One-Way ANOVA

Preliminaries

Load Necessary Packages

```
> library(car)      # for leveneTest()
> library(multcomp) # for glht(), mcp()  DO BEFORE dplyr!!
> library(FSA)      # for filterD(), hist(), Summarize(), dunnTest()
> library(dplyr)    # for mutate(), select()
> library(plotrix)  # for plotCI()
```

Load Data

```
> # Set your working directory to where your external data files (and scripts) are located.
> setwd("C:/aaaWork/Web/GitHub/RcourseNunavut2016/Handouts")
> dSC <- read.csv("SawyerCo_reduced.csv")
> dSC <- mutate(dSC,sex=mapvalues(sex,from="",to="ND"),fyear=factor(year))
> LChip_LMB <- filterD(dSC,waterbody=="LAKE CHIPPEWA",species=="Largemouth Bass")
```

Quick Summaries

```
> Summarize(len~fyear,data=LChip_LMB)
  fyear   n nvalid     mean       sd min    Q1 median  Q3 max percZero
1  2010  59     59 326.9831  45.84400 229 301.0  330.0 351 457        0
2  2011  48     48 357.1458  73.51769  97 350.2  374.5 386 478        0
3  2012  67     67 317.9851  67.17041 178 259.0  340.0 372 439        0
4  2013 147    147 338.8503  70.55430 152 277.0  356.0 385 526        0
5  2014  81     81 173.4321 111.22151  64 102.0  112.0 264 445        0
```

```
> boxplot(len~fyear,data=LChip_LMB,xlab="Year",ylab="Total Length (mm)")
```
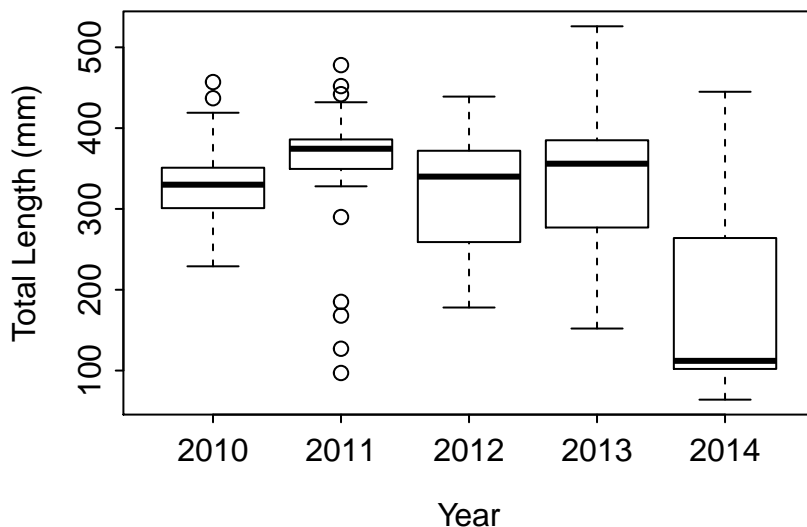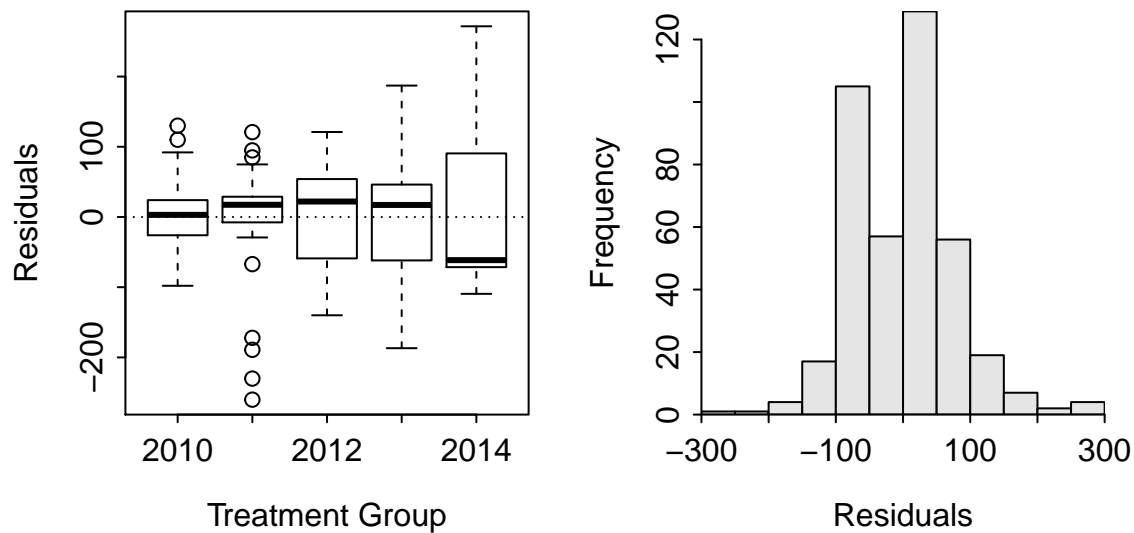
```
> hist(len~fyear,data=LChip_LMB,same.ylim=FALSE)
```


2010 **2011** **2012**

2013 **2014**
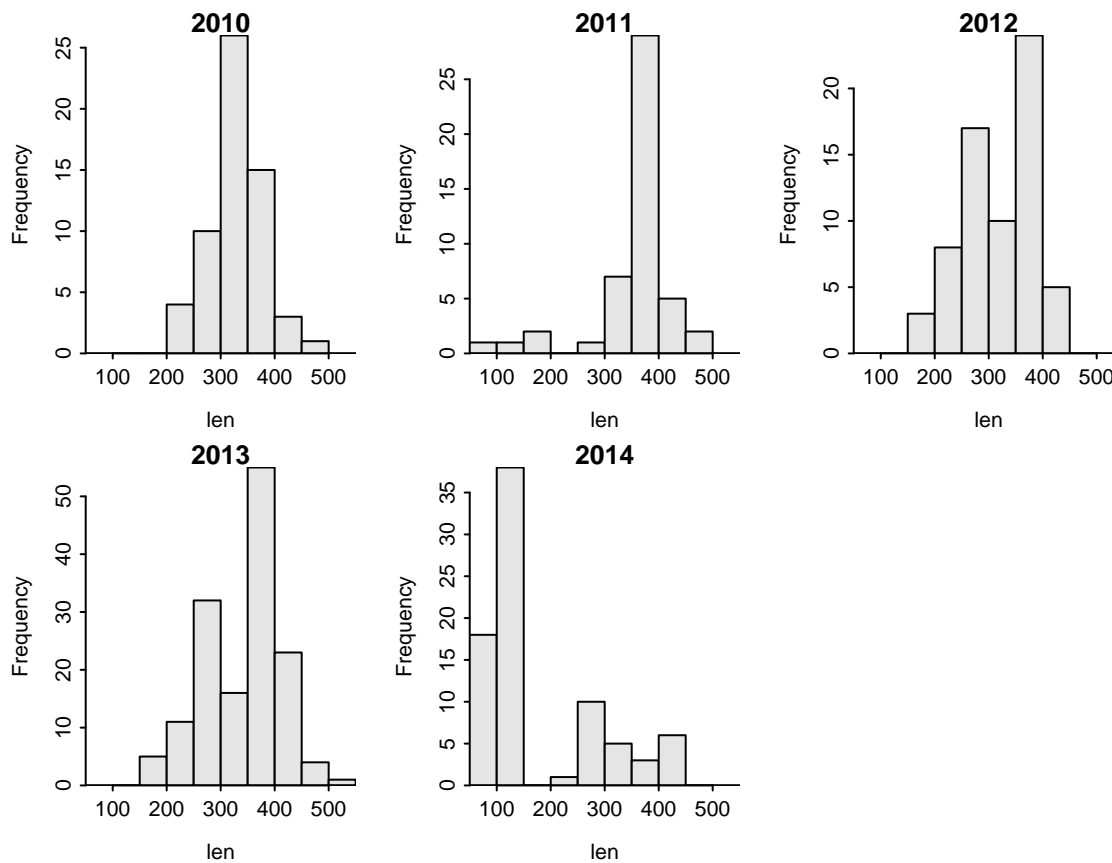
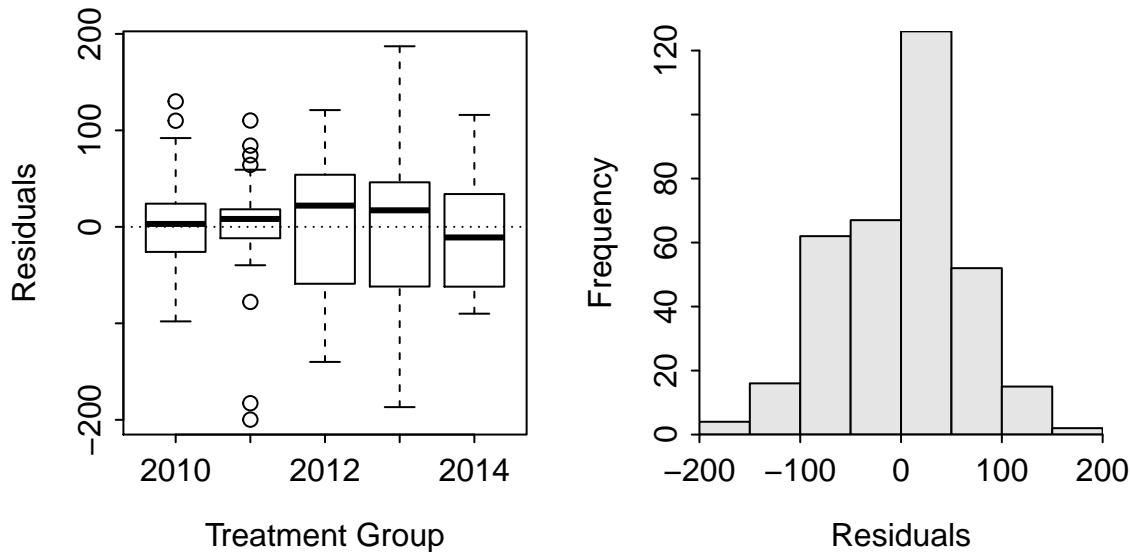# 1-Way ANOVA

Assumption Checking

```
> aov1 <- lm(len~fyear,data=LChip_LMB)
> residPlot(aov1)
```

```
> leveneTest(aov1)
Levene's Test for Homogeneity of Variance (center = median)
       Df F value    Pr(>F)
group   4  4.8125 0.0008431
      397
```

```
> LChip_LMB2 <- filterD(LChip_LMB,len>150)
> aov2 <- lm(len~fyear,data=LChip_LMB2)
> residPlot(aov2)
```



```
> leveneTest(aov2)
Levene's Test for Homogeneity of Variance (center = median)
       Df F value    Pr(>F)
group   4  6.1649 8.467e-05
      339
```

ANOVA Table and Test

```
> anova(aov2)
Analysis of Variance Table

Response: len
           Df  Sum Sq Mean Sq F value   Pr(>F)
fyear       4   75487 18871.8  4.6436 0.001161
Residuals 339 1377714  4064.1
```

Multiple Comparisons

```
> mc2 <- glht(aov2,mcp(fyear="Tukey"))
> summary(mc2)

     Simultaneous Tests for General Linear Hypotheses

Multiple Comparisons of Means: Tukey Contrasts


Fit: lm(formula = len ~ fyear, data = LChip_LMB2)

Linear Hypotheses:
                Estimate Std. Error t value Pr(>|t|)
2011 - 2010 == 0   40.821     12.539   3.255 0.010287
2012 - 2010 == 0   -8.998     11.382  -0.791 0.930321
2013 - 2010 == 0   11.867      9.825   1.208 0.738547
2014 - 2010 == 0    2.017     15.213   0.133 0.999926
2012 - 2011 == 0  -49.819     12.207  -4.081 0.000495
2013 - 2011 == 0  -28.954     10.770  -2.688 0.055087
2014 - 2011 == 0  -38.804     15.840  -2.450 0.100307
2013 - 2012 == 0   20.865      9.397   2.220 0.167778
2014 - 2012 == 0   11.015     14.941   0.737 0.945268
2014 - 2013 == 0   -9.850     13.792  -0.714 0.951031
(Adjusted p values reported -- single-step method)
```

```
> cld(mc2)
2010 2011 2012 2013 2014
 "a"  "b"  "a" "ab" "ab"
```

Summary Graphic

```
> sum_LMB2 <- Summarize(len~fyear,data=LChip_LMB2)
> sum_LMB2 <- select(sum_LMB2,fyear,n,mean,sd)
> sum_LMB2 <- mutate(sum_LMB2,year=fact2num(fyear),se=sd/sqrt(n),
               LCI=mean-qt(0.975,df=n-1)*se,UCI=mean+qt(0.975,df=n-1)*se)
> sum_LMB2
  fyear   n    mean       sd year       se      LCI      UCI
1  2010  59 326.9831 45.84400 2010  5.968380 315.0360 338.9301
2  2011  46 367.8043 53.36650 2011  7.868461 351.9565 383.6522
3  2012  67 317.9851 67.17041 2012  8.206171 301.6009 334.3692
4  2013 147 338.8503 70.55430 2013  5.819220 327.3495 350.3511
5  2014  25 329.0000 65.54261 2014 13.108521 301.9453 356.0547
```

```
> with(sum_LMB2,plotCI(year,mean,li=LCI,ui=UCI,pch=19,ylim=c(300,400),xlim=c(2009.8,2014.2),
                 xlab="Year",ylab="Mean Total Length (mm)"))
> with(sum_LMB2,text(year,UCI,c("a","b","a","ab","ab"),pos=3))
> axis(1,c("2011","2013"))
```
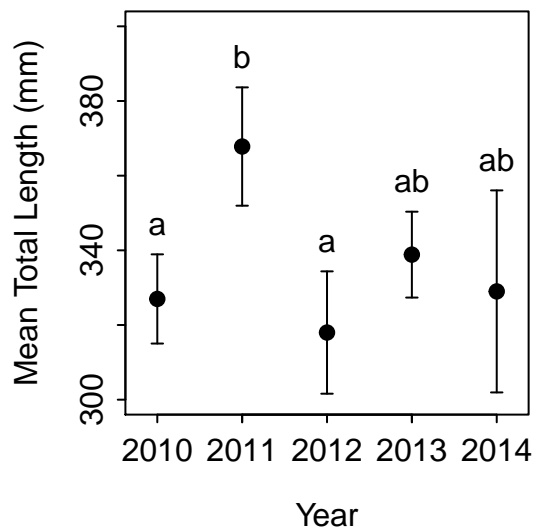
Kruskal-Wallis Test

```
> kruskal.test(len~fyear,data=LChip_LMB2)

    Kruskal-Wallis rank sum test

data:  len by fyear
Kruskal-Wallis chi-squared = 23.447, df = 4, p-value = 0.0001031
```

```
> dunnTest(len~fyear,data=LChip_LMB2)
Dunn (1964) Kruskal-Wallis multiple comparison
  p-values adjusted with the Holm method.
    Comparison          Z      P.unadj         P.adj
1   2010 - 2011 -4.1681228 3.071185e-05 0.0003071185
2   2010 - 2012 -0.1623240 8.710507e-01 0.8710507178
3   2011 - 2012  4.1302625 3.623493e-05 0.0003261144
4   2010 - 2013 -2.1841883 2.894841e-02 0.1736904732
5   2011 - 2013  2.8602657 4.232862e-03 0.0296300373
6   2012 - 2013 -2.0870383 3.688467e-02 0.1844233645
7   2010 - 2014 -0.4310591 6.664254e-01 1.0000000000
8   2011 - 2014  2.8855142 3.907748e-03 0.0312619867
9   2012 - 2014 -0.3152718 7.525553e-01 1.0000000000
10  2013 - 2014  1.0804842 2.799266e-01 1.0000000000
```