Practice Markdown Script for Alaska Plaice GAMs

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Loading Alaska Plaice Data and Environmental Data

This chunk will load Alaska plaice data into the global environment. This dataset includes

When you click the **Knit** button a document will be generated that includes both content as well as the output of any embedded R code chunks within the document.

```
aplarv.ctd<-read.csv(file='../Ichthyo Data/Cleaned_Cut_ApLarv_wCTD.csv',header=TRUE,check.names=TRUE)
head(aplarv.ctd)
```

```
##    X  CRUISE STATION HAUL    GMT_DATE_TIME               HAUL_ID Cper10m2
## 1  9   4MF07       5    2 2007-05-08 17:47     4MF07 5 2 60BON 1        0
## 2 10   4MF07      22    2 2007-05-10 15:06    4MF07 22 2 60BON 1        0
## 3 13   4MF07      74    2 2007-05-15 23:40    4MF07 74 2 60BON 1        0
## 4 14 BE13-03     172    2 2013-09-17 16:04 BE13-03 172 2 60BON 1        0
## 5 15 BE13-03     176    2  2013-09-19 3:19 BE13-03 176 2 60BON 1        0
## 6 17 BE13-03     195    2 2013-09-24 16:07 BE13-03 195 2 60BON 1        0
##   Cper1000m3 year month      lat       lon doy       vol bottom_depth
## 1          0 2007     5 55.41167 -169.3653 128 408.73367         2364
## 2          0 2007     5 55.72917 -170.1652 130 358.30121         2428
## 3          0 2007     5 55.79016 -172.6337 135 387.37268         3205
## 4          0 2013     9 63.49245 -165.9990 260  42.49383           25
## 5          0 2013     9 63.00184 -167.0096 262  36.63332           26
## 6          0 2013     9 60.51539 -168.0088 267  21.49008           30
##                                                 id count  SS       date    SSB
## 1   4MF07_55.41167_-169.36533_2007-05-08 17:47_505     0 446 2007-05-08 234261
## 2   4MF07_55.72917_-170.16516_2007-05-10 15:06_505     0 446 2007-05-10 234261
## 3   4MF07_55.79016_-172.63367_2007-05-15 23:40_505     0 446 2007-05-15 234261
## 4 BE13-03_63.49245_-165.99901_2013-09-17 16:04_505     0  63 2013-09-17 234526
## 5  BE13-03_63.00184_-167.00956_2013-09-19 3:19_505     0  63 2013-09-19 234526
## 6 BE13-03_60.51539_-168.00882_2013-09-24 16:07_505     0  63 2013-09-24 234526
##         Link_ID temperature salinity   CTD_date      CTD_link CTD_time
## 1     4MF07_5_2    3.693791 32.84541 2007-05-08     4MF07_5_2     1747
## 2    4MF07_22_2    3.121164 32.18688 2007-05-10    4MF07_22_2     1506
## 3    4MF07_74_2    3.128455 32.32710 2007-05-15    4MF07_74_2     2325
## 4 BE13-03_172_2    9.476573 30.58420 2013-09-17 BE13-03_172_2     1604
## 5 BE13-03_176_2    9.027160 30.45578 2013-09-19 BE13-03_176_2      319
## 6 BE13-03_195_2    9.293682 30.70109 2013-09-24 BE13-03_195_2     1607
##   date_diff
## 1         0
## 2         0
```

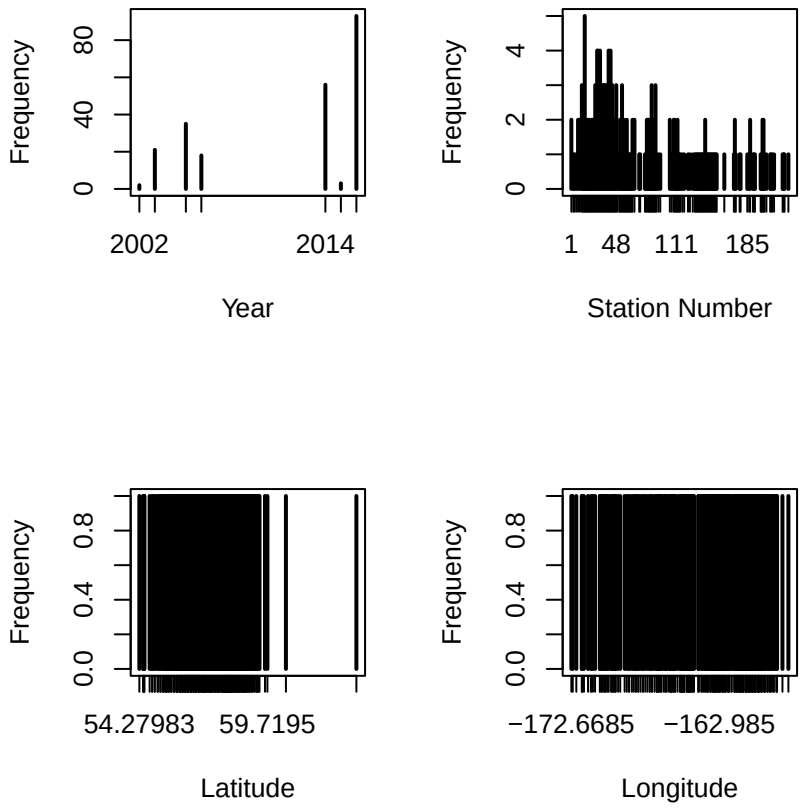
```
## 3          0
## 4          0
## 5          0
## 6          0
```

These data include the cruise on which ichthyoplankton were collected, the station and haul which indicate location and net deployment, respectively, the catch per area and catch per volume, the year, day of year, geographic position, and the raw count of larvae.

Initial Data Visualization

Before continuing on to the creation of a generalized additive model, it is instructive to generate plots to better visualize these data.

```
windows()
par(mfrow=c(2,2))
plot(table(aplarv.ctd$year[aplarv.ctd$Cper10m2>0]),ylab='Frequency',xlab='Year')
plot(table(aplarv.ctd$STATION[aplarv.ctd$Cper10m2>0]),ylab='Frequency',xlab='Station Number')
plot(table(aplarv.ctd$lat[aplarv.ctd$Cper10m2>0]),ylab='Frequency',xlab='Latitude')
plot(table(aplarv.ctd$lon[aplarv.ctd$Cper10m2>0]),ylab='Frequency',xlab='Longitude')
```



Now that we understand a bit more about the data, we can run a generalized additive model (GAM).

Generalized Additive Model of Larval Biogeography

Now we will create a GAM that models the distribution of Alaska plaice larvae as it relates to temperature and salinity. The temperature and salinity data were collected by conductivity-temperature-depth casts at every station and haul aboard these cruises. We will create a GAM with a two-dimensional smooth; this means that temperature and salinity act together as covariates to influence larval biogeography in this model.

```
library(mgcv)
```

```
## Loading required package: nlme
```

```
## This is mgcv 1.8-35. For overview type 'help("mgcv-package")'.
```

```
lv.2d<-gam((Cper10m2+1)~factor(year)+s(lon,lat)+s(doy,k=7)+s(bottom_depth)+
             s(temperature,salinity),data=aplarv.ctd,family=tw(link='log'),
           method='REML')

summary(lv.2d)
```

```
##
## Family: Tweedie(p=1.99)
## Link function: log
##
## Formula:
## (Cper10m2 + 1) ~ factor(year) + s(lon, lat) + s(doy, k = 7) +
##     s(bottom_depth) + s(temperature, salinity)
##
## Parametric coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)        0.558493   0.144966   3.853 0.000120 ***
## factor(year)1998   0.198585   0.282576   0.703 0.482267
## factor(year)1999   0.433149   0.223810   1.935 0.053062 .
## factor(year)2000 -0.112157   0.193117  -0.581 0.561447
## factor(year)2001 -0.273245   0.335157  -0.815 0.414993
## factor(year)2002 -0.615851   0.176898  -3.481 0.000507 ***
## factor(year)2003   0.006481   0.179946   0.036 0.971274
## factor(year)2004   0.395337   0.327906   1.206 0.228071
## factor(year)2005   0.654477   0.168209   3.891 0.000103 ***
## factor(year)2006   0.057439   0.157053   0.366 0.714596
## factor(year)2007 -0.012157   0.168388  -0.072 0.942452
## factor(year)2008 -0.236235   0.180423  -1.309 0.190540
## factor(year)2009 -0.289113   0.157744  -1.833 0.066952 .
## factor(year)2010 -0.063496   0.154594  -0.411 0.681308
## factor(year)2011 -0.300430   0.182558  -1.646 0.099959 .
## factor(year)2012 -0.366095   0.159599  -2.294 0.021883 *
## factor(year)2013 -0.135728   0.184578  -0.735 0.462200
## factor(year)2014 -0.041952   0.156760  -0.268 0.789015
## factor(year)2015 -0.020075   0.160129  -0.125 0.900244
## factor(year)2016   0.763784   0.167763   4.553 5.55e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

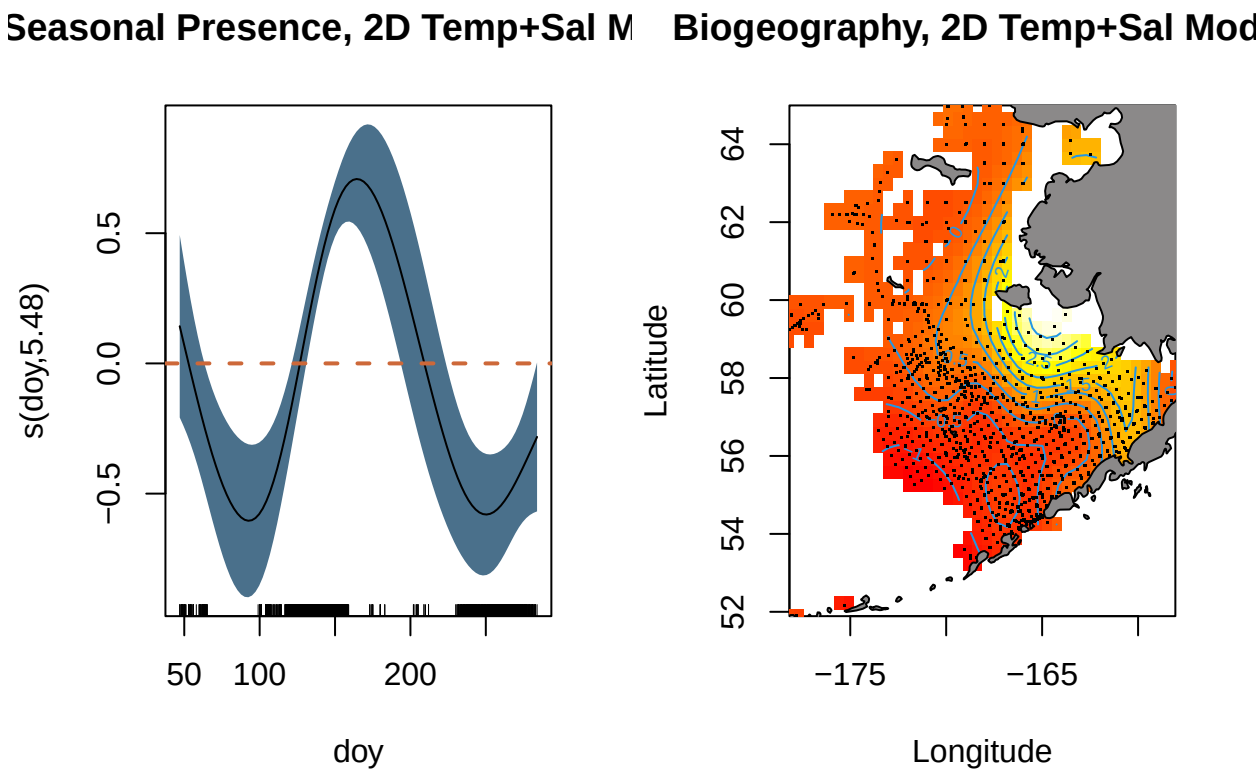
```
## Approximate significance of smooth terms:
##                             edf Ref.df     F p-value
## s(lon,lat)               28.072  28.94 42.80  <2e-16 ***
## s(doy)                    5.481   5.89 27.10  <2e-16 ***
## s(bottom_depth)           1.000   1.00  4.44  0.0352 *
## s(temperature,salinity) 26.384  28.58 21.64  <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## R-sq.(adj) =  0.397   Deviance explained =   83%
## -REML = 3999.2  Scale est. = 0.56273   n = 2564
```

This model actually does a great job of explaining larval biogeography with a deviance explained of 83%. All variables included are significant, though bottom depth is less significant than the others. We included bottom depth to account for variation in sampling presence across the shelf. While these are superficially good results, the predictions for each factor(year) vary in significance which may decrease our faith in the model.

Now we can plot these results.

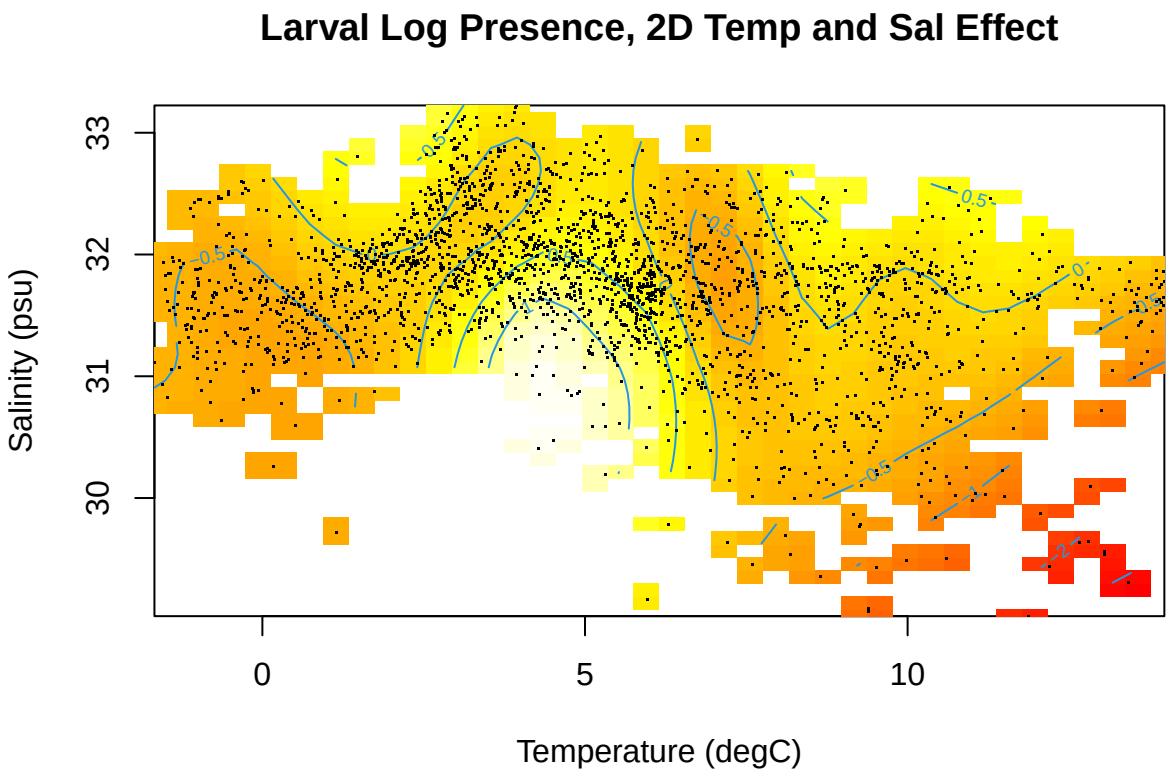
```
library(maps)

windows()
par(mfrow=c(1,2))
plot(lv.2d,select=2,seWithMean=TRUE,shade=TRUE,shade.col='skyblue4',
     main='Seasonal Presence, 2D Temp+Sal Model')
abline(h=0,col='sienna3',lty=2,lwd=2)
plot(lv.2d,select=1,scheme=2,seWithMean=TRUE,too.far=0.025,
     xlab='Longitude',ylab='Latitude',main='Biogeography, 2D Temp+Sal Model')
map("world",fill=T,col="snow4",add=T)
```



This above figure shows the model output for seasonal presence (at what day of year larvae are caught) and biogeography (where larvae are caught).

```
windows()
plot(lv.2d,select=4,scheme=2,main='Larval Log Presence, 2D Temp and Sal Effect',
     too.far=0.025,
     xlab='Temperature (degC)',ylab='Salinity (psu)')
```



This above figure shows the influence that temperature and salinity, when working together in a two-dimensional smooth, have on larval catch anomalies. Positive values in this figure (more yellow) reflect temperature and salinity values at which one can expect a *higher than average* larval catch.