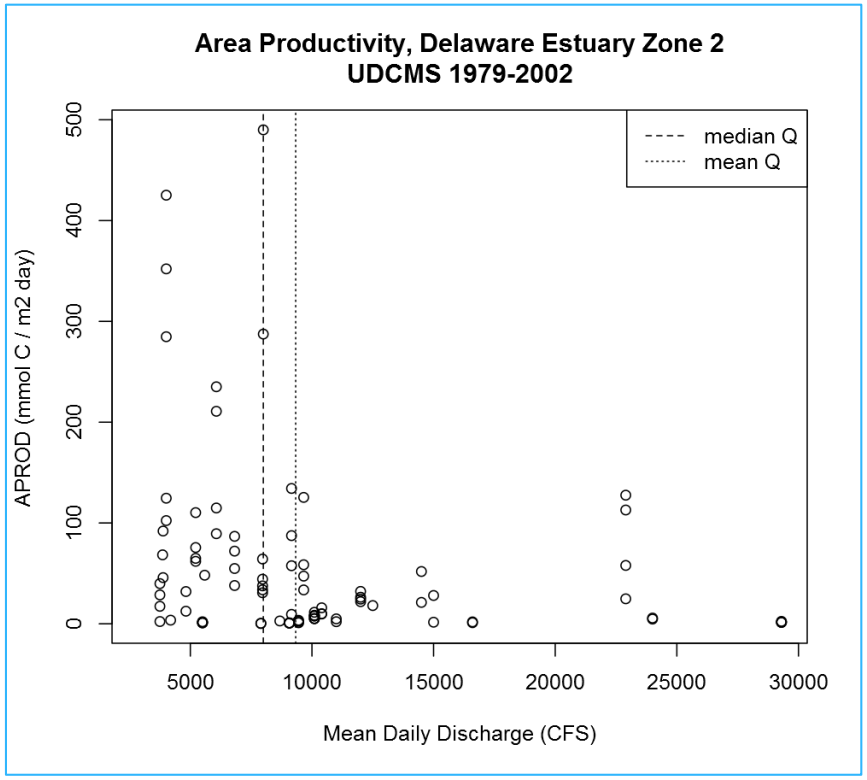
* Provide plots / assessments for Expert Panel feedback. Including:
  - Plot Zone 2 primary productivity as a function of flow;
  - Compare loadings & concentrations of CBOD5 and TOC – look at ratios;
  - Contact Dr. Chapra to obtain formulas to represent CBOD-5 as carbon;
  - Overplot nutrient concentrations / chlorophyll a / DO;
  - Overplot Secchi / turbidity / TSS / PAR. Chapra can provide equations re light extinction using PAR/Secchi depth/turbidity.

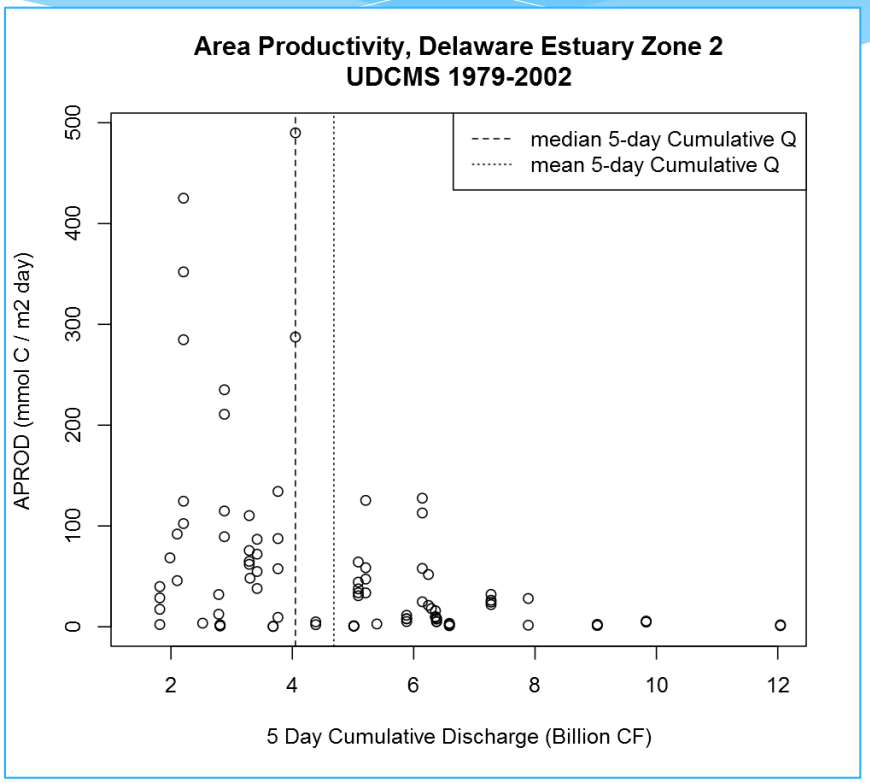
Area Productivity in Zone 2 by 3-day Cumulative Discharge at Trenton



* UDCMS Database
* Dr. Jonathan Sharp
* 1979-2002

Area Productivity in Zone 2 Other Cumulative Periods





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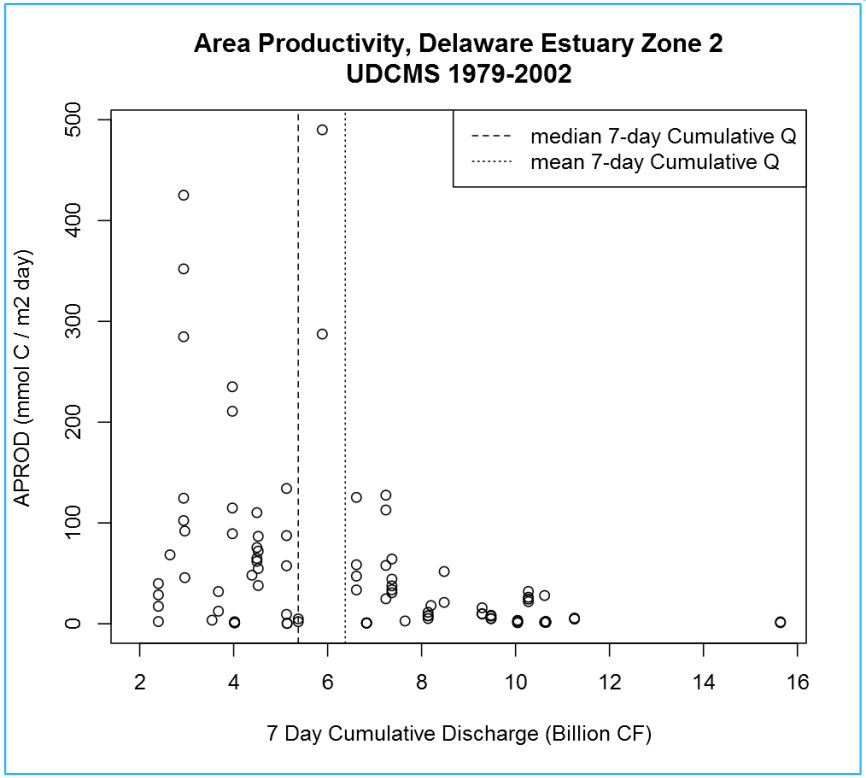
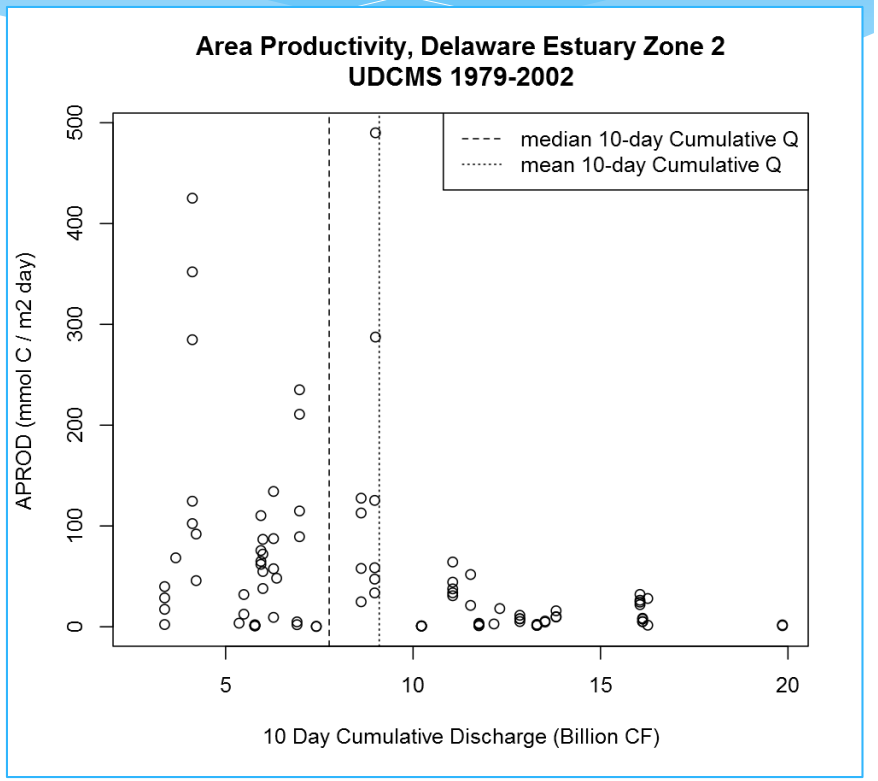
Area Productivity in Zone 2 Other Cumulative Periods (continued)





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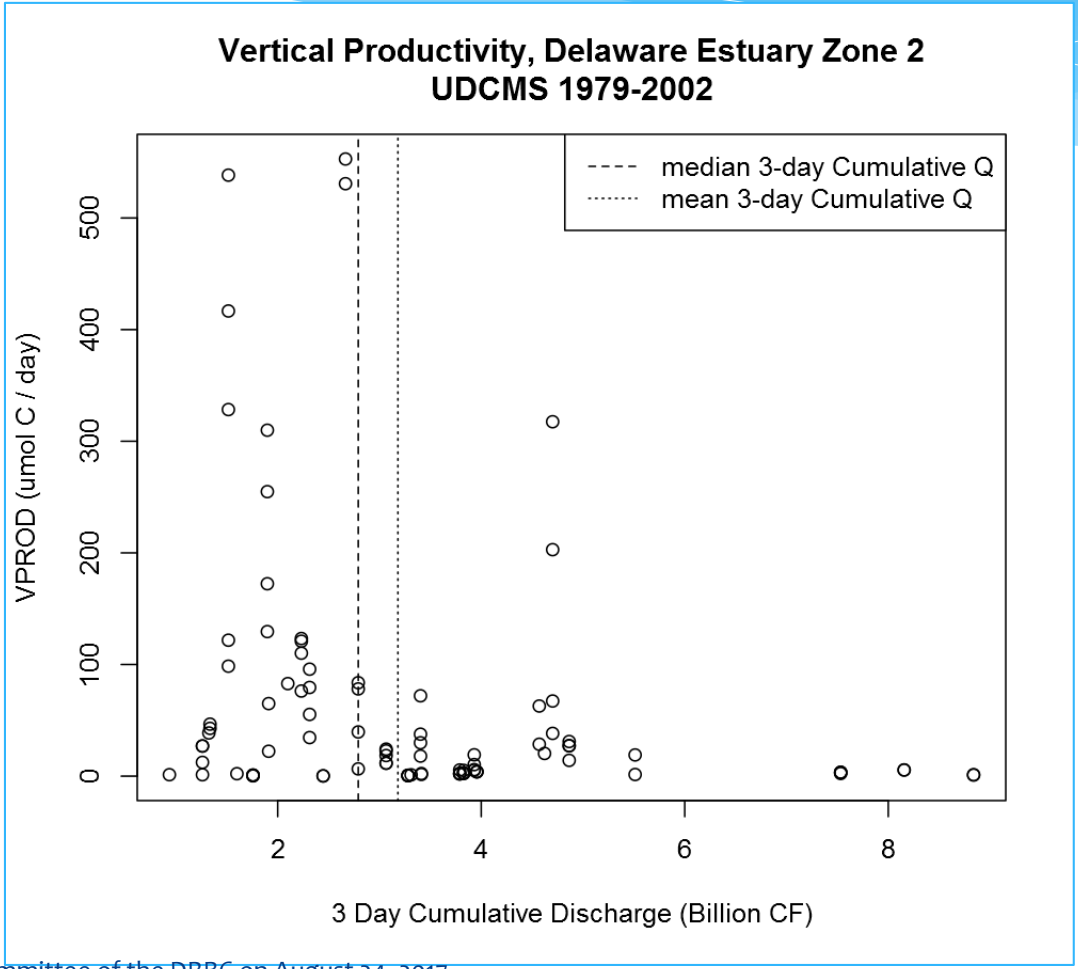
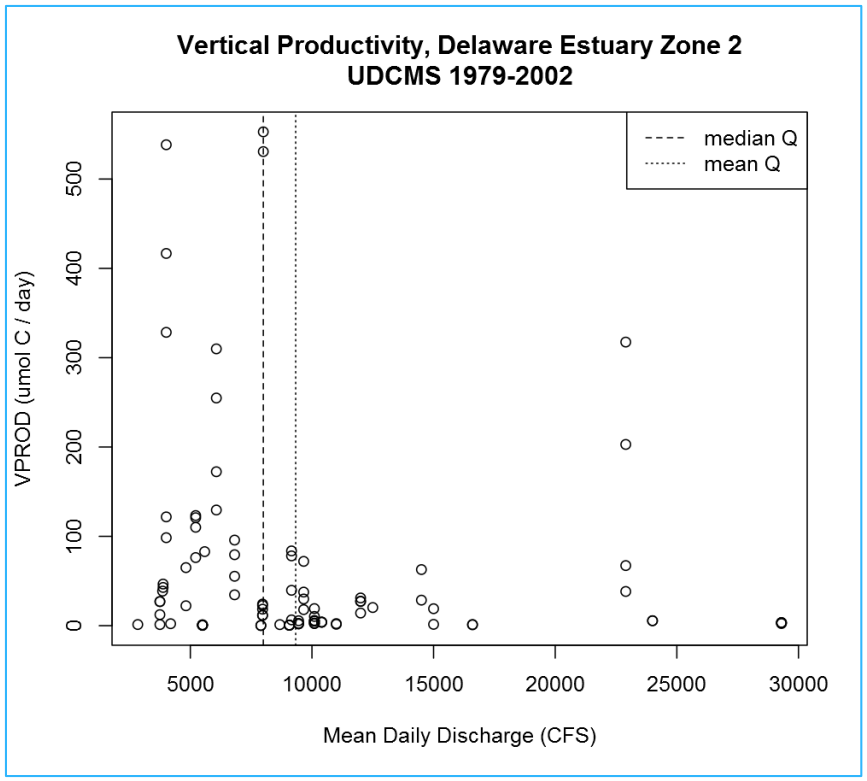
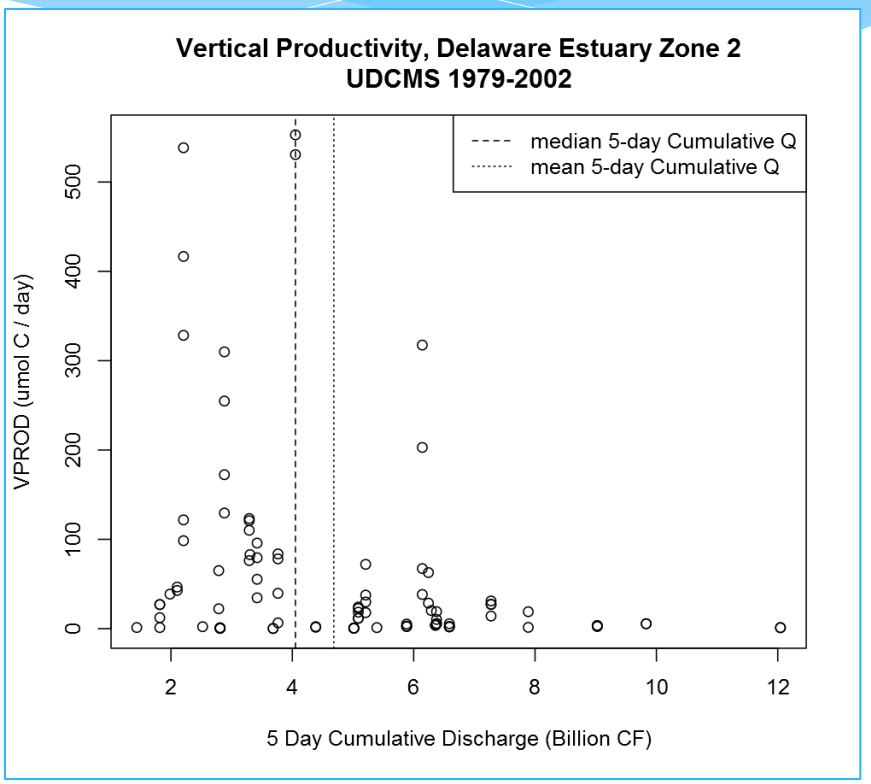
Vertical Productivity in Zone 2 by 3-day Cumulative Discharge at Trenton



Vertical Productivity in Zone 2 Other Cumulative Periods





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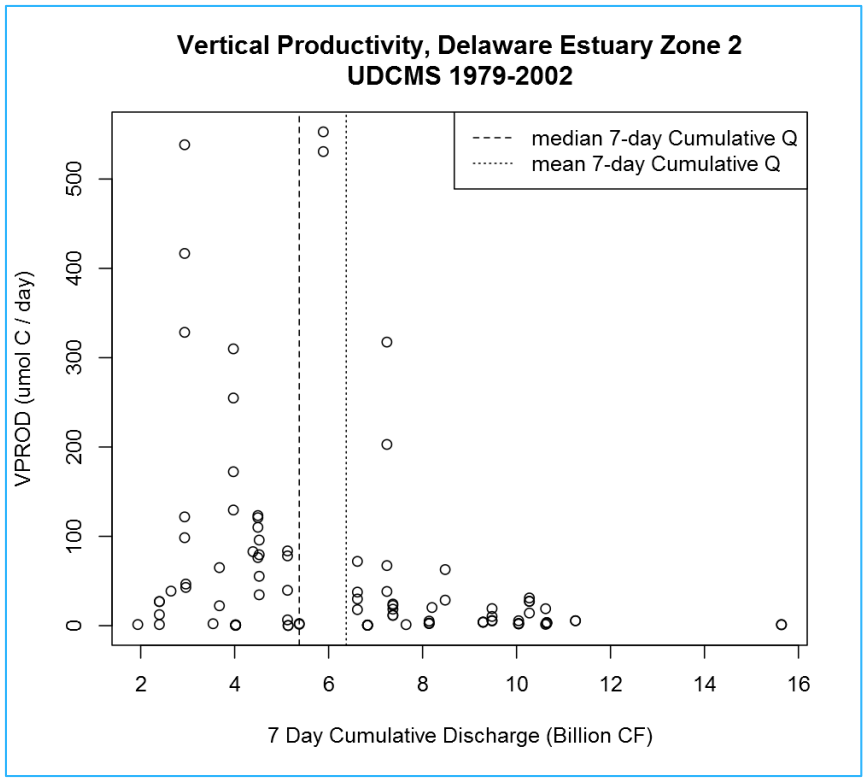
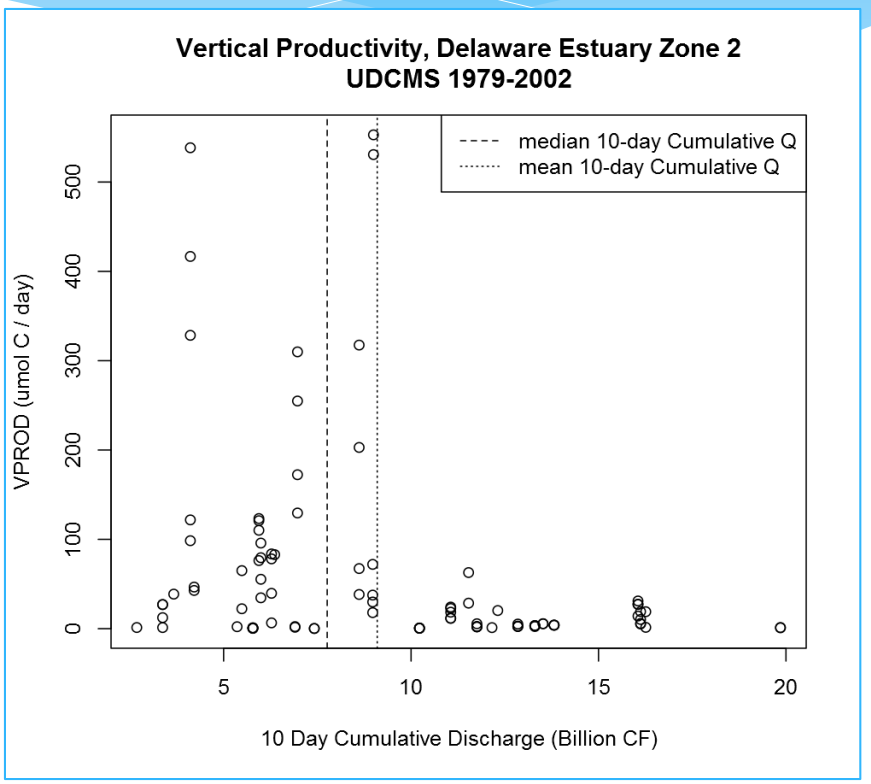
Vertical Productivity in Zone 2 Other Cumulative Periods (continued)





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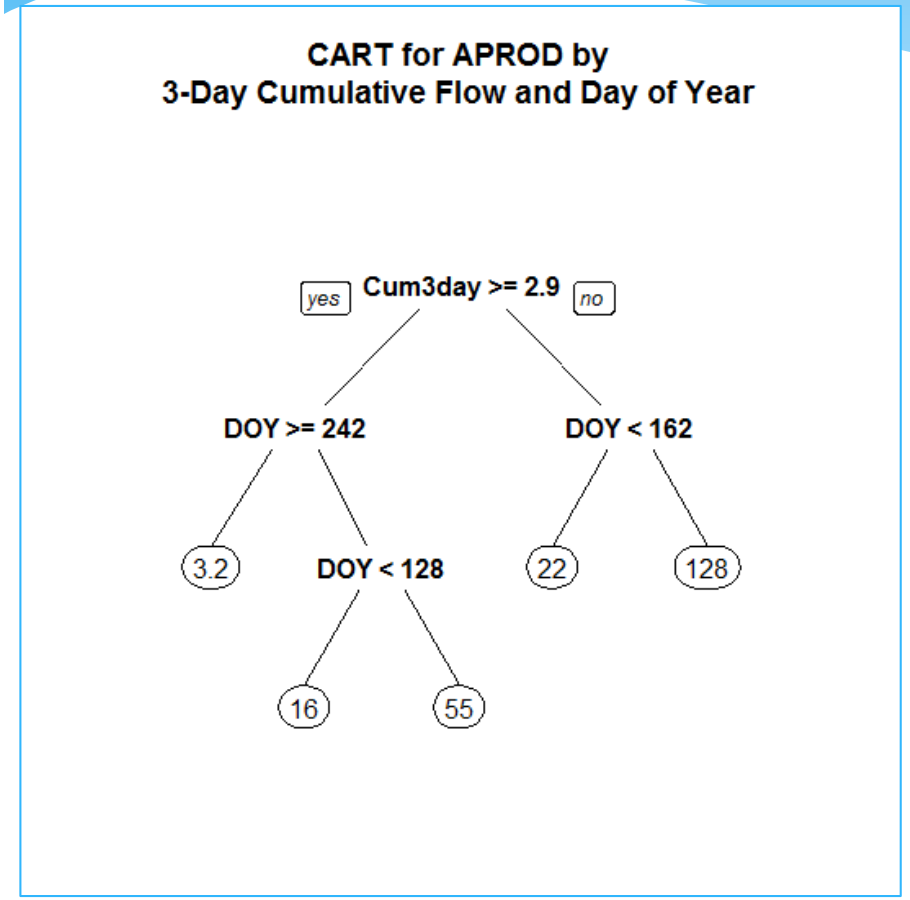
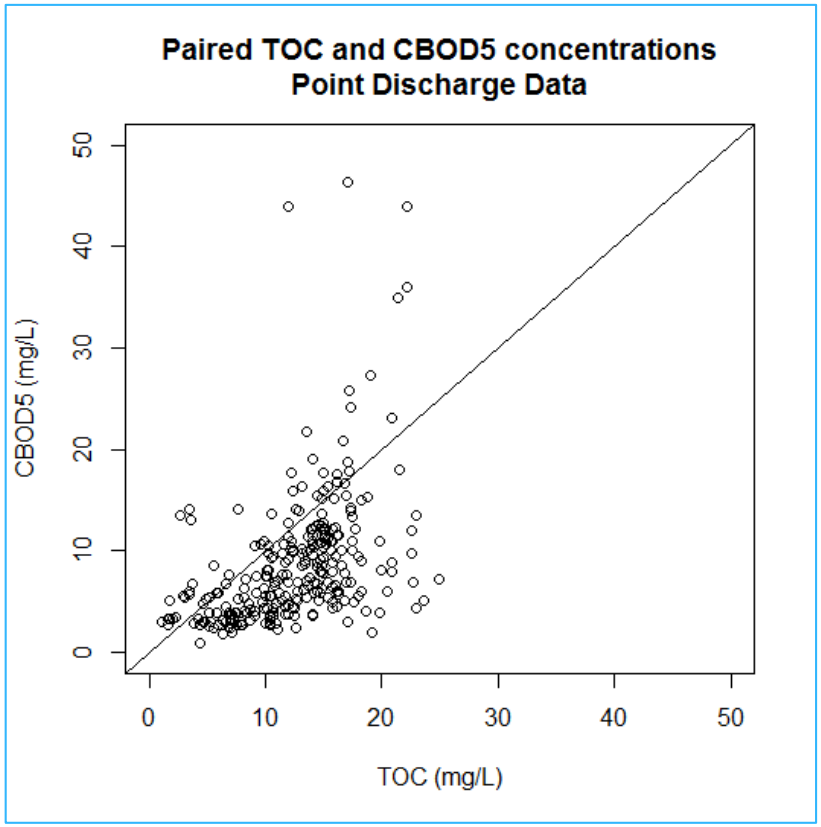
Classification and Regression Tree high productivity conditions



* 2 explanatory variables
  * 3-day cumulative flow
  * Day of Year (Jan 1 = 1)
* Conditions with highest productivity
  * 3-Day flow < 2.9 Billion CF
  * *And* After June 11th

  * 46 APROD observations
  * Min bucket = 10
  * Method = Anova
  * Pruned on min cp xerror

Paired TOC and CBOD5 Concentrations Point Discharge Data



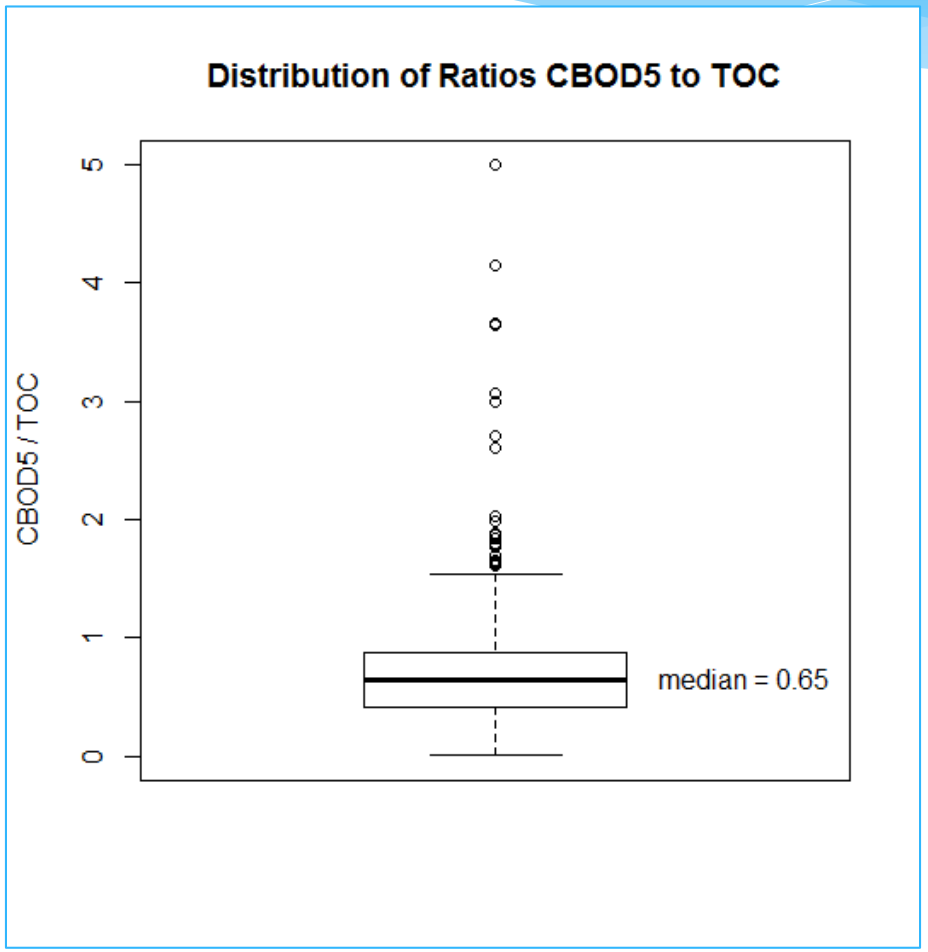
* DRBC Point Discharge Monitoring Data

* TOC was not required
* However 26 of the 78 NPDES submitted TOC results
* CBOD5 – 1384 observations
* TOC – 425 observations
* 414 paired CBOD5 and TOC
* Not tied to size or any other factor

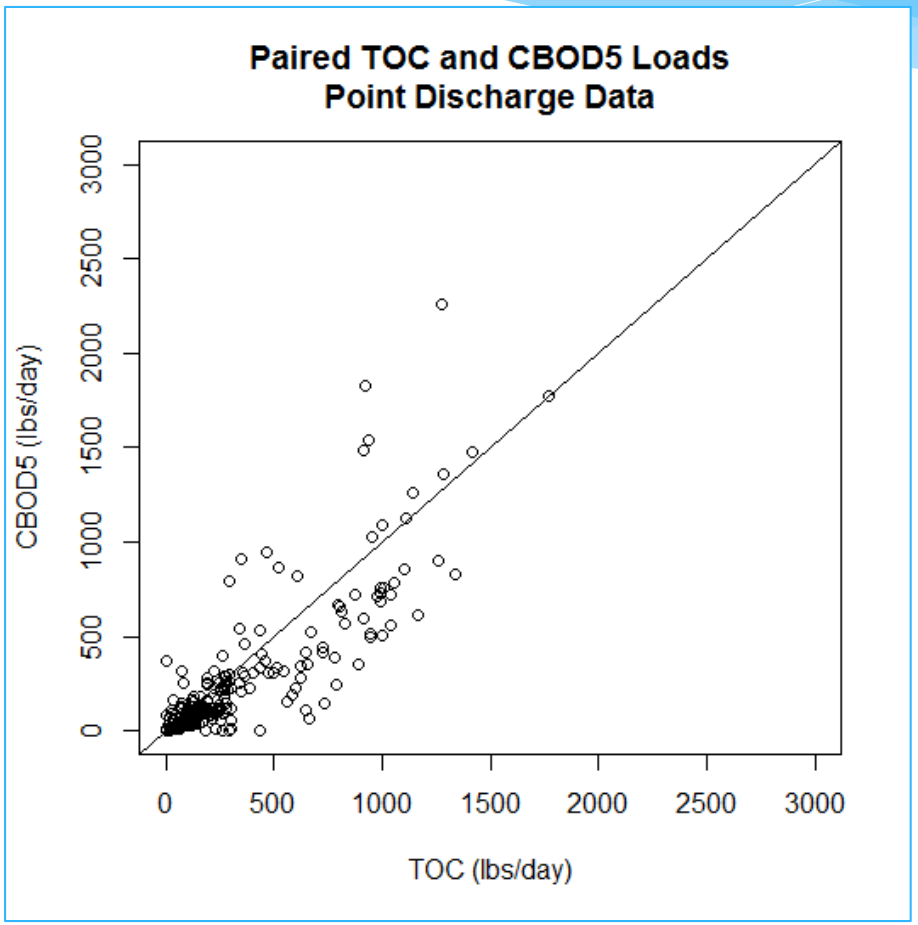
Of the paired results

* TOC – 1 missing value (NA)
* CBOD5 – 154 missing values (NA) 37%

Boxplot of Ratios CBOD5 to TOC Point Discharge Data



Paired TOC and CBOD5 Loads Point Discharge Data



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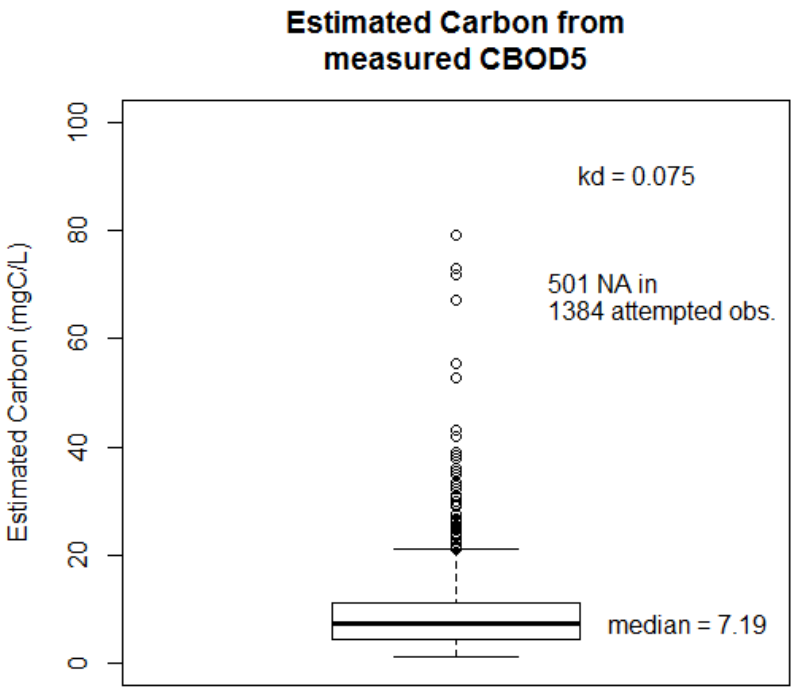
CBOD5 as Carbon Point Discharge Data



$$c = \frac{CBOD_5}{r_{oc}(1 - e^{-kd(5)})}$$

* r_{oc} = 2.67 gO_2/gC
* Approx. 64% quantified CBOD5 measurements
* Median Carbon 7.19 mgC/L
* k_d set to 0.075
* Median k_d from all paired CBOD5 and CBOD20 was 0.087 but only 36% of all pairs quantified for both

Overplots of Ambient Nutrient Observations

* Delaware Estuary Used Boat Run Monitoring Data
* 22 stations from river mile 6.5 to near head of tide
* April through October
* Used 2005 through 2016 data
* Interactive web app:
  * https://johnyagecic.shinyapps.io/Overplots/

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Assess Light Extinction as a function of model state variables

* Boat Run data set includes paired PAR in air and at 1-meter depth since 2015
* Also collect TSS, Chl. A, and Salinity
* Compute k_e using Beer-Lambert law
* Assess viability of 2 statistical models for computing k_e as a function of likely model state variables.

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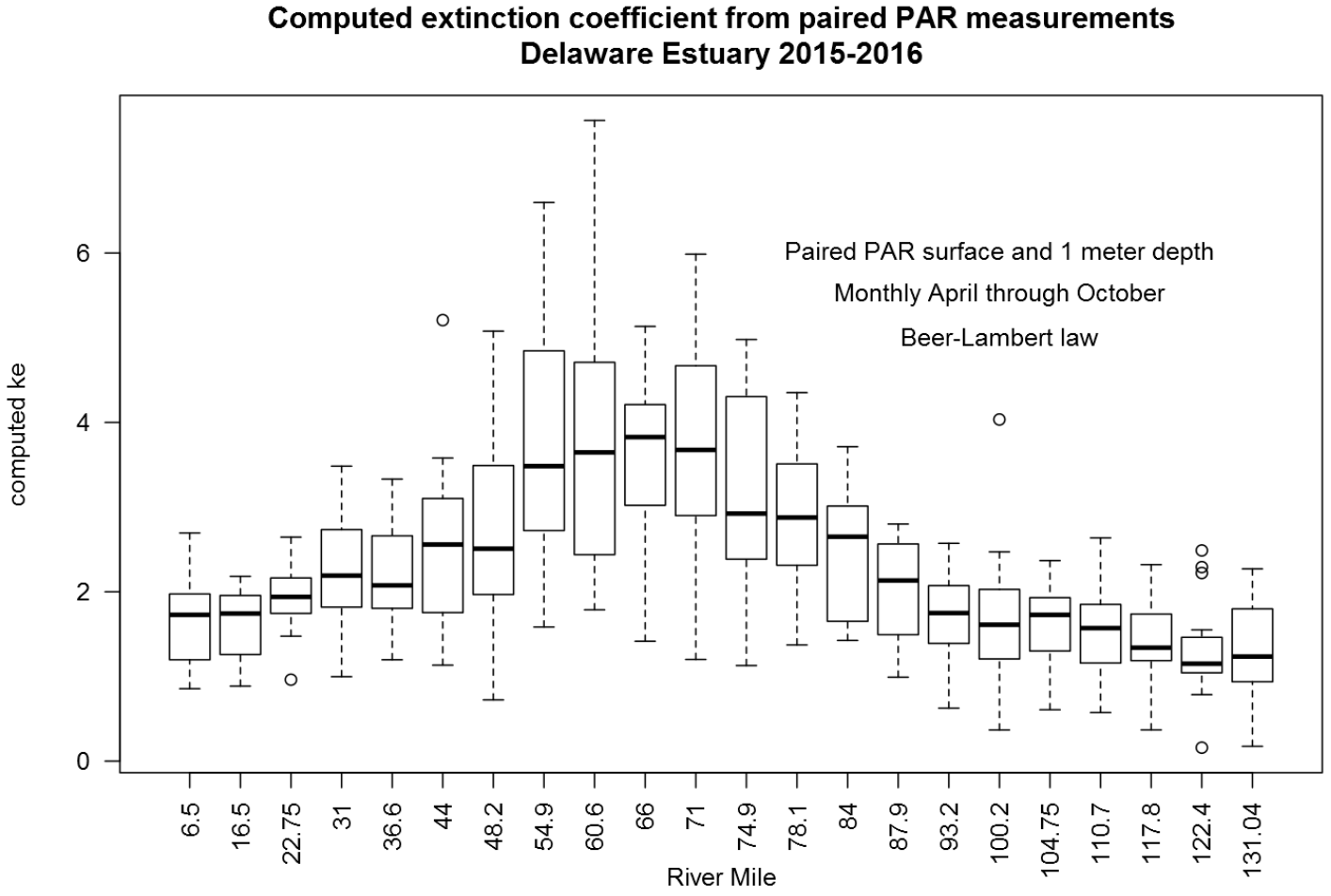
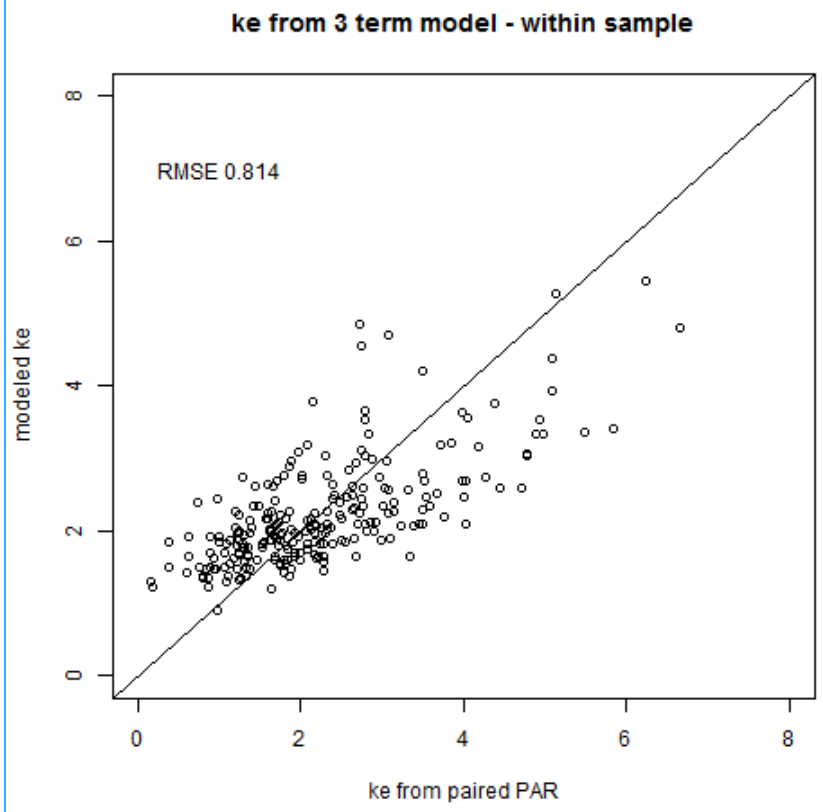
Computed k_e from paired air & 1-meter PAR

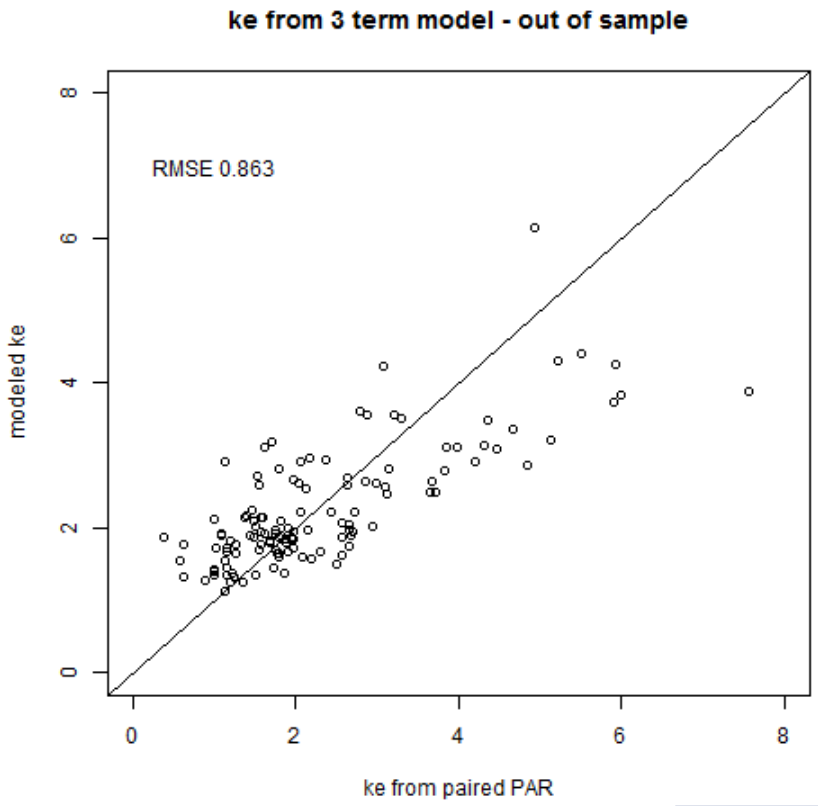


3 term model details

```
Call:
lm(formula = ke ~ TSS + Salinity + Chl.a, data = brwide, subset = train)

Residuals:
    Min      1Q  Median      3Q     Max
-2.1313 -0.5789 -0.0675  0.4821  2.4284

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.163194   0.110083  10.567  < 2e-16 ***
TSS          0.048026   0.003100  15.493  < 2e-16 ***
Salinity    -0.022996   0.006673  -3.446 0.000672 ***
Chl.a        0.042098   0.010369   4.060 6.66e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.8208 on 239 degrees of freedom
Multiple R-squared:  0.5174,    Adjusted R-squared:  0.5113
F-statistic:  85.4 on 3 and 239 DF,  p-value: < 2.2e-16
```

Bivariate Plots 3 term model

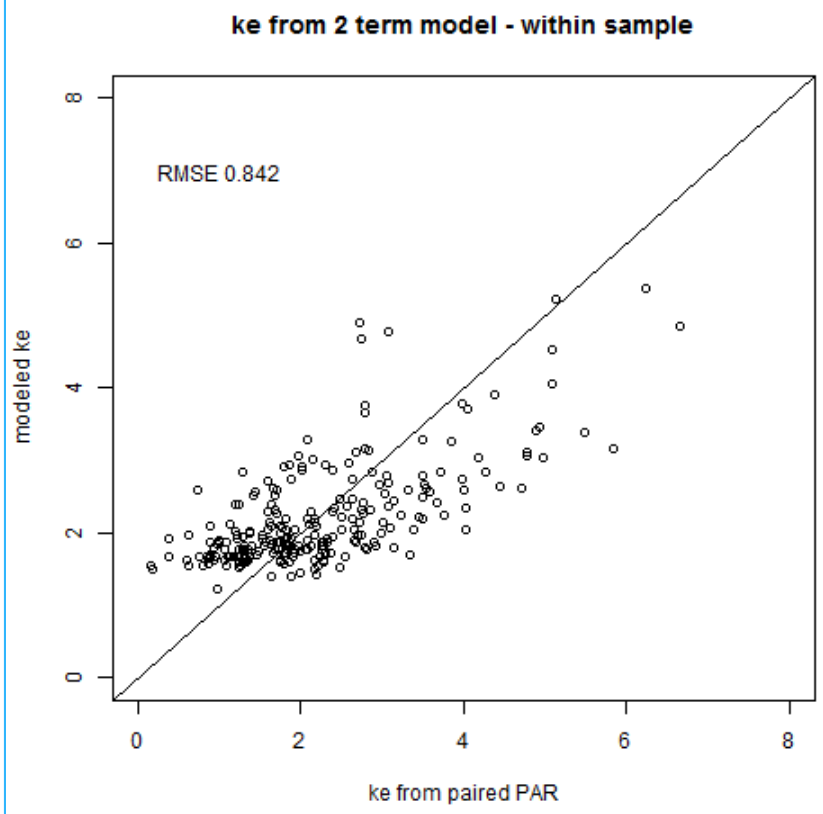


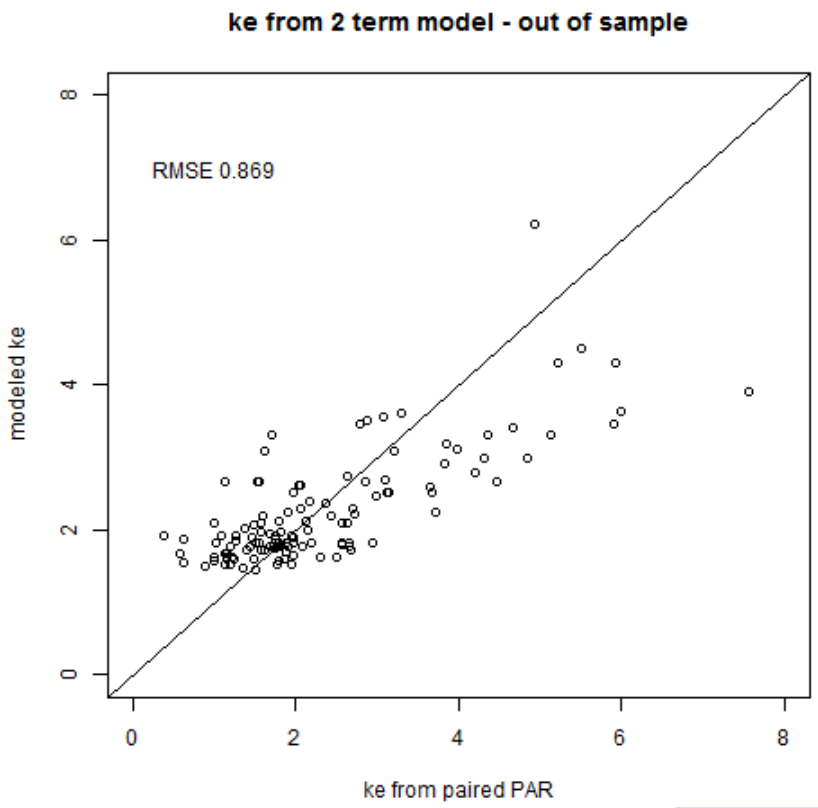


2 term model details

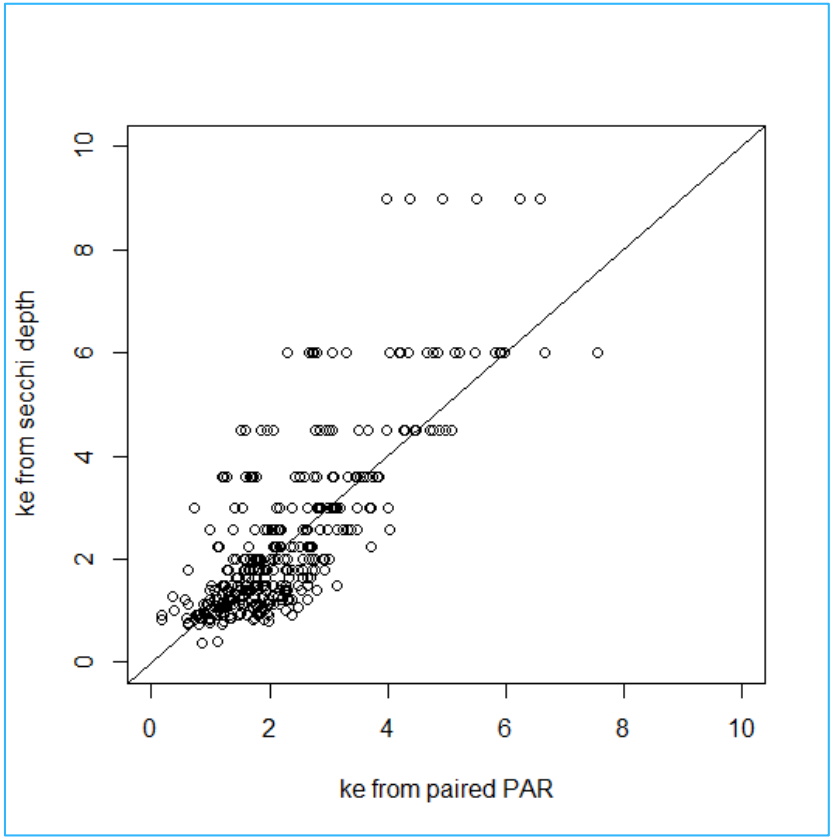
```
Call:
lm(formula = ke ~ TSS + Salinity, data = brwide, subset = train)

Residuals:
     Min       1Q   Median       3Q      Max
-2.17598 -0.59630 -0.08452  0.53138  2.66086

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  1.444510   0.088255  16.367   <2e-16 ***
TSS          0.046911   0.003186  14.725   <2e-16 ***
Salinity    -0.015249   0.006598  -2.311   0.0217 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.8468 on 240 degrees of freedom
Multiple R-squared:  0.4841,    Adjusted R-squared:  0.4798
F-statistic: 112.6 on 2 and 240 DF,  p-value: < 2.2e-16
```

Bivariate plots 2 term model



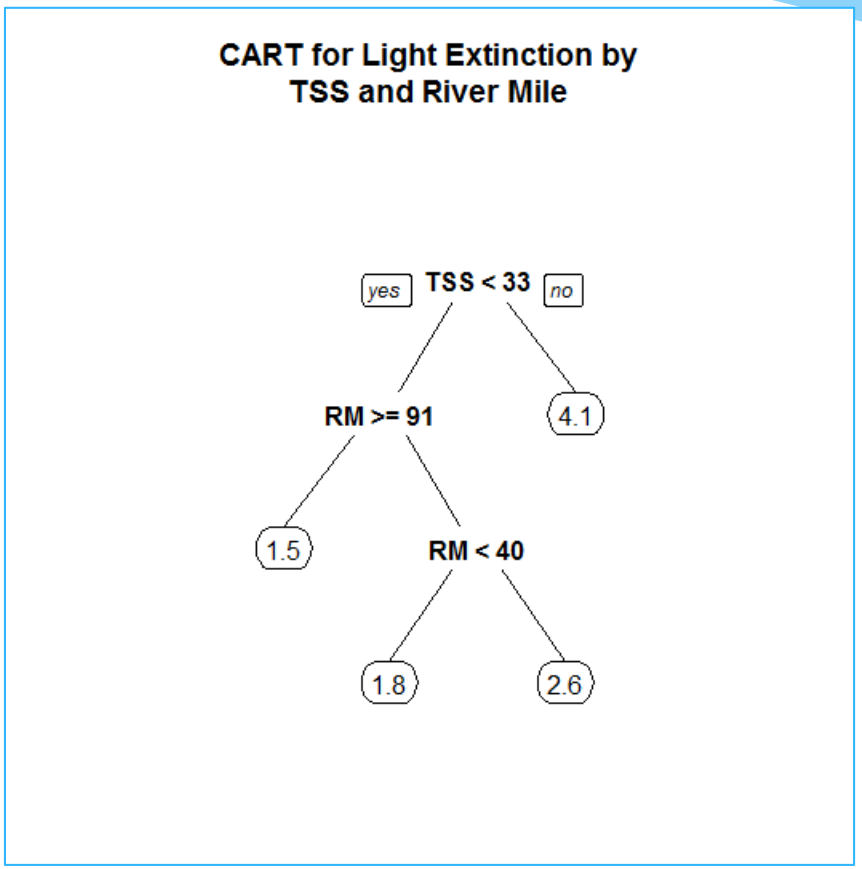


Compare k_e computed from secchi depth



* k_e=1.8/SD
* R^2 = 0.44

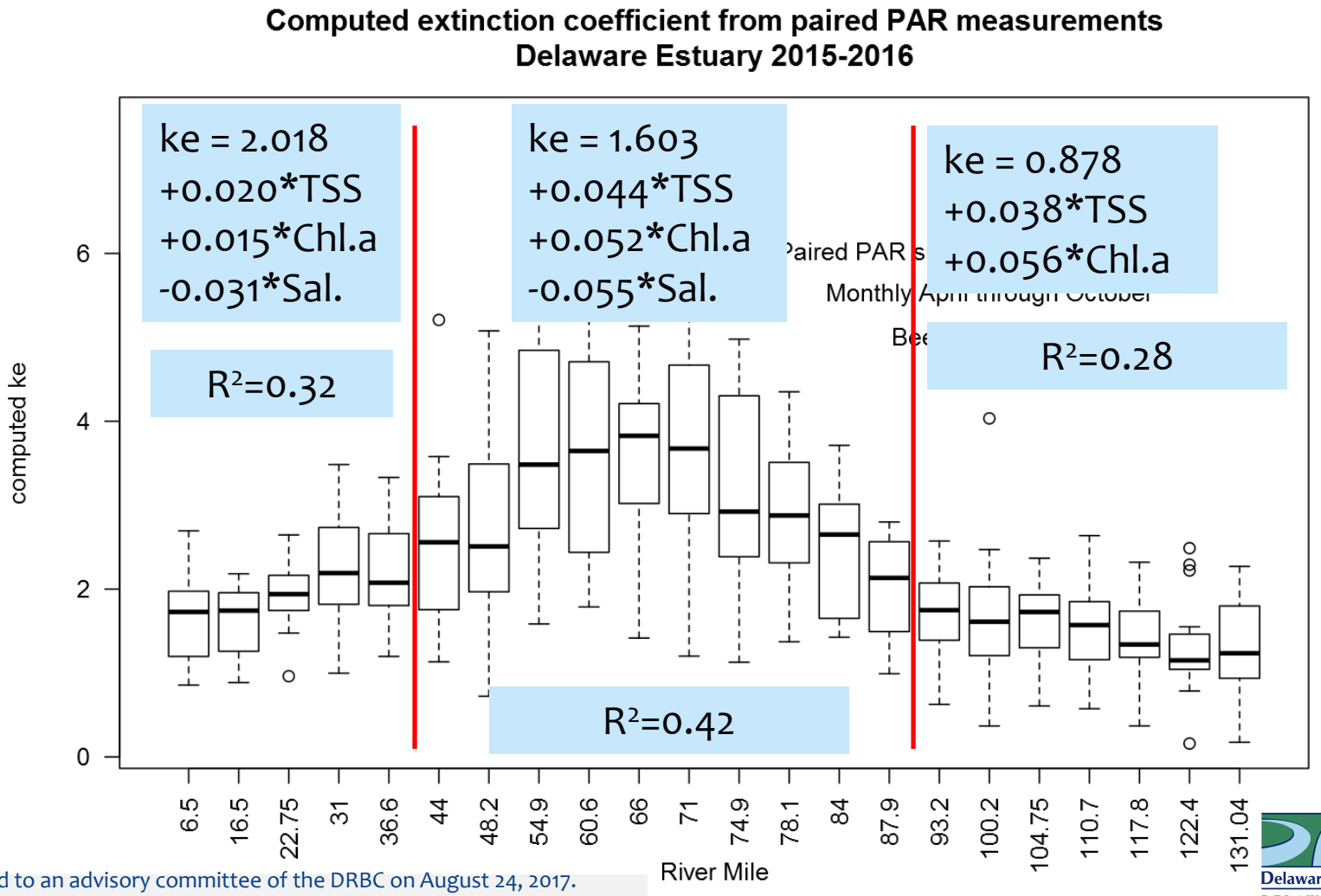
Used CART to look for 'natural' splits in the ke values



* Using River Mile and TSS only
* 'Natural' splits at TSS=33, RM 91, and RM 40

* Minbucket=50
* Method="anova"
* Pruned on min cp xerror

3 subarea statistical models



More work to be done on light extinction

* Statistical model tweaking
* Included in our 106 grant application project to collect additional PAR, TSS, Chl. a, and salinity data in 2018
  * 180 samples in Zones 2 through 5
* Evaluate other formulations of k_e as a function of water quality parameters:
  * More state variables in model?
* Targets for an acceptable statistical model?
  * Signal versus noise

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