Compare VBGFs

Preliminaries

Load Necessary Packages

```
> library(FSA)      # for filterD(), headtail(), col2rgbt(), vbFuns(), vbStart()
> library(dplyr)    # for mutate(), select()
> library(nlstools) # for nlsBoot()
```

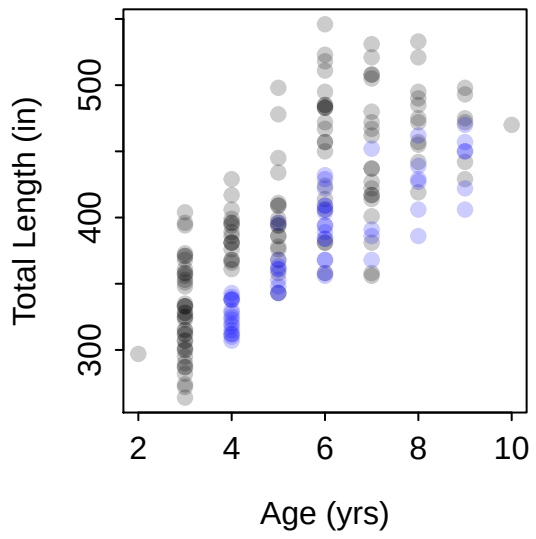
Load Data and Make Some Preparations

```
> # 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")
> wae <- filterD(dSC,waterbody %in% c("LAKE CHIPPEWA","SAND LAKE"),
                 species=="Walleye",!is.na(len),!is.na(age))
```

```
> xlbl <- "Age (yrs)"
> ylbl <- "Total Length (in)"
> clr1 <- c("black","blue")
> clr2 <- col2rgbt(clr1,1/5)
```

Quick Summaries

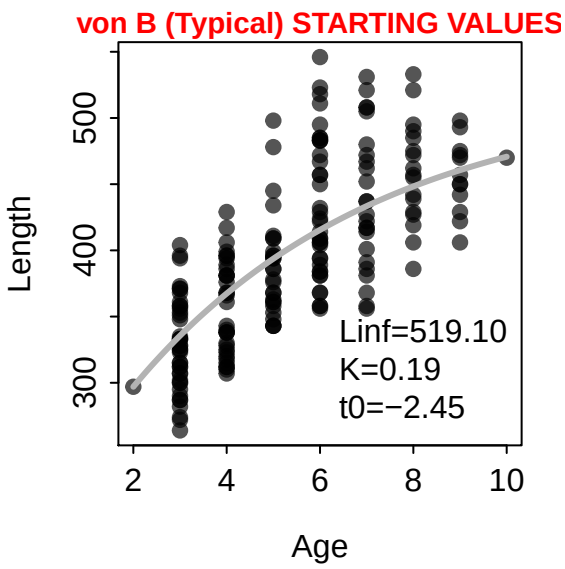
```
> plot(len~age,data=wae,pch=19,col=clr2[waterbody],xlab=xlbl,ylab=ylbl)
```



```
> Summarize(len~age+waterbody,data=wae,digits=1)
Warning: First RHS variable was converted to a factor.
   age     waterbody  n nvalid  mean   sd min    Q1 median    Q3 max percZero
1    2 LAKE CHIPPEWA  1      1 297.0   NA 297 297.0  297.0 297.0 297        0
2    3 LAKE CHIPPEWA 40     40 328.6 35.7 264 301.5  326.5 356.5 404        0
3    4 LAKE CHIPPEWA 17     17 387.9 18.4 361 376.0  386.0 396.0 429        0
4    5 LAKE CHIPPEWA 18     18 403.4 39.5 343 380.0  395.0 410.5 498        0
5    6 LAKE CHIPPEWA 21     21 460.9 50.4 358 424.0  472.0 485.0 546        0
6    7 LAKE CHIPPEWA 20     20 446.1 52.5 356 416.2  437.0 486.2 531        0
7    8 LAKE CHIPPEWA 11     11 476.7 33.4 419 456.0  475.0 492.5 533        0
8    9 LAKE CHIPPEWA  6      6 468.2 27.5 429 449.5  473.5 488.5 498        0
9   10 LAKE CHIPPEWA  1      1 470.0   NA 470 470.0  470.0 470.0 470        0
10   4     SAND LAKE 16     16 324.8 12.0 307 314.2  324.0 338.0 343        0
11   5     SAND LAKE  9      9 359.6 16.4 343 348.0  361.0 363.0 396        0
12   6     SAND LAKE 16     16 394.1 23.8 356 380.0  394.0 409.0 432        0
13   7     SAND LAKE  4      4 399.2 36.5 368 381.5  388.5 406.2 452        0
14   8     SAND LAKE  6      6 424.8 26.3 386 411.2  428.0 436.5 462        0
15   9     SAND LAKE  6      6 442.5 23.8 406 429.0  450.0 455.2 470        0
```

Fitting Most Complex Model and Checking Assumptions

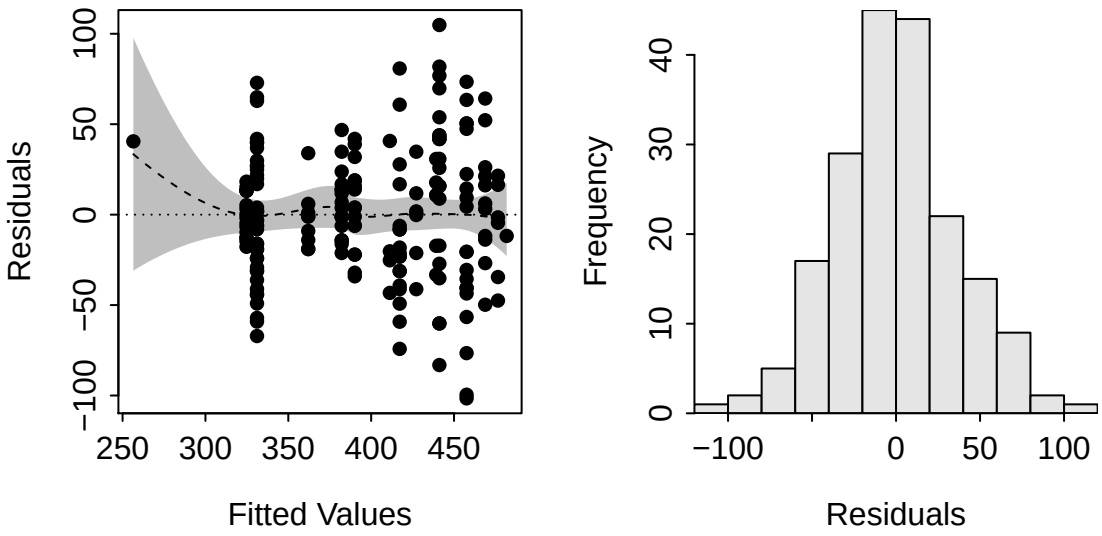
```
> ( svOm <- vbStarts(len~age,data=wae,plot=TRUE) )
```




```
$Linf
[1] 519.1043

$K
[1] 0.1905709

$t0
[1] -2.454813
```

```
> ( svLKt <- Map(rep,svOm,c(2,2,2)) )
$Linf
[1] 519.1043 519.1043

$K
[1] 0.1905709 0.1905709

$t0
[1] -2.454813 -2.454813
```

```
> vbLKt <- len~Linf[waterbody]*(1-exp(-K[waterbody]*(age-t0[waterbody])))
> fitLKt <- nls(vbLKt,data=wae,start=svLKt)
> residPlot(fitLKt)
```



Are There Any Differences?

```
> vbOm <- len~Linf*(1-exp(-K*(age-t0)))
> fitOm <- nls(vbOm,data=wae,start=svOm)
```

```
> extraSS(fitOm,com=fitLKt,sim.name="{Omega}",com.name="{Linf,K,t0}")
Model 1: {Omega}
Model A: {Linf,K,t0}

    DfO    RSSO DfA    RSSA Df     SS      F    Pr(>F)
1vA 189 338461 186 241781  3  96679 24.791 1.535e-13
```

```
> lrt(fitOm,com=fitLKt,sim.name="{Omega}",com.name="{Linf,K,t0}")
Model 1: {Omega}
Model A: {Linf,K,t0}

    DfO  logLikO DfA  logLikA Df   logLik  Chisq Pr(>Chisq)
1vA 189 -990.004 186 -957.712  3 -32.292 64.584  6.157e-14
```

Is the Most Complex Model Warranted?

```
> vbLK <- len~Linf[waterbody]*(1-exp(-K[waterbody]*(age-t0)))
> ( svLK <- Map(rep,svOm,c(2,2,1)) )
$Linf
[1] 519.1043 519.1043

$K
[1] 0.1905709 0.1905709

$t0
[1] -2.454813
```

```
> fitLK <- nls(vbLK,data=wae,start=svLK)
> vbLt <- len~Linf[waterbody]*(1-exp(-K*(age-t0[waterbody])))
> svLt <- Map(rep,svOm,c(2,1,2))
> fitLt <- nls(vbLt,data=wae,start=svLt)
> vbKt <- len~Linf*(1-exp(-K[waterbody]*(age-t0[waterbody])))
> svKt <- Map(rep,svOm,c(1,2,2))
> fitKt <- nls(vbKt,data=wae,start=svKt)
> extraSS(fitLK,fitLt,fitKt,com=fitLKt,com.name="{Linf,K,t0}",
          sim.names=c("{Linf,K}","{Linf,t0}","{K,t0}"))
Model 1: {Linf,K}
Model 2: {Linf,t0}
Model 3: {K,t0}
Model A: {Linf,K,t0}

    DfO       RSSO DfA       RSSA Df         SS      F Pr(>F)
1vA 187 241786.383 186 241781.303  1      5.081 0.0039 0.9502
2vA 187 242080.068 186 241781.303  1    298.765 0.2298 0.6322
3vA 187 241871.187 186 241781.303  1     89.884 0.0691 0.7929
```

Can the Model be Reduced to Only One Parameter that Differs?

```
> vbL <- len~Linf[waterbody]*(1-exp(-K*(age-t0)))
> ( svL <- Map(rep,svOm,c(2,1,1)) )
$Linf
[1] 519.1043 519.1043

$K
[1] 0.1905709

$t0
[1] -2.454813
```

```
> fitL <- nls(vbL,data=wae,start=svL)
> vbK <- len~Linf*(1-exp(-K[waterbody]*(age-t0)))
> svK <- Map(rep,svOm,c(1,2,1))
> fitK <- nls(vbK,data=wae,start=svK)
Error in nls(vbK, data = wae, start = svK): step factor 0.000488281 reduced below 'minFactor' of 0.000976562
```

```
> fitK <- nls(vbK,data=wae,start=svK,control=list(minFactor=1e-15,maxiter=500))
> extraSS(fitL,fitK,com=fitLK,com.name="{Linf,K}",sim.names=c("{Linf}","{K}"))
```

```
Model 1: {Linf}
Model 2: {K}
Model A: {Linf,K}

    DfO     RSSO DfA     RSSA Df       SS      F  Pr(>F)
1vA 188 246207.2 187 241786.4  1   4420.8 3.4191 0.06602
2vA 188 242717.7 187 241786.4  1    931.3 0.7203 0.39713
```

Summarize Final Model

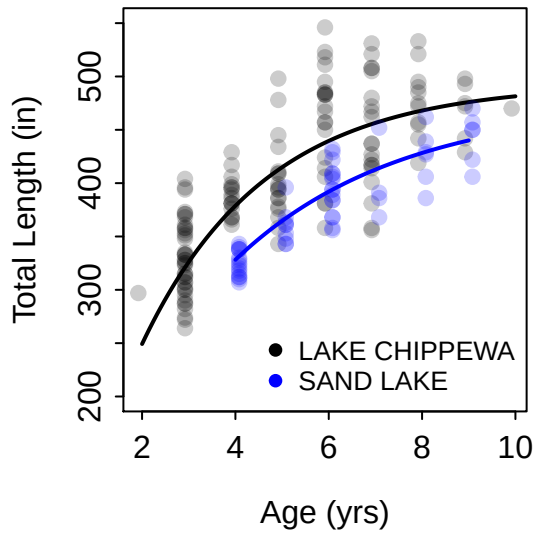
```
> summary(fitK,correlation=TRUE)

Formula: len ~ Linf * (1 - exp(-K[waterbody] * (age - t0)))

Parameters:
       Estimate Std. Error t value Pr(>|t|)
Linf  4.922e+02  1.711e+01  28.774  < 2e-16
K1    3.743e-01  8.318e-02   4.500 1.19e-05
K2    2.638e-01  4.688e-02   5.627 6.57e-08
t0   -9.452e-04  5.156e-01  -0.002    0.999

Residual standard error: 35.93 on 188 degrees of freedom

Correlation of Parameter Estimates:
   Linf  K1    K2
K1 -0.95
K2 -0.94  0.98
t0 -0.87  0.97  0.96

Number of iterations to convergence: 16
Achieved convergence tolerance: 1.431e-06
```

```
> round(cbind(coef(fitK),confint(fitK)),3)
Waiting for profiling to be done...
                2.5%   97.5%
Linf 492.234 467.551 539.594
K1     0.374   0.230   0.540
K2     0.264   0.175   0.352
t0    -0.001  -1.277   0.768
```

```
> vb <- vbFuns("typical")
> # Lake Chippewa
> crLC <- filterD(wae,waterbody=="LAKE CHIPPEWA")
> svLC <- list(Linf=492,K=0.37,t0=0)
> fitLC <- nls(len~vb(age,Linf,K,t0),data=crLC,start=svLC)
> # Sand Lake
> crSL <- filterD(wae,waterbody=="SAND LAKE")
> svSL <- list(Linf=492,K=0.26,t0=0)
> fitSL <- nls(len~vb(age,Linf,K,t0),data=crSL,start=svSL)
```

```
> offset <- 0.08
> # Lake Chippewa
> plot(len~I(age-offset),data=crLC,pch=19,col=clr2[1],ylim=c(200,550),xlab=xlbl,ylab=ylbl)
> curve(vb(x-offset,coef(fitLC)),from=2,to=10,col=clr1[1],lwd=2,add=TRUE)
```

```
> # Sand Lake
> points(len~I(age+offset),data=crSL,pch=19,col=clr2[2])
> curve(vb(x+offset,coef(fitSL)),from=4,to=9,col=clr1[2],lwd=2,add=TRUE)
> legend("bottomright",levels(wae$waterbody),pch=19,col=clr1,bty="n",cex=0.8)
```



Using Information Criterion

Fit the Only Other Model not Fit Above

```
> vbt <- len~Linf*(1-exp(-K*(age-t0[waterbody])))
> svt <- Map(rep,svOm,c(1,1,2))
> fitt <- nls(vbt,data=wae,start=svt)
```

AICc Table

```
> library(AICcmodavg)
> ms <- list(fitOm,fitL,fitK,fitt,fitLK,fitLt,fitKt,fitLKt)
> mnames <- c("{Omega}","{Linf}","{K}","{t0}","{Linf,K}","{Linf,t0}","{K,t0}","{Linf,K,t0}")
> aictab(ms,mnames)

Model selection based on AICc:

            K    AICc Delta_AICc AICcWt Cum.Wt      LL
{K}         5 1926.49       0.00   0.35   0.35 -958.08
{Linf,K}    6 1927.88       1.39   0.17   0.52 -957.71
{K,t0}      6 1927.95       1.46   0.17   0.69 -957.75
{Linf,t0}   6 1928.12       1.63   0.16   0.85 -957.83
{Linf}      5 1929.23       2.74   0.09   0.94 -959.45
{Linf,K,t0} 7 1930.03       3.54   0.06   1.00 -957.71
{t0}        5 1935.54       9.05   0.00   1.00 -962.61
{Omega}     4 1988.22      61.73   0.00   1.00 -990.00
```