Growth Rate Analysis

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```r
# Load Packages
    library("plyr")
    library("dplyr")
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:plyr':
##
##     arrange, count, desc, failwith, id, mutate, rename, summarise,
##     summarize

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```r
    library("reshape2")
    library("ggplot2")
    library("AICcmodavg")

# Load Data Frame
df.blacktemp <- read.csv("Temp_Data_Black.csv")
df.coppertemp <- read.csv("Temp_Data_Copper.csv")
df.growth <- read.csv("Fish_Measurement_Data_w_IDs.csv")

# Subset Dataframe to Include only Those Necessary for Analysis
df.subgrowth  <- subset(df.growth, select = c("Date", "Died_0_Lived_1", "Length_mm",
                                        "Weight_g","Experimental_Treatment_C", "Bucket" ))

# Remove columns with any NAs
df.completegrowth <- na.omit(df.subgrowth)

df.completegrowth$exp.temp <- c(rep(10.51111, 12), rep(10.58704, 8), rep(13.46111, 12),
                            rep(13.71667, 12), rep(15.10000, 12), rep(17.15000, 4),
                            rep(17.97037, 16), rep(19.22222, 12), rep(18.90926, 8),
                            rep(19.98889, 4), rep(19.91852, 4), rep(21.03333, 8),
                            rep(21.40741, 4), rep(22.01296, 8))
```

```r
## Length Data ##
    # Get measurement data from first day and last day of experiment
        correct.day.cp <- which(df.completegrowth$Date==20150704)
        start.length.cp <- tapply(df.completegrowth$Length_mm[correct.day.cp],
                                df.completegrowth$exp.temp[correct.day.cp],mean)
```

```r
      last.day.cp <- which(df.completegrowth$Date==20150718)
      end.length.cp <- tapply(df.completegrowth$Length_mm[last.day.cp],
                              df.completegrowth$exp.temp[last.day.cp], mean, na.rm=TRUE)

   # Create data frames for starting data and ending data and merge them
      df.start.length.cp <- data.frame(bucket=names(start.length.cp), start.length.cp)
      df.end.length.cp <- data.frame(bucket=names(end.length.cp), end.length.cp)
      df.length.cp <- merge(df.start.length.cp, df.end.length.cp)

   # Add in temperature data
   #  df.length.cp$exp.temp <- c(10.51111, 19.98889, 19.91852, 21.03333, 21.40741, 22.01296,
   #             10.58704, 13.46111, 13.71667, 15.10000, 17.15000, 17.97037,
   #             19.22222, 18.90926)

## Growth Data ##
# Get weight data from first day and last day of experiment
      start.weight.cp <- tapply(df.completegrowth$Weight_g[correct.day.cp],
                                df.completegrowth$exp.temp[correct.day.cp], mean)
      end.weight.cp <- tapply(df.completegrowth$Weight_g[last.day.cp],
                              df.completegrowth$exp.temp[last.day.cp], mean, na.rm=TRUE)

   # Create data frames for starting data and ending data and merge them
      df.start.weight.cp <- data.frame(bucket=names(start.weight.cp), start.weight.cp)
      df.end.weight.cp <- data.frame(bucket=names(end.weight.cp), end.weight.cp)
      df.weight.cp <- merge(df.start.weight.cp, df.end.weight.cp)


## Combined Data ##
  # Combine Length and Weight data
    df.growth.cp <- merge(df.length.cp, df.weight.cp)


### Calculate Growth Statistics ###

  ## Condition Factor ##

    # start and end condition factor calculation
      df.growth.cp$CF.start <- ((df.growth.cp$start.weight.cp)/(df.growth.cp$start.length.cp)^3)*100
      df.growth.cp$CF.end <- ((df.growth.cp$end.weight.cp)/(df.growth.cp$end.length.cp)^3)*100

    # Change in CF
      df.growth.cp$CF.change <- (df.growth.cp$CF.end-df.growth.cp$CF.start)

  ## % Weight Gain ##

    df.growth.cp$weight.change <- (df.growth.cp$end.weight.cp-df.growth.cp$start.weight.cp)
    df.growth.cp$percent.weight <- ((df.growth.cp$weight.change/df.growth.cp$start.weight.cp)*100)

# as.numeric
df.growth.cp$exp.temp <- as.numeric(paste(df.growth.cp$bucket))


### Plots ###

  # Scatterplot
```
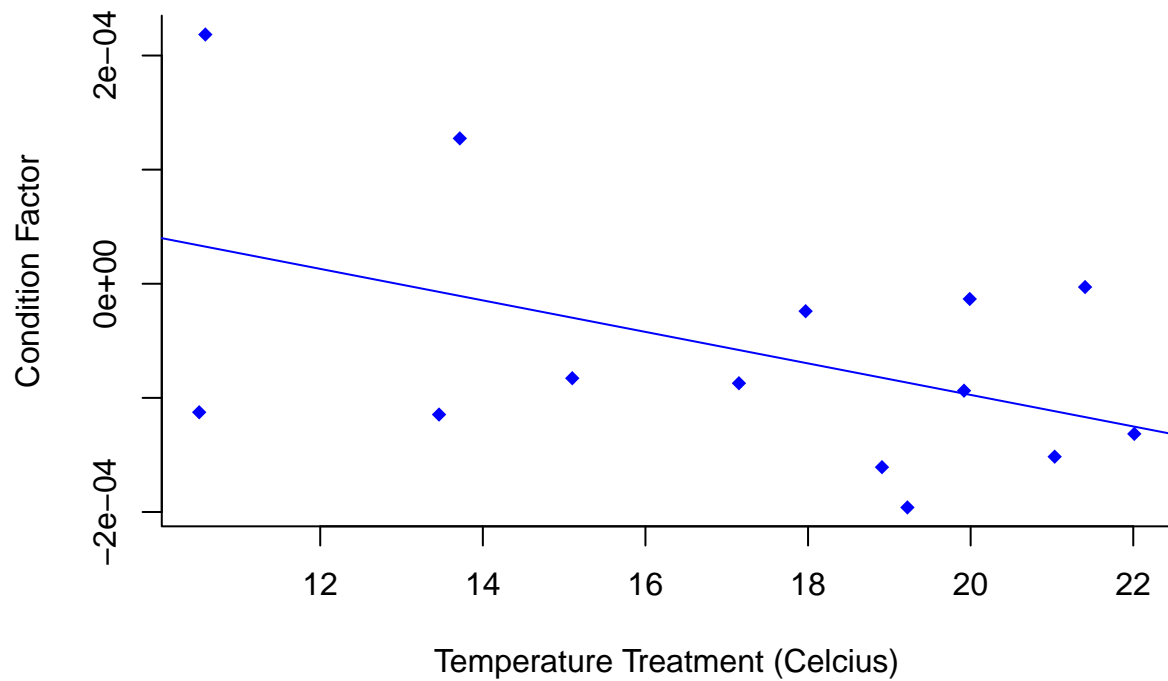
```
plot(df.growth.cp$exp.temp, df.growth.cp$CF.change, pch = 18,
        bty = "l", main = "Condition Factor - Copper Rockfish",
        ylab = "Condition Factor",
        xlab = "Temperature Treatment (Celcius)", col = "blue")

abline(lm(df.growth.cp$CF.change~df.growth.cp$exp.temp), col = "blue")
```
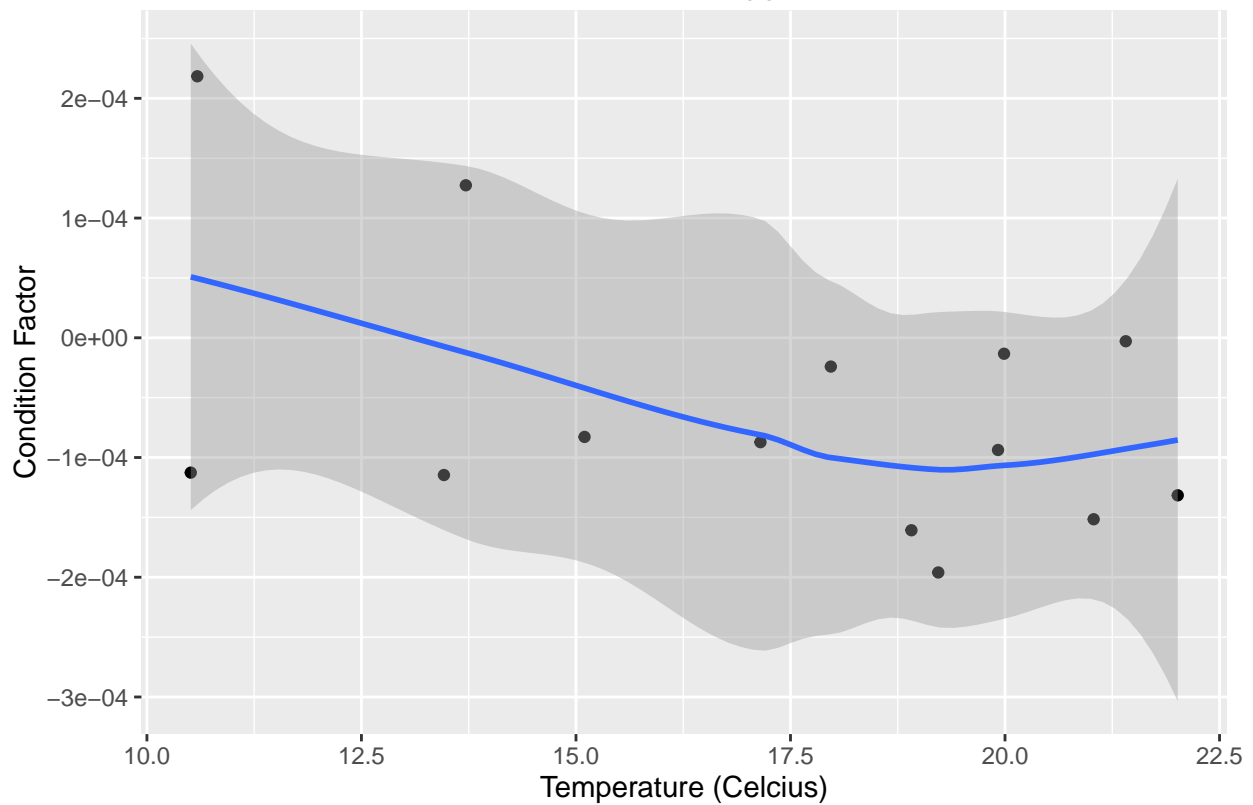
Condition Factor – Copper Rockfish


```
# General Additive Model (GAM)
ggplot(df.growth.cp, aes(x=exp.temp, y=CF.change)) + labs(x = "Temperature (Celcius)",
        y = "Condition Factor") + ggtitle("Condition Factor - Copper Rockfish") + geom_point() + ge
```
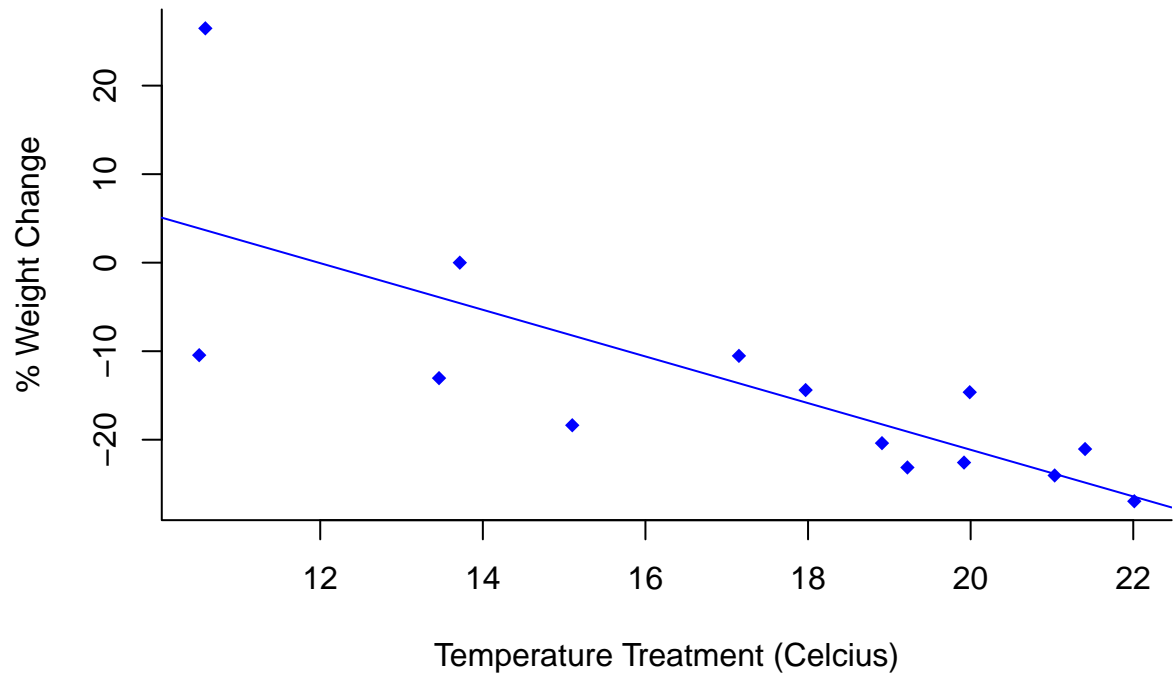
Condition Factor – Copper Rockfish


```r
# Scatterplot
plot(df.growth.cp$exp.temp, df.growth.cp$percent.weight, pch = 18, bty = "l",
     main = "% Weight Change - Copper Rockfish", ylab = "% Weight Change",
     xlab = "Temperature Treatment (Celcius)", col = "blue")

abline(lm(df.growth.cp$percent.weight~df.growth.cp$exp.temp), col = "blue")
```

% Weight Change – Copper Rockfish


```
# General Additive Model (GAM)
ggplot(df.growth.cp, aes(x=exp.temp, y=percent.weight)) + labs(x = "Temperature (Celcius)",
        y = "% Weight Change") + ggtitle("% Weight Change – Copper Rockfish") + geom_point() + geom_
```

% Weight Change – Copper Rockfish
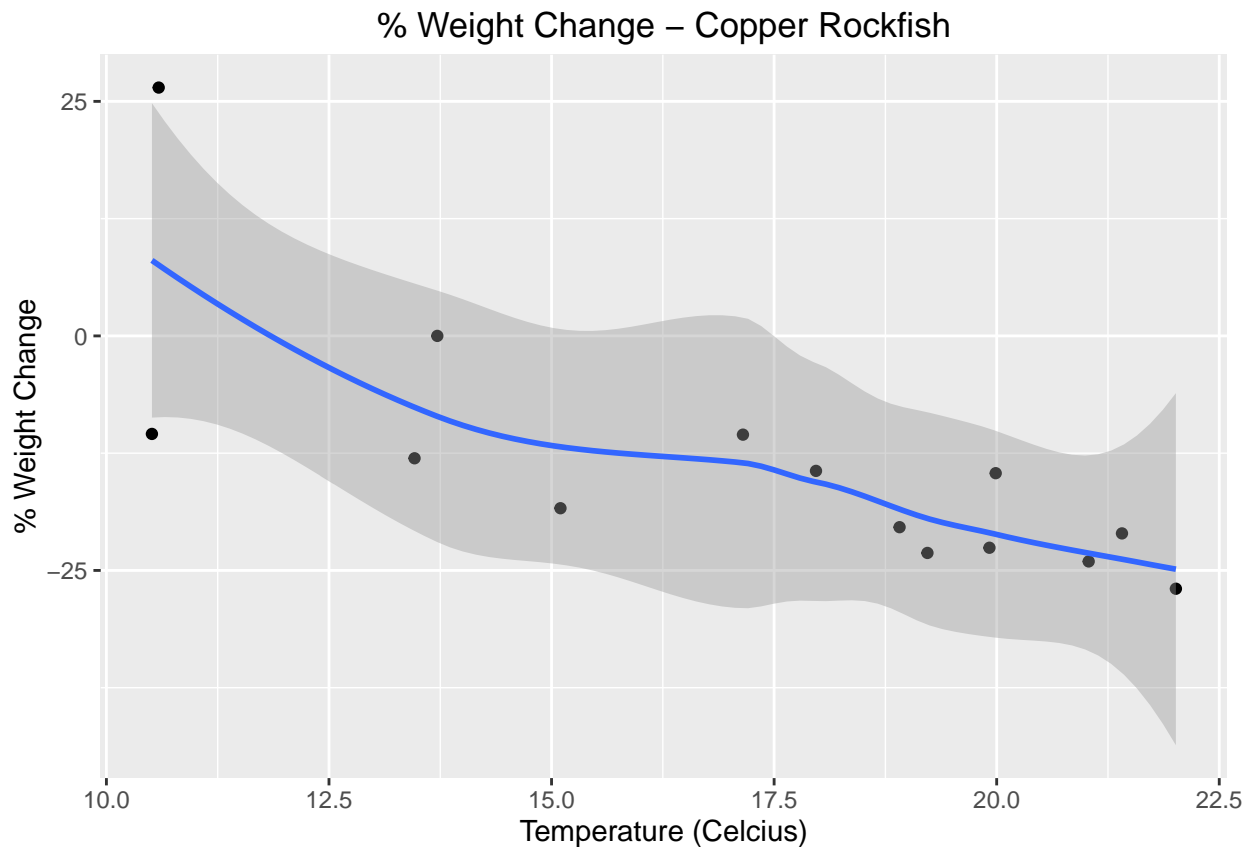

```
### Analysis ###

# Condition Factor #
  full.cp.CF <- lm(df.growth.cp$CF.change~df.growth.cp$exp.temp + I(df.growth.cp$exp.temp^2)
                    + df.growth.cp$start.weight.cp)
  summary(full.cp.CF)
```

```
##
## Call:
## lm(formula = df.growth.cp$CF.change ~ df.growth.cp$exp.temp +
##     I(df.growth.cp$exp.temp^2) + df.growth.cp$start.weight.cp)
##
## Residuals:
##        Min        1Q    Median        3Q       Max
## -1.749e-04 -3.449e-05 -1.980e-05  5.530e-05  1.376e-04
##
## Coefficients:
##                               Estimate Std. Error t value Pr(>|t|)
## (Intercept)                  6.434e-04  5.658e-04   1.137   0.2820
## df.growth.cp$exp.temp       -6.714e-05  7.248e-05  -0.926   0.3761
## I(df.growth.cp$exp.temp^2)   1.908e-06  2.237e-06   0.853   0.4137
## df.growth.cp$start.weight.cp -3.855e-04  2.045e-04  -1.885   0.0888 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.71e-05 on 10 degrees of freedom
```

```
## Multiple R-squared:  0.4442, Adjusted R-squared:  0.2774
## F-statistic: 2.664 on 3 and 10 DF,  p-value: 0.1049
```

```r
drop1(full.cp.CF)
```

```
## Single term deletions
##
## Model:
## df.growth.cp$CF.change ~ df.growth.cp$exp.temp + I(df.growth.cp$exp.temp^2) +
##     df.growth.cp$start.weight.cp
##                               Df  Sum of Sq         RSS     AIC
## <none>                                     9.4281e-08 -255.43
## df.growth.cp$exp.temp          1 8.0910e-09 1.0237e-07 -256.27
## I(df.growth.cp$exp.temp^2)     1 6.8580e-09 1.0114e-07 -256.44
## df.growth.cp$start.weight.cp   1 3.3508e-08 1.2779e-07 -253.17
```

```r
# Drop start.weight
drop.start.cp.CF <- lm(df.growth.cp$CF.change~df.growth.cp$exp.temp + I(df.growth.cp$exp.temp^2))

summary(drop.start.cp.CF)
```

```
##
## Call:
## lm(formula = df.growth.cp$CF.change ~ df.growth.cp$exp.temp +
##     I(df.growth.cp$exp.temp^2))
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -1.718e-04 -6.316e-05 -2.011e-05  7.957e-05  1.616e-04
##
## Coefficients:
##                              Estimate Std. Error t value Pr(>|t|)
## (Intercept)                 5.467e-04  6.254e-04   0.874    0.401
## df.growth.cp$exp.temp      -6.203e-05  8.040e-05  -0.772    0.457
## I(df.growth.cp$exp.temp^2)  1.489e-06  2.471e-06   0.603    0.559
##
## Residual standard error: 0.0001078 on 11 degrees of freedom
## Multiple R-squared:  0.2466, Adjusted R-squared:  0.1097
## F-statistic: 1.801 on 2 and 11 DF,  p-value: 0.2106
```

```r
drop1(drop.start.cp.CF)
```

```
## Single term deletions
##
## Model:
## df.growth.cp$CF.change ~ df.growth.cp$exp.temp + I(df.growth.cp$exp.temp^2)
##                            Df  Sum of Sq         RSS     AIC
## <none>                                  1.2779e-07 -253.17
## df.growth.cp$exp.temp       1 6.9148e-09 1.3470e-07 -254.43
## I(df.growth.cp$exp.temp^2)  1 4.2174e-09 1.3201e-07 -254.71
```

```
# Drop squared term
   drop.square.cp.CF <- lm(df.growth.cp$CF.change~df.growth.cp$exp.temp)
   summary(drop.square.cp.CF)
```

```
##
## Call:
## lm(formula = df.growth.cp$CF.change ~ df.growth.cp$exp.temp)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -1.462e-04 -7.204e-05 -1.773e-05  7.429e-05  1.859e-04
##
## Coefficients:
##                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)            1.787e-04  1.315e-04   1.359   0.1992
## df.growth.cp$exp.temp -1.381e-05  7.466e-06  -1.849   0.0892 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.0001049 on 12 degrees of freedom
## Multiple R-squared:  0.2218, Adjusted R-squared:  0.1569
## F-statistic:  3.42 on 1 and 12 DF,  p-value: 0.08919
```

```
# Marginally significant 0.08919.

# % Weight Gain #
  full.cp.perc <- lm(df.growth.cp$percent.weight~df.growth.cp$exp.temp
                     + df.growth.cp$start.weight.cp)
  summary(full.cp.perc)
```

```
##
## Call:
## lm(formula = df.growth.cp$percent.weight ~ df.growth.cp$exp.temp +
##     df.growth.cp$start.weight.cp)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -14.080  -3.898  -0.100   2.849  21.775
##
## Coefficients:
##                              Estimate Std. Error t value Pr(>|t|)
## (Intercept)                   31.1631    11.3747   2.740   0.0192 *
## df.growth.cp$exp.temp         -2.1312     0.7684  -2.774   0.0181 *
## df.growth.cp$start.weight.cp -22.9647    18.9990  -1.209   0.2521
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.065 on 11 degrees of freedom
## Multiple R-squared:  0.6225, Adjusted R-squared:  0.5539
## F-statistic: 9.069 on 2 and 11 DF,  p-value: 0.004711
```

```
    drop1(full.cp.perc)
```

```
## Single term deletions
##
## Model:
## df.growth.cp$percent.weight ~ df.growth.cp$exp.temp + df.growth.cp$start.weight.cp
##                               Df Sum of Sq     RSS     AIC
## <none>                                      903.98 64.349
## df.growth.cp$exp.temp          1    632.19 1536.17 69.772
## df.growth.cp$start.weight.cp   1    120.07 1024.05 64.094
```

```
# WOOOOOOOT significant.
```

Black Rockfish

```
    # Subset Dataframe to Include only Those Necessary for Analysis
    df.subgrowth.blk  <- subset(df.growth, select = c("Date", "Length_mm",
                                        "Weight_g","Experimental_Treatment_C",
                                        "Bucket" ))

    df.growth.2<- na.omit(df.subgrowth.blk)
```

```
## Length Data ##
    # Get measurement data from first day and last day of experiment
    correct.day.blk <- which(df.growth.2$Date==20150620)
    start.length.blk <- tapply(df.growth.2$Length_mm[correct.day.blk],
                                df.growth.2$Bucket[correct.day.blk], mean)
    last.day.blk <- which(df.growth.2$Date==20150703)
    end.length.blk <- tapply(df.growth.2$Length_mm[last.day.blk],
                                df.growth.2$Bucket[last.day.blk], mean, na.rm=TRUE)

  # Create data frames for starting data and ending data and merge them
    df.start.length.blk <- data.frame(bucket=names(start.length.blk), start.length.blk)
    df.end.length.blk <- data.frame(bucket=names(end.length.blk), end.length.blk)
    df.length.blk <- merge(df.start.length.blk, df.end.length.blk)

  # Add in exp.temp
    df.length.blk$exp.temp <- c(10.45769, 19.45192, 20.18269,
                                20.71346, 20.97308, 22.61731,
                                10.33846, 13.46111, 13.89808,
                                15.23462, 17.86923, 19.35962,
                                18.48462, 19.98462)


  ## Weight Data ##

    start.weight.blk <- tapply(df.growth.2$Weight_g[correct.day.blk],
                                df.growth.2$Bucket[correct.day.blk], mean)
    end.weight.blk <- tapply(df.growth.2$Weight_g[last.day.blk],
                                df.growth.2$Bucket[last.day.blk], mean, na.rm=TRUE)
```

```
    # Create data frames for starting data and ending data and merge them
      df.start.weight.blk <- data.frame(bucket=names(start.weight.blk), start.weight.blk)
      df.end.weight.blk <- data.frame(bucket=names(end.weight.blk), end.weight.blk)
      df.weight.blk <- merge(df.start.weight.blk, df.end.weight.blk)

  ## Combine Data ##

    df.growth.blk <- merge(df.length.blk, df.weight.blk)
```

```
### Calculate Growth Statistics ###

## Condition Factor ##
      df.growth.blk$CF.start <- ((df.growth.blk$start.weight.blk)/(df.growth.blk$start.length.blk)^3)*10
      df.growth.blk$CF.end <- ((df.growth.blk$end.weight.blk)/(df.growth.blk$end.length.blk)^3)*100

    # Change in CF
      df.growth.blk$CF.change <- (df.growth.blk$CF.end-df.growth.blk$CF.start)

## % Weight Change ##

      df.growth.blk$weight.change <- (df.growth.blk$end.weight.blk-df.growth.blk$start.weight.blk)
      df.growth.blk$percent.weight <- ((df.growth.blk$weight.change/df.growth.blk$start.weight.blk)*100)
```
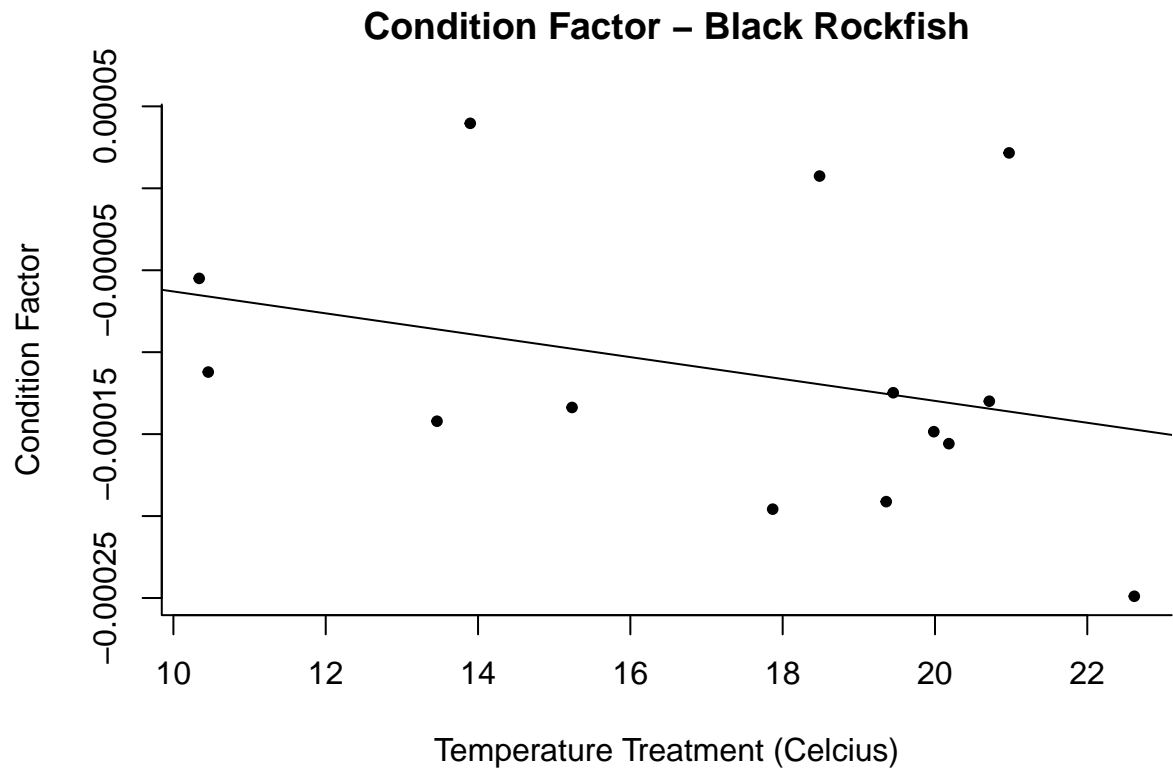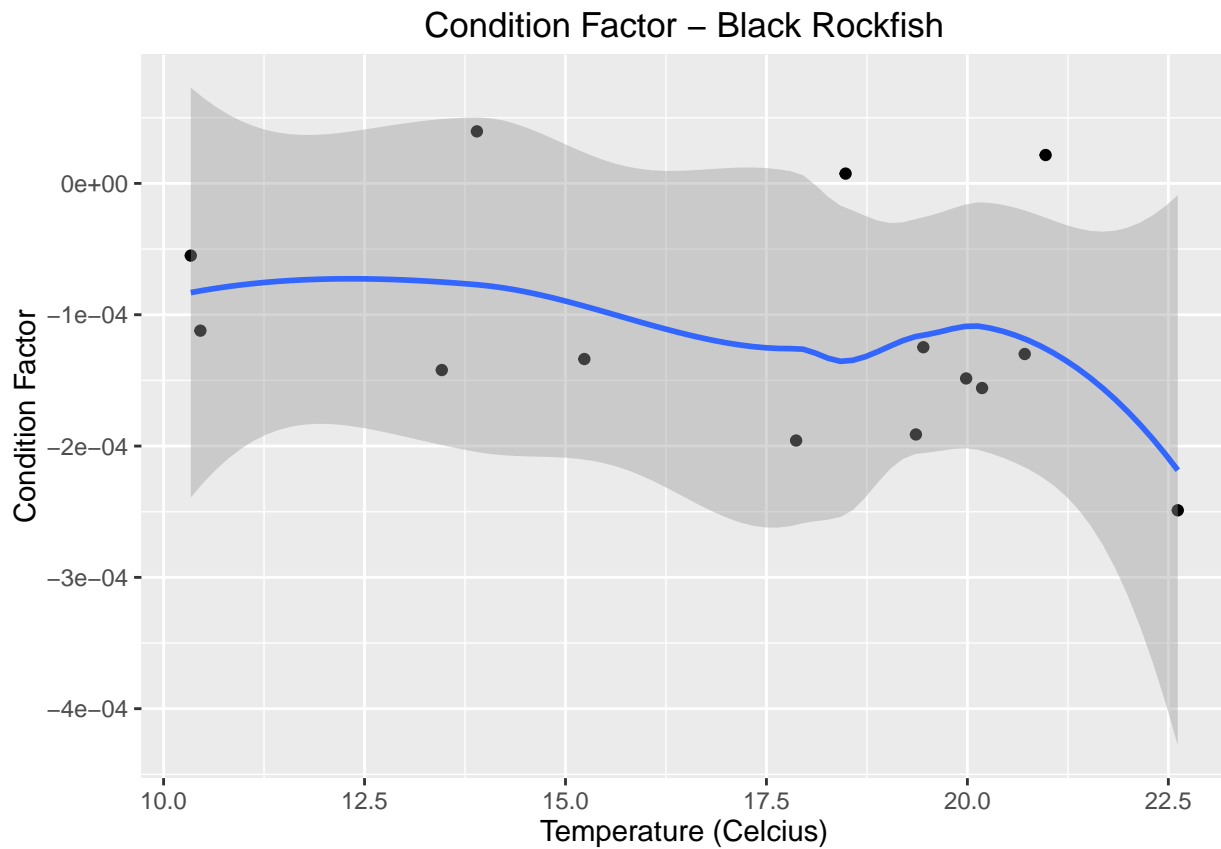
```
### Plots ###
 plot(df.growth.blk$exp.temp, df.growth.blk$CF.change, pch = 20,
          bty = "l", main = "Condition Factor - Black Rockfish",
          ylab = "Condition Factor",
          xlab = "Temperature Treatment (Celcius)")

  abline(lm(df.growth.blk$CF.change~df.growth.blk$exp.temp))
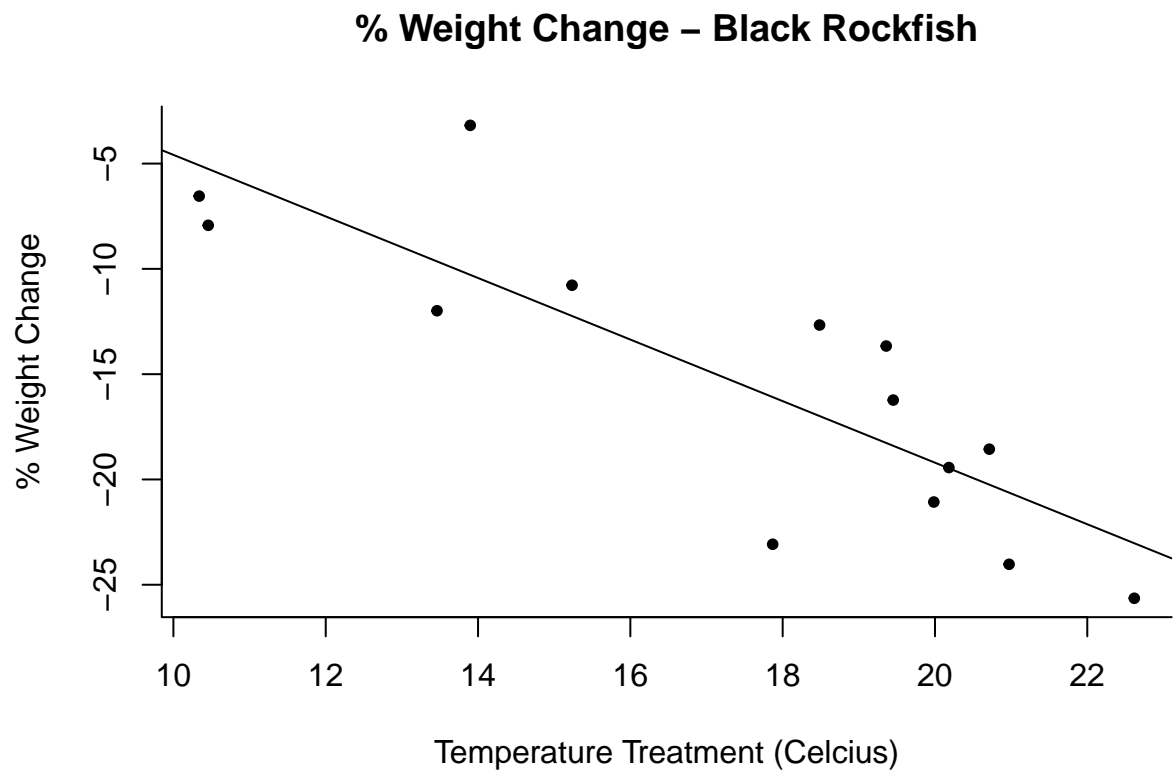```

## Condition Factor – Black Rockfish



```r
# General Additive Model (GAM)
  ggplot(df.growth.blk, aes(x=exp.temp, y=CF.change)) + labs(x = "Temperature (Celcius)",
           y = "Condition Factor") + ggtitle("Condition Factor - Black Rockfish") + geom_point() + geom
```

Condition Factor – Black Rockfish


```r
# Scatterplot
plot(df.growth.blk$exp.temp, df.growth.blk$percent.weight, pch = 20, bty = "l",
     main = "% Weight Change - Black Rockfish", ylab = "% Weight Change",
     xlab = "Temperature Treatment (Celcius)")

abline(lm(df.growth.blk$percent.weight~df.growth.blk$exp.temp))
```

% Weight Change – Black Rockfish


```
# General Additive Model (GAM)
ggplot(df.growth.blk, aes(x=exp.temp, y=percent.weight)) + labs(x = "Temperature (Celcius)",
        y = "% Weight Change") + ggtitle("% Weight Change - Black Rockfish") + geom_point() + geom_s
```

% Weight Change – Black Rockfish
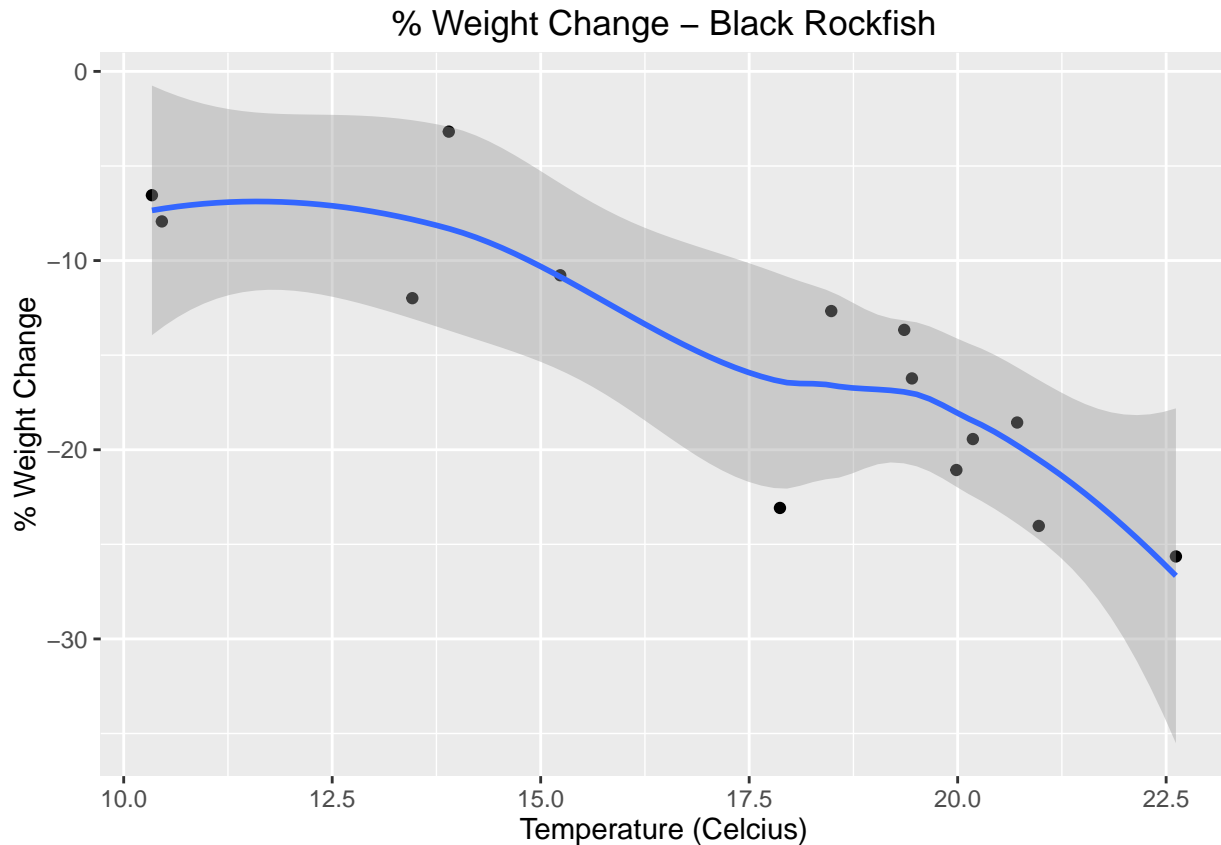

```
### Analysis ###

# Condition Factor #
  full.blk.CF <- lm(df.growth.blk$CF.change~df.growth.blk$exp.temp + I(df.growth.blk$exp.temp^2)
                     + df.growth.blk$start.weight.blk)
  summary(full.cp.CF)
```

```
##
## Call:
## lm(formula = df.growth.cp$CF.change ~ df.growth.cp$exp.temp +
##     I(df.growth.cp$exp.temp^2) + df.growth.cp$start.weight.cp)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -1.749e-04 -3.449e-05 -1.980e-05  5.530e-05  1.376e-04
##
## Coefficients:
##                               Estimate Std. Error t value Pr(>|t|)
## (Intercept)                  6.434e-04  5.658e-04   1.137   0.2820
## df.growth.cp$exp.temp       -6.714e-05  7.248e-05  -0.926   0.3761
## I(df.growth.cp$exp.temp^2)   1.908e-06  2.237e-06   0.853   0.4137
## df.growth.cp$start.weight.cp -3.855e-04  2.045e-04  -1.885   0.0888 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 9.71e-05 on 10 degrees of freedom
```

```
## Multiple R-squared:  0.4442, Adjusted R-squared:  0.2774
## F-statistic: 2.664 on 3 and 10 DF,  p-value: 0.1049
```

```r
drop1(full.cp.CF)
```

```
## Single term deletions
##
## Model:
## df.growth.cp$CF.change ~ df.growth.cp$exp.temp + I(df.growth.cp$exp.temp^2) +
##     df.growth.cp$start.weight.cp
##                               Df  Sum of Sq        RSS     AIC
## <none>                                     9.4281e-08 -255.43
## df.growth.cp$exp.temp          1 8.0910e-09 1.0237e-07 -256.27
## I(df.growth.cp$exp.temp^2)     1 6.8580e-09 1.0114e-07 -256.44
## df.growth.cp$start.weight.cp   1 3.3508e-08 1.2779e-07 -253.17
```

```r
# Drop start.weight
drop.start.blk.CF <- lm(df.growth.blk$CF.change~df.growth.blk$exp.temp + I(df.growth.blk$exp.temp^2
summary(drop.start.cp.CF)
```

```
##
## Call:
## lm(formula = df.growth.cp$CF.change ~ df.growth.cp$exp.temp +
##     I(df.growth.cp$exp.temp^2))
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -1.718e-04 -6.316e-05 -2.011e-05  7.957e-05  1.616e-04
##
## Coefficients:
##                              Estimate Std. Error t value Pr(>|t|)
## (Intercept)                 5.467e-04  6.254e-04   0.874    0.401
## df.growth.cp$exp.temp      -6.203e-05  8.040e-05  -0.772    0.457
## I(df.growth.cp$exp.temp^2)  1.489e-06  2.471e-06   0.603    0.559
##
## Residual standard error: 0.0001078 on 11 degrees of freedom
## Multiple R-squared:  0.2466, Adjusted R-squared:  0.1097
## F-statistic: 1.801 on 2 and 11 DF,  p-value: 0.2106
```

```r
drop1(drop.start.cp.CF)
```

```
## Single term deletions
##
## Model:
## df.growth.cp$CF.change ~ df.growth.cp$exp.temp + I(df.growth.cp$exp.temp^2)
##                            Df  Sum of Sq        RSS     AIC
## <none>                                  1.2779e-07 -253.17
## df.growth.cp$exp.temp       1 6.9148e-09 1.3470e-07 -254.43
## I(df.growth.cp$exp.temp^2)  1 4.2174e-09 1.3201e-07 -254.71
```

```
  # Best model but not significant

  # Drop squared term
    drop.square.blk.CF <- lm(df.growth.blk$CF.change~df.growth.blk$exp.temp)
    summary(drop.square.blk.CF)
```

```
##
## Call:
## lm(formula = df.growth.blk$CF.change ~ df.growth.blk$exp.temp)
##
## Residuals:
##        Min         1Q     Median         3Q        Max
## -1.017e-04 -5.358e-05 -2.190e-05  8.824e-06  1.578e-04
##
## Coefficients:
##                         Estimate Std. Error t value Pr(>|t|)
## (Intercept)            3.812e-06  1.052e-04   0.036    0.972
## df.growth.blk$exp.temp -6.676e-06  5.921e-06  -1.128    0.282
##
## Residual standard error: 8.484e-05 on 12 degrees of freedom
## Multiple R-squared:  0.09581,    Adjusted R-squared:  0.02046
## F-statistic: 1.272 on 1 and 12 DF,  p-value: 0.2815
```

```
  # Also not significant.

# % Weight Gain #
  full.blk.perc <- lm(df.growth.blk$percent.weight~df.growth.blk$exp.temp + I(df.growth.blk$exp.temp^2)
                      + df.growth.blk$start.weight.blk)
  summary(full.blk.perc)
```

```
##
## Call:
## lm(formula = df.growth.blk$percent.weight ~ df.growth.blk$exp.temp +
##     I(df.growth.blk$exp.temp^2) + df.growth.blk$start.weight.blk)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -8.1225 -1.6184  0.2145  1.4015  6.4150
##
## Coefficients:
##                                Estimate Std. Error t value Pr(>|t|)
## (Intercept)                    -21.3483    27.5280  -0.776    0.456
## df.growth.blk$exp.temp           2.4994     3.2762   0.763    0.463
## I(df.growth.blk$exp.temp^2)     -0.1232     0.1020  -1.208    0.255
## df.growth.blk$start.weight.blk   1.0335     3.1743   0.326    0.751
##
## Residual standard error: 4.003 on 10 degrees of freedom
## Multiple R-squared:  0.7433, Adjusted R-squared:  0.6663
## F-statistic: 9.652 on 3 and 10 DF,  p-value: 0.002674
```

```
  drop1(full.blk.perc)
```

```
## Single term deletions
##
## Model:
## df.growth.blk$percent.weight ~ df.growth.blk$exp.temp + I(df.growth.blk$exp.temp^2) +
##     df.growth.blk$start.weight.blk
##                                 Df Sum of Sq    RSS    AIC
## <none>                                       160.24 42.127
## df.growth.blk$exp.temp           1    9.3261 169.56 40.919
## I(df.growth.blk$exp.temp^2)      1   23.3900 183.63 42.034
## df.growth.blk$start.weight.blk   1    1.6987 161.94 40.274
```

```r
  # drop starting weight
    drop.start.blk.perc <- lm(df.growth.blk$percent.weight~df.growth.blk$exp.temp +
                              I(df.growth.blk$exp.temp^2))
    summary(drop.start.blk.perc)
```

```
##
## Call:
## lm(formula = df.growth.blk$percent.weight ~ df.growth.blk$exp.temp +
##     I(df.growth.blk$exp.temp^2))
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -8.3864 -1.7685  0.0794  2.0400  5.9284
##
## Coefficients:
##                             Estimate Std. Error t value Pr(>|t|)
## (Intercept)                -15.94976   21.06247  -0.757    0.465
## df.growth.blk$exp.temp       1.96688    2.72093   0.723    0.485
## I(df.growth.blk$exp.temp^2) -0.10613    0.08382  -1.266    0.232
##
## Residual standard error: 3.837 on 11 degrees of freedom
## Multiple R-squared:  0.7406, Adjusted R-squared:  0.6934
## F-statistic:  15.7 on 2 and 11 DF,  p-value: 0.0005984
```

```r
    drop1(drop.start.blk.perc)
```

```
## Single term deletions
##
## Model:
## df.growth.blk$percent.weight ~ df.growth.blk$exp.temp + I(df.growth.blk$exp.temp^2)
##                             Df Sum of Sq    RSS    AIC
## <none>                                   161.94 40.274
## df.growth.blk$exp.temp       1    7.6926 169.63 38.924
## I(df.growth.blk$exp.temp^2)  1   23.6027 185.54 40.179
```

```r
  #drop linear
    drop.linear.blk.perc <- lm(df.growth.blk$percent.weight~I(df.growth.blk$exp.temp^2))
    summary(drop.linear.blk.perc)
```

```
##
## Call:
```

```
## lm(formula = df.growth.blk$percent.weight ~ I(df.growth.blk$exp.temp^2))
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -7.5822 -2.0208 -0.3466  1.9695  6.5279
##
## Coefficients:
##                             Estimate Std. Error t value Pr(>|t|)
## (Intercept)                 -0.859578   2.744556  -0.313 0.759510
## I(df.growth.blk$exp.temp^2) -0.045834   0.008082  -5.671 0.000104 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.76 on 12 degrees of freedom
## Multiple R-squared:  0.7283, Adjusted R-squared:  0.7056
## F-statistic: 32.16 on 1 and 12 DF,  p-value: 0.0001038
```

```
  #highly significant squared term
```