Seminoff EPac green turtle Stable Isotope Data Analysis

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## Metadata from Jeff

**Site** - an ordinal code for each site  
**Site code** - 3 letter code for each site  
**Ordered\_SITE** - combined site code with ordered # roughly North to South for graphing ordering **Location\_Label** - shortened location names for graphing labeling purposes **Location** - location of turtle capture  
**LAB ID** - self explanatory  
**Collection Date** - self explanatory  
**Run Date** - self explanatory  
**%N** - elemental concentration of N. that is, how much each sample is made up of nitrogen. this is used as a diagnostic to know sample quality (anything outside of ~9-17% N raises a red flag)  
**%C** - elemental concentration of C. that is, how much each sample is made up of carbon. this is used as a diagnostic to know sample quality (anything outside of ~40-60% C raises a red flag)  
**d15N** - stable isotope value for N  
**d13C** - stable isotope value for C  
**Color** - rarely filled in. This is largely for the Galapagos and Colombia, where black turtles (eastern Pacific stock) and yellow turtles (west Pacific origins) co-exist. Safe to say that anything that is not filled in here would be a ‘black’ morph.  
**SCL** - straight carapace length **CCL\_calc\_fromSCL** - used formula from Seminoff et al. 2003 to interpolate CCLs from SCLs **CCL\_empirical** - curved carapace length-these are only the empirically collected values **CCL\_combined** - curved carapace length-I pasted over all the empirical values, and then for ones that were missing empirical CCL but had **CCL\_calc\_fromSCL**, I added these in; so this is the combined variable that we'll use for size relationships

Plan for figures:  
1. Carbon Histogram by Site  
2. Nitrogen Histogram by Site  
3. Boxplots, 2 panel (C then N)  
4. Ellipses  
5. Whisker plot (C vs. N)  
6. Map-large with insets of regions

## Setup

## Load Required Libraries

## Read in data

## Coarse data QC checks to note obvious data structure problems, etc.:

#see version 1 for more in depth QC checks  
summary(data)

## SITE\_No SITE\_CODE Ordered\_SITE  
## Min. : 1.00 SDB : 88 3-SDB : 88   
## 1st Qu.: 9.00 GOR : 76 18-GOR : 76   
## Median :15.00 DUL : 74 13-DUL : 74   
## Mean :13.79 PPE : 74 24-PPE : 74   
## 3rd Qu.:19.00 COC : 67 17-COC : 67   
## Max. :24.00 BLA : 53 9-BLA : 53   
## (Other):255 (Other):255   
## Location\_Label Habitat\_Type  
## San Diego Bay, USA : 88 coastal:355   
## Isla Gorgona, Colombia : 76 insular:258   
## Golfo Dulce, Costa Rica : 74 oceanic: 74   
## Oceanic Waters, Peru (Longline): 74   
## Cocos Island, Costa Rica : 67   
## Bahia de los Angeles, GoC, MX : 53   
## (Other) :255   
## Region   
## Cen-SoAm Pac Coast:116   
## EPac Islands :258   
## Gulf of Cal : 81   
## Oceanic : 74   
## SC-BC Pac Coast :158   
##   
##   
## Location LABID   
## San Diego Bay, United States : 88 101 : 1   
## Isla Gorgona, Colombia : 76 102 : 1   
## Golfo Dulce, Costa Rica : 74 103 : 1   
## Oceanic Waters, Peru (Longline) : 74 104 : 1   
## Cocos Island, Costa Rica : 67 105087 : 1   
## Bahia de los Angeles, Gulf of California, Mexico: 53 105088 : 1   
## (Other) :255 (Other):681   
## Collect\_Date Run\_Date   
## Min. :0000-03-23 00:00:00 Min. :0003-01-17 00:00:00   
## 1st Qu.:0004-08-30 00:00:00 1st Qu.:0005-02-01 00:00:00   
## Median :0007-12-17 00:00:00 Median :0007-06-07 00:00:00   
## Mean :0009-05-26 17:57:16 Mean :0007-07-30 01:04:34   
## 3rd Qu.:0010-11-03 00:00:00 3rd Qu.:0007-08-09 00:00:00   
## Max. :0099-02-04 00:00:00 Max. :0014-02-10 00:00:00   
## NA's :32 NA's :397   
## Percent\_N Percent\_C d15N d13C   
## Min. : 4.80 Min. :16.30 Min. : 5.90 Min. :-25.50   
## 1st Qu.:11.68 1st Qu.:38.08 1st Qu.:11.85 1st Qu.:-16.80   
## Median :13.25 Median :42.40 Median :13.50 Median :-15.90   
## Mean :12.92 Mean :41.04 Mean :13.66 Mean :-15.82   
## 3rd Qu.:14.70 3rd Qu.:45.23 3rd Qu.:15.40 3rd Qu.:-14.90   
## Max. :21.00 Max. :65.70 Max. :21.20 Max. : -8.10   
## NA's :87 NA's :87   
## COLOR SCL CCL\_calc\_fromSCL CCL\_empirical   
## :611 Min. : 39.70 Min. : 43.39 Min. : 42.70   
## BLACK : 29 1st Qu.: 56.55 1st Qu.: 60.85 1st Qu.: 65.50   
## YELLOW: 47 Median : 64.90 Median : 69.50 Median : 75.00   
## Mean : 68.47 Mean : 73.21 Mean : 75.29   
## 3rd Qu.: 76.20 3rd Qu.: 81.21 3rd Qu.: 82.40   
## Max. :110.40 Max. :116.65 Max. :116.50   
## NA's :368 NA's :368 NA's :295   
## CCL\_combined Alt.ID   
## Min. : 42.70 :561   
## 1st Qu.: 62.01 Alt ID : 24   
## Median : 72.35 : 4   
## Mean : 73.03 100 : 1   
## 3rd Qu.: 81.00 105 : 1   
## Max. :116.50 106 : 1   
## NA's :197 (Other): 95   
## Notes   
## :678   
## : 8   
## no measurements taken, confirmed in SDB Binder: 1   
##   
##   
##   
##

data$Ordered\_SITE<-factor(data$Ordered\_SITE)#reset variable to get rid of excluded sites in count  
table(data$Ordered\_SITE) #frequency table

##   
## 1-SGR\_SBN 3-SDB 4-NGU 6-BMA 9-BLA 11-CIN 13-DUL   
## 25 88 19 26 53 28 74   
## 14-PAR 15-MEJ 17-COC 18-GOR 19-IGP 20-IGE 21-IGD   
## 21 21 67 76 41 37 37   
## 24-PPE   
## 74

## Figures

#### 1. Faceted Histograms

levels(data$Location\_Label)

## [1] "Bahia de los Angeles, GoC, MX"   
## [2] "Bahia Elizabeth, Isabela, Galapagos"   
## [3] "Bahia Magdalena, BCS, MX"   
## [4] "Caleta Derek, Isabela, Galapagos"   
## [5] "Cocos Island, Costa Rica"   
## [6] "El Pardito Island, GoC, MX"   
## [7] "Golfo Dulce, Costa Rica"   
## [8] "Infiernillo Channel, GoC, MX"   
## [9] "Isla Gorgona, Colombia"   
## [10] "Isla San Lazaro, GoC, MX"   
## [11] "Long Beach, USA"   
## [12] "Loreto, GoC, MX"   
## [13] "Mejillones, Chile"   
## [14] "North Gulf of Ulloa, BCS, MX"   
## [15] "Oceanic Waters, Peru (Longline)"   
## [16] "Pisco / Paracas Bay, Peru"   
## [17] "Punta Nunez, Santa Cruz, Galapagos"   
## [18] "Puta Espinosa, Fernandina, Galapagos"  
## [19] "San Diego Bay, USA"

#come back and remake with codes in parentheses(?)  
data$Location\_Label<-factor(data$Location\_Label, levels =c(  
"Long Beach, USA", "Bahia de los Angeles, GoC, MX", "Isla Gorgona, Colombia" ,"Oceanic Waters, Peru (Longline)",  
"San Diego Bay, USA", "Infiernillo Channel, GoC, MX" , "Bahia Elizabeth, Isabela, Galapagos","Pisco / Paracas Bay, Peru" ,  
"North Gulf of Ulloa, BCS, MX", "Golfo Dulce, Costa Rica", "Caleta Derek, Isabela, Galapagos","Mejillones, Chile" ,  
"Bahia Magdalena, BCS, MX", "Cocos Island, Costa Rica" , "Puta Espinosa, Fernandina, Galapagos"))  
C<-ggplot(data, aes(x=d13C)) + geom\_histogram(alpha=.4, fill="yellow",colour="black")+theme\_bw()+  
geom\_vline(aes(xintercept=mean(d13C, na.rm=T)), #Ignore NA values for mean  
 color="red", linetype="dashed", size=0.5)  
pdf("carbon\_faceted\_histogram.pdf", 12, 5)  
C+facet\_wrap( ~ Location\_Label, ncol=4)

## `stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.

dev.off()

## quartz\_off\_screen   
## 2

N<-ggplot(data, aes(x=d15N)) + geom\_histogram(alpha=.4, fill="forest green",colour="black")+theme\_bw()+  
geom\_vline(aes(xintercept=mean(d15N, na.rm=T)), #Ignore NA values for mean  
 color="red", linetype="dashed", size=0.5)  
pdf("nitrogen\_faceted\_histogram.pdf", 12, 5)  
N+facet\_wrap( ~ Location\_Label, ncol=4)

## `stat\_bin()` using `bins = 30`. Pick better value with `binwidth`.

dev.off()

## quartz\_off\_screen   
## 2

#### 2. Boxplots, 2 panel (C then N)

data$Region<-factor(data$Region,levels=c("SC-BC Pac Coast","Gulf of Cal","Cen-SoAm Pac Coast" , "Oceanic" , "EPac Islands"))  
reg\_palette<-c("forest green","red", "purple","deepskyblue3","orange")  
  
levels(data$Ordered\_SITE)

## [1] "1-SGR\_SBN" "3-SDB" "4-NGU" "6-BMA" "9-BLA"   
## [6] "11-CIN" "13-DUL" "14-PAR" "15-MEJ" "17-COC"   
## [11] "18-GOR" "19-IGP" "20-IGE" "21-IGD" "24-PPE"

#for bottom to top order  
data$Ordered\_SITE<-factor(data$Ordered\_SITE,levels=c("1-SGR\_SBN" ,"3-SDB", "4-NGU" , "6-BMA" , "9-BLA" , "11-CIN" , "13-DUL" ,"14-PAR", "15-MEJ","24-PPE" ,"17-COC", "18-GOR", "20-IGE" , "21-IGD" ,"19-IGP" ))  
  
#for top to bottom order  
data$Ordered\_SITE<-factor(data$Ordered\_SITE,levels=c("19-IGP","21-IGD","20-IGE","18-GOR","17-COC","24-PPE","15-MEJ","14-PAR","13-DUL","11-CIN","9-BLA","6-BMA","4-NGU","3-SDB","1-SGR\_SBN"))  
  
pdf("nitrogen\_boxplot.pdf", 8, 5)  
ggplot(data, aes(y=d15N, x=Ordered\_SITE,fill=Region)) +   
 geom\_boxplot(outlier.shape = 1,width=0.75) +theme\_bw()+ guides(fill=FALSE)+  
 theme(panel.grid.major.x=element\_blank(),  
 panel.grid.minor.x=element\_blank(),  
 panel.grid.major.y=element\_line(colour="grey60",linetype="dashed"))+ scale\_fill\_manual(values=reg\_palette,guide=FALSE)+xlab("Location ") +ylab("d15N") +coord\_flip(ylim = c(5, 22))  
dev.off()

## quartz\_off\_screen   
## 2

pdf("carbon\_boxplot.pdf", 8, 5)  
ggplot(data, aes(y=d13C, x=Ordered\_SITE,fill=Region)) +   
 geom\_boxplot(outlier.shape = 1,width=0.75) +theme\_bw()+ guides(fill=FALSE)+  
 theme(panel.grid.major.x=element\_blank(),  
 panel.grid.minor.x=element\_blank(),  
 panel.grid.major.y=element\_line(colour="grey60",linetype="dashed"))+ scale\_fill\_manual(values=reg\_palette,guide=FALSE)+xlab("Location ") +ylab("d13C")+coord\_flip()  
dev.off()

## quartz\_off\_screen   
## 2

#### 3. Ellipses

[stat\_ellipse function info](http://docs.ggplot2.org/current/stat_ellipse.html)  
*notes say 'group by region 95% CI's, but not sure if mean ellipes by region or faceting by region, so doing both for now*

data\_new2$Region<-factor(data\_new2$Region,levels=c("SC-BC Pac Coast","Gulf of Cal","Cen-SoAm Pac Coast" , "EPac Islands"))  
reg\_palette1<-c("forest green","red", "purple","orange")  
pal1<-c("yellow","deepskyblue","forestgreen","red","deepskyblue","yellow","deepskyblue","yellow","red","yellow","deepskyblue","red","forestgreen", "grey80")  
data\_new2$Ordered\_SITE<-factor(data\_new2$Ordered\_SITE)  
  
pdf("ellipse\_facet1.pdf", 8, 5)  
#with data points and ellipse for each site by region-points on top  
levels(data\_new2$Ordered\_SITE)

## [1] "1-SGR\_SBN" "3-SDB" "4-NGU" "6-BMA" "9-BLA"   
## [6] "11-CIN" "13-DUL" "14-PAR" "15-MEJ" "17-COC"   
## [11] "18-GOR" "19-IGP" "20-IGE" "21-IGD"

ggplot(data\_new2, aes(x=d13C,y=d15N)) +  
 stat\_ellipse(geom="polygon",alpha=.5, aes(fill=Ordered\_SITE),color="black")+ geom\_point(size=3, alpha=.8,shape=21,position=position\_jitter(width=.5,height=.5),aes(fill=Ordered\_SITE))+theme\_bw()+theme(axis.text.x = element\_text(angle=0, vjust=0.5))+scale\_fill\_manual(values=pal1)+facet\_wrap( ~ Region, ncol=2)  
dev.off()

## quartz\_off\_screen   
## 2

pdf("ellipse\_facet2.pdf", 8, 5)  
#with data points and ellipse for each site by region-points on bottom  
ggplot(data\_new2, aes(x=d13C,y=d15N)) +  
 geom\_point(size=3, alpha=.8,shape=21,position=position\_jitter(width=.5,height=.5),aes(fill=Ordered\_SITE))+theme\_bw()+theme(axis.text.x = element\_text(angle=0, vjust=0.5))+  
stat\_ellipse(geom="polygon",alpha=.5, aes(fill=Ordered\_SITE),color="black")+scale\_fill\_manual(values=pal1)+facet\_wrap( ~ Region, ncol=2)  
dev.off()

## quartz\_off\_screen   
## 2

pdf("ellipse\_facet3.pdf", 8, 5)  
#with just ellipse for each site by region   
ggplot(data\_new2, aes(x=d13C,y=d15N)) + theme\_bw()+theme(axis.text.x = element\_text(angle=0, vjust=0.5))+  
 stat\_ellipse(geom="polygon",alpha=.5, aes(fill=Ordered\_SITE),color="black")+scale\_fill\_manual(values=pal1)+facet\_wrap( ~ Region, ncol=2)  
dev.off()

## quartz\_off\_screen   
## 2

pdf("ellipse\_region1.pdf", 8, 5)  
#with data and ellipse for each region-point on top  
ggplot(data\_new2, aes(x=d13C,y=d15N)) +  
 stat\_ellipse(geom="polygon",alpha=.6, aes(fill=Region),color="black")+   
 geom\_point(size=3, alpha=.9,shape=21,position=position\_jitter(width=.5,height=.5),aes(fill=Region))+theme\_bw()+theme(axis.text.x = element\_text(angle=0, vjust=0.5))+scale\_fill\_manual(values=reg\_palette1)  
dev.off()

## quartz\_off\_screen   
## 2

pdf("ellipse\_region2.pdf", 8, 5)  
#with data and ellipse for each region-point on bottom  
ggplot(data\_new2, aes(x=d13C,y=d15N)) +geom\_point(size=3, alpha=.9,shape=21,position=position\_jitter(width=.5,height=.5),aes(fill=Region))+  
 stat\_ellipse(geom="polygon",alpha=.6, aes(fill=Region),color="black") +  
 theme\_bw()+theme(axis.text.x = element\_text(angle=0, vjust=0.5))+scale\_fill\_manual(values=reg\_palette1)  
dev.off()

## quartz\_off\_screen   
## 2

pdf("ellipse\_region3.pdf", 8, 5)  
#with just ellipse for each region  
ggplot(data\_new2, aes(x=d13C,y=d15N, fill=Region)) + theme\_bw()+theme(axis.text.x = element\_text(angle=0, vjust=0.5))+scale\_fill\_manual(values=reg\_palette1)+  
 stat\_ellipse(geom="polygon",alpha=.6, aes(fill=Region),color="black")#default settings assume multivariate t distribution and 0.95 CI  
dev.off()

## quartz\_off\_screen   
## 2

#### 4. Whiskers

CNsum\_merge<-merge(data\_Csum,data\_Nsum)  
CNsum\_merge$SITENS<-paste(CNsum\_merge$N\_to\_S\_ordination, "-",CNsum\_merge$Ordered\_SITE)  
CNsum\_merge$SITENS

## [1] "1 - MEJ" "10 - COC" "11 - DUL" "13 - BMA"   
## [5] "16 - NGU" "18 - CIN" "19 - BLA" "2 - PAR"   
## [9] "20 - SDB" "21 - SGR\_SBN" "3 - PPE" "6 - IGD"   
## [13] "7 - IGE" "8 - IGP" "9 - GOR"

CNsum\_merge$SITENS<-factor(CNsum\_merge$SITENS,levels= c("1 - MEJ","2 - PAR","3 - PPE" ,"6 - IGD",  
"7 - IGE","8 - IGP","9 - GOR", "10 - COC", "11 - DUL","13 - BMA", "16 - NGU" ,"18 - CIN","19 - BLA","20 - SDB","21 - SGR\_SBN"))   
  
CNsum\_merge$Region<-factor(CNsum\_merge$Region,levels=c("SC-BC Pac Coast","Gulf of Cal","Cen-SoAm Pac Coast" , "Oceanic" , "EPac Islands"))  
  
pdf("C vs. N Whisker plot.pdf", 8, 5)  
ggplot(CNsum\_merge, aes(x=mean\_d13C,y=mean\_d15N,fill=Region)) +  
 geom\_errorbar(aes(ymin=mean\_d15N-se\_d15N,ymax=mean\_d15N+se\_d15N),size=0.25)+  
 geom\_errorbarh(aes(xmin=mean\_d13C-se\_d13C,xmax=mean\_d13C+se\_d13C),size=0.25)+  
 geom\_point(size=3, alpha=.9,shape=21)+theme\_bw()+theme(axis.text.x = element\_text(angle=0, vjust=0.5))+scale\_fill\_manual(values=reg\_palette)+ylab("Mean d15N per Location")+xlab("Mean d13C per Location")+geom\_text(aes(label=Ordered\_SITE),hjust=1.5, vjust=0.5,size=3)  
dev.off()

## quartz\_off\_screen   
## 2

#### 5. Map

# Load map packages  
library("maps")

## Warning: package 'maps' was built under R version 3.2.5

##   
## Attaching package: 'maps'

## The following object is masked from 'package:plyr':  
##   
## ozone

library("mapproj")  
library("mapplots")  
library("mapdata")  
library("ggmap")  
#don't need all these packages just for this one map, but I use them later for other map  
#stuff in the script that I am not including here  
  
#Usage:  
#get\_map(location = c(lon = -95.3632715, lat = 29.7632836),  
#zoom = "auto", scale = "auto",   
#maptype = c("terrain", "terrain-background", "satellite", "roadmap",   
#"hybrid", "toner", "watercolor", "terrain-labels", "terrain-lines", "toner-2010",   
#"toner-2011", "toner-background", "toner-hybrid", "toner-labels", "toner-lines", "toner-lite"),   
#source = c("google", "osm", "stamen", "cloudmade"),   
#force = ifelse(source == "google", TRUE, TRUE), messaging = FALSE,   
#urlonly = FALSE, filename = "ggmapTemp", crop = TRUE, color = c("color", "bw"), language = "en-EN", api\_key)  
  
EPGT\_latlong<-read.csv("Lat\_long\_EPGT.csv")  
EPGT\_latlong$mean\_d15N\_scale<-EPGT\_latlong$mean\_d15N\*0.4  
EPGT\_latlong$mean\_d15N\_scale\_1<-EPGT\_latlong$mean\_d15N\*0.75  
#Entire Study Region Map  
description<-"EPacRegion"  
myLocation <- c(-175, -45, -62, 45)  
#bounding box lowerleftlon, lowerleftlat, upperrightlon, upperrightlat  
  
myMap <- get\_map(location=myLocation, source="google",  
 maptype="hybrid", crop=TRUE)

## Warning: bounding box given to google - spatial extent only approximate.

## converting bounding box to center/zoom specification. (experimental)

## Map from URL : http://maps.googleapis.com/maps/api/staticmap?center=0,-118.5&zoom=3&size=640x640&scale=2&maptype=hybrid&language=en-EN&sensor=false

pdf(paste(description, "\_Gmap", ".pdf",sep=""), width = 11, height = 8.5)  
ggmap(myMap) +  
 geom\_point(aes(x = Longitude, y = Latitude),   
 data = EPGT\_latlong, fill = "red", alpha=0.65,   
 size = 6,shape=21)  
  
dev.off()

## quartz\_off\_screen   
## 2

#SoCal\_Baja\_inset  
description1<-"SoCal-Baja\_region"  
SoCal\_Baja <- c(-121, 22.5, -109, 35)  
#bounding box lowerleftlon, lowerleftlat, upperrightlon, upperrightlat  
  
myMap1 <- get\_map(location=SoCal\_Baja,   
 source="google", maptype="satellite", crop=TRUE)

## Warning: bounding box given to google - spatial extent only approximate.

## converting bounding box to center/zoom specification. (experimental)

## Map from URL : http://maps.googleapis.com/maps/api/staticmap?center=28.75,-115&zoom=6&size=640x640&scale=2&maptype=satellite&language=en-EN&sensor=false

pdf(paste(description1, "\_Gmap", ".pdf",sep=""), width = 8, height = 8.5)  
ggmap(myMap1) +  
 geom\_point(aes(x = Longitude, y = Latitude),   
 data = EPGT\_latlong,fill = "red", alpha=0.65,   
 size = 16, shape=21)

## Warning: Removed 9 rows containing missing values (geom\_point).

dev.off()

## quartz\_off\_screen   
## 2

#Cen-Islands\_inset  
description2<-"Islands\_region"  
Islands\_region <- c(-100, -10, -75, 11)  
#bounding box lowerleftlon, lowerleftlat, upperrightlon, upperrightlat  
  
myMap2 <- get\_map(location=Islands\_region,   
 source="google", maptype="satellite", crop=TRUE)

## Warning: bounding box given to google - spatial extent only approximate.

## converting bounding box to center/zoom specification. (experimental)

## Map from URL : http://maps.googleapis.com/maps/api/staticmap?center=0.5,-87.5&zoom=5&size=640x640&scale=2&maptype=satellite&language=en-EN&sensor=false

pdf(paste(description2, "\_Gmap", ".pdf",sep=""), width = 8, height = 8.5)  
ggmap(myMap2) +  
 geom\_point(aes(x = Longitude, y = Latitude),   
 data = EPGT\_latlong, fill = "red", alpha=0.65,   
 size = 16, shape=21)

## Warning: Removed 8 rows containing missing values (geom\_point).

dev.off()

## quartz\_off\_screen   
## 2

#So America Region Map  
description3<-"SoAm\_Region"  
SoAm\_Region <- c(-81, -25, -68,-13)  
#bounding box lowerleftlon, lowerleftlat, upperrightlon, upperrightlat  
  
myMap3 <- get\_map(location=SoAm\_Region,   
 source="google", maptype="satellite", crop=TRUE)

## Warning: bounding box given to google - spatial extent only approximate.

## converting bounding box to center/zoom specification. (experimental)

## Map from URL : http://maps.googleapis.com/maps/api/staticmap?center=-19,-74.5&zoom=6&size=640x640&scale=2&maptype=satellite&language=en-EN&sensor=false

pdf(paste(description3, "\_Gmap", ".pdf",sep=""), width = 8, height = 8.5)  
ggmap(myMap3) +  
 geom\_point(aes(x = Longitude, y = Latitude),   
 data = EPGT\_latlong, fill = "red", alpha=0.65,   
 size = 16,shape=21)

## Warning: Removed 13 rows containing missing values (geom\_point).

dev.off()

## quartz\_off\_screen   
## 2

#### 6. LMMs and Linear Models

#LMM region- Nitrogen  
region\_Nm1<-lmer(data=data\_new2, d15N~Region\*CCL\_combined+(1|Region/SITE\_CODE))#interactive  
summary(region\_Nm1)

## Linear mixed model fit by REML t-tests use Satterthwaite approximations  
## to degrees of freedom [lmerMod]  
## Formula: d15N ~ Region \* CCL\_combined + (1 | Region/SITE\_CODE)  
## Data: data\_new2  
##   
## REML criterion at convergence: 1813.5  
##   
## Scaled residuals:   
## Min 1Q Median 3Q Max   
## -5.9785 -0.4130 0.0350 0.5089 5.1712   
##   
## Random effects:  
## Groups Name Variance Std.Dev.  
## SITE\_CODE:Region (Intercept) 5.127 2.264   
## Region (Intercept) 8.859 2.976   
## Residual 2.084 1.444   
## Number of obs: 489, groups: SITE\_CODE:Region, 14; Region, 4  
##   
## Fixed effects:  
## Estimate Std. Error df  
## (Intercept) 11.587590 3.165136 0.000000  
## RegionGulf of Cal 3.256741 4.840711 0.000000  
## RegionCen-SoAm Pac Coast 3.276701 4.688938 0.000000  
## RegionEPac Islands -0.727088 4.635607 0.000000  
## CCL\_combined 0.035297 0.007621 478.300000  
## RegionGulf of Cal:CCL\_combined -0.021483 0.020867 474.200000  
## RegionCen-SoAm Pac Coast:CCL\_combined -0.055132 0.019586 481.000000  
## RegionEPac Islands:CCL\_combined -0.004667 0.015663 474.700000  
## t value Pr(>|t|)   
## (Intercept) 3.661 0.97668   
## RegionGulf of Cal 0.673 0.98080   
## RegionCen-SoAm Pac Coast 0.699 0.98246   
## RegionEPac Islands -0.157 0.99146   
## CCL\_combined 4.631 4.69e-06 \*\*\*  
## RegionGulf of Cal:CCL\_combined -1.030 0.30374   
## RegionCen-SoAm Pac Coast:CCL\_combined -2.815 0.00508 \*\*   
## RegionEPac Islands:CCL\_combined -0.298 0.76589   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Correlation of Fixed Effects:  
## (Intr) RgnGoC RgC-SAPC RgnEPI CCL\_cm RGoC:C RC-SAPC:  
## RegnGlfofCl -0.654   
## RgnCn-SAmPC -0.675 0.441   
## RgnEPcIslnd -0.683 0.446 0.461   
## CCL\_combind -0.164 0.108 0.111 0.112   
## RgnGoC:CCL\_ 0.060 -0.308 -0.041 -0.041 -0.365   
## RC-SAPC:CCL 0.064 -0.042 -0.272 -0.044 -0.389 0.142   
## RgnEPI:CCL\_ 0.080 -0.052 -0.054 -0.232 -0.487 0.178 0.189

Anova(region\_Nm1)

## Analysis of Deviance Table (Type II Wald chisquare tests)  
##   
## Response: d15N  
## Chisq Df Pr(>Chisq)   
## Region 0.3758 3 0.94519   
## CCL\_combined 19.7301 1 8.919e-06 \*\*\*  
## Region:CCL\_combined 8.4453 3 0.03765 \*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

#including oceanic  
 region\_Nm2<-lmer(data=data, d15N~Region\*CCL\_combined+(1|Region/SITE\_CODE))#interactive

## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

summary(region\_Nm2)

## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient  
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient  
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## Linear mixed model fit by REML t-tests use Satterthwaite approximations  
## to degrees of freedom [lmerMod]  
## Formula: d15N ~ Region \* CCL\_combined + (1 | Region/SITE\_CODE)  
## Data: data  
##   
## REML criterion at convergence: 1813.5  
##   
## Scaled residuals:   
## Min 1Q Median 3Q Max   
## -5.9785 -0.4113 0.0348 0.5080 5.1712   
##   
## Random effects:  
## Groups Name Variance Std.Dev.  
## SITE\_CODE:Region (Intercept) 5.127 2.264   
## Region (Intercept) 7.796 2.792   
## Residual 2.084 1.444   
## Number of obs: 490, groups: SITE\_CODE:Region, 15; Region, 5  
##   
## Fixed effects:  
## Estimate Std. Error df  
## (Intercept) 11.587590 2.992427 0.000000  
## RegionGulf of Cal 3.256741 4.615793 0.000000  
## RegionCen-SoAm Pac Coast 3.276701 4.456367 0.000000  
## RegionOceanic -1.241865 4.869288 0.000000  
## RegionEPac Islands -0.727088 4.400218 0.000000  
## CCL\_combined 0.035297 0.007621 478.300000  
## RegionGulf of Cal:CCL\_combined -0.021483 0.020867 474.200000  
## RegionCen-SoAm Pac Coast:CCL\_combined -0.055132 0.019586 481.000000  
## RegionEPac Islands:CCL\_combined -0.004667 0.015663 474.700000  
## t value Pr(>|t|)   
## (Intercept) 3.872 0.98427   
## RegionGulf of Cal 0.706 0.98622   
## RegionCen-SoAm Pac Coast 0.735 0.98758   
## RegionOceanic -0.255 0.98913   
## RegionEPac Islands -0.165 0.99356   
## CCL\_combined 4.631 4.69e-06 \*\*\*  
## RegionGulf of Cal:CCL\_combined -1.030 0.30374   
## RegionCen-SoAm Pac Coast:CCL\_combined -2.815 0.00508 \*\*   
## RegionEPac Islands:CCL\_combined -0.298 0.76589   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1  
##   
## Correlation of Fixed Effects:  
## (Intr) RgnGoC RgC-SAPC RgnOcn RgnEPI CCL\_cm RGoC:C RC-SAPC:  
## RegnGlfofCl -0.648   
## RgnCn-SAmPC -0.671 0.435   
## RegionOcenc -0.601 0.390 0.404   
## RgnEPcIslnd -0.680 0.441 0.457 0.409   
## CCL\_combind -0.174 0.113 0.117 0.029 0.118   
## RgnGoC:CCL\_ 0.064 -0.323 -0.043 -0.011 -0.043 -0.365   
## RC-SAPC:CCL 0.068 -0.044 -0.286 -0.011 -0.046 -0.389 0.142   
## RgnEPI:CCL\_ 0.085 -0.055 -0.057 -0.014 -0.245 -0.487 0.178 0.189   
## fit warnings:  
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

Anova(region\_Nm2)

## Analysis of Deviance Table (Type II Wald chisquare tests)  
##   
## Response: d15N  
## Chisq Df Pr(>Chisq)   
## Region 0.5392 4 0.96957   
## CCL\_combined 19.7301 1 8.919e-06 \*\*\*  
## Region:CCL\_combined 8.4453 3 0.03765 \*   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

#LMM region-Carbon  
region\_Cm1<-lmer(data=data\_new2, d13C~Region\*CCL\_combined+(1|Region/SITE\_CODE))#interactive  
summary(region\_Cm1)

## Linear mixed model fit by REML t-tests use Satterthwaite approximations  
## to degrees of freedom [lmerMod]  
## Formula: d13C ~ Region \* CCL\_combined + (1 | Region/SITE\_CODE)  
## Data: data\_new2  
##   
## REML criterion at convergence: 1932.2  
##   
## Scaled residuals:   
## Min 1Q Median 3Q Max   
## -4.6032 -0.3337 0.0876 0.4487 5.2285   
##   
## Random effects:  
## Groups Name Variance Std.Dev.  
## SITE\_CODE:Region (Intercept) 2.260 1.5034   
## Region (Intercept) 0.575 0.7583   
## Residual 2.725 1.6507   
## Number of obs: 489, groups: SITE\_CODE:Region, 14; Region, 4  
##   
## Fixed effects:  
## Estimate Std. Error df  
## (Intercept) -15.830060 1.159333 0.000000  
## RegionGulf of Cal 0.454900 2.375935 0.000000  
## RegionCen-SoAm Pac Coast -0.403314 2.107894 0.000000  
## RegionEPac Islands 0.236843 1.961329 0.000000  
## CCL\_combined 0.000248 0.008635 479.400000  
## RegionGulf of Cal:CCL\_combined 0.002491 0.023778 479.000000  
## RegionCen-SoAm Pac Coast:CCL\_combined 0.016424 0.021993 453.700000  
## RegionEPac Islands:CCL\_combined -0.001133 0.017839 479.700000  
## t value Pr(>|t|)  
## (Intercept) -13.654 1.000  
## RegionGulf of Cal 0.191 0.999  
## RegionCen-SoAm Pac Coast -0.191 1.000  
## RegionEPac Islands 0.121 1.000  
## CCL\_combined 0.029 0.977  
## RegionGulf of Cal:CCL\_combined 0.105 0.917  
## RegionCen-SoAm Pac Coast:CCL\_combined 0.747 0.456  
## RegionEPac Islands:CCL\_combined -0.063 0.949  
##   
## Correlation of Fixed Effects:  
## (Intr) RgnGoC RgC-SAPC RgnEPI CCL\_cm RGoC:C RC-SAPC:  
## RegnGlfofCl -0.488   
## RgnCn-SAmPC -0.550 0.268   
## RgnEPcIslnd -0.591 0.288 0.325   
## CCL\_combind -0.510 0.249 0.281 0.302   
## RgnGoC:CCL\_ 0.185 -0.715 -0.102 -0.110 -0.363   
## RC-SAPC:CCL 0.200 -0.098 -0.681 -0.118 -0.393 0.143   
## RgnEPI:CCL\_ 0.247 -0.121 -0.136 -0.626 -0.484 0.176 0.190

Anova(region\_Cm1)

## Analysis of Deviance Table (Type II Wald chisquare tests)  
##   
## Response: d13C  
## Chisq Df Pr(>Chisq)  
## Region 0.2625 3 0.9669  
## CCL\_combined 0.0963 1 0.7563  
## Region:CCL\_combined 0.6024 3 0.8959

#including oceanic  
 region\_Cm2<-lmer(data=data, d13C~Region\*CCL\_combined+(1|Region/SITE\_CODE))#interactive

## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

summary(region\_Cm2)

## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient  
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient  
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

## Linear mixed model fit by REML t-tests use Satterthwaite approximations  
## to degrees of freedom [lmerMod]  
## Formula: d13C ~ Region \* CCL\_combined + (1 | Region/SITE\_CODE)  
## Data: data  
##   
## REML criterion at convergence: 1932.2  
##   
## Scaled residuals:   
## Min 1Q Median 3Q Max   
## -4.6032 -0.3336 0.0875 0.4482 5.2285   
##   
## Random effects:  
## Groups Name Variance Std.Dev.  
## SITE\_CODE:Region (Intercept) 2.2603 1.5034   
## Region (Intercept) 0.2014 0.4488   
## Residual 2.7248 1.6507   
## Number of obs: 490, groups: SITE\_CODE:Region, 15; Region, 5  
##   
## Fixed effects:  
## Estimate Std. Error df  
## (Intercept) -15.830060 0.985118 0.000000  
## RegionGulf of Cal 0.454900 2.213114 0.000000  
## RegionCen-SoAm Pac Coast -0.403314 1.922505 0.000000  
## RegionOceanic 0.017736 2.415253 0.000000  
## RegionEPac Islands 0.236843 1.760573 0.000000  
## CCL\_combined 0.000248 0.008635 479.400000  
## RegionGulf of Cal:CCL\_combined 0.002491 0.023778 479.000000  
## RegionCen-SoAm Pac Coast:CCL\_combined 0.016424 0.021993 453.700000  
## RegionEPac Islands:CCL\_combined -0.001133 0.017839 479.700000  
## t value Pr(>|t|)  
## (Intercept) -16.069 1.000  
## RegionGulf of Cal 0.206 0.999  
## RegionCen-SoAm Pac Coast -0.210 0.999  
## RegionOceanic 0.007 1.000  
## RegionEPac Islands 0.135 1.000  
## CCL\_combined 0.029 0.977  
## RegionGulf of Cal:CCL\_combined 0.105 0.917  
## RegionCen-SoAm Pac Coast:CCL\_combined 0.747 0.456  
## RegionEPac Islands:CCL\_combined -0.063 0.949  
##   
## Correlation of Fixed Effects:  
## (Intr) RgnGoC RgC-SAPC RgnOcn RgnEPI CCL\_cm RGoC:C RC-SAPC:  
## RegnGlfofCl -0.445   
## RgnCn-SAmPC -0.512 0.228   
## RegionOcenc -0.301 0.134 0.154   
## RgnEPcIslnd -0.560 0.249 0.287 0.169   
## CCL\_combind -0.601 0.267 0.308 0.067 0.336   
## RgnGoC:CCL\_ 0.218 -0.768 -0.112 -0.024 -0.122 -0.363   
## RC-SAPC:CCL 0.236 -0.105 -0.747 -0.026 -0.132 -0.393 0.143   
## RgnEPI:CCL\_ 0.291 -0.129 -0.149 -0.033 -0.698 -0.484 0.176 0.190   
## fit warnings:  
## fixed-effect model matrix is rank deficient so dropping 1 column / coefficient

Anova(region\_Cm2)

## Analysis of Deviance Table (Type II Wald chisquare tests)  
##   
## Response: d13C  
## Chisq Df Pr(>Chisq)  
## Region 0.3858 4 0.9836  
## CCL\_combined 0.0963 1 0.7563  
## Region:CCL\_combined 0.6024 3 0.8959

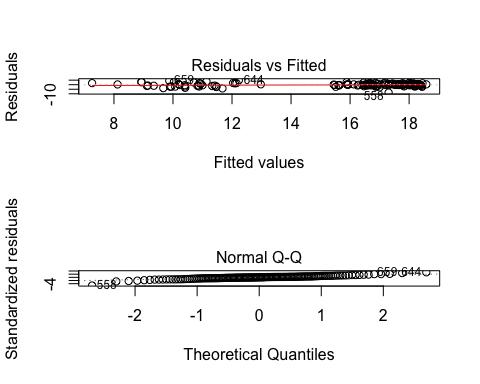
#Linear models-For each region seperately  
summary(data\_new2$Region)

## SC-BC Pac Coast Gulf of Cal Cen-SoAm Pac Coast   
## 158 81 116   
## EPac Islands   
## 258

SC<-subset(data\_new2, Region=="SC-BC Pac Coast")   
SC.1<-subset(SC, CCL\_combined !="NA")  
GC<-subset(data\_new2, Region=="Gulf of Cal")  
GC.1<-subset(GC, CCL\_combined !="NA")  
CSC<-subset(data\_new2, Region== "Cen-SoAm Pac Coast")   
CSC.1<-subset(CSC, CCL\_combined !="NA")  
EPI<- subset(data\_new2, Region== "EPac Islands")  
EPI.1<-subset(EPI, CCL\_combined !="NA")  
  
SC\_Nm1<-aov(data=SC.1, d15N~Ordered\_SITE\*CCL\_combined)  
GC\_Nm1<-aov(data=GC.1, d15N~Ordered\_SITE\*CCL\_combined)  
CSC\_Nm1<-aov(data=CSC.1, d15N~Ordered\_SITE\*CCL\_combined)  
EPI\_Nm1<-aov(data=EPI.1, d15N~Ordered\_SITE\*CCL\_combined)  
  
summary(SC\_Nm1)

## Df Sum Sq Mean Sq F value Pr(>F)   
## Ordered\_SITE 3 1253.2 417.7 147.638 < 2e-16 \*\*\*  
## CCL\_combined 1 46.5 46.5 16.442 8.5e-05 \*\*\*  
## Ordered\_SITE:CCL\_combined 3 59.6 19.9 7.019 0.000203 \*\*\*  
## Residuals 133 376.3 2.8   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

par(mfrow=c(2, 1))  
plot(SC\_Nm1, which=1:2)



dev.off()

## null device   
## 1

SC.1$Nresid = resid(SC\_Nm1)  
ggplot(SC.1,aes(x=CCL\_combined,y=Nresid))+geom\_point()  
ggplot(SC.1,aes(x=Ordered\_SITE,y=Nresid))+geom\_boxplot()+geom\_point()  
  
#variance issues, trying transformation  
SC.1$logdN<-log(SC.1$d15N)  
SC\_Nm3<-aov(data=SC.1, logdN~Ordered\_SITE\*CCL\_combined)  
summary(SC\_Nm3)

## Df Sum Sq Mean Sq F value Pr(>F)   
## Ordered\_SITE 3 7.480 2.4934 128.609 < 2e-16 \*\*\*  
## CCL\_combined 1 0.150 0.1496 7.718 0.006259 \*\*   
## Ordered\_SITE:CCL\_combined 3 0.414 0.1381 7.124 0.000179 \*\*\*  
## Residuals 133 2.578 0.0194   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

par(mfrow=c(2, 1))  
plot(SC\_Nm3, which=1:2)  
dev.off()

## null device   
## 1

SC.1$logNresid = resid(SC\_Nm3)  
ggplot(SC.1,aes(x=CCL\_combined,y=logNresid))+geom\_point()  
ggplot(SC.1,aes(x=Ordered\_SITE,y=logNresid))+geom\_boxplot()+geom\_point()  
  
  
summary(GC\_Nm1)

## Df Sum Sq Mean Sq F value Pr(>F)  
## Ordered\_SITE 1 0.83 0.8291 0.650 0.423  
## CCL\_combined 1 1.07 1.0695 0.839 0.363  
## Ordered\_SITE:CCL\_combined 1 0.00 0.0005 0.000 0.984  
## Residuals 63 80.32 1.2749

par(mfrow=c(2, 1))  
plot(GC\_Nm1, which=1:2)  
dev.off()

## null device   
## 1

GC.1$Nresid = resid(GC\_Nm1)  
ggplot(GC.1,aes(x=CCL\_combined,y=Nresid))+geom\_point()  
ggplot(GC.1,aes(x=Ordered\_SITE,y=Nresid))+geom\_boxplot()  
  
summary(CSC\_Nm1)

## Df Sum Sq Mean Sq F value Pr(>F)   
## Ordered\_SITE 2 49.19 24.597 9.455 0.000186 \*\*\*  
## CCL\_combined 1 2.32 2.316 0.890 0.347891   
## Ordered\_SITE:CCL\_combined 2 8.70 4.349 1.672 0.193661   
## Residuals 91 236.73 2.601   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

par(mfrow=c(2, 1))  
plot(CSC\_Nm1, which=1:2)  
dev.off()

## null device   
## 1

CSC.1$Nresid = resid(CSC\_Nm1)  
ggplot(CSC.1,aes(x=CCL\_combined,y=Nresid))+geom\_point()  
ggplot(CSC.1,aes(x=Ordered\_SITE,y=Nresid))+geom\_boxplot()#come back here-what's up with Chile?  
  
#variance issues, trying transformation  
CSC.1$logdN<-log(CSC.1$d15N)  
CSC\_Nm3<-aov(data=CSC.1, logdN~Ordered\_SITE\*CCL\_combined)  
summary(CSC\_Nm3)

## Df Sum Sq Mean Sq F value Pr(>F)   
## Ordered\_SITE 2 0.2895 0.14473 7.979 0.000641 \*\*\*  
## CCL\_combined 1 0.0182 0.01822 1.005 0.318839   
## Ordered\_SITE:CCL\_combined 2 0.0628 0.03138 1.730 0.183085   
## Residuals 91 1.6506 0.01814   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

par(mfrow=c(2, 1))  
plot(CSC\_Nm3, which=1:2)  
dev.off()

## null device   
## 1

CSC.1$logNresid = resid(CSC\_Nm3)  
ggplot(CSC.1,aes(x=CCL\_combined,y=logNresid))+geom\_point()  
ggplot(CSC.1,aes(x=Ordered\_SITE,y=logNresid))+geom\_boxplot()+geom\_point()  
  
  
summary(EPI\_Nm1)

## Df Sum Sq Mean Sq F value Pr(>F)   
## Ordered\_SITE 2 70.51 35.26 28.223 2.26e-11 \*\*\*  
## CCL\_combined 1 10.62 10.62 8.505 0.004 \*\*   
## Ordered\_SITE:CCL\_combined 2 3.08 1.54 1.231 0.295   
## Residuals 178 222.36 1.25   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

par(mfrow=c(2, 1))  
plot(EPI\_Nm1, which=1:2)  
dev.off()

## null device   
## 1

EPI.1$Nresid = resid(EPI\_Nm1)  
ggplot(EPI.1,aes(x=CCL\_combined,y=Nresid))+geom\_point()  
ggplot(EPI.1,aes(x=Ordered\_SITE,y=Nresid))+geom\_boxplot()  
  
#to double check that dropped data in full models (bc CCL data missing) isn't influencing site relationships  
SC\_Nm2<-aov(data=SC, d15N~Ordered\_SITE)  
GC\_Nm2<-aov(data=GC, d15N~Ordered\_SITE)  
CSC\_Nm2<-aov(data=CSC, d15N~Ordered\_SITE)  
EPI\_Nm2<-aov(data=EPI, d15N~Ordered\_SITE)  
  
summary(SC\_Nm2)

## Df Sum Sq Mean Sq F value Pr(>F)   
## Ordered\_SITE 3 1423.9 474.6 129.9 <2e-16 \*\*\*  
## Residuals 154 562.5 3.7   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

par(mfrow=c(2, 1))  
plot(SC\_Nm2, which=1:2)  
dev.off()

## null device   
## 1

SC$Nresid = resid(SC\_Nm2)  
ggplot(SC,aes(x=Ordered\_SITE,y=Nresid))+geom\_boxplot()  
  
summary(GC\_Nm2)

## Df Sum Sq Mean Sq F value Pr(>F)  
## Ordered\_SITE 1 2.28 2.276 1.826 0.18  
## Residuals 79 98.45 1.246

par(mfrow=c(2, 1))  
plot(GC\_Nm2, which=1:2)  
dev.off()

## null device   
## 1

GC$Nresid = resid(GC\_Nm2)  
ggplot(GC,aes(x=Ordered\_SITE,y=Nresid))+geom\_boxplot()  
  
summary(CSC\_Nm2)

## Df Sum Sq Mean Sq F value Pr(>F)   
## Ordered\_SITE 2 213.4 106.72 31.68 1.2e-11 \*\*\*  
## Residuals 113 380.7 3.37   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

par(mfrow=c(2, 1))  
plot(CSC\_Nm2, which=1:2)  
dev.off()

## null device   
## 1

CSC$Nresid = resid(CSC\_Nm2)  
ggplot(CSC,aes(x=Ordered\_SITE,y=Nresid))+geom\_boxplot()#chile resids look much better here...what's difference?  
  
summary(EPI\_Nm2)

## Df Sum Sq Mean Sq F value Pr(>F)   
## Ordered\_SITE 4 198.5 49.62 35.66 <2e-16 \*\*\*  
## Residuals 253 352.1 1.39   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

par(mfrow=c(2, 1))  
plot(EPI\_Nm2, which=1:2)  
dev.off()

## null device   
## 1

EPI$Nresid = resid(EPI\_Nm2)  
ggplot(EPI,aes(x=Ordered\_SITE,y=Nresid))+geom\_boxplot()  
  
#-------  
 #Carbon   
SC\_Cm1<-aov(data=SC.1, d13C~Ordered\_SITE\*CCL\_combined)  
GC\_Cm1<-aov(data=GC.1, d13C~Ordered\_SITE\*CCL\_combined)  
CSC\_Cm1<-aov(data=CSC.1, d13C~Ordered\_SITE\*CCL\_combined)  
EPI\_Cm1<-aov(data=EPI.1, d13C~Ordered\_SITE\*CCL\_combined)  
  
SC\_Cm2<-aov(data=SC, d13C~Ordered\_SITE)  
GC\_Cm2<-aov(data=GC, d13C~Ordered\_SITE)  
CSC\_Cm2<-aov(data=CSC, d13C~Ordered\_SITE)  
EPI\_Cm2<-aov(data=EPI, d13C~Ordered\_SITE)  
  
summary(SC\_Cm1)

## Df Sum Sq Mean Sq F value Pr(>F)  
## Ordered\_SITE 3 24.5 8.156 1.591 0.195  
## CCL\_combined 1 0.2 0.234 0.046 0.831  
## Ordered\_SITE:CCL\_combined 3 22.5 7.496 1.462 0.228  
## Residuals 133 681.8 5.126

par(mfrow=c(2, 1))  
plot(SC\_Cm1, which=1:2)  
dev.off()

## null device   
## 1

SC.1$Cresid = resid(SC\_Cm1)  
ggplot(SC.1,aes(x=CCL\_combined,y=Cresid))+geom\_point()  
ggplot(SC.1,aes(x=Ordered\_SITE,y=Cresid))+geom\_boxplot()+geom\_point()  
  
summary(GC\_Cm1)

## Df Sum Sq Mean Sq F value Pr(>F)   
## Ordered\_SITE 1 10.89 10.887 11.847 0.00103 \*\*  
## CCL\_combined 1 0.07 0.072 0.079 0.77988   
## Ordered\_SITE:CCL\_combined 1 3.60 3.604 3.921 0.05205 .   
## Residuals 63 57.89 0.919   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

par(mfrow=c(2, 1))  
plot(GC\_Cm1, which=1:2)  
dev.off()

## null device   
## 1

GC.1$Cresid = resid(GC\_Cm1)  
ggplot(GC.1,aes(x=CCL\_combined,y=Cresid))+geom\_point()  
ggplot(GC.1,aes(x=Ordered\_SITE,y=Cresid))+geom\_boxplot()  
  
summary(CSC\_Cm1)

## Df Sum Sq Mean Sq F value Pr(>F)  
## Ordered\_SITE 2 3.45 1.7228 1.883 0.158  
## CCL\_combined 1 1.81 1.8083 1.976 0.163  
## Ordered\_SITE:CCL\_combined 2 2.05 1.0271 1.123 0.330  
## Residuals 91 83.25 0.9149

par(mfrow=c(2, 1))  
plot(CSC\_Cm1, which=1:2)  
dev.off()

## null device   
## 1

CSC.1$Cresid = resid(CSC\_Cm1)  
ggplot(CSC.1,aes(x=CCL\_combined,y=Cresid))+geom\_point()  
ggplot(CSC.1,aes(x=Ordered\_SITE,y=Cresid))+geom\_boxplot()  
  
summary(EPI\_Cm1)

## Df Sum Sq Mean Sq F value Pr(>F)   
## Ordered\_SITE 2 837.8 418.9 167.334 <2e-16 \*\*\*  
## CCL\_combined 1 0.0 0.0 0.006 0.937   
## Ordered\_SITE:CCL\_combined 2 6.4 3.2 1.275 0.282   
## Residuals 178 445.6 2.5   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

par(mfrow=c(2, 1))  
plot(EPI\_Cm1, which=1:2)  
dev.off()

## null device   
## 1

EPI.1$Cresid = resid(EPI\_Cm1)  
ggplot(EPI.1,aes(x=CCL\_combined,y=Cresid))+geom\_point()  
ggplot(EPI.1,aes(x=Ordered\_SITE,y=Cresid))+geom\_boxplot()  
  
summary(SC\_Cm2)

## Df Sum Sq Mean Sq F value Pr(>F)   
## Ordered\_SITE 3 38.9 12.981 2.432 0.0672 .  
## Residuals 154 822.0 5.338   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

par(mfrow=c(2, 1))  
plot(SC\_Cm2, which=1:2)  
dev.off()

## null device   
## 1

SC$Cresid = resid(SC\_Cm2)  
ggplot(SC,aes(x=Ordered\_SITE,y=Cresid))+geom\_boxplot()  
  
summary(GC\_Cm2)

## Df Sum Sq Mean Sq F value Pr(>F)   
## Ordered\_SITE 1 12.65 12.646 12.46 0.000696 \*\*\*  
## Residuals 79 80.16 1.015   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

par(mfrow=c(2, 1))  
plot(GC\_Cm2, which=1:2)  
dev.off()

## null device   
## 1

GC$Cresid = resid(GC\_Cm2)  
ggplot(GC,aes(x=Ordered\_SITE,y=Cresid))+geom\_boxplot()  
  
summary(CSC\_Cm2)

## Df Sum Sq Mean Sq F value Pr(>F)   
## Ordered\_SITE 2 4.4 2.198 2.573 0.0807 .  
## Residuals 113 96.5 0.854   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

par(mfrow=c(2, 1))  
plot(CSC\_Cm2, which=1:2)  
dev.off()

## null device   
## 1

CSC$Cresid = resid(CSC\_Cm2)  
ggplot(CSC,aes(x=Ordered\_SITE,y=Cresid))+geom\_boxplot() #moderate fanning, not sure if issue  
  
summary(EPI\_Cm2)

## Df Sum Sq Mean Sq F value Pr(>F)   
## Ordered\_SITE 4 845.0 211.25 65.29 <2e-16 \*\*\*  
## Residuals 253 818.6 3.24   
## ---  
## Signif. codes: 0 '\*\*\*' 0.001 '\*\*' 0.01 '\*' 0.05 '.' 0.1 ' ' 1

par(mfrow=c(2, 1))  
plot(EPI\_Cm2, which=1:2)  
dev.off()

## null device   
## 1

EPI$Cresid = resid(EPI\_Cm2)  
ggplot(EPI,aes(x=Ordered\_SITE,y=Cresid))+geom\_boxplot()  
  
#Corresponding visuals  
#Nitrogen  
  
pdf("nitrogen\_faceted\_scatter.pdf", 12, 8)  
N1<-ggplot(data\_new2, aes(x=CCL\_combined,y=d15N, fill=Ordered\_SITE)) + geom\_point(size=3, alpha=.8,shape=21,position=position\_jitter(width=.5,height=.5))+theme\_bw()+theme(axis.text.x = element\_text(angle=90, vjust=0.5))+geom\_smooth(method=lm)+scale\_fill\_manual(values=pal1)  
N1+facet\_wrap( ~ Region, ncol=2)

## Warning: Removed 124 rows containing non-finite values (stat\_smooth).

## Warning: Removed 124 rows containing missing values (geom\_point).

dev.off()

## pdf   
## 2

pdf("carbon\_faceted\_scatter.pdf", 12, 8)  
C1<-ggplot(data\_new2, aes(x=CCL\_combined,y=d13C, fill=Ordered\_SITE)) + geom\_point(size=3, alpha=.8,shape=21,position=position\_jitter(width=.5,height=.5))+theme\_bw()+theme(axis.text.x = element\_text(angle=90, vjust=0.5))+geom\_smooth(method=lm)+scale\_fill\_manual(values=pal1)  
C1+facet\_wrap( ~ Region, ncol=2)

## Warning: Removed 124 rows containing non-finite values (stat\_smooth).  
  
## Warning: Removed 124 rows containing missing values (geom\_point).

dev.off()

## pdf   
## 2