Data Analysis Journal II

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Contents

1 Introduction

This document extends the contents of the original Data Analysis Journal begun in 2006.

2 17 Jan 2010 Reanalysis of the Temp Experiment

2.1 Goal

I re analyzed the temperature experiment data without removing the points greater than 2 SD from the mean as was done before. I also analyzed the oxygen concentrations as mmol L^{-1}.

2.2 Data Manipulation

A new R data frame called *Temp.all* was made from a text file called *benthic Q10 17jan10.txt* and **saved in the R *slash* data folder** created from the original Excel file called *benthic Q10 current 2006* **saved in calculations 2006 *slash* current analyses**. This file contains the corrected actual incubation times and none of the outliers are removed. The workspace was saved as *Temp.all* in the **R folder**.

2.3 Stats

2.3.1 Summary Stats

```
> stats(sum.flux, Lake)
                      E4     GTH91        S3
N              36.000000 40.000000 36.000000
mean           13.414919 15.716207 16.882708
Std.Dev.        6.982578  4.551162  3.071423
min            -3.314563  4.462297 11.485027
Q1             10.385049 12.996356 14.687699
median         12.571366 15.327468 16.255202
Q3             15.341793 19.076406 19.118965
max            38.996393 25.515351 22.798704
missing values  0.000000  0.000000  0.000000
```

2.3.2 Correlation of Temperature and Initial Oxygen

Temperature and initial oxygen are significantly correlated and thus cannot be both used as predictor variables in the multiple regression.

```
> cor.test(Temp.C, T0.O2.mmolL)

        Pearson's product-moment correlation

data:  Temp.C and T0.O2.mmolL
t = -4.0376, df = 110, p-value = 0.0001002
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
```

```
 -0.5107707 -0.1861162
sample estimates:
       cor
-0.3592648
```

2.3.3 Analysis of SOD as a function of Temperature and Lake

Since initial oxygen was correlated with temperature only it could not be used in the model and only temperature and Lake are used. There is a significant effect of Temperature and Lake but no interaction between the variables.

```
> anova(lm(sum.flux~Temp.C*Lake))
Analysis of Variance Table

Response: sum_flux
             Df  Sum Sq Mean Sq F value    Pr(>F)
Temp.C        1 1056.15 1056.15 62.4495 2.726e-12 ***
Lake          2  202.81  101.40  5.9960  0.003412 **
Temp.C:Lake   2   17.58    8.79  0.5196  0.596252
Residuals   106 1792.67   16.91
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1

> summary(lm(sum.flux~Temp.C*Lake))

Call:
lm(formula = sum.flux ~ Temp.C * Lake)

Residuals:
     Min       1Q   Median       3Q      Max
-12.1789  -2.0360  -0.1079   1.5846  21.0309

Coefficients:
                 Estimate Std. Error t value Pr(>|t|)
(Intercept)       7.65083    1.35148   5.661 1.30e-07 ***
Temp.C            0.60675    0.12261   4.949 2.83e-06 ***
LakeGTH91         2.09960    1.91899   1.094   0.2764
LakeS3            4.86839    1.94310   2.505   0.0137 *
Temp.C:LakeGTH91 -0.01017    0.17136  -0.059   0.9528
Temp.C:LakeS3    -0.15921    0.17491  -0.910   0.3648
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1

Residual standard error: 4.112 on 106 degrees of freedom
Multiple R-squared: 0.4159,     Adjusted R-squared: 0.3884
F-statistic:  15.1 on 5 and 106 DF,  p-value: 3.520e-11
```

2.3.4 Calculation of the $CI_{95\%}$ of the model evaluating the effect of temperature and lake on SOD

NOTE: This analysis was added 22 June 2010

```
> confint(lm(sum.flux ~ Temp.C * Lake))
                       2.5 %     97.5 %
(Intercept)        4.9713920 10.3302680
Temp.C             0.3636627  0.8498298
LakeGTH91         -1.7049769  5.9041826
LakeS3             1.0160102  8.7207754
Temp.C:LakeGTH91 -0.3499115  0.3295738
Temp.C:LakeS3    -0.5059931  0.1875745
```

3 18 Jan 2010 Oxygen Avaialbility Experiment; Repeated Measures Analysis

3.1 Goal

I reanalyzed the data from the oxygen avaialbiliy experiment with the outliers back in the dataset using R

3.1.1 Data Maipulation

Using the excel file *benthic O2 conc updated 2006* as the starting point I created a txt file *benthic O2 18jan10* save in the R data folder. I removed the 2 observations that were clearly incorrect: GTH 91 Y7 T3 and GTH 91 Y7 T4. The object and workspace are saved as *O2.all*.

To truncate the dataset to the time step where all data were present, I used:

```
O2.trunk <- O2.all[c(1:135),]
```

3.1.2 Repeated Measures Analysis of O2, Lake, and Flux

Using the nlme package I specified the model using the time step as the random variable.

```
> O2.rmtest <- (lme(O2.flux.mmol~mmolO2.L*Lake, random = ~1 | O2.Time.Step,
 na.action=na.omit, data=O2.all))
> anova(O2.rmtest)
              numDF denDF   F-value p-value
(Intercept)       1   131 168.08616  <.0001
mmolO2.L          1   131   8.35259  0.0045
Lake              2   131  13.83037  <.0001
mmolO2.L:Lake     2   131   1.00465  0.3690
```

```
> summary(O2.rmtest)
Linear mixed-effects model fit by REML
 Data: O2.all
       AIC      BIC    logLik
  884.6242 907.9254 -434.3121
Random effects:
 Formula: ~1 | O2.Time.Step
        (Intercept) Residual
StdDev:    1.718605 5.700371

Fixed effects: O2.flux.mmol ~ mmolO2.L * Lake
                       Value Std.Error  DF    t-value p-value
(Intercept)          1.29320  4.197695 131  0.3080750  0.7585
mmolO2.L            52.82877 21.157146 131  2.4969705  0.0138
LakeGTH91          -11.84236  5.945516 131 -1.9918139  0.0485
LakeS3              -2.65702  4.813132 131 -0.5520346  0.5819
mmolO2.L:LakeGTH91  35.99675 27.156010 131  1.3255535  0.1873
mmolO2.L:LakeS3     24.86578 23.618446 131  1.0528118  0.2944
 Correlation:
                   (Intr) mmO2.L LGTH91 LakeS3 mO2.L:LG
mmolO2.L           -0.963
LakeGTH91          -0.425  0.386
LakeS3             -0.566  0.546  0.408
mmolO2.L:LakeGTH91  0.491 -0.487 -0.975 -0.433
mmolO2.L:LakeS3     0.575 -0.592 -0.402 -0.968  0.457

Standardized Within-Group Residuals:
        Min          Q1         Med          Q3         Max
-4.47634775 -0.48087798  0.01920891  0.37571418  4.37721848

Number of Observations: 142
Number of Groups: 6
```

3.1.3 Repeated Measures Analysis of O2, Lake, and Flux using Truncated Data

This analysis is based on the data.frame *O2.trunk* which is limited to those time steps where all three lakes have data.

```
> O2.trunk.rmtest <- (lme(O2.flux.mmol~mmolO2.L*Lake, random = ~1 |
 O2.Time.Step, na.action=na.omit, data=O2.trunk))
> anova(O2.trunk.rmtest)
              numDF denDF   F-value p-value
(Intercept)       1   123 243.09955  <.0001
```

```
mmolO2.L          1   123   7.98394  0.0055
Lake              2   123  11.24230  <.0001
mmolO2.L:Lake     2   123   0.82398  0.4411

> summary(O2.trunk.rmtest)
Linear mixed-effects model fit by REML
 Data: O2.trunk
      AIC      BIC    logLik
  812.741 835.4945 -398.3705

Random effects:
 Formula: ~1 | O2.Time.Step
        (Intercept) Residual
StdDev:    1.432272 5.409612

Fixed effects: O2.flux.mmol ~ mmolO2.L * Lake
                      Value Std.Error  DF    t-value p-value
(Intercept)         2.16481  3.940644 123  0.5493542  0.5838
mmolO2.L           49.81105 19.740292 123  2.5233186  0.0129
LakeGTH91          -9.85773  6.358272 123 -1.5503780  0.1236
LakeS3             -2.62977  4.567293 123 -0.5757836  0.5658
mmolO2.L:LakeGTH91 29.52559 28.119716 123  1.0499961  0.2958
mmolO2.L:LakeS3    24.87486 22.412023 123  1.1098890  0.2692
 Correlation:
                   (Intr) mmO2.L LGTH91 LakeS3 mO2.L:LG
mmolO2.L           -0.965
LakeGTH91          -0.295  0.279
LakeS3             -0.573  0.556  0.364
mmolO2.L:LakeGTH91  0.376 -0.390 -0.977 -0.399
mmolO2.L:LakeS3     0.581 -0.602 -0.355 -0.968  0.418

Standardized Within-Group Residuals:
        Min          Q1         Med          Q3         Max
-4.06310362 -0.50997317 -0.03838316  0.36690219  4.60628365

Number of Observations: 133
Number of Groups: 5
```

3.1.4 Calculation of the $CI_{95\%}$ of the linear model of O2 and SOD in all lakes

NOTE: These analyses were added 22 June 2010

```
> summary(lm(O2.flux.mmol ~ mmolO2.L))
```

```
Call:
lm(formula = O2.flux.mmol ~ mmolO2.L)

Residuals:
     Min       1Q   Median       3Q      Max 
-23.9371  -3.1799  -0.3365   2.4096  24.3386 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept)    2.074      2.224   0.932    0.353    
mmolO2.L      49.453     10.375   4.766 4.91e-06 ***
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1 

Residual standard error: 5.941 on 131 degrees of freedom
  (2 observations deleted due to missingness)
Multiple R-squared: 0.1478,     Adjusted R-squared: 0.1413 
F-statistic: 22.72 on 1 and 131 DF,  p-value: 4.91e-06 

> confint(lm(O2.flux.mmol ~ mmolO2.L))
                2.5 %    97.5 %
(Intercept) -2.326427  6.474508
mmolO2.L    28.928462 69.977627
```

4 21 Jan 2010, Analysis of the DIC and Oxygen flux in the light experiment in the dark cores

4.1 Goal

I reanalyzed the data on the oxygen and DIC flux from the light experiment specifically focusing on the dark cores. I was concerned that the correlation between the DIC and Oxygen flux was due primarily to photosynthesis and therefore not reflecting the ability of SOD to capture carbon mineralization.

4.2 Data Manipulation

I used the BenthicLight.sort data frame in the BenthicLight workspace image. The only manipulation that I made was to multiply the Oflux times -1 to create a column of Oflux.pos which shows the Oflux as positive when oxygen is fluxing into the sediments. This makes it consistent with the other SOD measurements in the paper.

4.3 Cflux as predicted by Oflux.pos in dark cores in both lakes

4.3.1 NOTE on analysis 24 Jan 2010

Note that since I used the CFlux, which is negative and the OFlux.pos which is positive, that the relationship between the variabels is actually negative – i.e., that as DIC flux increases, O flux decreases. I have no idea what this means. I have reanalyzed the relationship with a simple paired-t test below

I ran a linear regression of the Cflux as a fcn of Oflux.pos where the light level was 0. The regression is margianlly significant. The slope of the relationship is 0.81 which converts to a ratio DICflux:SOD of 1.23

```
> summary(lm(Cflux[I.um.==0]~Oflux.pos[I.um.==0]))

Call:
lm(formula = Cflux[I.um. == 0] ~ Oflux.pos[I.um. == 0])

Residuals:
      1       2       3       4       5       6
 1.8170 -3.9260  5.3943 -1.1729 -1.3348 -0.7777

Coefficients:
                      Estimate Std. Error t value Pr(>|t|)
(Intercept)           -44.4243     8.9875  -4.943   0.0078 **
Oflux.pos[I.um. == 0]   0.8101     0.3414   2.373   0.0766 .
---


Residual standard error: 3.591 on 4 degrees of freedom
Multiple R-squared: 0.5846,     Adjusted R-squared: 0.4808
F-statistic:  5.63 on 1 and 4 DF,  p-value: 0.07659
```

4.3.2 Analysis of the DIC and Oxygen flux in each lake in the dark cores

The lack of significance appears to be due to varition in the sediments from lake E-4. The relationship is not significant in the sediments from lake E-4 but essentaily perfect in lake S-3. Furthermore, the DIC flux:SOD is 1.33 which is exactly what you would expect for aerobic respiration of autochthonous sediments.

```
> summary(lm(Cflux[I.um.==0 & Lake=="E-4"]~Oflux.pos[I.um.==0 & Lake=="E-4"]))
```

```
Call:
lm(formula = Cflux[I.um. == 0 & Lake == "E-4"] ~ Oflux.pos[I.um. ==
    0 & Lake == "E-4"])

Residuals:
     1      2      3 
-2.058 -2.367  4.426 

Coefficients:
                                      Estimate Std. Error t value Pr(>|t|)
(Intercept)                            -62.390     27.069  -2.305    0.261
Oflux.pos[I.um. == 0 & Lake == "E-4"]    1.616      1.137   1.421    0.390

Residual standard error: 5.425 on 1 degrees of freedom
Multiple R-squared: 0.6688,	Adjusted R-squared: 0.3377 
F-statistic:  2.02 on 1 and 1 DF,  p-value: 0.3904 

> summary(lm(Cflux[I.um.==0 & Lake=="S-3"]~Oflux.pos[I.um.==0 & Lake=="S-3"]))

Call:
lm(formula = Cflux[I.um. == 0 & Lake == "S-3"] ~ Oflux.pos[I.um. ==
    0 & Lake == "S-3"])

Residuals:
        1         2         3 
-0.008136  0.005585  0.002551 

Coefficients:
                                       Estimate Std. Error t value
(Intercept)                           -43.976166   0.039271 -1119.8
Oflux.pos[I.um. == 0 & Lake == "S-3"]   0.755610   0.001372   550.8
                                      Pr(>|t|)    
(Intercept)                           0.000569 ***
Oflux.pos[I.um. == 0 & Lake == "S-3"] 0.001156 ** 
---


Residual standard error: 0.01019 on 1 degrees of freedom
Multiple R-squared:     1,	Adjusted R-squared:     1 
F-statistic: 3.034e+05 on 1 and 1 DF,  p-value: 0.001156 
```

5 24 Jan 2010; Analysis of the difference in magnitude of oxygen and DIC flux from the dark cores of the light exp

5.1 Goal

In order to assess the relationship between SOD and DIC flux I tested to see if there was a difference in the DIC flux and SOD in the dark cores of the light experiment.

5.2 Data and Data Manipulation

The data in the BenthicLight workspace and the BenthicLight.sort data frame were used without modification.

5.3 Paired t-test of the Cflux and Oflux in the dark cores of the light experiment

A paired t-test was used because the SOD and DIC flux measurements were taken on the same cores. The analysis shows no significant difference between the DIC and SOD flux of the dark cores.

```
> t.test(Cflux[I.um.==0], Oflux[I.um.==0], paired=T)

Paired t-test

data:  Cflux[I.um. == 0] and Oflux[I.um. == 0]
t = 0.6963, df = 5, p-value = 0.5173
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -6.962656 12.135786
sample estimates:
mean of the differences
               2.586565
```

6 25 Jan 2010; Slope Determination for the depth by area realtionship in the lakes

6.1 Goal

In order to quantify how much the surface area of the lake above the thermocline would change with changing thermocline depth, I calculated the slope of the depth by cumultive area reationship for each lake.

6.2 Data Manipulation

I used the data in the *bathy* workspace in R and the *bathy* data frame. The data were unmanipulated

6.3 Calculation of the depth by cumulative area for each lake

For lakes E-4 and S-3, I ln transformed the Cum.Area variable to get a better fit. Cum.Area is in m^2

```
> summary(lm(log(Cum.Area[Lake=="E4"])~Zbelow[Lake=="E4"]))

Call:
lm(formula = log(Cum.Area[Lake == "E4"]) ~ Zbelow[Lake == "E4"])

Residuals:
       1        2        3        4        5 
-0.15841  0.21824 -0.03881  0.05655 -0.07757 

Coefficients:
                     Estimate Std. Error t value Pr(>|t|)    
(Intercept)          10.74849    0.12918   83.20 3.83e-06 ***
Zbelow[Lake == "E4"] -0.77741    0.05274  -14.74 0.000677 ***
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1 

Residual standard error: 0.1668 on 3 degrees of freedom
Multiple R-squared: 0.9864,Adjusted R-squared: 0.9818 
F-statistic: 217.3 on 1 and 3 DF,  p-value: 0.0006773 


> summary(lm(log(Cum.Area[Lake=="S3"])~Zbelow[Lake=="S3"]))

Call:
lm(formula = log(Cum.Area[Lake == "S3"]) ~ Zbelow[Lake == "S3"])

Residuals:
       1        2        3        4        5 
-0.25690  0.28465  0.09562 -0.01756 -0.10580 

Coefficients:
                     Estimate Std. Error t value Pr(>|t|)    
(Intercept)          10.90121    0.18312   59.53 1.04e-05 ***
```

```
Zbelow[Lake == "S3"] -0.91777    0.07476  -12.28  0.00116 **
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1

Residual standard error: 0.2364 on 3 degrees of freedom
Multiple R-squared: 0.9805,Adjusted R-squared: 0.974
F-statistic: 150.7 on 1 and 3 DF,  p-value: 0.001164
```

NOTE Cum.Area is not ln transformed for GTH 91

```
>
> summary(lm(Cum.Area[Lake=="GTH91"]~Zbelow[Lake=="GTH91"]))

Call:
lm(formula = Cum.Area[Lake == "GTH91"] ~ Zbelow[Lake == "GTH91"])

Residuals:
    Min      1Q  Median      3Q     Max
-1844.0 -1313.0  -223.2  1132.1  3213.4

Coefficients:
                        Estimate Std. Error t value Pr(>|t|)
(Intercept)              21906.1      956.2   22.91 2.73e-09 ***
Zbelow[Lake == "GTH91"]  -2263.5      161.6  -14.01 2.04e-07 ***
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1

Residual standard error: 1695 on 9 degrees of freedom
Multiple R-squared: 0.9561,Adjusted R-squared: 0.9513
F-statistic: 196.1 on 1 and 9 DF,  p-value: 2.044e-07
```

7 12 March 2010 Estimation of proportion of water column to sediment oxygen demand in hypolimnion IGNORE THIS. SEE 29 JUN 2010

7.1 Goal

Using the relationship in LivingstoneandImboden1996 to estimate the relationship between SOD, water column oxygen demand and lake morphometry:

$J(z) = J_v(z) + J_A(z)\alpha(z)$

Where $J(z)$ is the total hypolimnetic oxygen demand, $= J_v(z)$ is the oxygen consumption of the water column $J_A(z)$ is the SOD and $\alpha(z)$ is the ratio of sediment area and water volume at that depth.

Based on this relationship the contribution of SOD to total hypolimnetic oxygen loss is proportional to the ratio of sediment area to volume at that depth. As such the ratio of the hypolimnion would give some indication of the impact of the sediments on the hypolimnetic oxygen loss.

7.2 Data Analysis

Using the LakeProf workspace I calculated the uppermost depth of the hypolimnion using the definition of a $< 1^{o}m^{-1}$ WetzelandLikens2001. Using this threshold I calculate the area weighted sediment area:lake volume for the whole hypolimnion as the sum of the sediment area:lake volume * the proportion of the lake sediment area for each 1 m depth slice.

7.3 Results

For the shallow lakes the ratio was always equal to 1, which means that in the shallow lakes the water column and sediments contribute equally to the hypolimnetic oxygen loss: $J_v(z)/(J_v(z)+(J_A(z)\alpha(z)$ or $1/(1+(1*1)) = 0.5$ For GTH 91, the ratio ranged between 0.024 and 0.057. The ratio increased as the summer progressed due to the deepening of the thermocline. In GTH 91 this means that the sediments contribute between 2 and 5% of the total hypolimnetic loss.

8 24 March 2010; Calculate Area-weighted temperatures and oxygen conc. in the Intensive Lakes

8.1 Goal

Previously I had calculated a mean temperature for the epi and hypolimnia of the intensive lakes for each of the dates with profiles. This however did not take into account the variation in the area that each depth strata occupied so I have now weighted each temperature by the area of the sediments in that depth strata.

8.2 Data Manipulation

in R workspace = LakeProf this workspace already contained an object "bathy" that had all of the bathy data in it.

I merged these data.frames for each lake separately based on the depth "Z.m" of the observation. This created the data.frames "E4.tot", "S3.tot" and "GTH91.tot" in the "LakeProf" workspace. Note that the depth resolution of the bathy data was only whole meters so the half meter resolution of the temp data was converted to whole meter resolution. Example code:

```
>E4.tot <- merge(E4.prof, E4.bathy, by.x="Z.m", by.y="Zbelow")
```

8.3 Calculations

To calculate the area-weighted averages of the temperature in the epi and hypolimnia of the lakes I used the following formula:

$t_{mean} = \Sigma(t_z(\frac{A_z}{A_{tot}}))$ where:

- t_{mean} = the area weighted averaged temperature of the epi or hypolimnion
- t_z = the temperature (dC) at depth z
- A_z = the sediment area at depth z in m^2
- A_{tot} is the total sediment area of the epi or hypolimnion

Sample Code in R:

```
> sum(Temp[Julian == 203 & Year == 2008 & Z.m <= 3]
 * (Area.m2[Julian == 203 & Year == 2008 & Z.m <=3]
/sum(Area.m2[Julian == 203 & Year == 2008 & Z.m <= 3])))
```

8.4 Results

The results are in tables table/waterprofshallow.tex and table/waterprofdeep.tex

The same calculations were applied to the oxygen concentration (mgO2.L).

9 9 June 2010: Analysis of Sediment OM by Till in the Sed Survey

9.1 Goal

Since there was a significant correlation between the distance between the lakes and the percent OM of the sediments, I looked for patterns in the spatial layout of the lakes. One pattern that emerges is that some of the lakes are on an older glacial surface (sd) and some are on a younger glacial surface (id) based on Hamilton 2002.

9.2 Data Manipulation

Using the ws_area workspace in /R_working and the survey_ws data.frame, I added a column called Till.

The designations in Till are derived from whether the lake iself was on one of the Itikillik Glacial surfaces (id) or the Sagavanirktok Glacial Surfaces (sd).

In all cases but 3 the lakes were completely within a single surface as is much of the surrounding area so likely most of their watershed is too.

The exceptions are:

1. S-3 is listed as being on the subglacial meltwater deposits of the Itkillik glaciation so this lake was added to id
2. GTH 98 is completley in the sd surface but directly adjacent to the Itkillik outwash so some of its watershed may be in this younger material
3. GTH 110 is partailly in solifluction deposits and partially in sd. This lake was included in the sd group

9.3 The effect of Till on mean and surface percent organic matter in the sediments

All relationships were assessed with Kruskal-Wallis Tests due to non-homogeneity of variance in some tests:

9.3.1 Mean Percent OM in the Shallow Samples

```
> kruskal.test(mean_perc_OM[Depth == "epi"], Till[Depth == "epi"])

        Kruskal-Wallis rank sum test

data:  mean_perc_OM[Depth == "epi"] and Till[Depth == "epi"]
Kruskal-Wallis chi-squared = 11.6667, df = 1, p-value = 0.0006363
```

9.3.2 Mean Percent OM in the Deep Samples

```
> kruskal.test(mean_perc_OM[Depth == "hypo"], Till[Depth == "hypo"])

        Kruskal-Wallis rank sum test

data:  mean_perc_OM[Depth == "hypo"] and Till[Depth == "hypo"]
Kruskal-Wallis chi-squared = 4.3214, df = 1, p-value = 0.03764
```

9.3.3 Surface Percent OM in the Shallow Samples

```
> kruskal.test(est_surf_OM[Depth == "epi"], Till[Depth == "epi"])

        Kruskal-Wallis rank sum test

data:  est_surf_OM[Depth == "epi"] and Till[Depth == "epi"]
Kruskal-Wallis chi-squared = 10.9275, df = 1, p-value = 0.0009474
```

9.3.4 Surface Percent OM in the Deep Samples

```
> kruskal.test(est_surf_OM[Depth == "hypo"], Till[Depth == "hypo"])

        Kruskal-Wallis rank sum test

data:  est_surf_OM[Depth == "hypo"] and Till[Depth == "hypo"]
Kruskal-Wallis chi-squared = 4.3214, df = 1, p-value = 0.03764
```

9.3.5 Loss of OM with Age in the Shallow Samples

NOTE: updated 30 June 2010; used correct loss data.

```
> kruskal.test(perc.OM.y[Depth == "epi"] ~ as.factor(Till[Depth == "epi"]))

        Kruskal-Wallis rank sum test

data:  perc.OM.y[Depth == "epi"] by as.factor(Till[Depth == "epi"])
Kruskal-Wallis chi-squared = 0.672, df = 1, p-value = 0.4123
```

9.3.6 Loss of OM with Age in the Deep Samples

NOTE: updated 30 June 2010; used correct loss data.

```
> kruskal.test(perc.OM.y[Depth == "hypo"] ~ as.factor(Till[Depth == "hypo"]))

        Kruskal-Wallis rank sum test

data:  perc.OM.y[Depth == "hypo"] by as.factor(Till[Depth == "hypo"])
Kruskal-Wallis chi-squared = 0.0374, df = 1, p-value = 0.8466
```

10 10 June 2010: Analysis of the %PAR and [DO] in the sediment survey lakes based on Till

10.1 Goal:

There is significantly greater percent OM in the sediments of the lakes on the younger surface. Since all of my results suggest that differences in sed OM are related to differences in benthic primary production and benthic PPR is thought to be limited by light, I analyzed the light environment based on the Till to see if there was a significant difference.

10.2 Data Manipulation

I used the ws_area workspace in /R_working and the survey_ws data.frame.

10.3 The effect of Till on % PAR

Since light essentially did not penetrate to the deep samples, I only analyzed this relationship for the shallow (epi) samples.

10.3.1 Summary Stats for %PAR by Till

```
  > stats(perc_PAR[Depth == "epi"], by=Till[Depth == "epi"])
                      id        sd
N                7.00000  5.000000
mean            24.52857  5.934000
Std.Dev.        17.00448  4.763841
min              5.50000  0.440000
Q1              13.75000  2.400000
median          20.90000  5.430000
Q3              30.40000  9.600000
max             57.00000 11.800000
missing values   4.00000  2.000000
```

10.3.2 Kruskal-Wallis Test of perc_PAR by Till in the Shallow samples

Since there was not homogeneity of variance in the samples, I used a K-W test instead of ANOVA

```
  > kruskal.test(perc_PAR[Depth == "epi"], Till[Depth == "epi"])

        Kruskal-Wallis rank sum test

data:  perc_PAR[Depth == "epi"] and Till[Depth == "epi"]
Kruskal-Wallis chi-squared = 6.3363, df = 1, p-value = 0.01183
```

10.4 The effect of Till on DO Concentration

10.4.1 Summary Stats for DO by Till

Shallow Samples

```
  > stats(DO_mgL[Depth == "epi"], by=Till[Depth == "epi"])
                       id       sd
N               7.000000 3.000000
```

```
mean             9.890000 7.376667
Std.Dev.         1.864949 1.065192
min              7.300000 6.300000
Q1               8.965000 6.850000
median          10.000000 7.400000
Q3              10.350000 7.915000
max             13.300000 8.430000
missing values   4.000000 4.000000
```

Deep Samples

```
> stats(DO_mgL[Depth == "hypo"], by=Till[Depth == "hypo"])
                      id       sd
N               5.000000 3.000000
mean            4.180000 4.806667
Std.Dev.        2.586590 3.081580
min             0.700000 1.400000
Q1              2.630000 3.510000
median          4.370000 5.620000
Q3              6.100000 6.510000
max             7.100000 7.400000
missing values  2.000000 1.000000
```

10.4.2 Kruskal-Wallis Test of DO_mgL by Till in the Shallow Samples

Although the variance is similar between groups for DO, I used the K-W test for consistency

```
> kruskal.test(DO_mgL[Depth == "epi"], Till[Depth == "epi"])

        Kruskal-Wallis rank sum test

data:  DO_mgL[Depth == "epi"] and Till[Depth == "epi"]
Kruskal-Wallis chi-squared = 3.7761, df = 1, p-value = 0.05199
```

10.4.3 Kruskal-Wallis Test of DO_mgL by Till in the Deep Samples

```
> kruskal.test(DO_mgL[Depth == "hypo"], Till[Depth == "hypo"])

        Kruskal-Wallis rank sum test

data:  DO_mgL[Depth == "hypo"] and Till[Depth == "hypo"]
Kruskal-Wallis chi-squared = 0.2, df = 1, p-value = 0.6547
```

11 17 June 2010: Reanalysis of DIC flux by percent OM in the bioassay

11.1 Goal

The oringinal analysis of the DIC flux by percent organic matter was done using data so the DIC flux was in the wrong units.

This analysis replaces the previous analysis.

11.2 Data Manipulation

Using the DIC.bioassay workspace in /R_working I created a new data.frame called treat.means that contained the mean DIC flux for each treatment and each lake. In this data.frame the DIC flux is in μg DIC (g organic matter)$^{-1}$ h^{-1}.

11.3 Results

The relationship between avg.Mean.flux.OM and percOM was determined with a linear model.

avg.Mean.flux.OM is the DIC flux (mean of T1 and T2) averaged across treatments in μg DIC (g organic matter)$^{-1}$ h^{-1}.

percOM is the percent organic matter in the sediment slurry

```
> summary(lm(avg.Mean.flux.OM ~ percOM))

Call:
lm(formula = avg.Mean.flux.OM ~ percOM)

Residuals:
   Min     1Q Median     3Q    Max
-7.549 -3.900 -2.173  4.253 11.469

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -11.3037     7.6343  -1.481   0.1892
percOM        0.6735     0.1796   3.751   0.0095 **
---

Residual standard error: 6.892 on 6 degrees of freedom
Multiple R-squared: 0.701,      Adjusted R-squared: 0.6512
F-statistic: 14.07 on 1 and 6 DF,  p-value: 0.009502
```

12 17 June 2010: Calculate the time required to mineralize the amount of OM lost in 10 cm of the intensive lake sediments based on the mean SOD of the Q10 exp and the stoich of aquatic and terrestrial OM

12.1 Goal

The previous calculations of the time requred to mineralize the measured OM loss in the intensive lakes ignored the stoichiometry of the organic matter and treated SOD:OM mineralization as 1:1. These calculations take this into account using the O_2:DIC and OM stoichiometry from table 1 in Torgersen and Branco 2007 (JGR 112: G03016).

12.2 Data Manipulation

Using the int_OM workspace in /R_working and the time_est data.frame:

I created new variables called **est.aquat.d** which is the time in days to mineralize the OM lost from 10 cm in the cores of the intensive lakes based on the mean SOD from the temperature experiments if all of the OM was aquatic in orign.

est.aquat.d = delta_OM_mmolm2 / ((15.35 * 0.77) * 1.16) where delta_OM_mmolm2 is the change in organic matter from the 0-1 cm slice to the 9-10 cm slice of the core in mmol OM m^{-2}, 15.35 is the mean SOD from the temperature experiment in mmol O_2 m^{-2} d^{-1}, 0.77 is the O_2:DIC of aquatic organic matter mineralization, and 1.16 is the OM:C of aquatic OM. Ratios come from Torgersen and Branco 2007.

I also created I created new variables called **est.terr.d** which is the time in days to mineralize the OM lost from 10 cm in the cores of the intensive lakes based on the mean SOD from the temperature experiments if all of the OM was terrestrial in orign.

est.terr.d = delta_OM_mmolm2 / ((15.35 * 0.98) * 1.01) where delta_OM_mmolm2 is the change in organic matter from the 0-1 cm slice to the 9-10 cm slice of the core in mmol OM m^{-2}, 15.35 is the mean SOD from the temperature experiment in mmol O_2 m^{-2} d^{-1}, 0.98 is the O_2:DIC of aquatic organic matter mineralization, and 1.01 is the OM:C of aquatic OM. Ratios come from Torgersen and Branco 2007.

These variables were added to the time_est data.frame in int_OM in /R_working

12.3 Results

12.3.1 Mean time to mineralize aquatic OM in each lake

removed the negative result from the means calculations ([-5])

```
> stats(est.aquat.d[-5], by = Lake)
                     E-4   GTH 91       S-3
N               24.00000   5.0000  23.00000
mean           233.54894 173.2219 218.13300
Std.Dev.        91.67875  90.0679 151.22655
min             59.42043 100.5254  28.47152
Q1             146.07412 100.9094 117.12494
median         264.76478 167.3503 160.78092
Q3             291.25924 176.1429 275.19846
max            404.70648 321.1814 512.00191
missing values   0.00000   1.0000   1.00000
```

12.3.2 Mean time to mineralize terrestrial OM in each lake

removed the negative result from the means calculations

```
> stats(est.terr.d[-5], by = Lake)
                     E-4    GTH 91       S-3
N               24.00000   5.00000  23.00000
mean           210.75562 156.31621 196.84421
Std.Dev.        82.73132  81.27768 136.46752
min             53.62127  90.71455  25.69283
Q1             131.81795  91.06109 105.69408
median         238.92493 151.01769 145.08943
Q3             262.83366 158.95217 248.34034
max            365.20896 289.83554 462.03284
missing values   0.00000   1.00000   1.00000
```

13 23 June 2010: Correlation of the surface area and volume in the complete list of bathymetry lakes

13.1 Goal

Generate a lake surface area by volume correlation to extrapolate to the lakes without complete bathymetry but with surface area measurements.

13.2 Data Manipulation

Using the bathy_summary data in R_working/data I made the bathy.summary object in R_working and created a new data.frame named Area.Vol which contained the surface area of each lake (Surf.Area.m2 = max Cum.Area) in m^2 and the volume (Vol.m3 = sum Cum.Area) in m^3.

```
> Area.Vol
          Lake Surf.Area.m2     Vol.m3
1           E1     31695.85  339548.59
2           E4     39738.34  155908.97
3          EX1     11292.25   76325.80
4       GTH110     81901.97  523892.35
5       GTH153     47178.12  254320.02
6       GTH155      5269.63   37400.76
7       GTH157     32677.66  209665.08
8       GTH158     45781.33  369893.68
9        GTH85     38195.56  362872.17
10       GTH86     34163.65  290276.27
11       GTH90    175841.82  794714.32
12       GTH91     25119.51  184959.79
13       GTH98     66290.10  521348.17
14     I minus    352858.24 3361014.78
15 Island Lake    664004.89 6548591.42
16          N3     10174.67   46681.92
17        NE10     20501.09   86366.90
18        NE14    262400.49 3477645.88
19          S3     41952.88  166806.47
20          S7      9727.42  108555.31
```

13.2.1 Correlation Analysis

```
> cor(Vol.m3, Surf.Area.m2)
[1] 0.9825636
```

14 26 June 2010: Analyze Oxygen Experiment using Diagenetic Model from Bouldin 1968

14.1 Goal:

Bouldin 1968 describes the flux of oxygen into the sediments using the model:

$\frac{dC}{dt} = D_s \frac{d^2C}{dx^2} - R = 0$

which can be solved for oxygen flux (SOD) as:

$SOD = \phi^2(2RD_oC_o)^{1/2}$

since C_o is unknown it is estimated using a linear function (k) of the oxygen concentration of the overlying water (C_b); assuming a constant diffusive boundary layer:

$SOD = \phi^2(2RD_okC_b)^{1/2}$
Where:

1. C = the oxygen concentration
2. t = time
3. x = depth below the sediment water interface
4. D_s = the sediment diffusion coefficent
5. R = the zero-order oxygen consumption rate
6. SOD = the flux of oxygen into the sediments
7. ϕ = the porosity
8. D_o = the molecular diffusion coefficent for oxygen
9. C_o = the oxygen concentration at the sediment water interface
10. C_b = the oxygen concentratio of the overlying water
11. k = a linear relationship between C_o and C_b

Since everything but k and R are known they can be fit to the exisitng data using a non-linear fit.

14.2 Data Manipulation

For some reason the original workspace of O2.all provides an error based around the nmle package, I created a new workspace called O2.new which contains the same data.frame *O2.trunk* created as:

```
O2.trunk <- O2.all[c(1:135),]
```

and saved in the R_working folder.

14.2.1 Mean Porosity

The mean porosity of the cores collected in 2008 was calculated from the porosity.2008 data.frame in the porosity workspace and saved as Mean.porosity data.frame. The epi samples were clipped from mean.porosity and merged with the O2.trunk data.frame in the O2.new workspace and saved as the O2.trunk data.frame – all saved in the O2.new workspace in R_working.

15 28 June 2010: Calculate Sediment Age Based on ^{137}Cs

15.1 Goal

After discussing the Pb-210 data with Marc Alperin, we decided that the presence of Cs-137 in the deeper parts of the core indicated that the sediments were mixed down to the base of the 10 cm core. This mixing invalidates the use of Pb-210 for sediment dating. The Cs-137 profile can still provide information however since even though the mixing spreads the peak and moves the peak downward the maximum value still provides a minimum age (i.e., and maximum sedimentation rate) for the sediments.

15.2 Data Manipulation

I used the pb.210.summary and the porosity.2008 data.frames in the int_OM and the porosity workspace in R_working. Both were saved under the int_OM workspace.

I added the bulkden.gml object to the porosity.2008 data frame which contains the bulk density of the sediments (g ml^{-1}) calculated as drysed.g/18.096 where drysed.g is the dry sediment mass of the sediments in the slice in grams and 18.096 is the volume of the slice in ml.

15.3 Results: Using Eq. from Sykes and Ramsay 1995 – NOT IN DISSERTATION SEE BELOW

15.3.1 Lake E–4

The maximum Cs-137 activity was at a depth of 4 and 5 cm below the sed-water interface.

```
> cbind(as.data.frame(z.below[Lake == "E-4"]), as.data.frame(Cs.137.dpm.g[Lake == "E-4"]))
   z.below[Lake == "E-4"] Cs.137.dpm.g[Lake == "E-4"]
1                       0                    7.018489
2                       1                    9.764716
3                       2                   11.832313
4                       3                   13.343688
5                       4                   14.476816
6                       5                   14.405853
7                       6                   11.644189
8                       7                    8.241446
9                       8                    5.987022
10                      9                    3.832180
```

The presence of Cs-137 activity down to the base of the core indicates that the core is mixed down to its base.

I am assuming the peak Cs-137 activity is associated with sediments deposited in 1963 (± 2 years). The cores were collected in 2008 so the peak represents an age or 43 to 47 years ago and 5 cm of sediment has accumulated in about 45 years.

This yields a sedimentation rate of 6 cm (45 y)$^{-1}$ or 0.13 cm y^{-1}.

The average mass sedimentation rate for the core can be calculated as:

$$R = \frac{T[BD_{wet} - (\phi WD)]}{t}$$

Where:

- R = the mass accumulation rate in g cm^{-2} y^{-1}
- T = the thickness of the sediment layer accumulated in time t
- BD_{wet} = the wet bulk density in g ml^{-1}
- ϕ = the porosity
- WD = the density of the water
- t = the time to accumulate T

Using the dry bulk density (BD_{dry}) this would simplify to:

$$R = \frac{T \cdot BD_{dry}}{t}$$

The mean bulk density of the sediments where these cores were collected is:

```
> stats(bulkden.gml[Depth == "H"], by = Lake[Depth == "H"])
                   GTH 114         E-4         S-3      GTH 91
N              20.00000000 40.00000000 40.00000000 40.00000000
mean            0.10909649  0.05300909  0.04705902  0.14977523
Std.Dev.        0.02288348  0.01383286  0.01327729  0.04162628
min             0.05522215  0.02564103  0.01839633  0.04655172
Q1              0.09646745  0.04307858  0.03999917  0.13496767
median          0.10872016  0.05282107  0.04895281  0.16435124
Q3              0.12198967  0.06177608  0.05598475  0.17730023
max             0.15292330  0.08432803  0.07235853  0.20561450
missing values  0.00000000  0.00000000  0.00000000  0.00000000
```

For Lake E–4 the relationship is:
$R = \frac{10 \cdot 0.053}{77} = 0.0069 g cm^{-2} y^{-1}$

Where $T = 10$ and t was calculated as $(\frac{S}{z})^{-1} = (\frac{0.13}{10})^{-1} = 76.9y$

Where S = the sedimentation rate in cm y^{-1} and z = the depth of the core in cm.

15.3.2 Lake S–3

The presence of Cs-137 activity all the way to the depth of the core indicates that the core was mixed to its whole length.

The Cs-137 activity for lake S–3 peaks at 4 cm below the sediment-water interface so the sedimentation rate is:

4 cm (45 y)$^{-1}$ = 0.089 cm y^{-1}

```
  > cbind(as.data.frame(z.below[Lake == "S-3"]), as.data.frame(Cs.137.dpm.g[Lake == "S-3"]))
   z.below[Lake == "S-3"] Cs.137.dpm.g[Lake == "S-3"]
1                       0                    3.200559
2                       1                    6.075896
3                       2                    8.027559
4                       3                    7.945228
5                       4                          NA
6                       5                    7.146869
7                       6                    5.992436
8                       7                    4.311119
9                       8                    3.067520
10                      9                    1.796047
```

For Lake S–3 the relationship is:
$R = \frac{10 \cdot 0.047}{112} = 0.0042 g cm^{-2} y^{-1}$

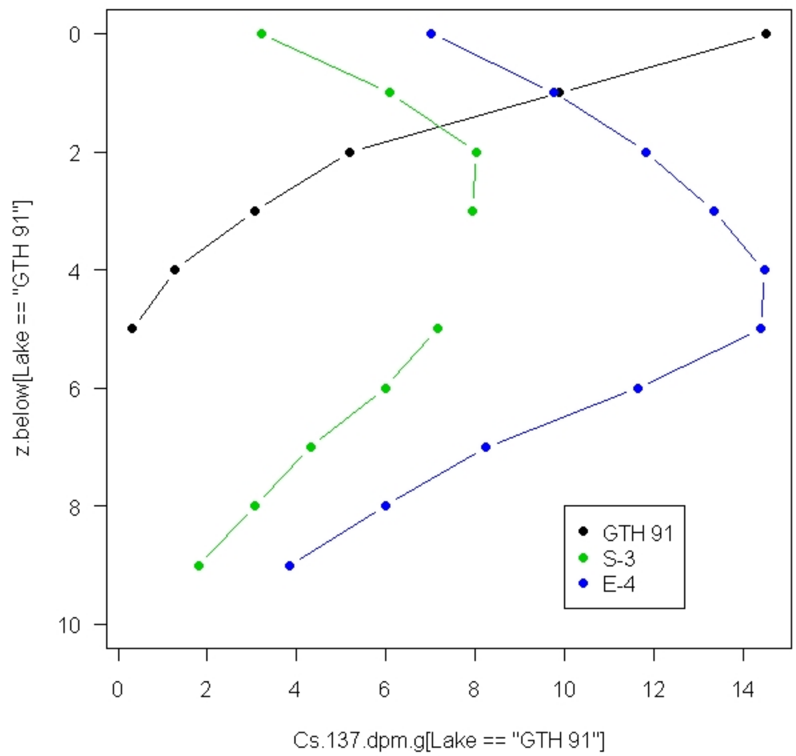
Where $T = 10$ and t was calculated as $(\frac{S}{z})^{-1} = (\frac{0.089}{10})^{-1} = 112y$

15.3.3 Lake GTH 91

The peak in Cs-137 activity is in the uppermost section of the core suggesting either a very low sedimentation rate of disruption of the core profile.

```
  > cbind(as.data.frame(z.below[Lake == "GTH 91"]), as.data.frame(Cs.137.dpm.g[Lake == "GTH
  z.below[Lake == "GTH 91"] Cs.137.dpm.g[Lake == "GTH 91"]
1                         0                     14.5268123
2                         1                      9.8909088
3                         2                      5.1988207
4                         3                      3.0642893
5                         4                      1.2726004
6                         5                      0.3168519
7                         6                             NA
8                         7                             NA
```

15.3.4 Cs-137 activity figure



15.4 Results: Using Eq. from Berner 1980

This relationship is:

$$R = dw(1 - \phi)$$

Where:

- R = mass sedimentation rate in g cm^{-2} y^{-1}
- d = the mean density of the solid material in the sediment
  - for all lakes I am assuming the $d = 2.0$, since clastic sediments = 2.5 and my sediments are more organic.
- w = the sedimentation rate in cm y^{-1}
- ϕ = the mean porostiy of the sediment core

15.4.1 Lake E–4

For Lake E–4:

- $w = 0.13$ cm y^{-1}
- $\phi = 0.98$

Thus:

$R = 2.0 \cdot 0.13 \cdot (1 - 0.98) = 0.0052gcm^{-2}y^{-1}$

15.4.2 Lake S–3

For Lake E–4:

- $w = 0.089$ cm y^{-1}
- $\phi = 0.98$

Thus:

$R = 2.0 \cdot 0.089 \cdot (1 - 0.98) = 0.0036gcm^{-2}y^{-1}$

16 29 June 2010: Recalculation of Percent Contribution of SOD to Hypolimnetic Oxygen Demand in GTH 91

16.1 Goal

16.2 Data Analysis

Based on Livingstone D. M., and Imboden D. M. 1996. The prediction of hypolimnetic oxygen profiles: a plea of a deductive approach. Canadian Journal of Fisheries and Aquatic Sciences. 53: 924-932.

Using the bath.summary workspace I created the GTH91.bathy data.frame from the bathy.summary data.frame in the R_working dir. I added Cum.Sed.Area.m2 to GTH91.bathy as the surface area of the complete sediments below that depth. Cum.Sed.Area.m2 was calculated as the sum of Area.m2 for all the depths below each depth. Vol.m3 was also added to GTH91.bathy and was calculated as Cum.Sed.Area.m2 multiplied by the thickness of the slice. The thickness was always 1.

16.2.1 Estimation of q and $\alpha(z)$ from Livingstone and Imboden 1996

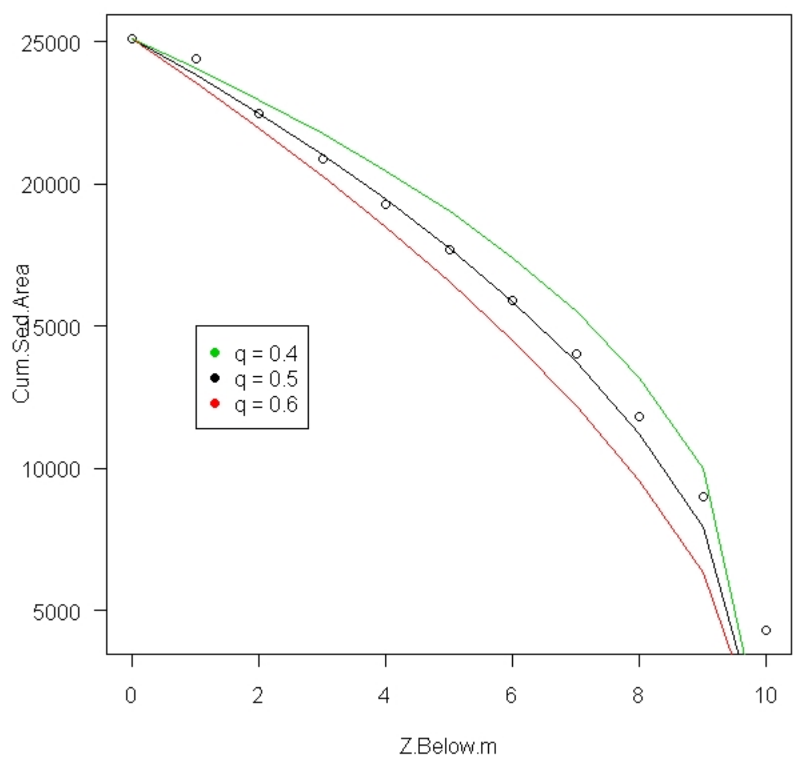
Eq 3 shows that the hyposgraphic curve can be estimated using the fcn:

$A(z) = A_o(1 - z/z_m)^q$

Where:

- $A(z)$ = the relationship between sediment area and depth
- A_o = the surface area of the lake
- z/z_m = the ratio of depth to maximum depth in m
- q = is a nondimentional exponent

I estimated q graphically to be 0.5:



16.2.2 Calculation of $\alpha(z)$

Equation 4 shows:

$\alpha(z) = \frac{q}{(z_m - z)}$
Where:

- z = depth in m
- z_m = maximum depth in m

For GTH 91:

```
> cbind(as.data.frame(Z.Below.m), as.data.frame(alpha.z))
   Z.Below.m    alpha.z
1          0 0.05000000
2          1 0.05555556
3          2 0.06250000
4          3 0.07142857
5          4 0.08333333
6          5 0.10000000
7          6 0.12500000
8          7 0.16666667
9          8 0.25000000
10         9 0.50000000
11        10        Inf
```

16.2.3 Estimation of Total Hypolimnetic Oxygen Consumption

Using oxygen concentration data collected on Julian days 207 and 213 in 2006 for depths 6, 7, and 8 m in GTH 91 (GTH91.tot data.frame in LakeProf workspace). These ranges were used because they showed similar trends at all 3 depths.

Change in Oxygen (mg O_2 L^{-1}) in GTH 91 Hypolimnion:

Z(m)	[O2] on 207	[O2] on 213	Δ[O2]	Δd	Δ[O2] d^{-1}
6	7.31	6.92	0.39	6	0.065
7	6.70	5.95	0.75	6	0.125
8	4.9	4.3	0.6	6	0.1
				Mean	0.097
				SD	0.030

16.2.4 Calculation of Water Column Oxygen Consumption

Based on Livingstone and Imboden 1996

$J_{V(z)} = J_z - J_{A(z)}\alpha(z)$
Where:

- $J_{V(z)}$ = the water column oxygen consumption at depth z (mmol O_2 d^{-1})

- J_z = the total hypolimnetic oxygen consumption at depth z (mmol O_2 d^{-1})
- $J_{A(z)}$ = the sediment oxygen consumption at depth z (mmol O_2 L^{-1} d^{-1})
- $\alpha(z)$ = the scaling fcn relating the lake area:vol

For lake GTH 91:

Z (m)	HOD (mmol O_2 m^{-3} d^{-1})	Vol (m^3)	J_z (mmol O_2 d^{-1})	SOD (mmol O_2 m^{-2} d^{-1})	Area (m^2)	$J_{A(Z)}$ (mmol O_2 d^{-1})	$\alpha(z)$	$J_{V(z)}$ (mmol O_2 d^{-1})	$\frac{J_{A(z)}}{J_z}$
6	5.4	7441	40181	12.8	1603	20518	0.13	37514	0.51
7	5.4	5838	31525	12.8	1614	20659	0.17	28013	0.66
8	5.4	4221	22793	12.8	1585	20288	0.25	17721	0.89
9	5.4	2638	14254	12.8	1942	24858	0.5	1825	1.7

To estimated the SOD in lake GTH 91 at hypolimnetic temperatures I used the relationship between temperature and SOD from the temperature dependence experiment:

$y = 0.61x + 7.65 + 2.1 = 0.61 \cdot 5 + 7.65 + 2.1 = 12.8$ mmol O_2 m^{-2} d^{-1} (see pg 5)

17 30 June 2010: Recalculate the Loss of Perc. OM with age based on the new ages of the lakes

17.1 Goal:

The ages of the lakes were recalculated using the Cs-137 instead of the Pb-210 so the the slope of the loss of OM with y has to be recalculated to reflect the new ages.

17.2 Data Manipulation

Using the survey workspace in the OM.models data.frame

I removed the perc.OM.yr and cm.yr.slope columns from the survey data.frame. I made a new variable perc.OM.y based on the mean sediment accumulation rate from the Cs-137 in lakes E-4 and S-3 of 0.11 cm y^{-1}. I multiplied the loss of OM by cm (perc.OM.slope) by 0.11 to give the loss in perc OM y^{-1} and added this to the survey workspace.

17.3 Results

```
  > stats(perc.OM.y)
                      [,1]
N               33.0000000
mean            -0.1113207
Std.Dev.         0.1334058
min             -0.5907000
Q1              -0.1532300
median          -0.0814000
Q3               0.0000000
max              0.0627000
missing values   0.0000000
```

18 30 June 2010: Reanalysis of Factors affecting loss of OM with age in the survey sediments using the new rate of loss based on the new ages

18.1 Goal

Since the loss of OM with age was recalculated based on the new sediment ages using Cs-137 (see above) the analysis of the factors affecting OM loss with age need to be redone.

18.2 Data Manipulation

Use survey data.frame in the OM.models workspace in R_working

18.3 Results

18.3.1 Correlations

The loss of OM with age (perc.OM.y) has correlations greater than 0.3 with the amoutn of surface irradiance (perc.PAR), the DOC of the water (DOC.Water.mgL), the r^2 of the model (perc.OM.R2), and the surface OM (est.surf.OM).

```
                est.surf.OM mean.perc.OM  sd.perc.OM notes   perc.OM.y
Lake                     NA           NA          NA    NA          NA
Year            -0.02688056   -0.0767547  0.02193361    NA -0.07354785
Depth                    NA           NA          NA    NA          NA
Depth.m         -0.22866786   -0.1878536 -0.08481748    NA  0.13216913
Temp.Water       0.26765106    0.2180840  0.07199763    NA -0.09032754
DO.mgL           0.49687474    0.4571278  0.26711339    NA -0.16557299
perc.PAR         0.66160865    0.6139770  0.35408265    NA -0.37805036
DOC.Water.mgL -0.34703912   -0.2395619 -0.43305593    NA  0.46190801
perc.OM.R2       0.35991985    0.2105060  0.14003713    NA -0.53951225
perc.OM.slope -0.30853522   -0.1448572 -0.75997140    NA  1.00000000
est.surf.OM      1.00000000    0.9656336  0.35630313    NA -0.30853522
mean.perc.OM     0.96563360    1.0000000  0.16779404    NA -0.14485719
sd.perc.OM       0.35630313    0.1677940  1.00000000    NA -0.75997140
notes                    NA           NA          NA    NA          NA
perc.OM.y       -0.30853522   -0.1448572 -0.75997140    NA  1.00000000
Warning messages:
1: In cor(survey, use = "pairwise.complete.obs") :
  NAs introduced by coercion
2: In cor(survey, use = "pairwise.complete.obs") :
  the standard deviation is zero
```

18.3.2 perc.OM.y by perc.PAR

```
> summary(lm(perc.OM.y~perc.PAR))

Call:
lm(formula = perc.OM.y ~ perc.PAR)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.47247 -0.05296  0.01708  0.07189  0.16833 

Coefficients:
             Estimate Std. Error t value Pr(>|t|)  
(Intercept) -0.071518   0.032293  -2.215   0.0370 *
perc.PAR    -0.003767   0.001924  -1.958   0.0624 .
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1 

Residual standard error: 0.1303 on 23 degrees of freedom
  (8 observations deleted due to missingness)
Multiple R-squared: 0.1429,     Adjusted R-squared: 0.1057 
F-statistic: 3.835 on 1 and 23 DF,  p-value: 0.06242 

> cor.test(perc.OM.y, perc.PAR, use = "pairwise.complete.obs")

        Pearson's product-moment correlation

data:  perc.OM.y and perc.PAR 
t = -1.9584, df = 23, p-value = 0.06242
alternative hypothesis: true correlation is not equal to 0 
95 percent confidence interval:
 -0.67269456  0.02008009 
sample estimates:
       cor 
-0.3780504 
```

18.3.3 perc.OM.y by DOC.Water.mgL

```
> summary(lm(perc.OM.y~DOC.Water.mgL))

Call:
lm(formula = perc.OM.y ~ DOC.Water.mgL)

Residuals:
```

```
     Min       1Q   Median       3Q      Max
-0.25744 -0.06730  0.02632  0.06984  0.13635

Coefficients:
               Estimate Std. Error t value Pr(>|t|)
(Intercept)   -0.222577   0.060733  -3.665  0.00192 **
DOC.Water.mgL  0.014135   0.006583   2.147  0.04649 *
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1

Residual standard error: 0.1062 on 17 degrees of freedom
  (14 observations deleted due to missingness)
Multiple R-squared: 0.2134,     Adjusted R-squared: 0.1671
F-statistic: 4.611 on 1 and 17 DF,  p-value: 0.04649

> cor.test(perc.OM.y, DOC.Water.mgL, use = "pairwise.complete.obs")

        Pearson's product-moment correlation

data:  perc.OM.y and DOC.Water.mgL
t = 2.1473, df = 17, p-value = 0.04649
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 0.009742792 0.757245079
sample estimates:
     cor
0.461908
```

18.3.4 perc.OM.y by est.surf.OM

```
  > summary(lm(perc.OM.y~est.surf.OM))

Call:
lm(formula = perc.OM.y ~ est.surf.OM)

Residuals:
     Min       1Q   Median       3Q      Max
-0.47750 -0.03066  0.02204  0.06621  0.18405

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.002463   0.066883   0.037   0.9709
est.surf.OM -0.002595   0.001437  -1.806   0.0806 .
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1
```

```
Residual standard error: 0.1289 on 31 degrees of freedom
Multiple R-squared: 0.09519,    Adjusted R-squared: 0.06601
F-statistic: 3.261 on 1 and 31 DF,  p-value: 0.08064

> cor.test(perc.OM.y, est.surf.OM, use = "pairwise.complete.obs")

        Pearson's product-moment correlation

data:  perc.OM.y and est.surf.OM
t = -1.806, df = 31, p-value = 0.08064
alternative hypothesis: true correlation is not equal to 0
95 percent confidence interval:
 -0.58941198  0.03889348
sample estimates:
       cor
-0.3085352
```

18.3.5 Loss of with age by sampling Depth

```
  > summary(lm(perc.OM.y ~ Depth))

Call:
lm(formula = perc.OM.y ~ Depth)

Residuals:
     Min       1Q   Median       3Q      Max
-0.44734 -0.06344  0.03204  0.06449  0.14336

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.14336    0.02889  -4.962 2.39e-05 ***
Depthhypo    0.08132    0.04603   1.767   0.0871 .
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1

Residual standard error: 0.1292 on 31 degrees of freedom
Multiple R-squared: 0.09149,    Adjusted R-squared: 0.06218
F-statistic: 3.122 on 1 and 31 DF,  p-value: 0.0871
```

19 7 July 2010: Revaluation of the proportion of HOC due to SOD based only on the oxygen consumption and the morphometry

19.1 Goal

I estimate the total HOC using the change in oxygen concentration in the hypolimnion between 2 dates multiplied by the hypolimnetic volume. This should give me units of mmol O_2 d^{-1}. I can convert SOD to these units by multiplying SOD by the sediment area. Since both values are in the same units, I should be able to directly calculate the proportion of HOC that is SOD.

19.2 Data Manipulation

As described on 29 June 2010; To estimated the SOD in lake GTH 91 at hypolimnetic temperatures I used the relationship between temperature and SOD from the temperature dependence experiment:

The morphometry came from the GTH91.bathy data.frame in the bathy.summary workspace in R_working (See 29 June 2010)

The total hypolimnetic oxygen consumption was estimated using the change in oxygen concentration between Julian days 207 and 213 in 2006 at depths 6, 7, and 8 (see June 29 2010).

19.3 Results

Estimate of SOD:
I used 4.5° C as the hypolimnetic temperature in GTH 91 during 2006 (see table waterprofdeep.tex) $y = 0.61x + 7.65 + 2.1 = 0.61 \cdot 4.5 + 7.65 + 2.1 = 10.5$ mmol O_2 m^{-2} d^{-1}
(see pg 5)

Calculation of total HOC: (all oxygen concentrations in mmol O_2 m^{-3}

Z(m)	[O2] on 207	[O2] on 213	Δ[O2]	Δd	Δ[O2] d^{-1}
6	406	384	22	6	3.7
7	372	331	42	6	7.0
8	272	239	33	6	5.5
				Mean	5.4
				SD	1.65

For lake GTH 91:

Z (m)	HOD (mmol O_2 m^{-3} d^{-1})	Vol (m^3)	J_z (mmol O_2 d^{-1})	SOD (mmol O_2 m^{-2} d^{-1})	Area (m^2)	$J_{A(Z)}$ (mmol O_2 d^{-1})	$\frac{J_{A(z)}}{J_z}$
6	3.7	7441	27532	10.5	1603	20518	0.75
7	7.0	5838	40866	10.5	1614	20659	0.51
8	5.5	4221	23215	10.5	1585	20288	0.87
Σ			91613			61465	0.67