ENV 710 Final Project

Emma Kaufman, Cara Kuuskvere, Jenn McNeill

2024-04-10

Contents

MODEL FIT ONE: Dissolved Oxygen by Total Phosphorus with a Seasonal Binary Indicator Variable and a Seasonal Interaction Term

a. What is the estimate of β_0 and what does it represent in terms of DO (dissolved oxygen)?

β_0 for this fit is 10.14 mg/L, which represents the expected value of DO in spring with zero total phosphorus.

b. What is the estimate of β_1 and what does it represent in terms of DO?

β_1 for this fit is -2.36, which represents the difference in DO between spring and summer with zero total phosphorus. In summer the expected dissolved oxygen is 8.7 mg/L.

c. What is the estimate of β_2 and what does it represent in terms of DO?

β_2 for this fit is -0.067 (mg/L)/ug, which represents the expected change in DO for each unit increase in total phosphorus during spring.

d. What is the estimate of β_3 and what does it represent in terms of DO?

β_3 for this fit is 0.02 (mg/L)/ug, which represents the adjustment to the slope for each unit increase in total phosphorus during the summer. In the summer the expected change in DO for each unit increase in total phosphorus is -0.045 (mg/L)/ug.

```
## Warning: Using 'size' aesthetic for lines was deprecated in ggplot2 3.4.0.
## i Please use 'linewidth' instead.
## This warning is displayed once every 8 hours.
## Call 'lifecycle::last_lifecycle_warnings()' to see where this warning was
## generated.
```

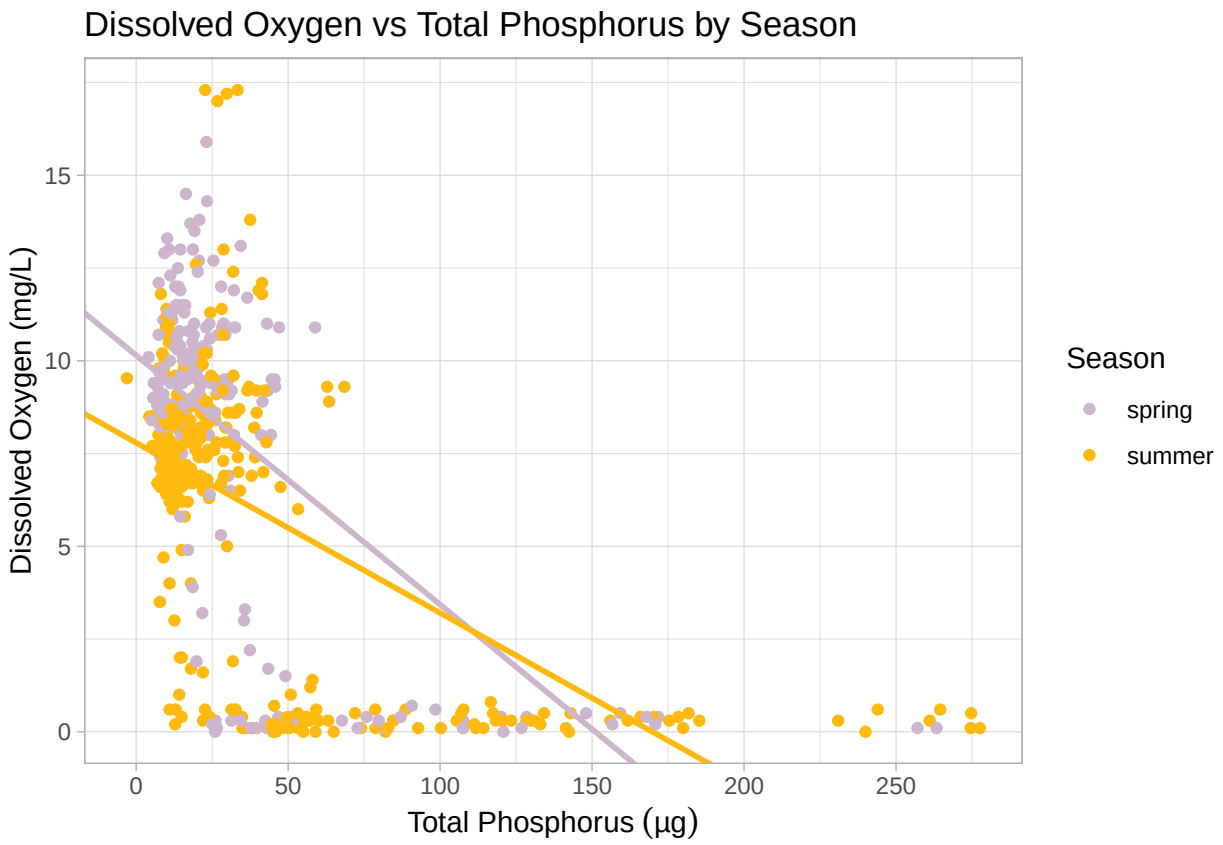


Figure 1: Figure 1

**discuss the poor model fit in results and talk about how we attempted to log transform the x axis and tried to use a subset of the y axis dissolved oxygen, but we still didn't see normal distribution of residuals or constant variance of residuals. reference the plots but include them in the appendix.

MODEL FIT TWO: Dissolved Oxygen by Total Phosphorus with a Water Depth Binary Indicator Variable and a Water Depth Interaction Term

a. What is the estimate of β_0 and what does it represent in terms of DO?

β_0 for this fit is 8.52 mg/L, which represents the expected value of DO in surface water with zero total phosphorus.

b. What is the estimate of β_1 and what does it represent in terms of DO?

β_1 for this fit is -7.67 mg/L, which represents the difference in DO between surface water and subsurface water with zero total phosphorus.

c. What is the estimate of β_2 and what does it represent in terms of DO?

β_2 for this fit is -0.0002 (mg/L)/ug, which represents the expected change in DO for each unit increase in total phosphorus in surface water.

d. What is the estimate of β_3 and what does it represent in terms of DO?

β_3 for this fit is -0.003 (mg/L)/ug, which represents the adjustment to the slope for each unit increase in total phosphorus in subsurface water.

```
## Warning: Removed 69 rows containing missing values (‘geom_point()‘).
```

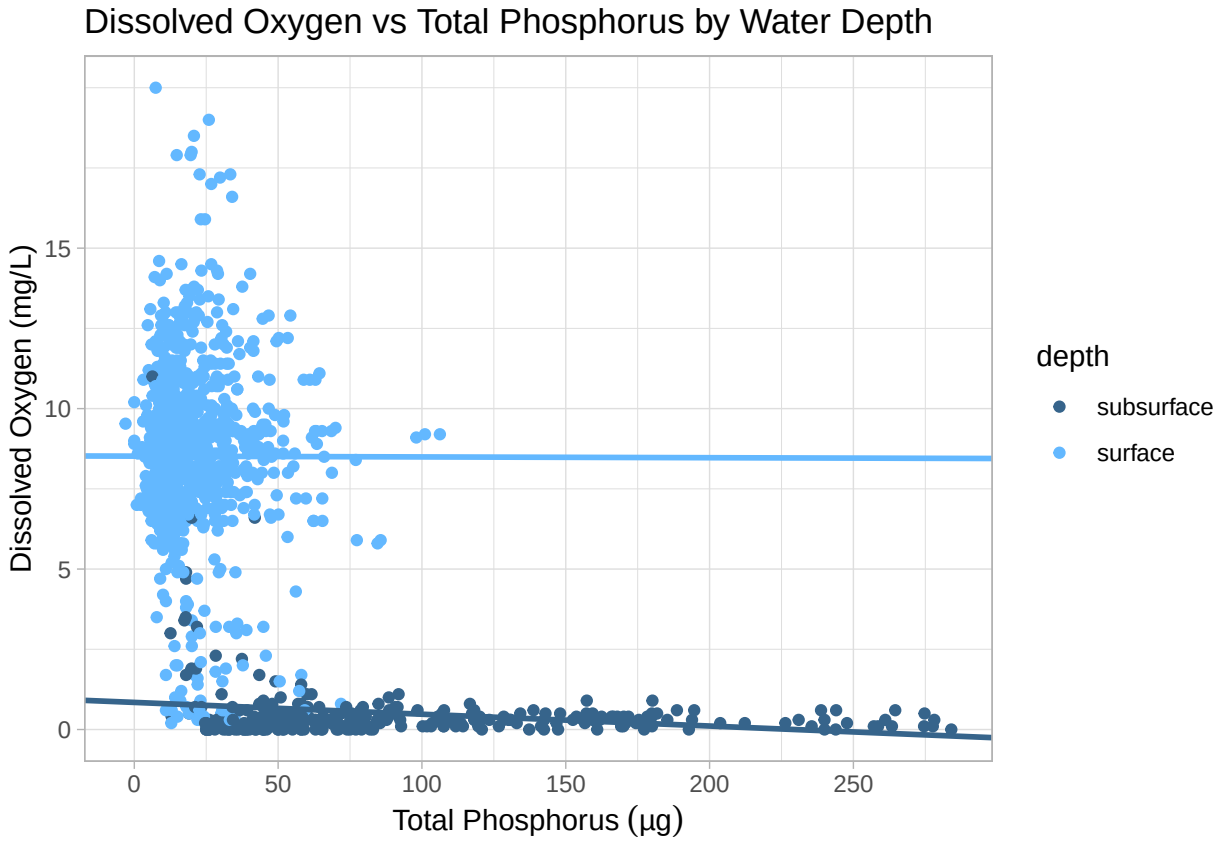


Figure 2: Figure 2

MODEL FIT THREE: Dissolved Oxygen by Total Phosphorus with a Hierarchical Linear Mixed Effects Lake Variable

a. β_0 (Intercept): 8.68 mg/L

This represents the expected value of dissolved oxygen in surface water with zero total phosphorus.

b. β_1 (tp_ug): -0.055 mg/L

This represents the change in dissolved oxygen for each unit increase in total phosphorus in surface water.

```
## Warning: Removed 69 rows containing non-finite values (`stat_smooth()`).
```

```
## Warning: Removed 69 rows containing missing values (`geom_point()`).
```

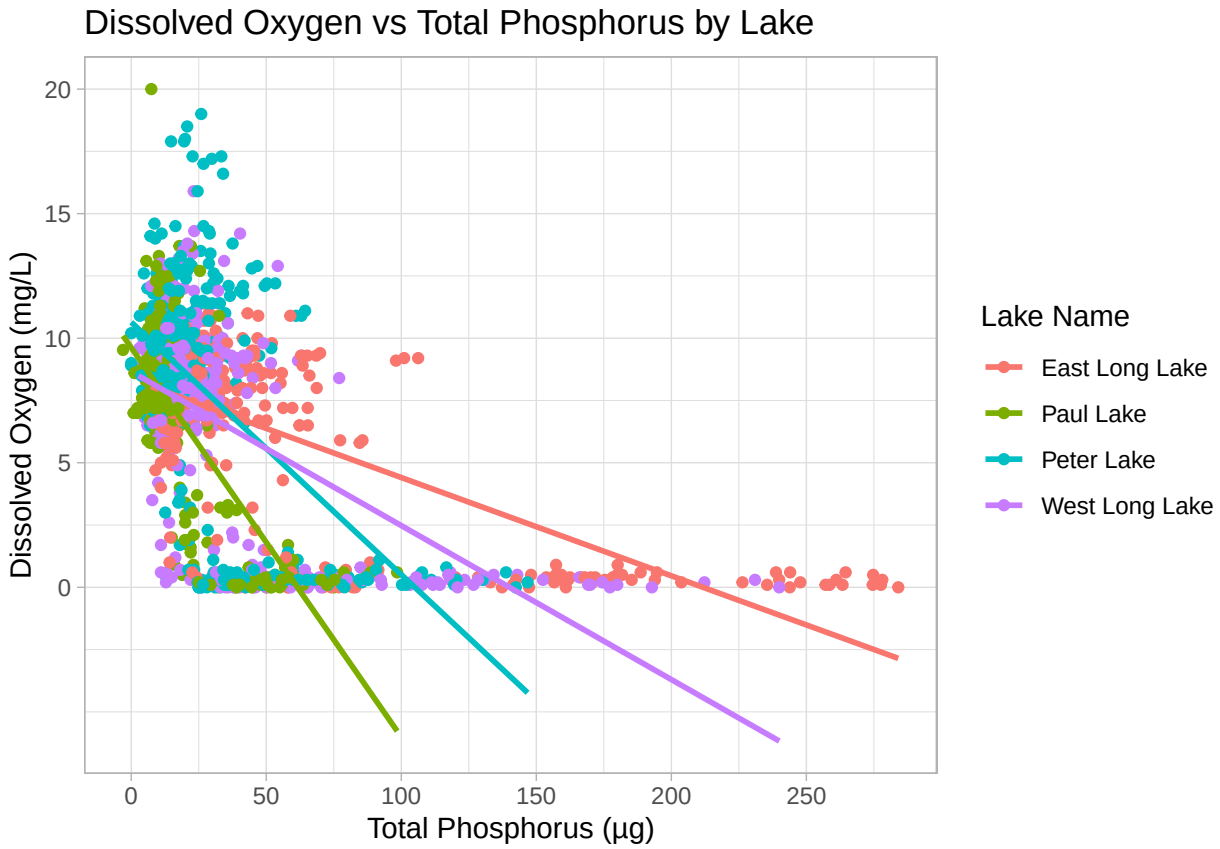
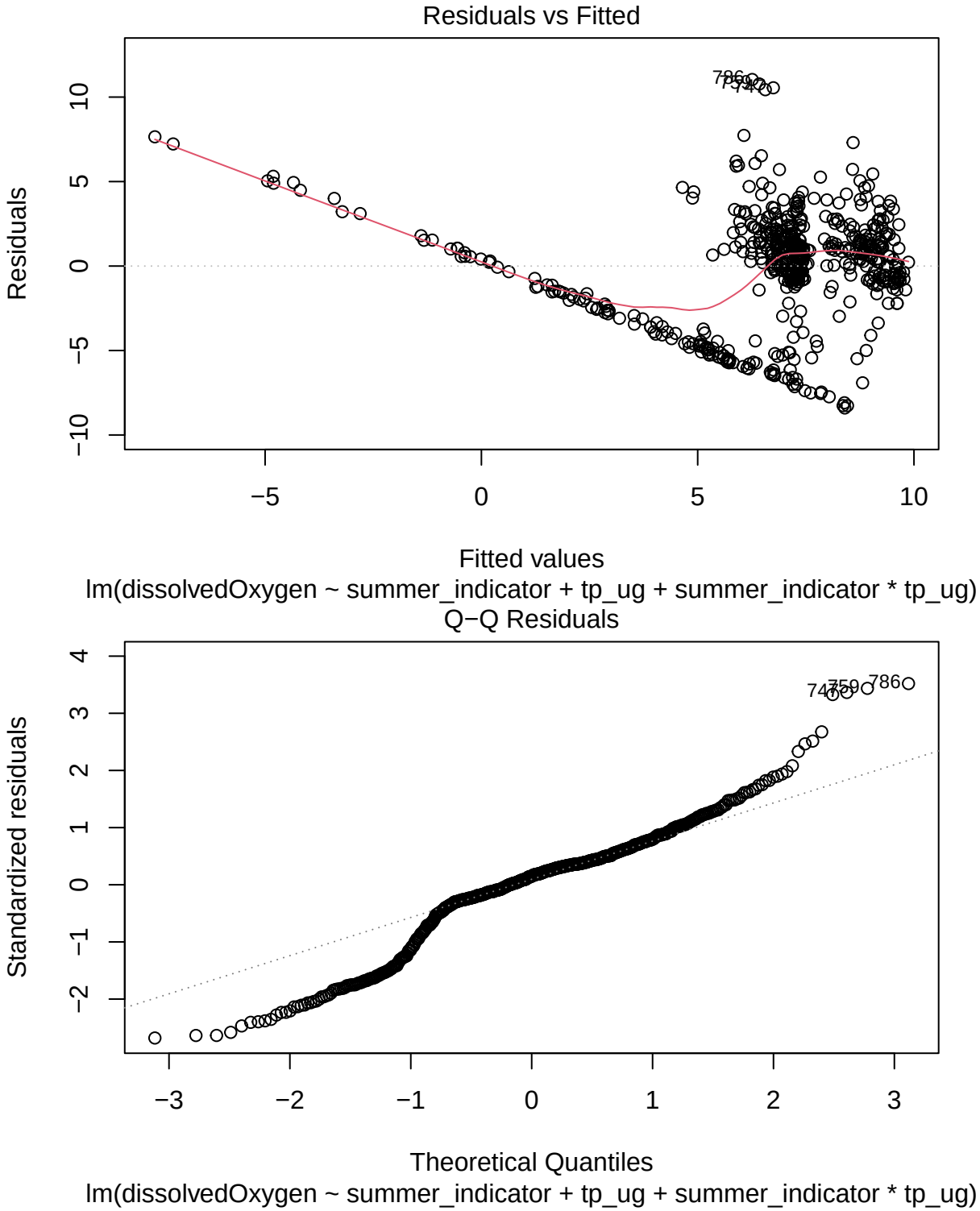
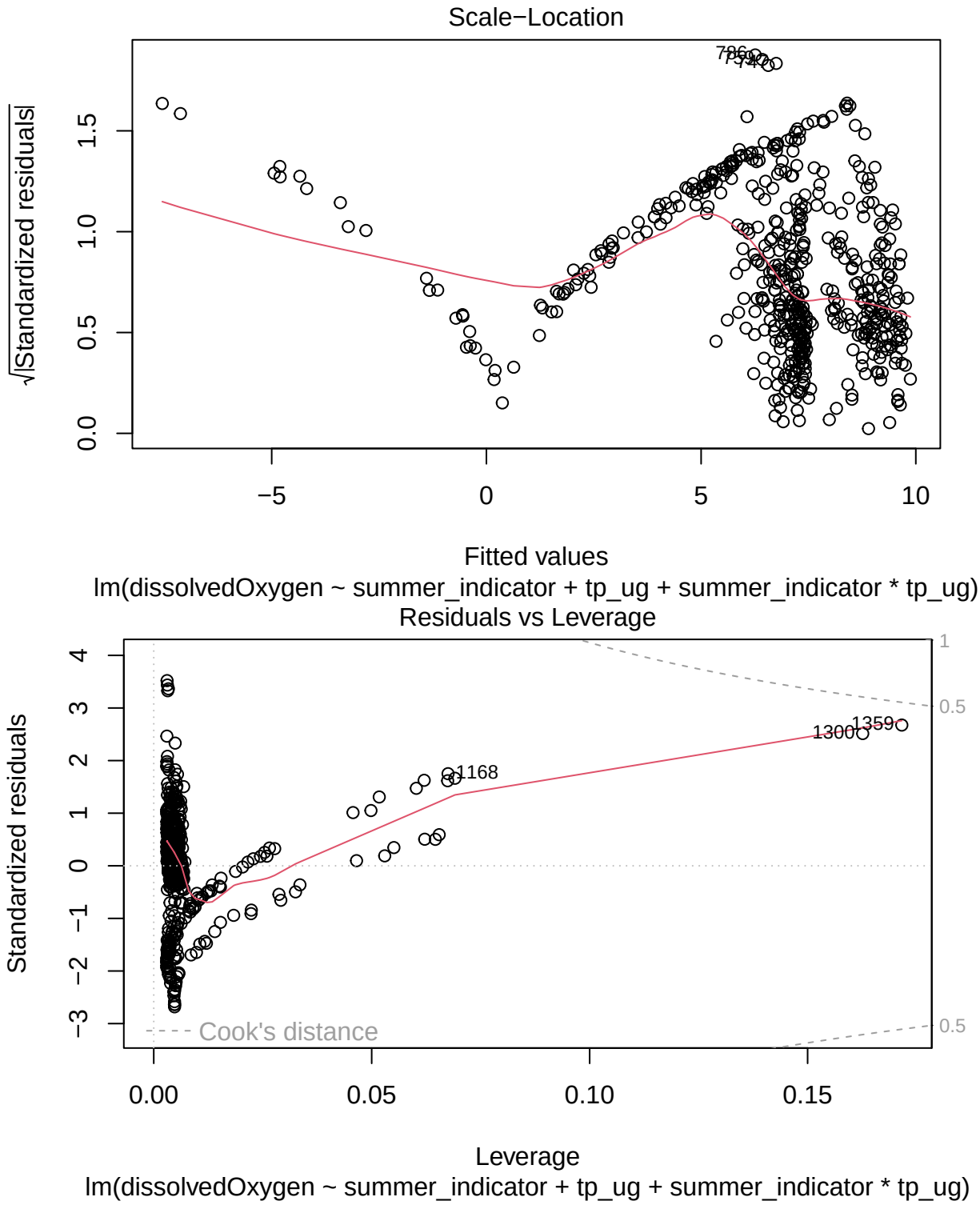


Figure 3: Figure 3

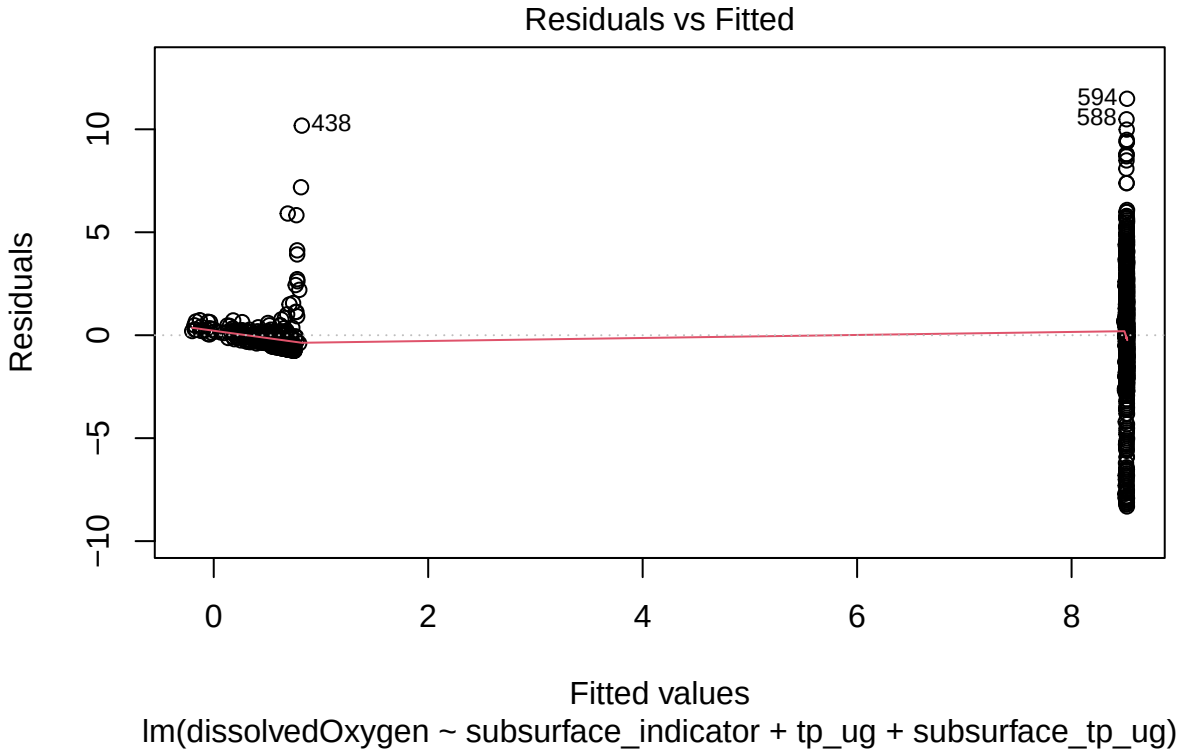
APPENDIX

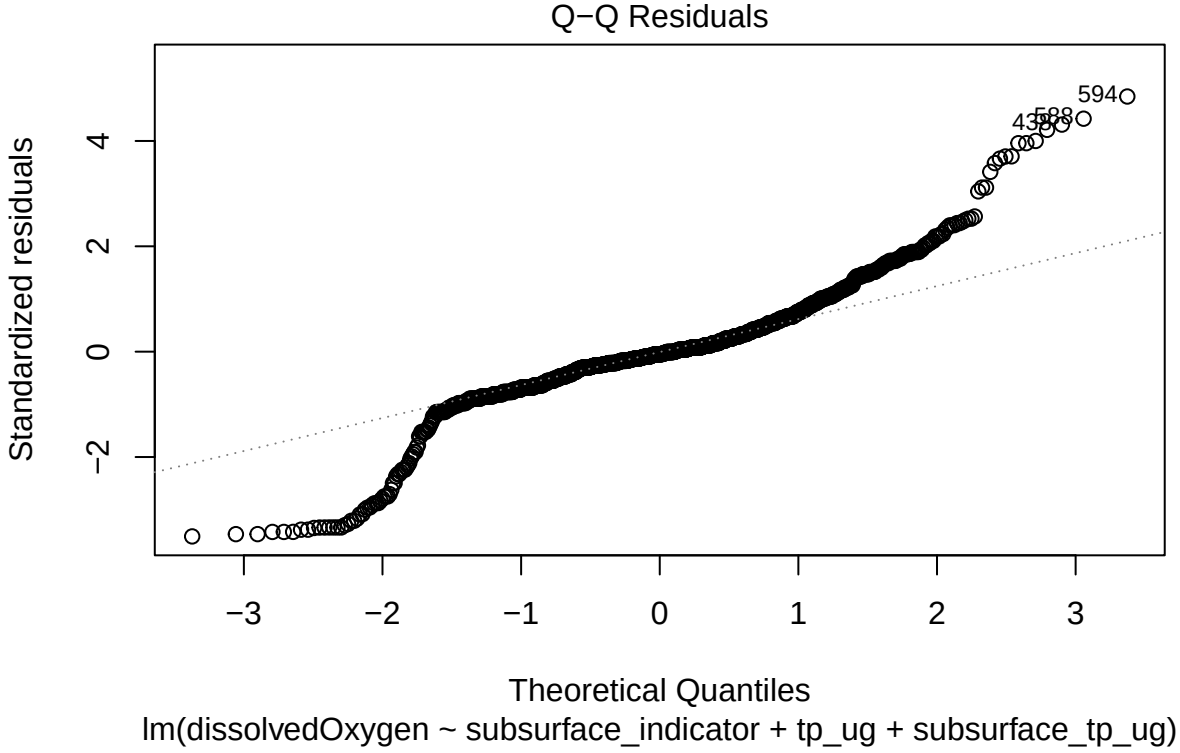
Model One Residuals

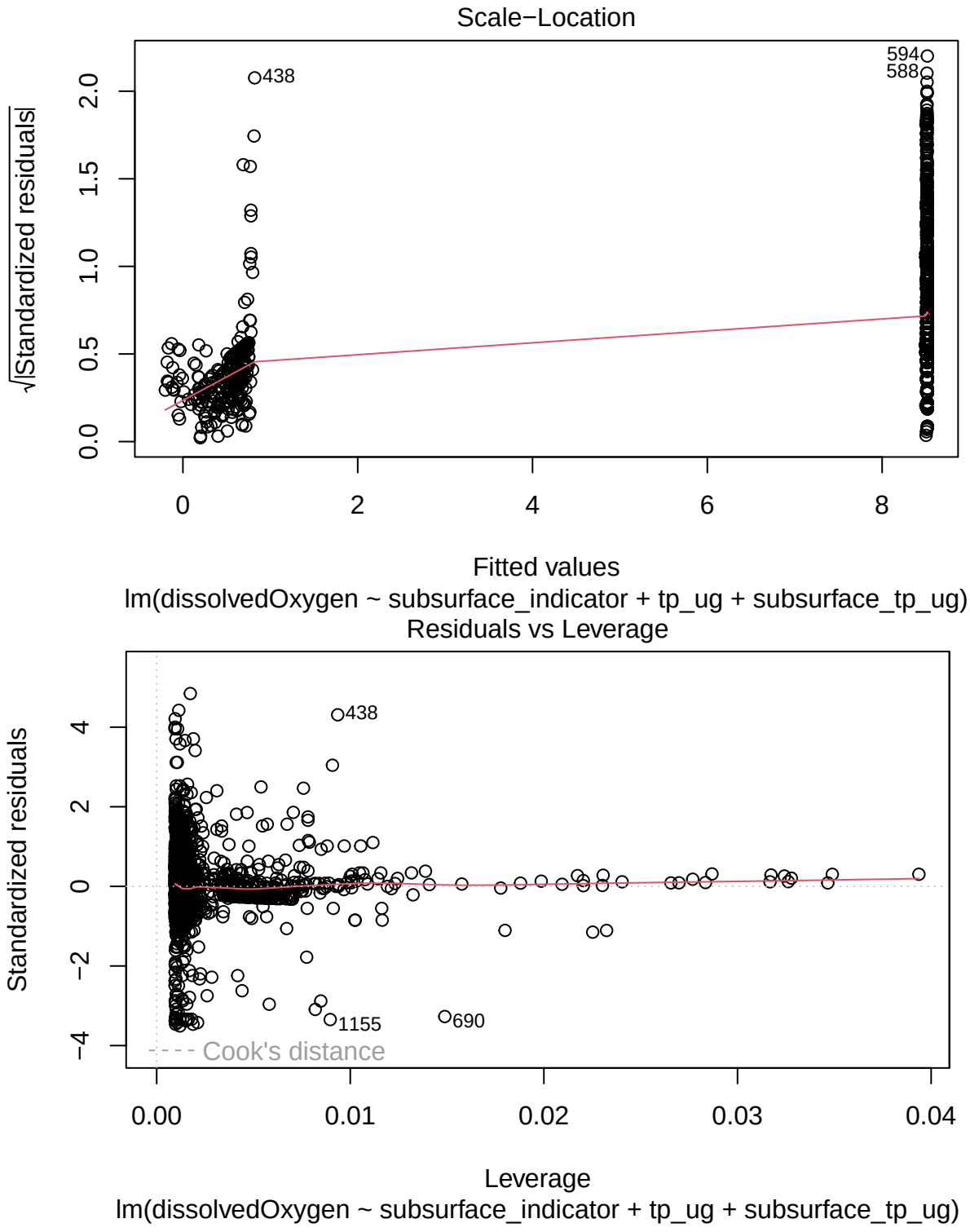



Scale−Location
√|Standardized residuals|
0.0
0.5
1.0
1.5
−5
0
5
10
Fitted values
lm(dissolvedOxygen ~ summer_indicator + tp_ug + summer_indicator * tp_ug)
Residuals vs Leverage
Standardized residuals
−3
−2
−1
0
1
2
3
4
1
0.5
0.5
1359
1300
1168
Cook's distance
0.00
0.05
0.10
0.15
Leverage
lm(dissolvedOxygen ~ summer_indicator + tp_ug + summer_indicator * tp_ug)

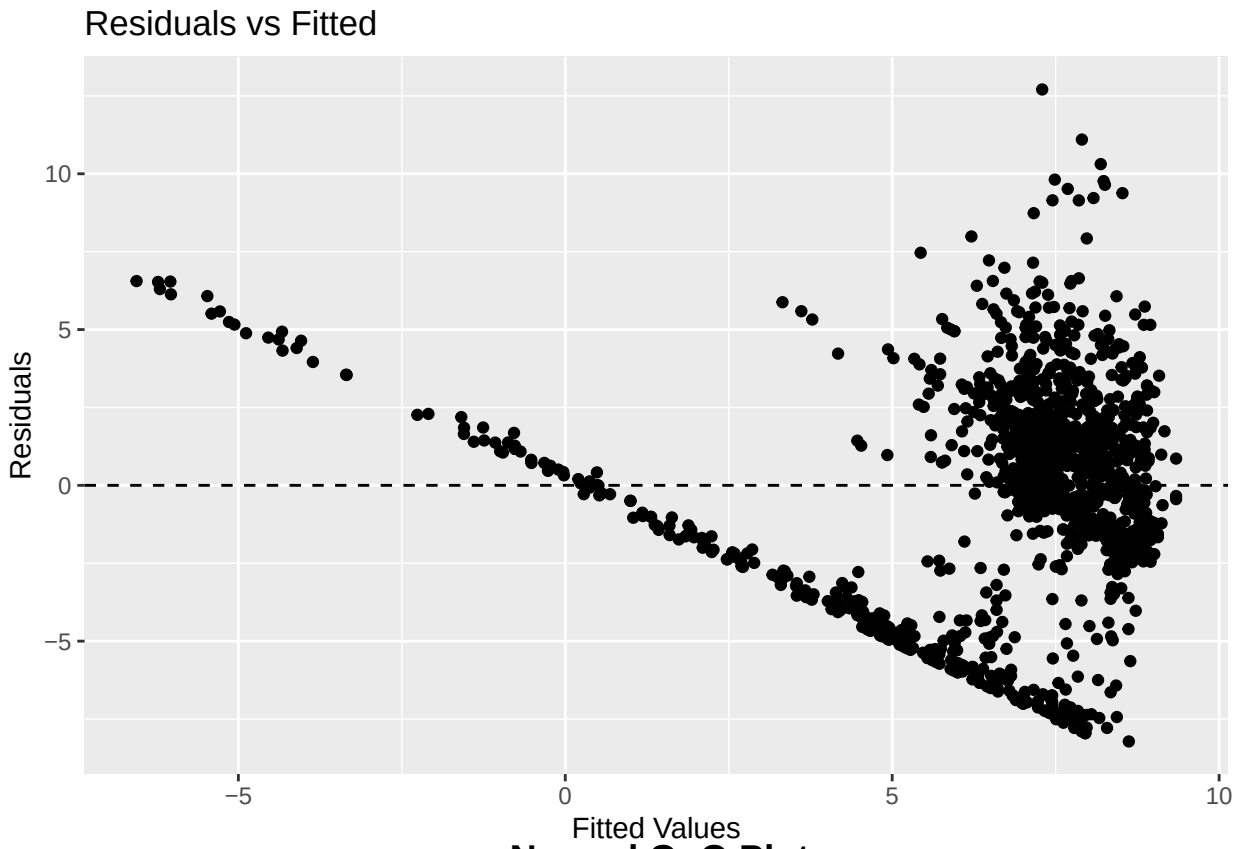
Model Two Residuals

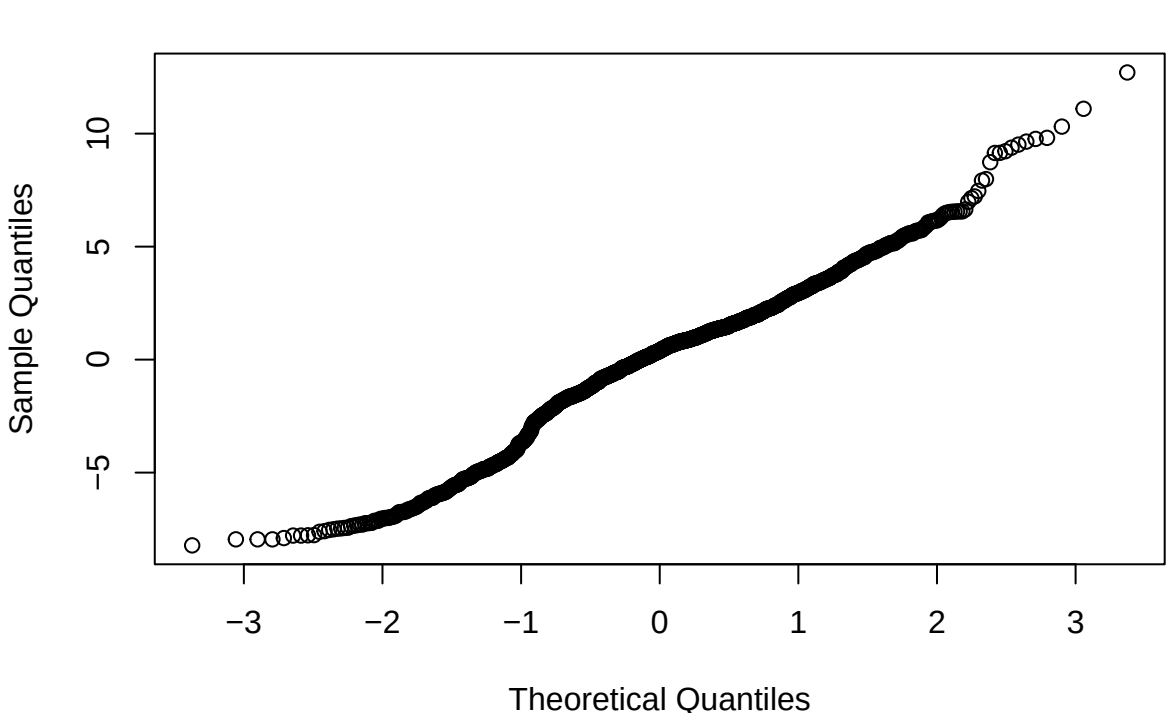


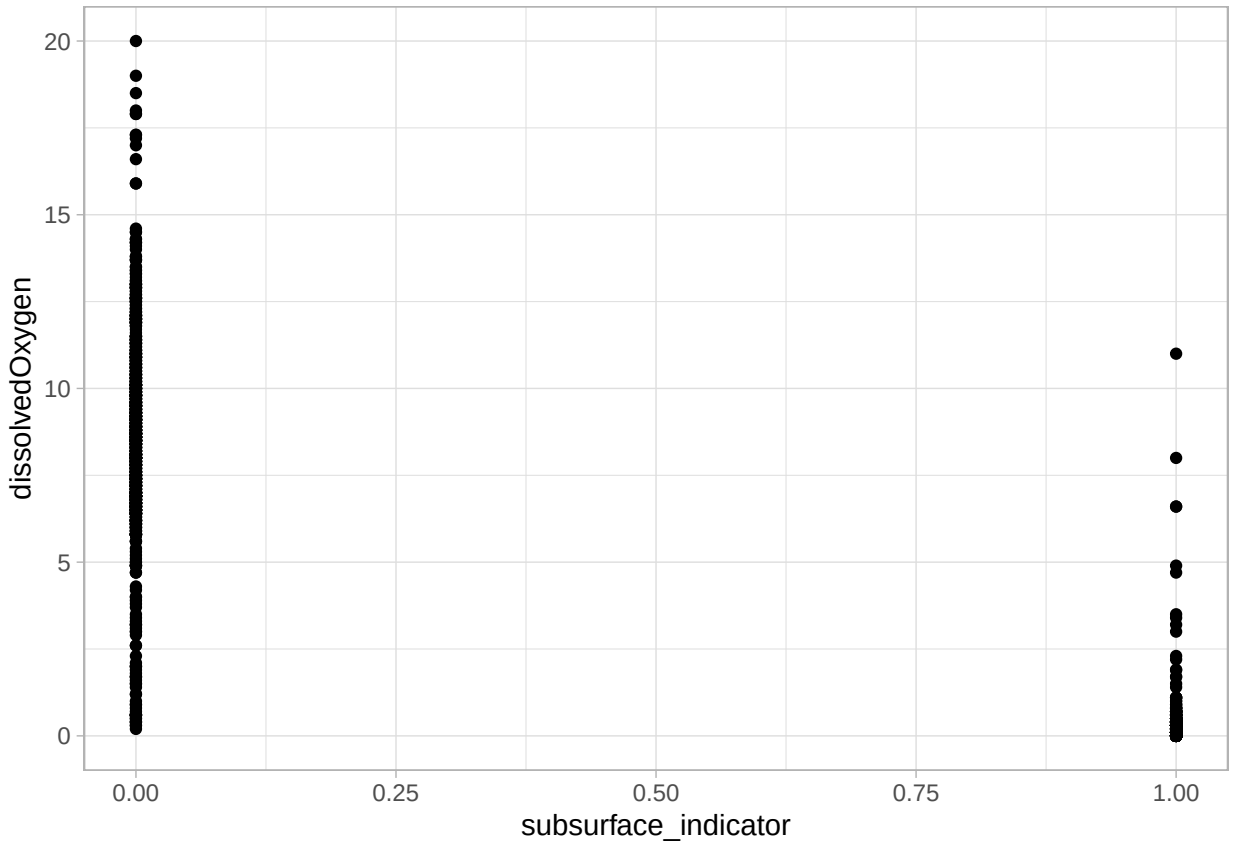


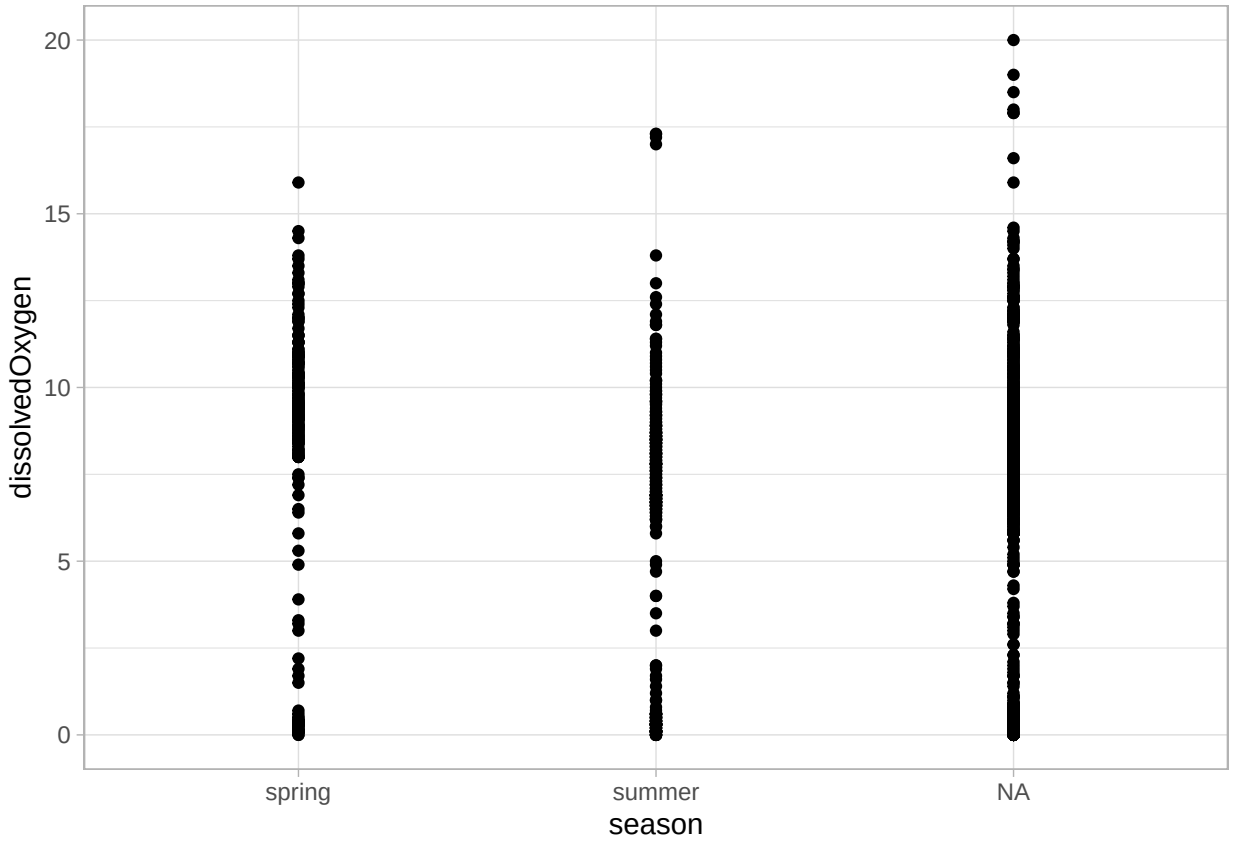

Scale−Location
√|Standardized residuals|
0.0
0.5
1.0
1.5
2.0
438
594
588
0
2
4
6
8
Fitted values
lm(dissolvedOxygen ~ subsurface_indicator + tp_ug + subsurface_tp_ug)
Residuals vs Leverage
Standardized residuals
−4
−2
0
2
4
438
1155
690
Cook's distance
0.00
0.01
0.02
0.03
0.04
Leverage
lm(dissolvedOxygen ~ subsurface_indicator + tp_ug + subsurface_tp_ug)

Model Three Residuals

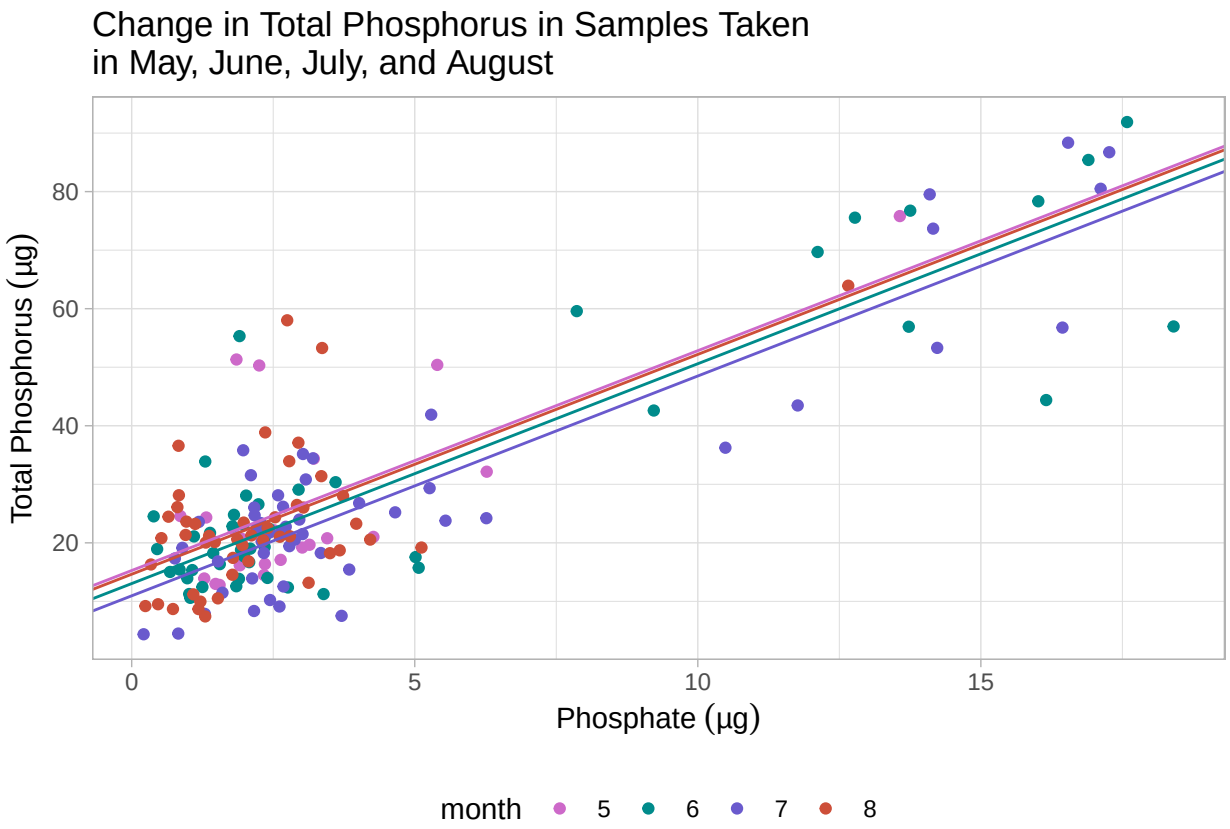




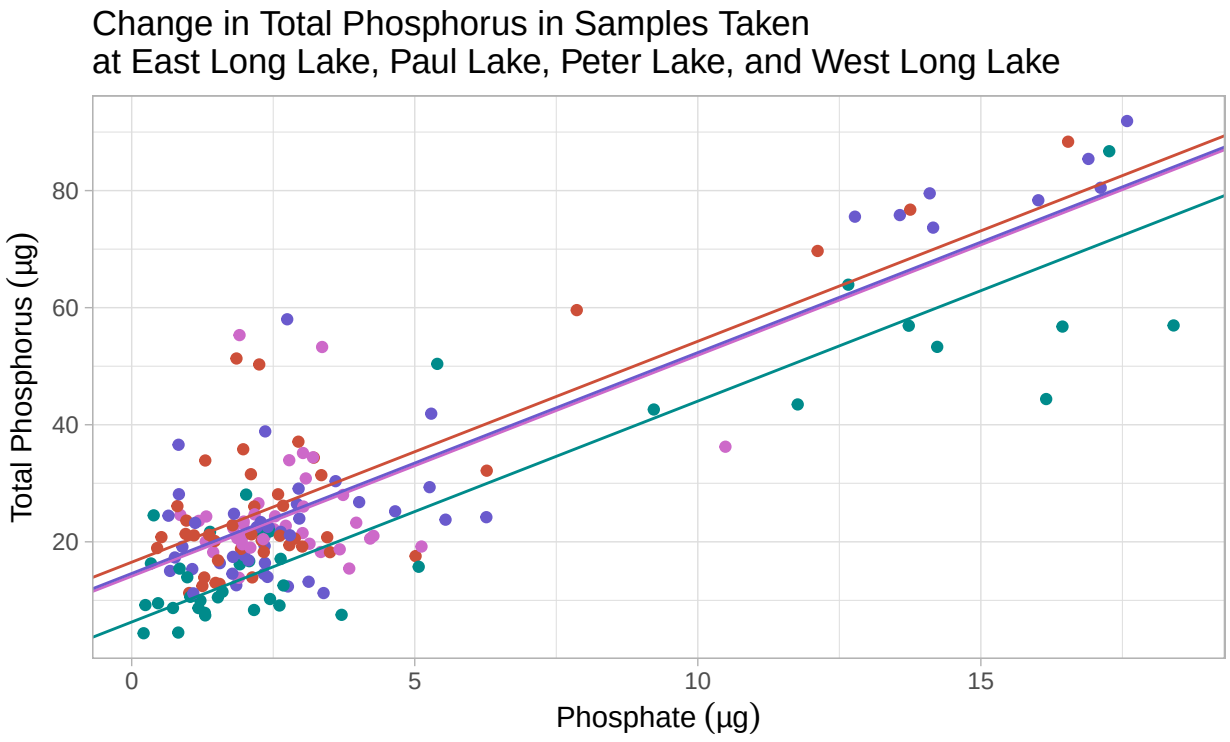

dissolvedOxygen
20
15
10
5
0
0.00
0.25
0.50
0.75
1.00
subsurface_indicator

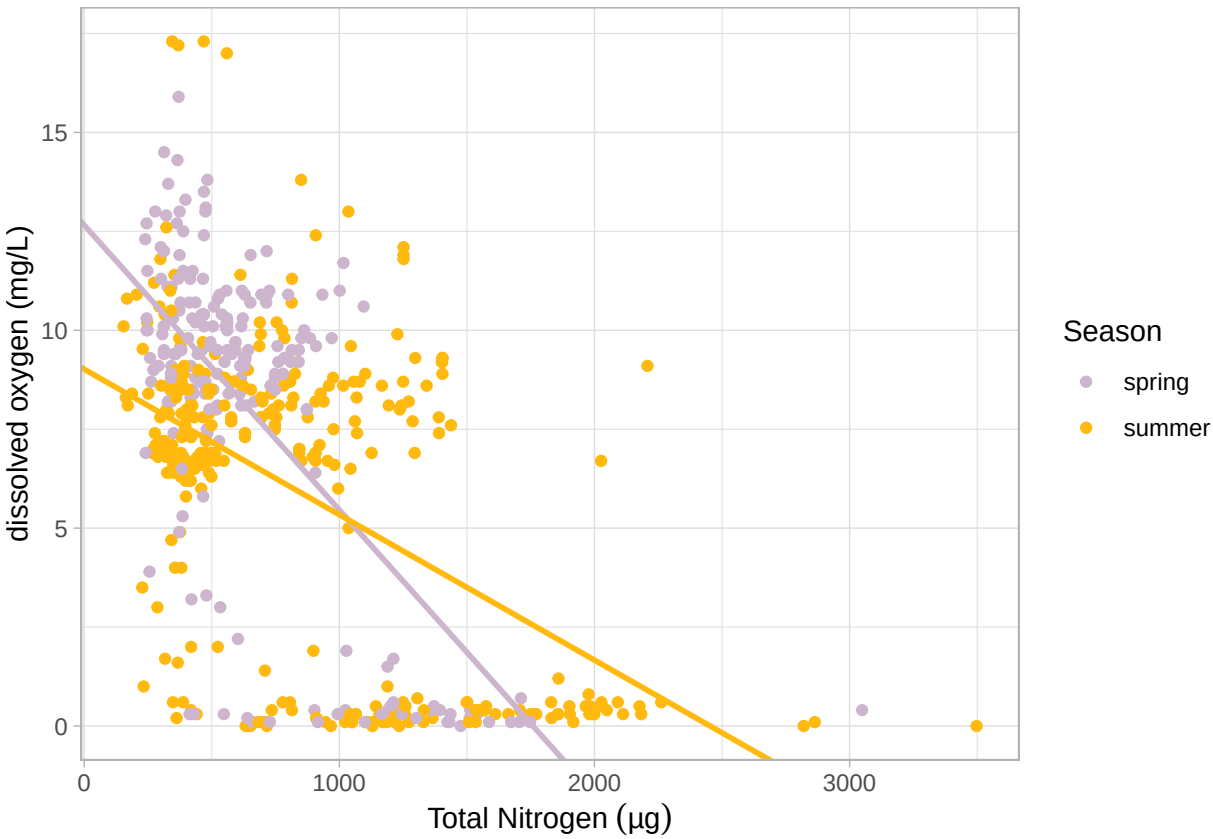

dissolvedOxygen
20
15
10
5
0
spring
summer
NA
season

```
##
## Call:
## lm(formula = tp_ug ~ month + po4, data = lake_1994)
##
## Coefficients:
## (Intercept)       month6       month7       month8          po4
##     15.2690      -2.2260      -4.3199      -0.6307       3.7553
```



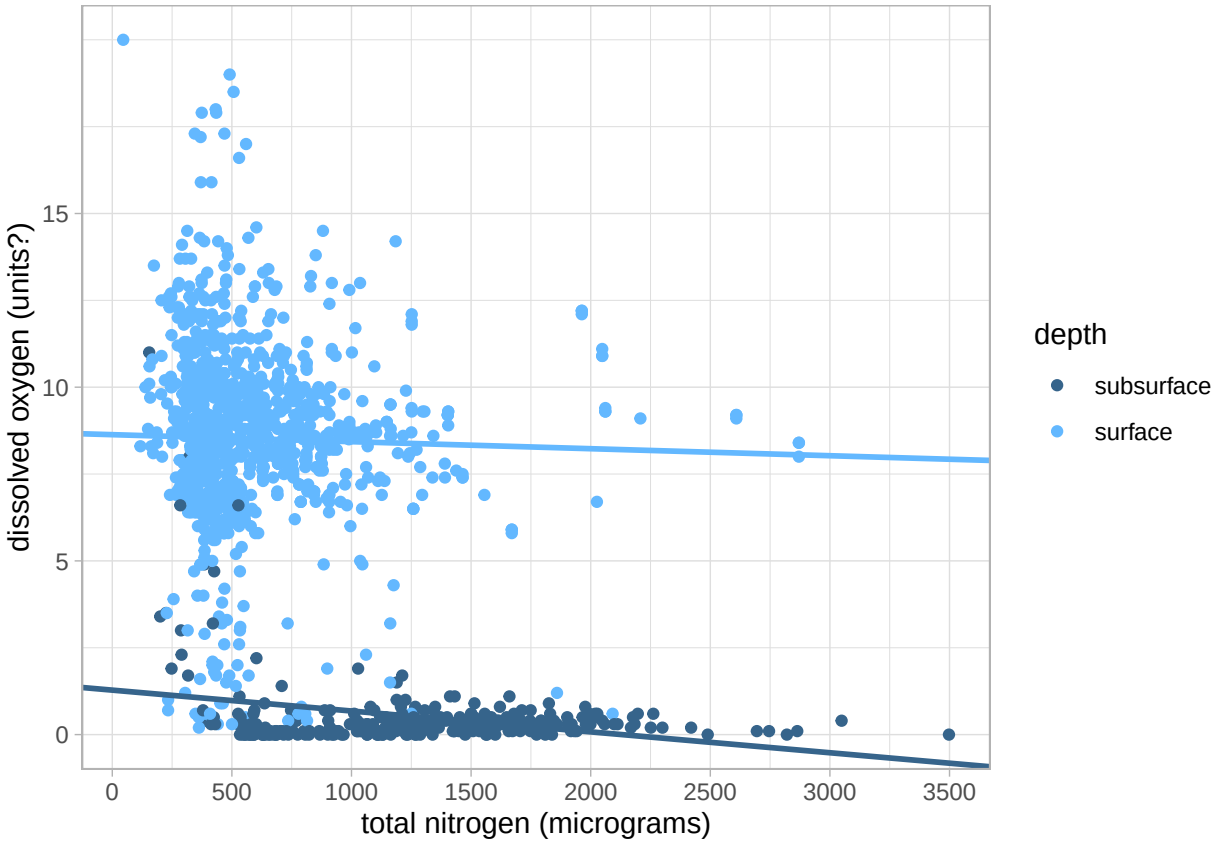

```
##
## Call:
## lm(formula = tp_ug ~ lakename + po4, data = lake_1994)
##
## Coefficients:
##            (Intercept)       lakenamePaul Lake      lakenamePeter Lake
##                14.1293                 -7.8305                  0.4614
## lakenameWest Long Lake                     po4
##                 2.3909                  3.7737
```


Change in Total Phosphorus in Samples Taken
at East Long Lake, Paul Lake, Peter Lake, and West Long Lake
Total Phosphorus (µg)
Phosphate (µg)
0
5
10
15
20
40
60
80
lakename
East Long Lake
Paul Lake
Peter Lake
West Long Lake


dissolved oxygen (mg/L)
Total Nitrogen (µg)
0
1000
2000
3000
5
10
15
Season
spring
summer

##

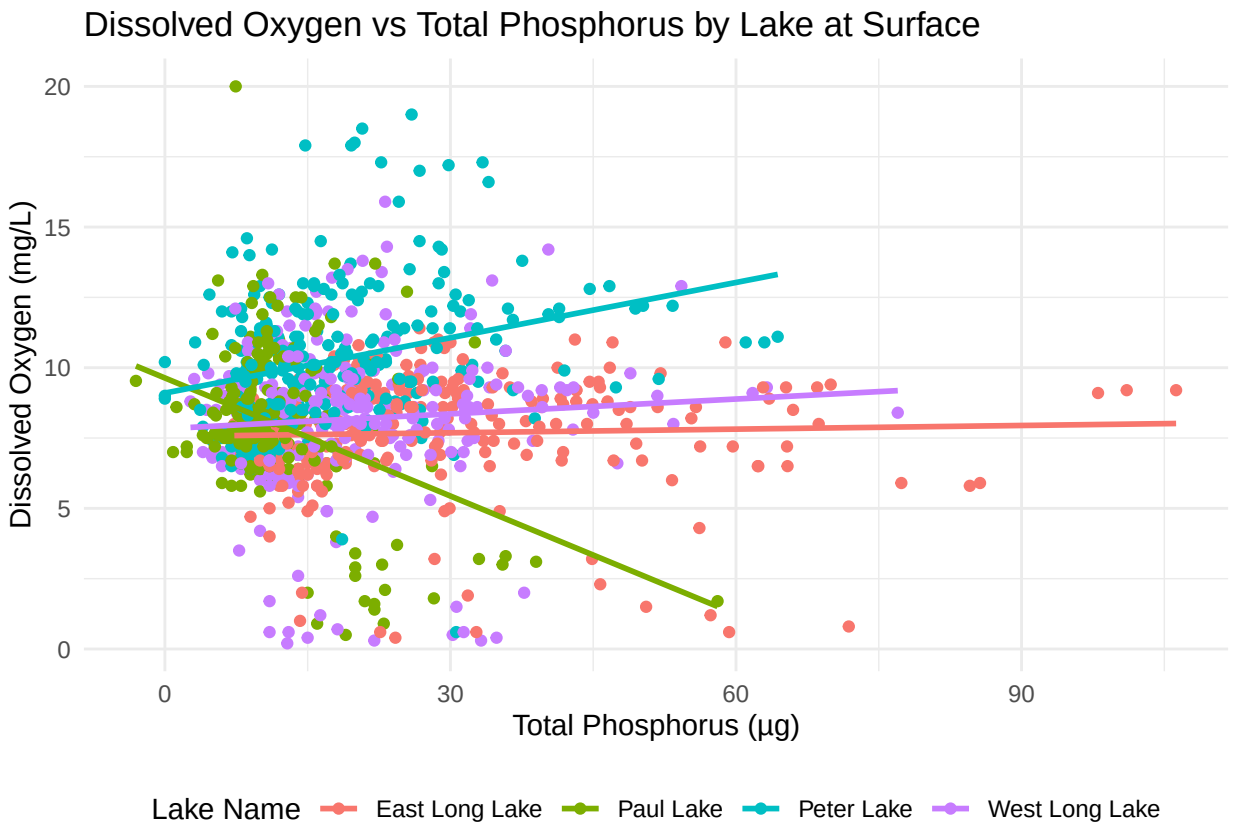
```
## Call:
## lm(formula = dissolvedOxygen ~ subsurface_indicator + tn_ug +
##     subsurface_tn_ug, data = jenn)
##
## Coefficients:
##          (Intercept)  subsurface_indicator                 tn_ug
##            8.6334713            -7.3533011            -0.0002020
##     subsurface_tn_ug
##           -0.0003988
```




```
## Linear mixed model fit by REML ['lmerMod']
## Formula: dissolvedOxygen ~ tp_ug + (1 | lakename)
##    Data: lakes_processed_surface
##
## REML criterion at convergence: 4851.2
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -4.0558 -0.5070  0.0015  0.5606  5.0058
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  lakename (Intercept) 1.441    1.200
##  Residual             5.819    2.412
## Number of obs: 1050, groups:  lakename, 4
##
```

```
## Fixed effects:
##             Estimate Std. Error t value
## (Intercept) 8.330860   0.616156  13.521
## tp_ug       0.009972   0.006026   1.655
##
## Correlation of Fixed Effects:
##       (Intr)
## tp_ug -0.191
```

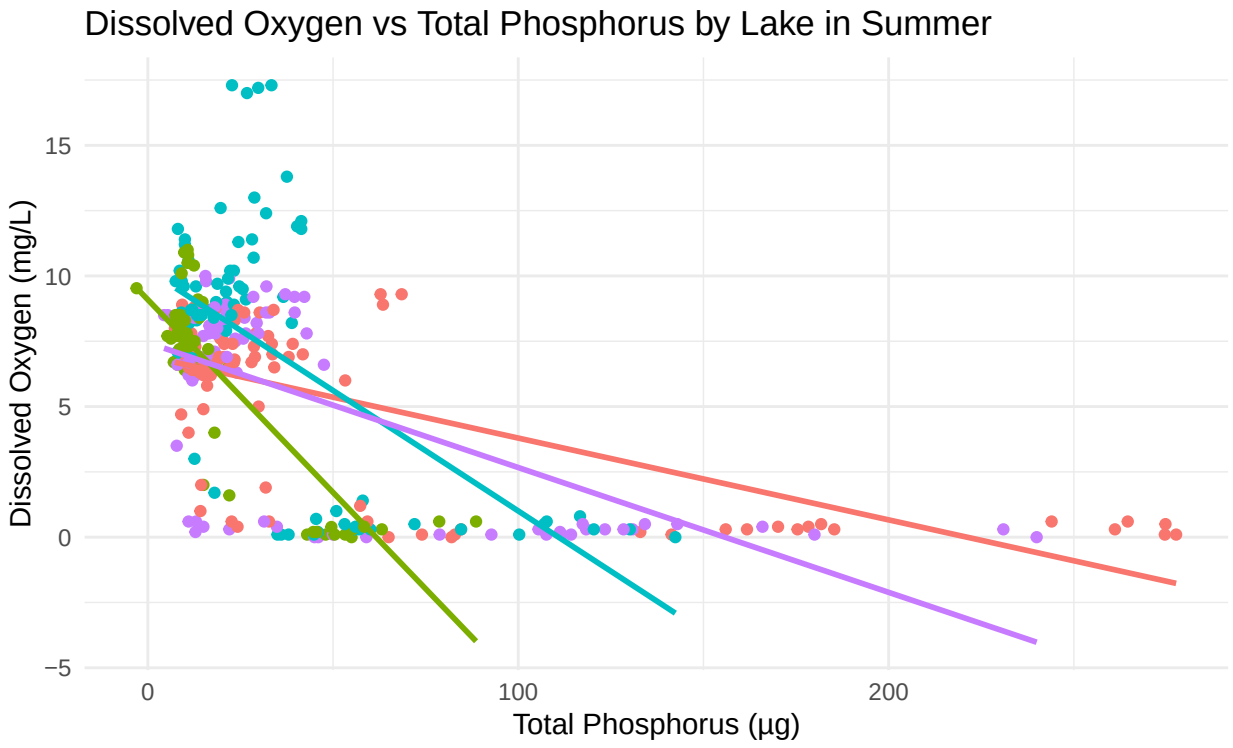
```
## Linear mixed model fit by REML ['lmerMod']
## Formula: dissolvedOxygen ~ tp_ug + (1 | lakename)
##    Data: lakes_processed_surface
## REML criterion at convergence: 4851.247
## Random effects:
##  Groups   Name        Std.Dev.
##  lakename (Intercept) 1.200
##  Residual             2.412
## Number of obs: 1050, groups:  lakename, 4
## Fixed Effects:
## (Intercept)        tp_ug
##    8.330860     0.009972
```

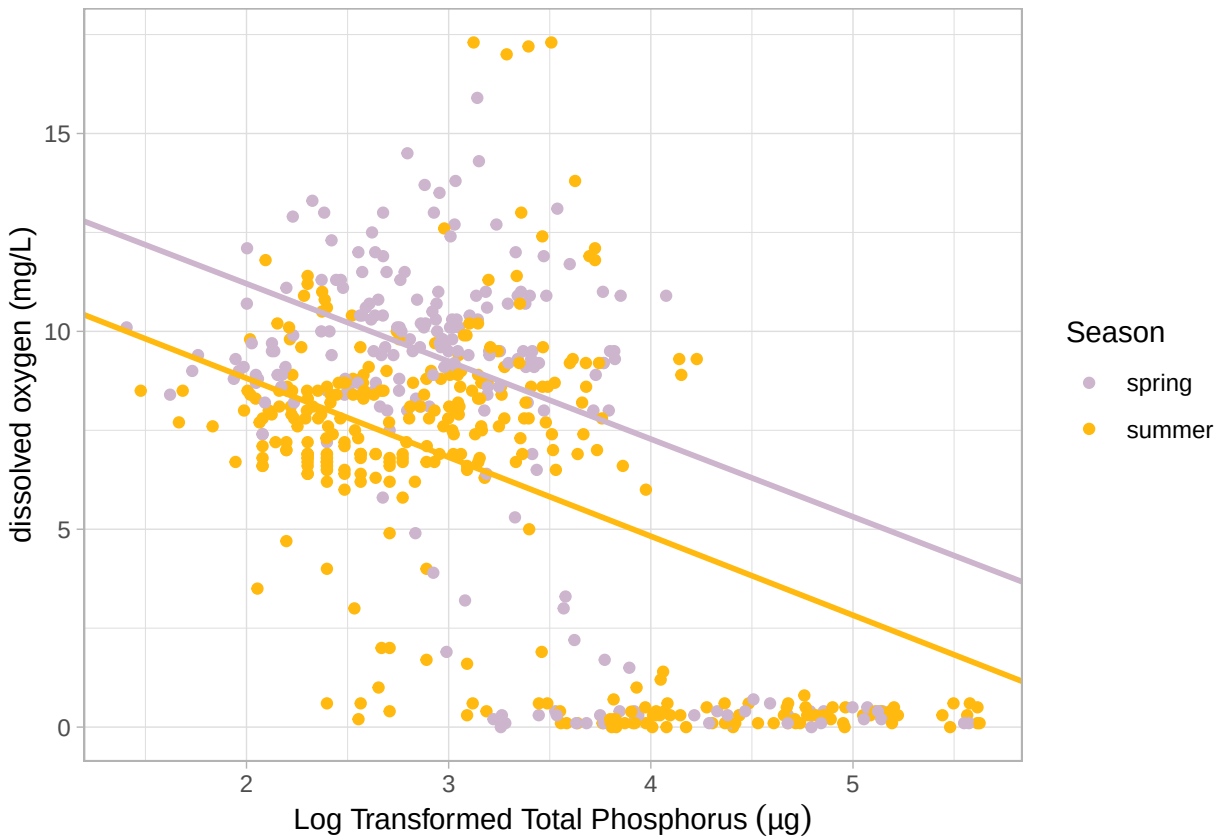



```
## Linear mixed model fit by REML ['lmerMod']
## Formula: dissolvedOxygen ~ tp_ug + (1 | lakename)
##    Data: lakes_processed_summer
##
## REML criterion at convergence: 1703.4
```

```
##
## Scaled residuals:
##     Min      1Q  Median      3Q     Max
## -2.2227 -0.3910  0.1498  0.5243  3.3339
##
## Random effects:
##  Groups   Name        Variance Std.Dev.
##  lakename (Intercept) 0.4257   0.6524
##  Residual             9.4989   3.0820
## Number of obs: 332, groups:  lakename, 4
##
## Fixed effects:
##              Estimate Std. Error t value
## (Intercept)  7.750824   0.391567   19.79
## tp_ug       -0.045821   0.003436  -13.34
##
## Correlation of Fixed Effects:
##       (Intr)
## tp_ug -0.342
```

```
## Linear mixed model fit by REML ['lmerMod']
## Formula: dissolvedOxygen ~ tp_ug + (1 | lakename)
##    Data: lakes_processed_summer
## REML criterion at convergence: 1703.426
## Random effects:
##  Groups   Name        Std.Dev.
##  lakename (Intercept) 0.6524
##  Residual             3.0820
## Number of obs: 332, groups:  lakename, 4
## Fixed Effects:
## (Intercept)        tp_ug
##     7.75082     -0.04582
```


Dissolved Oxygen vs Total Phosphorus by Lake in Summer
Dissolved Oxygen (mg/L)
15
10
5
0
−5
0
100
200
Total Phosphorus (µg)
Lake Name
East Long Lake
Paul Lake
Peter Lake
West Long Lake


dissolved oxygen (mg/L)
15
10
5
0
2
3
4
5
Log Transformed Total Phosphorus (µg)
Season
spring
summer