Part I:

Problem 1) The experimental design used here is a split plot design. At the primary level, the experimental unit is the pond – this is the “whole plot” level. At the secondary level, the experimental unit is the depth – this is the “split plot”.

Problem 2) mod1 = aov(sodium~species\*depth\*season + Error(pond/species/depth/season), data = fisheggs)

For mod1: Error: pond

Df Sum Sq Mean Sq F value Pr(>F)

species 1 6110 6110 11.08 0.0291 \*

Residuals 4 2206 551

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Error: pond:depth

Df Sum Sq Mean Sq F value Pr(>F)

depth 1 90.25 90.25 11.051 0.0293 \*

species:depth 1 2.25 2.25 0.276 0.6274

Residuals 4 32.67 8.17

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Error: pond:depth:season

Df Sum Sq Mean Sq F value Pr(>F)

season 1 1261.5 1261.5 53.681 8.18e-05 \*\*\*

species:season 1 140.2 140.2 5.965 0.0404 \*

depth:season 1 8.2 8.2 0.348 0.5718

species:depth:season 1 4.2 4.2 0.177 0.6848

Residuals 8 188.0 23.5

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Error: Within

Df Sum Sq Mean Sq F value Pr(>F)

Residuals 12 165.3 13.78

For mod1\_a: Linear mixed-effects model fit by REML

Data: fisheggs

AIC BIC logLik

196.139 214.9879 -82.06951

Random effects:

Formula: ~1 | pond

(Intercept)

StdDev: 9.430663

Formula: ~1 | depth %in% pond

(Intercept)

StdDev: 0.0002698655

Formula: ~1 | season %in% depth %in% pond

(Intercept) Residual

StdDev: 4.218664 0.1184955

Fixed effects: sodium ~ species \* depth \* season

Value Std.Error DF t-value p-value

(Intercept) 259.33333 5.965137 16 43.47484 0.0000

speciesSpecies 2 -31.00000 8.435977 4 -3.67474 0.0213

depthshallow -5.00000 3.445883 4 -1.45101 0.2204

seasonmiddle -9.00000 3.445883 16 -2.61181 0.0189

seasonlate -21.33333 3.445883 16 -6.19096 0.0000

speciesSpecies 2:depthshallow 0.66667 4.873215 4 0.13680 0.8978

speciesSpecies 2:seasonmiddle 5.00000 4.873215 16 1.02602 0.3201

speciesSpecies 2:seasonlate 11.33333 4.873215 16 2.32564 0.0335

depthshallow:seasonmiddle 3.00000 4.873215 16 0.61561 0.5468

depthshallow:seasonlate 4.00000 4.873215 16 0.82081 0.4238

speciesSpecies 2:depthshallow:seasonmiddle -1.66667 6.891767 16 -0.24183 0.8120

speciesSpecies 2:depthshallow:seasonlate -3.33333 6.891767 16 -0.48367 0.6352

Correlation:

(Intr) spcsS2 dpthsh ssnmdd sesnlt spcsSpcs2:d spcsSpcs2:ssnm spcsSpcs2:ssnl

speciesSpecies 2 -0.707

depthshallow -0.289 0.204

seasonmiddle -0.289 0.204 0.500

seasonlate -0.289 0.204 0.500 0.500

speciesSpecies 2:depthshallow 0.204 -0.289 -0.707 -0.354 -0.354

speciesSpecies 2:seasonmiddle 0.204 -0.289 -0.354 -0.707 -0.354 0.500

speciesSpecies 2:seasonlate 0.204 -0.289 -0.354 -0.354 -0.707 0.500 0.500

depthshallow:seasonmiddle 0.204 -0.144 -0.707 -0.707 -0.354 0.500 0.500 0.250

depthshallow:seasonlate 0.204 -0.144 -0.707 -0.354 -0.707 0.500 0.250 0.500

speciesSpecies 2:depthshallow:seasonmiddle -0.144 0.204 0.500 0.500 0.250 -0.707 -0.707 -0.354

speciesSpecies 2:depthshallow:seasonlate -0.144 0.204 0.500 0.250 0.500 -0.707 -0.354 -0.707

dpthshllw:ssnm dpthshllw:ssnl spcsSpcs2:dpthshllw:ssnm

speciesSpecies 2

depthshallow

seasonmiddle

seasonlate

speciesSpecies 2:depthshallow

speciesSpecies 2:seasonmiddle

speciesSpecies 2:seasonlate

depthshallow:seasonmiddle

depthshallow:seasonlate 0.500

speciesSpecies 2:depthshallow:seasonmiddle -0.707 -0.354

speciesSpecies 2:depthshallow:seasonlate -0.354 -0.707 0.500

Standardized Within-Group Residuals:

Min Q1 Med Q3 Max

-0.05050732 -0.01226928 0.00146505 0.01624109 0.04456740

Number of Observations: 36

Number of Groups:

pond depth %in% pond season %in% depth %in% pond

6 12 36

Problem 3)



Problem 4) 

Problem 5)

Eggs in species 1 generally had a higher sodium concentration than the eggs of Species 2. This does not seem to vary significantly with depth nor pond. However, early season eggs had a higher overall concentration of sodium than eggs laid late in the season, regardless of location within or across ponds. Sodium content, in both split and whole plots, decayed continuously across season with the sole exception of the eggs of species 2 in the deep sample site at pond 4. The declines in sodium content are less pronounced, with more gentle slopes and less striking variation between ponds than previously relayed when season was interpreted as a categorical variable. These slopes are nonetheless fairly consistent across ponds, species, and depths. This is additionally supported from inspecting the slopes of the predicted values from my final model, mod3 (black line, Problem 4).

Part II:

#Molly Jenkins

#Assignment 5

#ENEC563

#02/27/2017

#

# 1) Explain the experimental design that was used here.

# Clearly identify the different kinds of experimental units and treatments using the language that is appropriate for this design.

#

# 2) Analyze the manner in which species, depth, and season affected the sodium content of fish eggs using a linear mixed model.

#

# 3) Prepare a graph that summarizes the results of your analysis.

#

# 4) Assume that the three values of the season variable are equally spaced in time.

# Refit your final model from question 2 but this time treat season as a continuous variable with equally spaced values.

# Superimpose your final continuous season model on the graph of Question 3.

#

# 5) Interpret your final model of Question 4.

# In terms of this model how does the sodium content of the eggs of the two species differ?

# Give both a qualitative and a quantitative answer.

#setwd("C:/git/coursework/ENEC563/")

library(ggplot2)

library(dplyr)

library(lme4)

fisheggs = read.table('https://sakai.unc.edu/access/content/group/7d7a0e1c-4adb-4ee2-ace8-490a89313a59/Data/fisheggs.txt', header = TRUE)

####Problem 1####

#This is a split-plot design

table(fisheggs$species, fisheggs$depth, fisheggs$season, fisheggs$pond)

#nicely balanced

fisheggs$species = as.factor(fisheggs$species)

fisheggs$pond = as.factor(fisheggs$pond)

fisheggs$season = factor(fisheggs$season,levels=c("early","middle","late"))

fisheggs$season\_num = as.numeric(as.character((factor(fisheggs$season,labels=c(1,2,3)))))

#add labels to species factor to look nice for plotting

fisheggs$species <- factor(fisheggs$species,

labels = c("Species 1", "Species 2"))

####Problem 2####

sink("A5\_table1.txt")

mod1 = aov(sodium~species\*depth\*season + Error(pond/depth/season), data = fisheggs) #structured error term

summary(mod1)

sink()

sink("A5\_table1a.txt")

mod1\_a = lme(sodium~species\*depth\*season, random = ~1|pond/depth/season, data = fisheggs)

summary(mod1\_a)

sink()

#season seems to have a non-trivial effect

####Problem 3####

altplot = ggplot(fisheggs,aes(x=season,y=sodium))

altplot+stat\_summary(aes(color=pond, group=pond),geom="line"

,fun.y="mean")+facet\_grid(species~depth)+theme\_bw()

####Problem 4####

# Refit your final model from question 2 but this time treat season as a continuous variable with equally spaced values.

# Superimpose your final continuous season model on the graph of Question 3.

fisheggs$season = as.integer(fisheggs$season)

mod2 = aov(sodium~species\*depth\*season + Error(pond/depth/season), data = fisheggs)

summary(mod2)

mod3 = lme(sodium~species\*depth\*season, random = ~1|pond/depth/season, data = fisheggs)

fisheggs$pred = as.integer(predict(mod3, level = 0))

altplot = ggplot(fisheggs,aes(x=season,y=sodium))

altplot+stat\_summary(aes(color=pond, group=pond),geom="line"

,fun.y="mean")+facet\_grid(species~depth)+

geom\_line(aes(y=pred),color="black")+theme\_bw()

####Problem 5####

#Eggs in species 1 generally had a higher sodium concentration than the eggs of Species 2.

#This does not seem to vary significantly with depth nor pond.

#However, early season eggs had an overall higher concentration of sodium than eggs laid late in the season, regardless of location within or across ponds.