

Cod Inversions

KE Lotterhos

2024-03-18

```
#install_github("jokergoo/ComplexHeatmap") Didn't install #didn't install BiocManager::install("inveRsion")
```

Load packages and data

```
library(devtools)

## Loading required package: usethis

library(bigstatsr)
library(bigsnpr)
library(ggplot2)
library(OutFLANK)

## Loading required package: qvalue
library(vegan)

## Loading required package: permute
##
## Attaching package: 'permute'
##
## The following object is masked from 'package:devtools':
## 
##     check

## Loading required package: lattice
## This is vegan 2.6-6.1

library(pheatmap)
sessionInfo()

## R version 4.4.0 (2024-04-24)
## Platform: x86_64-apple-darwin20
## Running under: macOS Sonoma 14.5
##
## Matrix products: default
## BLAS:    /Library/Frameworks/R.framework/Versions/4.4-x86_64/Resources/lib/libRblas.0.dylib
## LAPACK:  /Library/Frameworks/R.framework/Versions/4.4-x86_64/Resources/lib/libRlapack.dylib;  LAPACK
##
## locale:
## [1] en_US.UTF-8/en_US.UTF-8/en_US.UTF-8/C/en_US.UTF-8/en_US.UTF-8
##
## time zone: America/New_York
## tzcode source: internal
```

```

## 
## attached base packages:
## [1] stats      graphics   grDevices utils      datasets   methods    base
## 
## other attached packages:
## [1] pheatmap_1.0.12  vegan_2.6-6.1    lattice_0.22-6  permute_0.9-7
## [5] OutFLANK_0.2     qvalue_2.36.0   ggplot2_3.5.1   bigsnpr_1.12.2
## [9] bigstatsr_1.5.12 devtools_2.4.5   usethis_2.2.3
## 
## loaded via a namespace (and not attached):
## [1] gtable_0.3.5       xfun_0.44        htmlwidgets_1.6.4  remotes_2.5.0
## [5] bigassertr_0.1.6   vctrs_0.6.5      tools_4.4.0       generics_0.1.3
## [9] parallel_4.4.0     tibble_3.2.1     fansi_1.0.6      cluster_2.1.6
## [13] pkgconfig_2.0.3    Matrix_1.7-0    data.table_1.15.4 RColorBrewer_1.1-3
## [17] rngtools_1.5.2     lifecycle_1.0.4  compiler_4.4.0   stringr_1.5.1
## [21] munsell_0.5.1     bigparallelr_0.3.2 codetools_0.2-20  httpuv_1.6.15
## [25] htmltools_0.5.8.1 yaml_2.3.8       later_1.3.2     pillar_1.9.0
## [29] urlchecker_1.0.1  MASS_7.3-60.2   ellipsis_0.3.2  cachem_1.1.0
## [33] doRNG_1.8.6       sessioninfo_1.2.2 iterators_1.0.14 foreach_1.5.2
## [37] nlme_3.1-164      mime_0.12       tidyselect_1.2.1 digest_0.6.35
## [41] stringi_1.8.4     reshape2_1.4.4  dplyr_1.1.4     purrr_1.0.2
## [45] splines_4.4.0     cowplot_1.1.3   fastmap_1.2.0   grid_4.4.0
## [49] colorspace_2.1-0  cli_3.6.2       magrittr_2.0.3   pkgbuild_1.4.4
## [53] utf8_1.2.4        withr_3.0.0     scales_1.3.0    promises_1.3.0
## [57] rmarkdown_2.27     bigparser_0.6.1 memoise_2.0.1   shiny_1.8.1.1
## [61] evaluate_0.23     knitr_1.46     doParallel_1.0.17 miniUI_0.1.1.1
## [65] mgcv_1.9-1       profvis_0.3.8  rlang_1.1.3     Rcpp_1.0.12
## [69] xtable_1.8-4     glue_1.7.0     pkgload_1.3.4   rstudioapi_0.16.0
## [73] plyr_1.8.9       R6_2.5.1       fs_1.6.4       flock_0.7
datadir <- "/Users/lotterhos/Library/CloudStorage/GoogleDrive-k.lotterhos@gmail.com/.shortcut-targets-by-id/0BwXyDzZPQjJtMkxqV2FhV2p3d2c"

bigSNP <- snp_attach(paste0(datadir, "acod_merged.MAF05_QC.rds"))

# drop the individual at the 17th position because it is a duplicate. It was a fish that was right in
# the wrong place.
G_full <- bigSNP$genotypes[,-17,]
pos_full <- bigSNP$map$physical.pos
samp_full <- bigSNP$fam$sample.ID[,-17]
pop_full <- bigSNP$fam$family.ID[,-17]
chrom_full <- bigSNP$map$chromosome

unique(chrom_full)

## [1] "NC_044048.1" "NC_044049.1" "NC_044050.1" "NC_044051.1" "NC_044052.1"
## [6] "NC_044053.1" "NC_044054.1" "NC_044055.1" "NC_044056.1" "NC_044057.1"
## [11] "NC_044058.1" "NC_044059.1" "NC_044060.1" "NC_044061.1" "NC_044062.1"
## [16] "NC_044063.1" "NC_044064.1" "NC_044065.1" "NC_044066.1" "NC_044067.1"
## [21] "NC_044068.1" "NC_044069.1" "NC_044070.1"

dim(G_full)

## [1] 294 2094293
NCORES <- nb_cores()

```

```

head(bigSNP$fam)

##   family.ID sample.ID paternal.ID maternal.ID sex affection
## 1      Pop1     16216          0          0    0      -9
## 2      Pop1     16220          0          0    0      -9
## 3      Pop1     16224          0          0    0      -9
## 4      Pop1     16225          0          0    0      -9
## 5      Pop1     16229          0          0    0      -9
## 6      Pop1     16231          0          0    0      -9

head(samp_full)

## [1] 16216 16220 16224 16225 16229 16231

pop.names <- paste0("Pop", 1:9)
pop.IDs<- c("GoM.Mass.Olive.Winter",
           "GoM.Mass.Red",
           "GoM.Mass.Olive.Unknown",
           "GoM.Cashes.Olive",
           "GoM.Cashes.Red",
           "Ice.Off.SW",
           "Ice.Near.SW",
           "Ice.Off.NE",
           "Ice.Near.NE")
pop.IDs2 <- c("GoM Nearshore Olive - Winter Spawner",
             "GoM Nearshore Red",
             "GoM Nearshore Olive",
             "GoM Nearshore Olive",
             "GoM Nearshore Red",
             "Iceland Offshore",
             "Iceland Nearshore",
             "Iceland Offshore",
             "Iceland Nearshore")
region <- c(rep("GoM", 5), rep("Iceland", 4))
ecotype <- c(rep("Nearshore",5), "Offshore", "Nearshore",
             "Offshore", "Nearshore")
pop.colors <- c(adjustcolor("darkgreen",1), #mass winter
               adjustcolor("salmon",1), #mass red
               adjustcolor("goldenrod3",0.5), #mass unknown
               adjustcolor("darkgreen",0.75), #cashes olive
               adjustcolor("salmon",0.75), #cashes red
               adjustcolor("darkviolet",1), # Iceland SW Off
               adjustcolor("cornflowerblue",0.5), #Iceland SW Near
               adjustcolor("darkviolet",0.5), #Iceland NE Off
               adjustcolor("cornflowerblue",1) #Iceland NE Near
               )

pop2.colors <- c(adjustcolor("darkgreen",1), #mass winter
                 adjustcolor("salmon",1), #mass red
                 adjustcolor("darkgreen",0.5), #mass unknown
                 adjustcolor("darkgreen",0.5), #cashes olive
                 adjustcolor("salmon",1), #cashes red
                 adjustcolor("darkviolet",0.75), # Iceland SW Off
                 adjustcolor("cornflowerblue",1), #Iceland SW Near
                 adjustcolor("darkviolet",0.75), #Iceland NE Off

```

```

        adjustcolor("cornflowerblue", 1) #Iceland NE Near
    )

write.table(data.frame(pop.names, pop.IDs, pop.colors, region, ecotype, pop.IDs2, pop2.colors), ".../output

samp_full <- data.frame(samp_full)

#Remove sample 17, duplicate
samp_full$Pop <- as.factor(bigSNP$fam$family.ID[-17])

# Add population name to smaple dataframe
samp_full$PopID <- factor(samp_full$Pop, ordered=TRUE)
levels(samp_full$PopID) = pop.IDs # this works because the
# populations are numbered

head(samp_full)

##   samp_full Pop          PopID
## 1      16216 Pop1 GoM.Mass.Olive.Winter
## 2      16220 Pop1 GoM.Mass.Olive.Winter
## 3      16224 Pop1 GoM.Mass.Olive.Winter
## 4      16225 Pop1 GoM.Mass.Olive.Winter
## 5      16229 Pop1 GoM.Mass.Olive.Winter
## 6      16231 Pop1 GoM.Mass.Olive.Winter

levels(samp_full$PopID)

## [1] "GoM.Mass.Olive.Winter"  "GoM.Mass.Red"           "GoM.Mass.Olive.Unknown"
## [4] "GoM.Cashes.Olive"       "GoM.Cashes.Red"        "Ice.Off.SW"
## [7] "Ice.Near.SW"           "Ice.Off.NE"           "Ice.Near.NE"

samp_full$Region <- "GoM"
samp_full$Region[samp_full$Pop %in% c("Pop6", "Pop7",
                                         "Pop8", "Pop9")] = "Iceland"
samp_full$Ecotype <- "1-Nearshore"
samp_full$Ecotype[samp_full$Pop %in% c("Pop6", "Pop8")] <- "2-Offshore"

samp_full$Region <- as.factor(samp_full$Region)
samp_full$Ecotype <- as.factor(samp_full$Ecotype)
head(samp_full)

##   samp_full Pop          PopID Region Ecotype
## 1      16216 Pop1 GoM.Mass.Olive.Winter   GoM 1-Nearshore
## 2      16220 Pop1 GoM.Mass.Olive.Winter   GoM 1-Nearshore
## 3      16224 Pop1 GoM.Mass.Olive.Winter   GoM 1-Nearshore
## 4      16225 Pop1 GoM.Mass.Olive.Winter   GoM 1-Nearshore
## 5      16229 Pop1 GoM.Mass.Olive.Winter   GoM 1-Nearshore
## 6      16231 Pop1 GoM.Mass.Olive.Winter   GoM 1-Nearshore

tail(samp_full)

##   samp_full Pop          PopID Region Ecotype
## 289     18096 Pop9 Ice.Near.NE Iceland 1-Nearshore
## 290     18097 Pop9 Ice.Near.NE Iceland 1-Nearshore
## 291     18098 Pop9 Ice.Near.NE Iceland 1-Nearshore

```

```

## 292      18099 Pop9 Ice.Near.NE Iceland 1-Nearshore
## 293      18100 Pop9 Ice.Near.NE Iceland 1-Nearshore
## 294      18101 Pop9 Ice.Near.NE Iceland 1-Nearshore

samp_full$label <- paste(samp_full$Region, samp_full$Ecotype, samp_full$PopID, samp_full$samp_full, sep="")

### colors for Region and Ecotype #####
samp_full$Region_color <- as.factor(samp_full$Region)
levels(samp_full$Region_color) <- c("blue4", "darkgoldenrod")
samp_full$Region_color <- as.character(samp_full$Region_color) # convert factor back to character

samp_full$Ecotype_color <- as.factor(samp_full$Ecotype)
levels(samp_full$Ecotype_color) <- c("darkcyan", "seagreen2")
samp_full$Ecotype_color <- as.character(samp_full$Ecotype_color) # convert factor back to character

### colors for populations #####
samp_full$PopID_color <- as.factor(samp_full$Pop)
levels(samp_full$PopID_color) <- pop.colors # this works because the populations are ordered by number

samp_full$PopID_color <- as.character(samp_full$PopID_color)

muts <- data.frame(chrom_full, pos_full, Glabel = paste(chrom_full, pos_full, sep="__"))

colnames(G_full) <- muts$Glabel

rownames(G_full) <- samp_full$label

```

Step 1: Subset data to 50,000 random SNPs and perform PCA.

```

set.seed(29435798)
index <- sort(sample(1:length(pos_full), 50000))

Gsub <- G_full[, index]

# Recode for bigsnpr package tools
Gsub.snp <- add_code256(big_copy(Gsub, type="raw"), code=bigsnpr:::CODE_012)

# PCA
# make sure this is run on a code 256 type
# snp object, or it will run forever!
set.seed(6345082)
svd7 <- big_randomSVD(Gsub.snp,
                       snp_scaleBinom(),
                       ncores = NCORES,
                       k=2)

# Add PC loadings to sample info
samp_full$Gsub_PC1 <- svd7$u[, 1]
samp_full$Gsub_PC2 <- svd7$u[, 2]

# Add PC loadings to muts

```

```

muts$Gsub_PC1 <- muts$Gsub_PC2 <-NA
muts$Gsub_PC1[index] <- svd7$v[,1]
muts$Gsub_PC2[index] <- svd7$v[,2]

#plot(abs(muts$Gsub_PC1), pch=19, col=adjustcolor("blue",0.01))

```

Perform PCAs on individual linkage groups to identify inversion breakpoints

Chrom 1

```

index <- sort(which(muts$chrom_full=="NC_044048.1"))
Gsub <- G_full[,index]
# Recode for bigsnpr package tools
Gsub.snp <- add_code256(big_copy(Gsub,type="raw"),code=bigsnpr:::CODE_012)
set.seed(62385534)
svd7 <- big_randomSVD(Gsub.snp,
                       .snp_scaleBinom(),
                        ncores = NCORES,
                        k=2)

muts$Gsub_LG1_PC1 <- NA
muts$Gsub_LG1_PC1[index] <- svd7$v[,1]

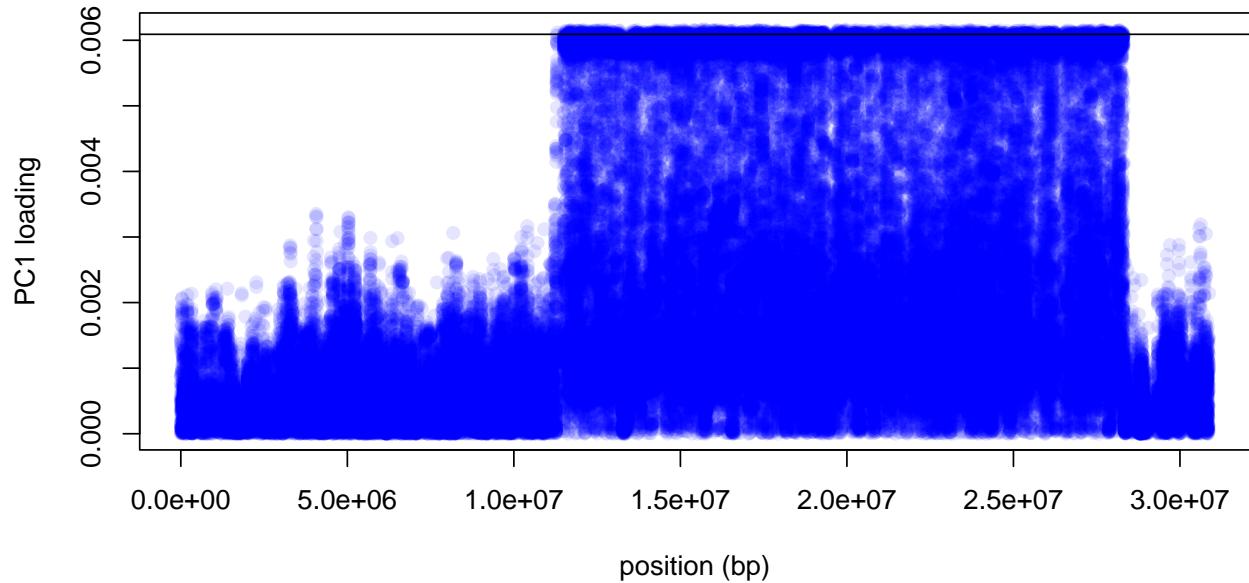
# Chrom 1
plot(muts$pos_full[muts$chrom_full=="NC_044048.1"],
      abs(muts$Gsub_LG1_PC1[muts$chrom_full=="NC_044048.1"]),
      pch=19, col=adjustcolor("blue",0.1),
      main="LG1", ylab="PC1 loading", xlab="position (bp)")

(maxload1 <- quantile(abs(muts$Gsub_LG1_PC1), probs=0.99, na.rm=TRUE))

##          99%
## 0.006090969
abline(h=maxload1)

```

LG1



```
#start
LG1start <- min(which(abs(muts$Gsub_LG1_PC1)>maxload1))
LG1end <- max(which(abs(muts$Gsub_LG1_PC1)>maxload1))

mutss[LG1start ,]

##      chrom_full pos_full          Glabel Gsub_PC2 Gsub_PC1 Gsub_LG1_PC1
## 33090 NC_044048.1 11299038 NC_044048.1_11299038      NA      NA 0.006117522
LG1start_minus1MB <- max(which(mutss$pos_full<mutss$pos_full[LG1start]-1000000 & mutss$chrom_full=="NC_044048.1")
mutss[LG1start_minus1MB,]

##      chrom_full pos_full          Glabel Gsub_PC2 Gsub_PC1 Gsub_LG1_PC1
## 29750 NC_044048.1 10298978 NC_044048.1_10298978      NA      NA 0.0002175627
mutss[LG1end,]

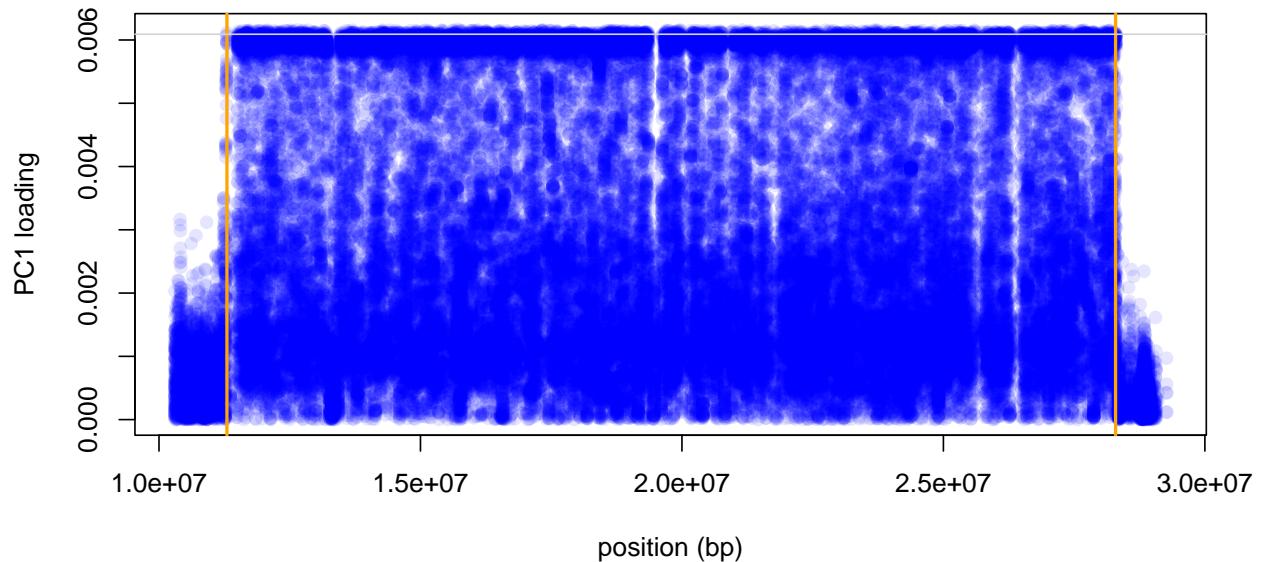
##      chrom_full pos_full          Glabel Gsub_PC2 Gsub_PC1
## 104012 NC_044048.1 28292263 NC_044048.1_28292263      NA      NA
##      Gsub_LG1_PC1
## 104012  0.006091121
LG1end_plus1MB <- max(which(mutss$pos_full<mutss$pos_full[LG1end]+1000000 & mutss$chrom_full=="NC_044048.1")
mutss[LG1end_plus1MB,]

##      chrom_full pos_full          Glabel Gsub_PC2 Gsub_PC1
## 106154 NC_044048.1 29268531 NC_044048.1_29268531      NA      NA
##      Gsub_LG1_PC1
## 106154 -0.0005602807

plot(mutss$pos_full[LG1start_minus1MB:LG1end_plus1MB] ,
     abs(mutss$Gsub_LG1_PC1[LG1start_minus1MB:LG1end_plus1MB]),
     pch=19, col=adjustcolor("blue",0.1),
     main="LG1", ylab="PC1 loading", xlab="position (bp)")
abline(v=mutss$pos_full[LG1start], col="orange", lwd=2)
abline(v=mutss$pos_full[LG1end], col="orange", lwd=2)
```

```
abline(h=maxload1, col="lightgrey")
```

LG1



Chrom 2

```
index <- sort(which(muts$chrom_full=="NC_044049.1"))
Gsub <- G_full[,index]
# Recode for bigsnpr package tools
Gsub_snp <- add_code256(big_copy(Gsub,type="raw"),code=bigsnpr:::CODE_012)
set.seed(235540968)
svd7 <- big_randomSVD(Gsub_snp,
                       snp_scaleBinom(),
                       ncores = NCORES,
                       k=2)

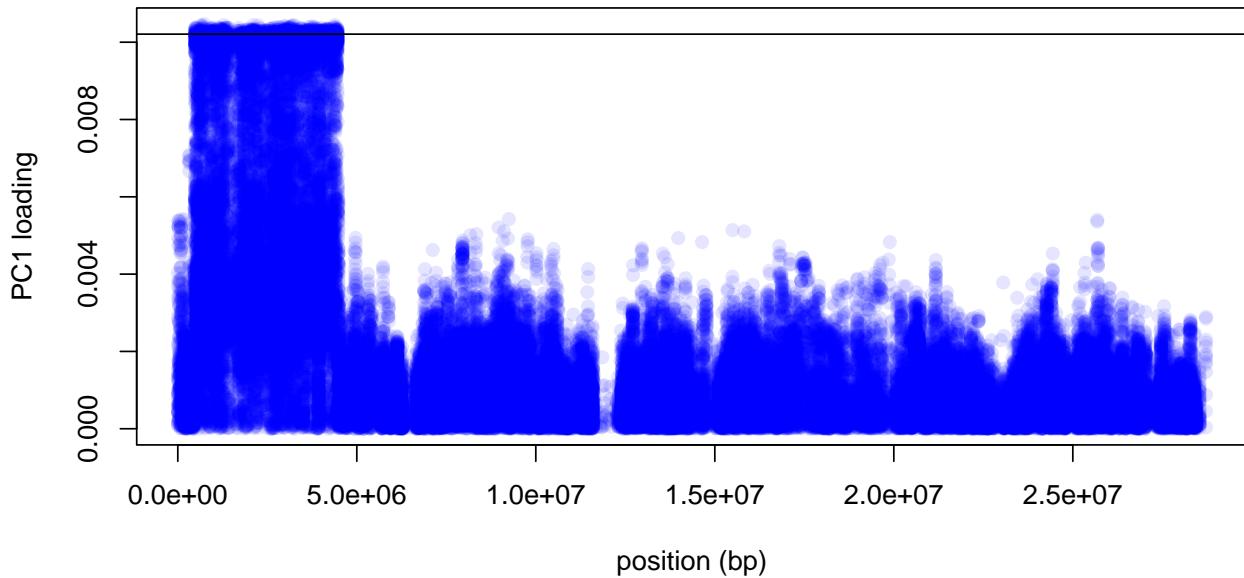
mutts$Gsub_LG2_PC1 <- NA
mutts$Gsub_LG2_PC1[index] <- svd7$v[,1]

# Chrom 2
plot(mutts$pos_full[mutts$chrom_full=="NC_044049.1"],
     abs(mutts$Gsub_LG2_PC1[mutts$chrom_full=="NC_044049.1"]),
     pch=19, col=adjustcolor("blue",0.1),
     main="LG2", ylab="PC1 loading", xlab="position (bp)")

(maxload1 <- quantile(abs(mutts$Gsub_LG2_PC1), probs=0.99, na.rm=TRUE))

##          99%
## 0.01020831
abline(h=maxload1)
```

LG2



```

#start
LG2start <- min(which(abs(muts$Gsub_LG2_PC1)>maxload1))
LG2end <- max(which(abs(muts$Gsub_LG2_PC1)>maxload1))

mutss[LG2start ,]

##      chrom_full pos_full          Glabel Gsub_PC2 Gsub_PC1 Gsub_LG1_PC1
## 111433 NC_044049.1    481246 NC_044049.1_481246        NA        NA        NA
##          Gsub_LG2_PC1
## 111433    0.01027682

LG2start_minus1MB <-min(which(mutss$chrom_full=="NC_044049.1"))
# in this case it's just the start of the chromosome
mutss[LG2start_minus1MB,]

##      chrom_full pos_full          Glabel Gsub_PC2 Gsub_PC1 Gsub_LG1_PC1
## 109720 NC_044049.1     884 NC_044049.1_884        NA        NA        NA
##          Gsub_LG2_PC1
## 109720 -0.0006092057

mutss[LG2end ,]

##      chrom_full pos_full          Glabel Gsub_PC2 Gsub_PC1 Gsub_LG1_PC1
## 132871 NC_044049.1 4466546 NC_044049.1_4466546        NA        NA        NA
##          Gsub_LG2_PC1
## 132871    0.01029919

LG2end_plus1MB <- max(which(mutss$pos_full<mutss$pos_full[LG2end]+1000000 & mutss$chrom_full=="NC_044049.1"))
mutss[LG2end_plus1MB,]

##      chrom_full pos_full          Glabel Gsub_PC2 Gsub_PC1 Gsub_LG1_PC1
## 135332 NC_044049.1 5434591 NC_044049.1_5434591        NA        NA        NA
##          Gsub_LG2_PC1
## 135332    0.0002754641

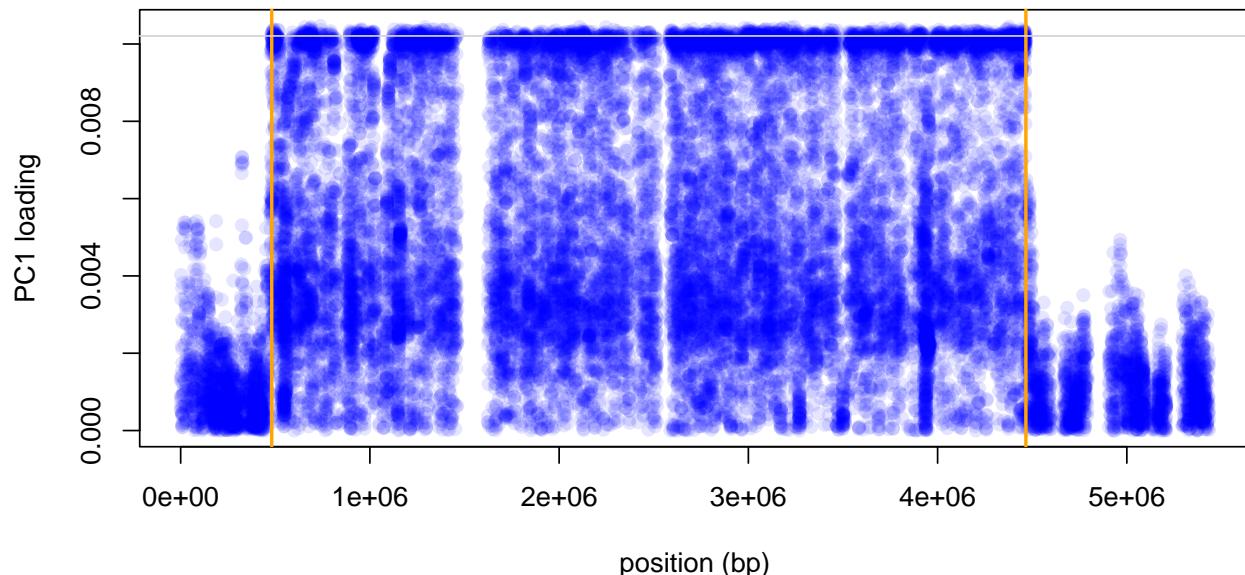
```

```

plot(muts$pos_full[LG2start_minus1MB:LG2end_plus1MB],
      abs(muts$Gsub_LG2_PC1[LG2start_minus1MB:LG2end_plus1MB]),
      pch=19, col=adjustcolor("blue",0.1),
      main="LG2", ylab="PC1 loading", xlab="position (bp)")
abline(v=muts$pos_full[LG2start], col="orange", lwd=2)
abline(v=muts$pos_full[LG2end], col="orange", lwd=2)
abline(h=maxload1, col="lightgrey")

```

LG2



Chrom 7

```

index <- sort(which(muts$chrom_full=="NC_044054.1"))
Gsub <- G_full[,index]
# Recode for bigsnpr package tools
Gsub_snp <- add_code256(big_copy(Gsub,type="raw"),code=bigsnpr:::CODE_012)
set.seed(42348064)
svd7 <- big_randomSVD(Gsub_snp,
                      snp_scaleBinom(),
                      ncores = NCORES,
                      k=2)

muts$Gsub_LG7_PC1 <- NA
muts$Gsub_LG7_PC1[index] <- svd7$v[,1]

# Chrom 7
plot(muts$pos_full[muts$chrom_full=="NC_044054.1"],
      abs(muts$Gsub_LG7_PC1[muts$chrom_full=="NC_044054.1"]),
      pch=19, col=adjustcolor("blue",0.1),
      main="LG7", ylab="PC1 loading", xlab="position (bp)")

(maxload1 <- quantile(abs(muts$Gsub_LG7_PC1), probs=0.99, na.rm=TRUE))

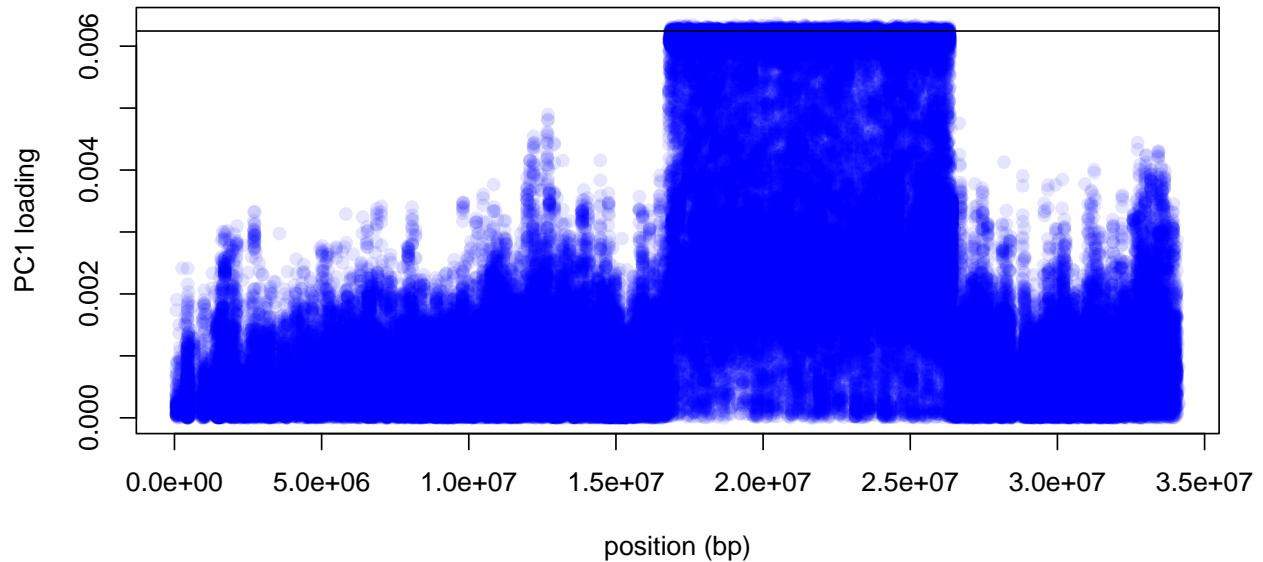
```

```

##          99%
## 0.006244065
abline(h=maxload1)

```

LG7



```

#start
LG7start <- min(which(abs(muts$Gsub_LG7_PC1)>maxload1))
LG7end <- max(which(abs(muts$Gsub_LG7_PC1)>maxload1))

mutss[LG7start ,]

##      chrom_full pos_full           Glabel Gsub_PC2 Gsub_PC1
## 648745 NC_044054.1 16828712 NC_044054.1__16828712      NA      NA
##      Gsub_LG1_PC1 Gsub_LG2_PC1 Gsub_LG7_PC1
## 648745          NA          NA -0.006261396

LG7start_minus1MB <- max(which(mutss$pos_full<mutss$pos_full[LG7start]-1000000 & mutss$chrom_full=="NC_044054.1"))
# in this case it's just the start of the chromosome
mutss[LG7start_minus1MB,]

##      chrom_full pos_full           Glabel Gsub_PC2 Gsub_PC1
## 645345 NC_044054.1 15828590 NC_044054.1__15828590      NA      NA
##      Gsub_LG1_PC1 Gsub_LG2_PC1 Gsub_LG7_PC1
## 645345          NA          NA 0.0002948823

mutss[LG7end ,]

##      chrom_full pos_full           Glabel Gsub_PC2 Gsub_PC1
## 696592 NC_044054.1 26336501 NC_044054.1__26336501      NA      NA
##      Gsub_LG1_PC1 Gsub_LG2_PC1 Gsub_LG7_PC1
## 696592          NA          NA -0.006245197

LG7end_plus1MB <- max(which(mutss$pos_full<mutss$pos_full[LG7end]+1000000 & mutss$chrom_full=="NC_044054.1"))
mutss[LG7end_plus1MB,]

##      chrom_full pos_full           Glabel Gsub_PC2 Gsub_PC1
## 700639 NC_044054.1 27336483 NC_044054.1__27336483      NA      NA

```

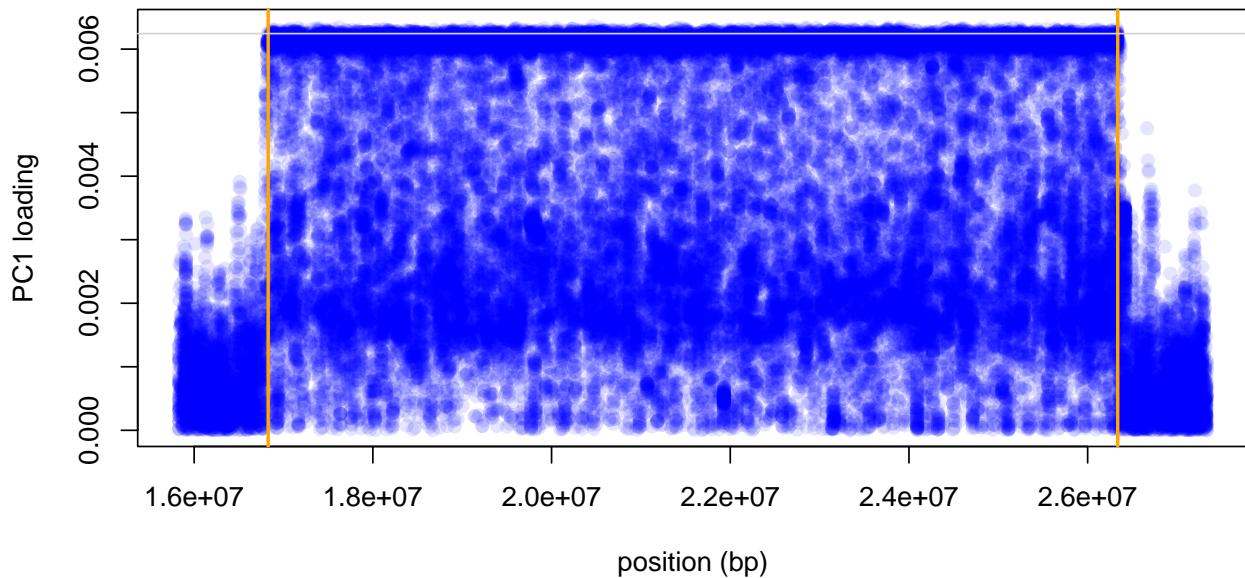
```

##          Gsub_LG1_PC1 Gsub_LG2_PC1 Gsub_LG7_PC1
## 700639           NA           NA -0.000523632

plot(muts$pos_full[LG7start_minus1MB:LG7end_plus1MB],
      abs(muts$Gsub_LG7_PC1[LG7start_minus1MB:LG7end_plus1MB]),
      pch=19, col=adjustcolor("blue",0.1),
      main="LG7", ylab="PC1 loading", xlab="position (bp)")
abline(v=muts$pos_full[LG7start], col="orange", lwd=2)
abline(v=muts$pos_full[LG7end], col="orange", lwd=2)
abline(h=maxload1, col="lightgrey")

```

LG7



Chrom 12

```

index <- sort(which(muts$chrom_full=="NC_044059.1"))
Gsub <- G_full[,index]
# Recode for bigsnpr package tools
Gsub_snp <- add_code256(big_copy(Gsub,type="raw"),code=bigsnpr:::CODE_012)
set.seed(73240982)
svd7 <- big_randomSVD(Gsub_snp,
                       snp_scaleBinom(),
                       ncores = NCORES,
                       k=2)

muts$Gsub_LG12_PC1 <- NA
muts$Gsub_LG12_PC1[index] <- svd7$v[,1]

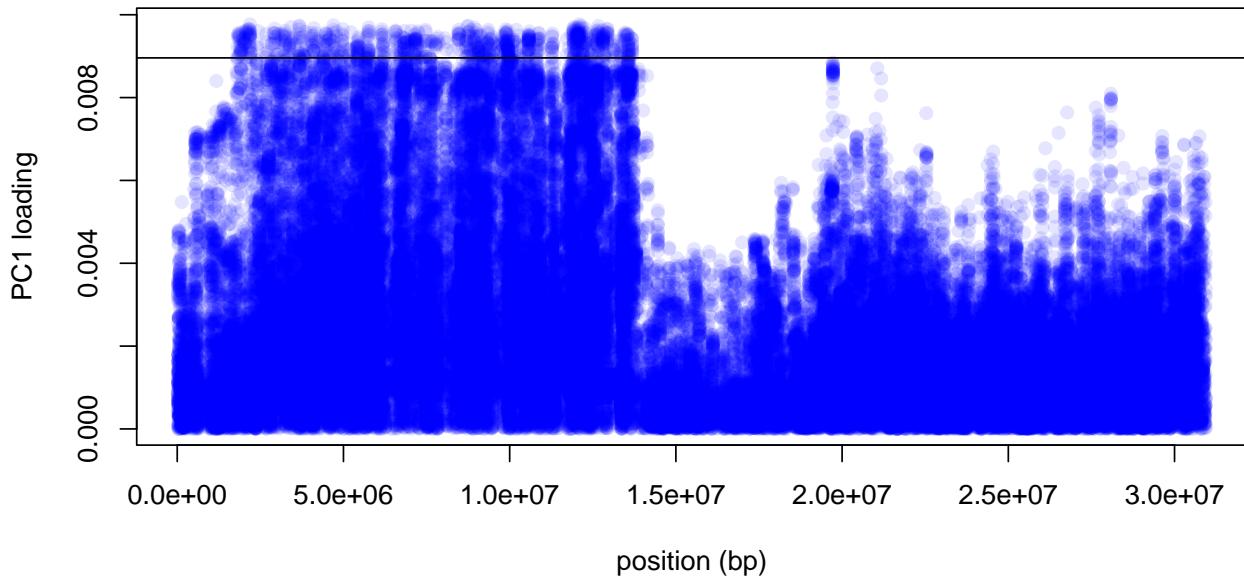
# Chrom 12
plot(muts$pos_full[muts$chrom_full=="NC_044059.1"],
      abs(muts$Gsub_LG12_PC1[muts$chrom_full=="NC_044059.1"]),
      pch=19, col=adjustcolor("blue",0.1),
      main="LG12", ylab="PC1 loading", xlab="position (bp)")

```

```
(maxload1 <- quantile(abs(muts$Gsub_LG12_PC1), probs=0.99, na.rm=TRUE))

##      99%
## 0.008958482
abline(h=maxload1)
```

LG12



```
#start
LG12start <- min(which(abs(muts$Gsub_LG12_PC1)>maxload1))
LG12end <- max(which(abs(muts$Gsub_LG12_PC1)>maxload1))

muts[LG12start ,]

##           chrom_full pos_full          Glabel Gsub_PC2 Gsub_PC1
## 1098771 NC_044059.1 1809214 NC_044059.1_1809214      NA      NA
##           Gsub_LG1_PC1 Gsub_LG2_PC1 Gsub_LG7_PC1 Gsub_LG12_PC1
## 1098771      NA          NA          NA -0.008967974

LG12start_minus1MB <- max(which(muts$pos_full<mut$pos_full[LG12start]-1000000 & muts$chrom_full=="NC_044059.1")
# in this case it's just the start of the chromosome
muts[LG12start_minus1MB,]

##           chrom_full pos_full          Glabel Gsub_PC2 Gsub_PC1 Gsub_LG1_PC1
## 1096496 NC_044059.1 721009 NC_044059.1_721009      NA      NA      NA
##           Gsub_LG2_PC1 Gsub_LG7_PC1 Gsub_LG12_PC1
## 1096496      NA          NA          NA -0.004226609

muts[LG12end,]

##           chrom_full pos_full          Glabel Gsub_PC2 Gsub_PC1
## 1141346 NC_044059.1 13690550 NC_044059.1_13690550      NA      NA
##           Gsub_LG1_PC1 Gsub_LG2_PC1 Gsub_LG7_PC1 Gsub_LG12_PC1
## 1141346      NA          NA          NA -0.009079696

LG12end_plus1MB <- max(which(muts$pos_full<mut$pos_full[LG12end]+1000000 & muts$chrom_full=="NC_044059.1")
```

```

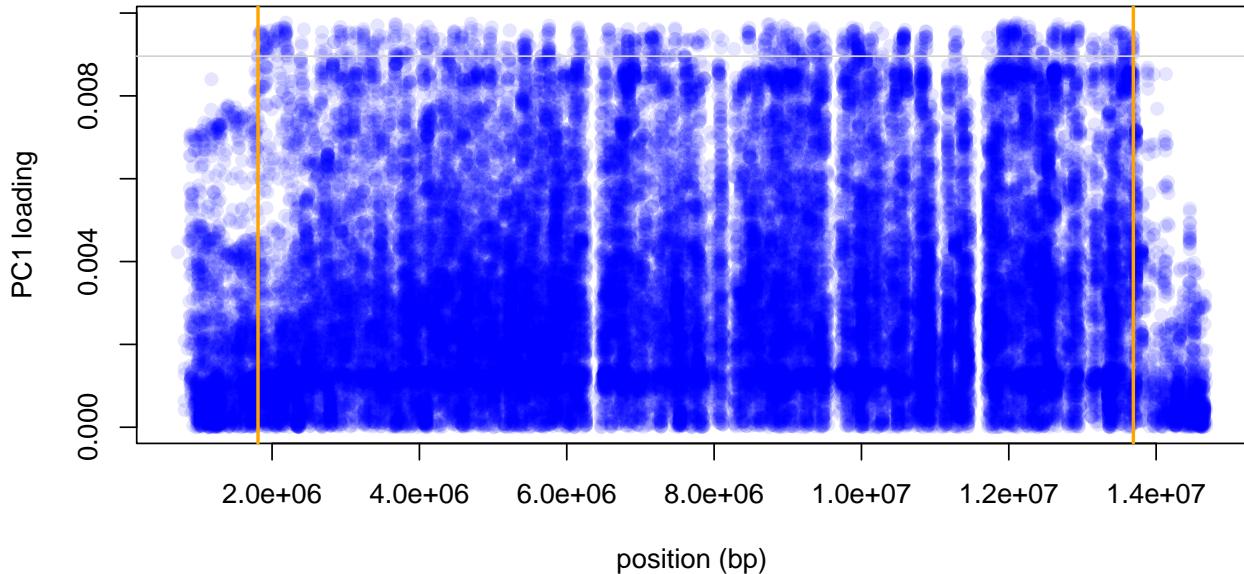
muts[LG12end_plus1MB,]

##          chrom_full pos_full           Glabel Gsub_PC2 Gsub_PC1
## 1142816 NC_044059.1 14677663 NC_044059.1_14677663      NA      NA
##          Gsub_LG1_PC1 Gsub_LG2_PC1 Gsub_LG7_PC1 Gsub_LG12_PC1
## 1142816      NA        NA       NA 2.969367e-05

plot(muts$pos_full[LG12start_minus1MB:LG12end_plus1MB],
      abs(muts$Gsub_LG12_PC1[LG12start_minus1MB:LG12end_plus1MB]),
      pch=19, col=adjustcolor("blue", 0.1),
      main="LG12", ylab="PC1 loading", xlab="position (bp)")
abline(v=muts$pos_full[LG12start], col="orange", lwd=2)
abline(v=muts$pos_full[LG12end], col="orange", lwd=2)
abline(h=maxload1, col="lightgrey")

```

LG12



summarize breakpoints

```

breakpoints <- data.frame(
  LG = c("LG1", "LG2", "LG7", "LG12"),
  LGstartIndex = c(LG1start, LG2start, LG7start, LG12start),
  LGendIndex = c(LG1end, LG2end, LG7end, LG12end),
  chrom=chrom_full[c(LG1start, LG2start, LG7start, LG12start)],
  LGstartPos = pos_full[c(LG1start, LG2start, LG7start, LG12start)],
  LGendPos = pos_full[c(LG1end, LG2end, LG7end, LG12end)],
  LGstartPos_minus1MB_index = c(LG1start_minus1MB,
                                 LG2start_minus1MB,
                                 LG7start_minus1MB,
                                 LG12start_minus1MB),
  LGendPos_plus1MB_index = c(LG1end_plus1MB,
                             LG2end_plus1MB,
                             LG7end_plus1MB,
                             LG12end_plus1MB)
)

```

PC just on inversions

Get all LG indexes

```
LGind <- c(LG1start:LG1end, LG2start:LG2end,
           LG7start:LG7end, LG12start:LG12end)

G_LG <- G_full[,LGind]

head(colnames(G_LG))

## [1] "NC_044048.1__11299038" "NC_044048.1__11299525" "NC_044048.1__11299592"
## [4] "NC_044048.1__11299650" "NC_044048.1__11302157" "NC_044048.1__11302179"
head(rownames(G_LG))

## [1] "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16216"
## [2] "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16220"
## [3] "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16224"
## [4] "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16225"
## [5] "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16229"
## [6] "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16231"

dim(G_LG)

## [1] 294 182786

# Recode for bigsnpr package tools
G_LG.snp <- add_code256(big_copy(G_LG,type="raw"),code=bigsnpr:::CODE_012)

# PCA
# make sure this is run on a code 256 type
#.snp object, or it will run forever!
set.seed(3459723)
svd7 <- big_randomSVD(G_LG.snp,
                       snp_scaleBinom(),
                       ncores = NCORES,
                       k=2)

samp_full$G_AllInv_PC1 <- svd7$u[,1]
samp_full$G_AllInv_PC2 <- svd7$u[,2]

str(samp_full)

## 'data.frame': 294 obs. of 13 variables:
## $ samp_full : int 16216 16220 16224 16225 16229 16231 16232 16233 16234 16236 ...
## $ Pop : Factor w/ 9 levels "Pop1","Pop2",...: 1 1 1 1 1 1 1 1 1 ...
## $ PopID : Ord.factor w/ 9 levels "GoM.Mass.Olive.Winter"<...: 1 1 1 1 1 1 1 1 1 ...
## $ Region : Factor w/ 2 levels "GoM","Iceland": 1 1 1 1 1 1 1 1 1 ...
## $ Ecotype : Factor w/ 2 levels "1-Nearshore",...: 1 1 1 1 1 1 1 1 1 ...
## $ label : chr "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16216" "GoM_1-Nearshore_GoM.Mass.Olive...
## $ Region_color : chr "blue4" "blue4" "blue4" "blue4" ...
## $ Ecotype_color: chr "darkcyan" "darkcyan" "darkcyan" "darkcyan" ...
## $ PopID_color : chr "#006400FF" "#006400FF" "#006400FF" "#006400FF" ...
## $ Gsub_PC1 : num -0.0589 -0.067 -0.0651 -0.0614 -0.0538 ...
## $ Gsub_PC2 : num 0.02733 0.00134 0.00245 0.00487 0.0154 ...
```

```

## $ G_AllInv_PC1 : num  0.0353 0.065 0.0613 0.0515 0.0319 ...
## $ G_AllInv_PC2 : num  -0.00791 -0.04903 -0.05377 -0.03753 0.01956 ...
pdf("../figures/PCA-samples-inversion-SNPs-only.pdf", width=6, height=6)
ggplot(samp_full) + geom_point(aes(x=G_AllInv_PC1,
                                    y=G_AllInv_PC2,
                                    colour = PopID,
                                    shape= Ecotype,
                                    pch=Ecotype,
                                    size=Ecotype)) +
  scale_colour_manual(values=pop.colors) +
  xlab("Sample loadings PC1 - inversion SNPs only") +
  ylab("Sample loadings PC2 - inversion SNPs only") +
  theme_classic()

## Warning: Duplicated aesthetics after name standardisation: shape
## Warning: Using size for a discrete variable is not advised.
## Warning: Duplicated aesthetics after name standardisation: shape
dev.off()

## pdf
## 2
dist <- dist(G_LG, diag=TRUE)

str(dist)

## 'dist' num [1:43071] 297 281 298 287 256 ...
## - attr(*, "Size")= int 294
## - attr(*, "Labels")= chr [1:294] "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16216" "GoM_1-Nearshore_GoM...
## - attr(*, "Diag")= logi TRUE
## - attr(*, "Upper")= logi FALSE
## - attr(*, "method")= chr "euclidean"
## - attr(*, "call")= language dist(x = G_LG, diag = TRUE)
hc <- hclust(dist)
str(hc)

## List of 7
## $ merge      : int [1:293, 1:2] -21 -8 -54 -223 -193 -218 -151 -138 7 -166 ...
## $ height     : num [1:293] 104 110 119 196 198 ...
## $ order      : int [1:294] 146 258 230 147 172 238 243 142 164 156 ...
## $ labels     : chr [1:294] "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16216" "GoM_1-Nearshore_GoM.Mass...
## $ method     : chr "complete"
## $ call       : language hclust(d = dist)
## $ dist.method: chr "euclidean"
## - attr(*, "class")= chr "hclust"

dhc <- as.dendrogram(hc)
cut_avg <- cutree(hc, k = 5)
str(cut_avg)

## Named int [1:294] 1 1 2 1 1 1 1 1 1 ...
## - attr(*, "names")= chr [1:294] "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16216" "GoM_1-Nearshore_GoM...

```

```
str(dhc)
```

```
## --[dendrogram w/ 2 branches and 294 members at h = 554]
##   |--[dendrogram w/ 2 branches and 97 members at h = 375]
##     |   |--[dendrogram w/ 2 branches and 54 members at h = 275]
##       |   |   |--[dendrogram w/ 2 branches and 6 members at h = 219]
##         |   |   |   |--leaf "Iceland_2-Offshore_Ice.Off.SW_18014"
##           |   |   |   `--[dendrogram w/ 2 branches and 5 members at h = 215]
##             |   |   |   |   |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18058"
##               |   |   |   |   `--[dendrogram w/ 2 branches and 4 members at h = 211]
##                 |   |   |   |   |   |--leaf "Iceland_2-Offshore_Ice.Off.NE_18122"
##                   |   |   |   |   |   `--[dendrogram w/ 2 branches and 3 members at h = 209]
##                     |   |   |   |   |   |   |--leaf "Iceland_2-Offshore_Ice.Off.SW_18015"
##                       |   |   |   |   |   |   `--[dendrogram w/ 2 branches and 2 members at h = 206]
##                         |   |   |   |   |   |   |   |--leaf "Iceland_2-Offshore_Ice.Off.SW_18047"
##                           |   |   |   |   |   |   |   `--leaf "Iceland_2-Offshore_Ice.Off.NE_18131"
##                             |   |   |   |   `--[dendrogram w/ 2 branches and 48 members at h = 234]
##                               |   |   |   |   |--[dendrogram w/ 2 branches and 10 members at h = 214]
##                                 |   |   |   |   |   |--leaf "Iceland_2-Offshore_Ice.Off.NE_18138"
##                                   |   |   |   |   |   `--[dendrogram w/ 2 branches and 9 members at h = 213]
##                                     |   |   |   |   |   |   |--[dendrogram w/ 2 branches and 4 members at h = 210]
##                                       |   |   |   |   |   |   |   |--[dendrogram w/ 2 branches and 2 members at h = 208]
##                                         |   |   |   |   |   |   |   |   |--leaf "Iceland_2-Offshore_Ice.Off.SW_18008"
##                                           |   |   |   |   |   |   |   |   `--leaf "Iceland_2-Offshore_Ice.Off.SW_18038"
##                                         |   |   |   |   |   |   |   `--[dendrogram w/ 2 branches and 2 members at h = 208]
##                                           |   |   |   |   |   |   |   |   |--leaf "Iceland_2-Offshore_Ice.Off.SW_18029"
##                                             |   |   |   |   |   |   |   |   `--leaf "Iceland_2-Offshore_Ice.Off.NE_18118"
##                                         |   |   |   |   |   `--[dendrogram w/ 2 branches and 5 members at h = 211]
##                                           |   |   |   |   |   |   |--leaf "Iceland_2-Offshore_Ice.Off.SW_18010"
##                                             |   |   |   |   |   |   `--[dendrogram w/ 2 branches and 4 members at h = 209]
##                                               |   |   |   |   |   |   |   |--leaf "Iceland_2-Offshore_Ice.Off.SW_18044"
##                                                 |   |   |   |   |   |   |   `--[dendrogram w/ 2 branches and 3 members at h = 207]
##                                                   |   |   |   |   |   |   |   |   |--leaf "Iceland_2-Offshore_Ice.Off.SW_18030"
##                                                     |   |   |   |   |   |   |   |   `--[dendrogram w/ 2 branches and 2 members at h = 204]
##                                                       |   |   |   |   |   |   |   |   |   |--leaf "Iceland_2-Offshore_Ice.Off.NE_18109"
##                                                         |   |   |   |   |   |   |   |   |   `--leaf "Iceland_2-Offshore_Ice.Off.NE_18124"
##                                         |   |   |   |   `--[dendrogram w/ 2 branches and 38 members at h = 219]
##                                           |   |   |   |   |   |--leaf "Iceland_2-Offshore_Ice.Off.NE_18140"
##                                             |   |   |   |   |   `--[dendrogram w/ 2 branches and 37 members at h = 217]
##                                               |   |   |   |   |   |   |--leaf "Iceland_2-Offshore_Ice.Off.NE_18147"
##                                                 |   |   |   |   |   |   `--[dendrogram w/ 2 branches and 36 members at h = 213]
##                                                   |   |   |   |   |   |   |   |--leaf "Iceland_2-Offshore_Ice.Off.NE_18146"
##                                                     |   |   |   |   |   |   |   `--[dendrogram w/ 2 branches and 35 members at h = 212]
##                                                       |   |   |   |   |   |   |   |   |--[dendrogram w/ 2 branches and 32 members at h = 211]
##                                                         |   |   |   |   |   |   |   |   |   |--[dendrogram w/ 2 branches and 30 members at h = 209]
##               |   |   |   |   |   |   |   |   |   |   |--[dendrogram w/ 2 branches and 2 members at h = 207]
##                 |   |   |   |   |   |   |   |   |   |   |   |--leaf "Iceland_2-Offshore_Ice.Off.SW_18001"
##                   |   |   |   |   |   |   |   |   |   |   |   `--leaf "Iceland_2-Offshore_Ice.Off.SW_18049"
##                     |   |   |   |   |   |   |   |   |   |   `--[dendrogram w/ 2 branches and 28 members at h = 209]
##                       |   |   |   |   |   |   |   |   |   |   |   |--[dendrogram w/ 2 branches and 19 members at h = 207]
##                         |   |   |   |   |   |   |   |   |   |   |   |   |--[dendrogram w/ 2 branches and 12 members at h = 206]
##                           |   |   |   |   |   |   |   |   |   |   |   |   |   |--[dendrogram w/ 2 branches and 8 members at h = 203]
##                             |   |   |   |   |   |   |   |   |   |   |   |   |   |   |--leaf "Iceland_2-Offshore_Ice.Off.SW_18003"
##                               |   |   |   |   |   |   |   |   |   |   |   |   |   |   `--[dendrogram w/ 2 branches and 7 members at h = 202]
```



```

## | | `--[dendrogram w/ 2 branches and 2 members at h = 208]
## | |   |--leaf "Iceland_2-Offshore_Ice.Off.NE_18123"
## | |   `--leaf "Iceland_2-Offshore_Ice.Off.NE_18139"
## | `--[dendrogram w/ 2 branches and 43 members at h = 344]
## |   |--[dendrogram w/ 2 branches and 28 members at h = 299]
## |   |   |--[dendrogram w/ 2 branches and 4 members at h = 249]
## |   |   |   |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18152"
## |   |   |   `--[dendrogram w/ 2 branches and 3 members at h = 243]
## |   |   |       |--leaf "Iceland_2-Offshore_Ice.Off.NE_18119"
## |   |   |       `--[dendrogram w/ 2 branches and 2 members at h = 229]
## |   |   |           |--leaf "Iceland_2-Offshore_Ice.Off.NE_18117"
## |   |   |           `--leaf "Iceland_2-Offshore_Ice.Off.NE_18148"
## |   |   `--[dendrogram w/ 2 branches and 24 members at h = 269]
## |   |       |--[dendrogram w/ 2 branches and 21 members at h = 236]
## |   |       |   |--leaf "Iceland_2-Offshore_Ice.Off.NE_18127"
## |   |       |   `--[dendrogram w/ 2 branches and 20 members at h = 232]
## |   |       |       |--leaf "Iceland_2-Offshore_Ice.Off.NE_18142"
## |   |       |       `--[dendrogram w/ 2 branches and 19 members at h = 229]
## |   |       |           |--[dendrogram w/ 2 branches and 17 members at h = 226]
## |   |       |           |   |--[dendrogram w/ 2 branches and 3 members at h = 225]
## |   |       |           |   |   |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18075"
## |   |       |           |   |   `--[dendrogram w/ 2 branches and 2 members at h = 223]
## |   |       |           |   |       |--leaf "Iceland_2-Offshore_Ice.Off.SW_18017"
## |   |       |           |   |       `--leaf "Iceland_2-Offshore_Ice.Off.SW_18032"
## |   |       |   `--[dendrogram w/ 2 branches and 14 members at h = 225]
## |   |       |       |--leaf "Iceland_2-Offshore_Ice.Off.SW_18037"
## |   |       |       `--[dendrogram w/ 2 branches and 13 members at h = 224]
## |   |       |           |--leaf "Iceland_2-Offshore_Ice.Off.SW_18019"
## |   |       |           `--[dendrogram w/ 2 branches and 12 members at h = 221]
## |   |       |               |--[dendrogram w/ 2 branches and 7 members at h = 220]
## |   |       |               |   |--leaf "Iceland_2-Offshore_Ice.Off.SW_18048"
## |   |       |               |   `--[dendrogram w/ 2 branches and 6 members at h = 219]
## |   |       |               |       |--leaf "Iceland_2-Offshore_Ice.Off.SW_18024"
## |   |       |               |       `--[dendrogram w/ 2 branches and 5 members at h = 217]
## |   |       |                   |--leaf "Iceland_2-Offshore_Ice.Off.NE_18132"
## |   |       |                   `--[dendrogram w/ 2 branches and 4 members at h = 216]
## |   |       |                       |--leaf "Iceland_2-Offshore_Ice.Off.SW_18006"
## |   |       |                       `--[dendrogram w/ 2 branches and 3 members at h = 214]
## |   |       |                           |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18093"
## |   |       |                           `--[dendrogram w/ 2 branches and 2 members at h = 213]
## |   |       |                               |--leaf "Iceland_2-Offshore_Ice.Off.SW_18041"
## |   |       |                               `--leaf "Iceland_2-Offshore_Ice.Off.NE_18115"
## |   |       `--[dendrogram w/ 2 branches and 5 members at h = 221]
## |   |           |--[dendrogram w/ 2 branches and 3 members at h = 217]
## |   |           |   |--leaf "Iceland_2-Offshore_Ice.Off.SW_18022"
## |   |           |   `--[dendrogram w/ 2 branches and 2 members at h = 215]
## |   |           |       |--leaf "Iceland_2-Offshore_Ice.Off.SW_18005"
## |   |           |       `--leaf "Iceland_2-Offshore_Ice.Off.SW_18043"
## |   |           `--[dendrogram w/ 2 branches and 2 members at h = 218]
## |   |               |--leaf "Iceland_2-Offshore_Ice.Off.SW_18020"
## |   |               `--leaf "Iceland_1-Nearshore_Ice.Near.NE_18081"
## |   |   `--[dendrogram w/ 2 branches and 2 members at h = 227]
## |   |       |--leaf "Iceland_2-Offshore_Ice.Off.NE_18116"
## |   |       `--leaf "Iceland_2-Offshore_Ice.Off.NE_18120"

```

```

## |   |   `--[dendrogram w/ 2 branches and 3 members at h = 242]
## |   |       |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18186"
## |   |       `--[dendrogram w/ 2 branches and 2 members at h = 228]
## |   |           |--leaf "Iceland_2-Offshore_Ice.Off.NE_18136"
## |   |           `--leaf "Iceland_1-Nearshore_Ice.Near.NE_18083"
## |   `--[dendrogram w/ 2 branches and 15 members at h = 313]
## |       |--[dendrogram w/ 2 branches and 3 members at h = 246]
## |           |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18187"
## |           `--[dendrogram w/ 2 branches and 2 members at h = 226]
## |               |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18160"
## |               `--leaf "Iceland_1-Nearshore_Ice.Near.NE_18078"
## |       `--[dendrogram w/ 2 branches and 12 members at h = 247]
## |           |--[dendrogram w/ 2 branches and 3 members at h = 223]
## |               |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18052"
## |               `--[dendrogram w/ 2 branches and 2 members at h = 218]
## |                   |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18059"
## |                   `--leaf "Iceland_1-Nearshore_Ice.Near.NE_18091"
## |           `--[dendrogram w/ 2 branches and 9 members at h = 233]
## |               |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18099"
## |           `--[dendrogram w/ 2 branches and 8 members at h = 232]
## |               |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18082"
## |           `--[dendrogram w/ 2 branches and 7 members at h = 230]
## |               |--[dendrogram w/ 2 branches and 5 members at h = 225]
## |                   |--leaf "Iceland_2-Offshore_Ice.Off.NE_18110"
## |                   `--[dendrogram w/ 2 branches and 4 members at h = 223]
## |                       |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18100"
## |                       `--[dendrogram w/ 2 branches and 3 members at h = 220]
## |                           |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18096"
## |                           `--[dendrogram w/ 2 branches and 2 members at h = 219]
## |                               |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18193"
## |                               `--leaf "Iceland_1-Nearshore_Ice.Near.NE_18088"
## |           `--[dendrogram w/ 2 branches and 2 members at h = 227]
## |               |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18159"
## |               `--leaf "Iceland_1-Nearshore_Ice.Near.SW_18162"
## |`--[dendrogram w/ 2 branches and 197 members at h = 466]
## |   |--[dendrogram w/ 2 branches and 21 members at h = 363]
## |       |--[dendrogram w/ 2 branches and 4 members at h = 307]
## |           |--[dendrogram w/ 2 branches and 2 members at h = 237]
## |               |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17016"
## |               `--leaf "GoM_1-Nearshore_GoM.Cashes.Red_17283"
## |           `--[dendrogram w/ 2 branches and 2 members at h = 252]
## |               |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_17285"
## |               `--leaf "GoM_1-Nearshore_GoM.Mass.Red_17008"
## |       `--[dendrogram w/ 2 branches and 17 members at h = 332]
## |           |--[dendrogram w/ 2 branches and 3 members at h = 262]
## |               |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18056"
## |               `--[dendrogram w/ 2 branches and 2 members at h = 240]
## |                   |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18155"
## |                   `--leaf "Iceland_1-Nearshore_Ice.Near.NE_18061"
## |           `--[dendrogram w/ 2 branches and 14 members at h = 306]
## |               |--[dendrogram w/ 2 branches and 5 members at h = 257]
## |                   |--[dendrogram w/ 2 branches and 2 members at h = 229]
## |                       |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18070"
## |                       `--leaf "Iceland_1-Nearshore_Ice.Near.NE_18094"

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## |   |   `--[dendrogram w/ 2 branches and 3 members at h = 234]
## |   |   |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18180"
## |   |   `--[dendrogram w/ 2 branches and 2 members at h = 229]
## |   |   |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18188"
## |   |   |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18086"
## |   `--[dendrogram w/ 2 branches and 9 members at h = 278]
## |   |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16241"
## |   `--[dendrogram w/ 2 branches and 8 members at h = 252]
## |   |--[dendrogram w/ 2 branches and 5 members at h = 232]
## |   |   |--[dendrogram w/ 2 branches and 3 members at h = 229]
## |   |   |   |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18084"
## |   |   |   `--[dendrogram w/ 2 branches and 2 members at h = 228]
## |   |   |       |--leaf "Iceland_2-Offshore_Ice.Off.SW_18042"
## |   |   |       `--[dendrogram w/ 2 branches and 2 members at h = 231]
## |   |   |           |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18154"
## |   |   |           `--[dendrogram w/ 2 branches and 2 members at h = 230]
## |   |   |               |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18161"
## |   |   |               `--[dendrogram w/ 2 branches and 3 members at h = 233]
## |   |   |                   |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18179"
## |   |   |                   `--[dendrogram w/ 2 branches and 2 members at h = 230]
## |   |   |                       |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18161"
## |   |   |                       `--[dendrogram w/ 2 branches and 2 members at h = 231]
## |   |   |                           |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18090"
## |   `--[dendrogram w/ 2 branches and 176 members at h = 401]
## |   |--[dendrogram w/ 2 branches and 99 members at h = 368]
## |   |   |--[dendrogram w/ 2 branches and 10 members at h = 299]
## |   |   |   |--[dendrogram w/ 2 branches and 4 members at h = 250]
## |   |   |   |   |--[dendrogram w/ 2 branches and 2 members at h = 228]
## |   |   |   |   |   |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18189"
## |   |   |   |   |   `--[dendrogram w/ 2 branches and 2 members at h = 230]
## |   |   |   |       |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18171"
## |   |   |   |       `--[dendrogram w/ 2 branches and 6 members at h = 270]
## |   |   |   |           |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18065"
## |   |   |   |           `--[dendrogram w/ 2 branches and 3 members at h = 234]
## |   |   |   |               |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18062"
## |   |   |   |               `--[dendrogram w/ 2 branches and 2 members at h = 225]
## |   |   |   |                   |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18173"
## |   |   |   |                   `--[dendrogram w/ 2 branches and 3 members at h = 241]
## |   |   |   |                       |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18164"
## |   |   |   |                       `--[dendrogram w/ 2 branches and 2 members at h = 219]
## |   |   |   |                           |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18194"
## |   |   |   |                           `--[dendrogram w/ 2 branches and 89 members at h = 358]
## |   |   |   |                               |--[dendrogram w/ 2 branches and 40 members at h = 302]
## |   |   |   |                               |--[dendrogram w/ 2 branches and 22 members at h = 254]
## |   |   |   |                               |   |--[dendrogram w/ 2 branches and 8 members at h = 249]
## |   |   |   |                               |   |   |--[dendrogram w/ 2 branches and 2 members at h = 246]
## |   |   |   |                               |   |   |   |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_17311"
## |   |   |   |                               |   |   |   `--[dendrogram w/ 2 branches and 6 members at h = 247]
## |   |   |   |                                   |--[dendrogram w/ 2 branches and 3 members at h = 244]
## |   |   |   |                                   |   |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Unknown_16227"
## |   |   |   |                                   |   `--[dendrogram w/ 2 branches and 2 members at h = 241]

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## |     |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Unknown_16248"
## |     `--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17240"
## `--[dendrogram w/ 2 branches and 3 members at h = 244]
## |     |--leaf "GoM_1-Nearshore_GoM.Cashes.Red_17273"
## |     `--[dendrogram w/ 2 branches and 2 members at h = 239]
## |         |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_17324"
## |         `--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Unknown_17288"
## `--[dendrogram w/ 2 branches and 14 members at h = 251]
## |     |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16220"
## |     `--[dendrogram w/ 2 branches and 13 members at h = 249]
## |         |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17028"
## |         `--[dendrogram w/ 2 branches and 12 members at h = 247]
## |             |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16238"
## |             `--[dendrogram w/ 2 branches and 2 members at h = 237]
## |                 |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Unknown_16240"
## |                 `--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Unknown_17292"
## `--[dendrogram w/ 2 branches and 9 members at h = 244]
## |     |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17010"
## |     `--[dendrogram w/ 2 branches and 4 members at h = 236]
## |         |--leaf "GoM_1-Nearshore_GoM.Cashes.Red_17265"
## |         `--[dendrogram w/ 2 branches and 2 members at h = 236]
## |             |--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17210"
## |             `--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17226"
## `--[dendrogram w/ 2 branches and 5 members at h = 242]
## |     |--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17248"
## |     `--[dendrogram w/ 2 branches and 4 members at h = 239]
## |         |--leaf "GoM_1-Nearshore_GoM.Cashes.Red_17253"
## |         `--leaf "GoM_1-Nearshore_GoM.Cashes.Red_17258"
## `--[dendrogram w/ 2 branches and 2 members at h = 237]
## |     |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Unknown_17002"
## |     `--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17245"
## `--[dendrogram w/ 2 branches and 18 members at h = 259]
## |     |--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17206"
## |     `--[dendrogram w/ 2 branches and 6 members at h = 239]
## |         |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Unknown_17033"
## |         `--[dendrogram w/ 2 branches and 5 members at h = 236]
## |             |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Unknown_17304"
## |             `--leaf "GoM_1-Nearshore_GoM.Cashes.Red_17270"
## `--[dendrogram w/ 2 branches and 3 members at h = 236]
## |     |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16231"
## |     `--[dendrogram w/ 2 branches and 2 members at h = 231]
## |         |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16234"
## |         `--leaf "GoM_1-Nearshore_GoM.Cashes.Red_17276"
## `--[dendrogram w/ 2 branches and 11 members at h = 248]
## |     |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_17308"
## |     `--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_17309"
## `--[dendrogram w/ 2 branches and 9 members at h = 245]
## |     |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_17309"
## |     `--[dendrogram w/ 2 branches and 6 members at h = 239]
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## | | | | | --[dendrogram w/ 2 branches and 2 members at h = 235]
## | | | | | |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16216"
## | | | | | `--leaf "GoM_1-Nearshore_GoM.Cashes.Red_17280"
## | | | | `--[dendrogram w/ 2 branches and 4 members at h = 238]
## | | | | | --[dendrogram w/ 2 branches and 2 members at h = 235]
## | | | | | | |--leaf "GoM_1-Nearshore_GoM.Mass.Red_16219"
## | | | | | | `--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17211"
## | | | | | `--[dendrogram w/ 2 branches and 2 members at h = 236]
## | | | | | | |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17007"
## | | | | | | `--leaf "GoM_1-Nearshore_GoM.Cashes.Red_17256"
## | | | | | `--[dendrogram w/ 2 branches and 3 members at h = 242]
## | | | | | | |--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17242"
## | | | | | | `--[dendrogram w/ 2 branches and 2 members at h = 234]
## | | | | | | | --leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16242"
## | | | | | | | `--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_17306"
## | | | | | | `--[dendrogram w/ 2 branches and 49 members at h = 339]
## | | | | | | | --[dendrogram w/ 2 branches and 10 members at h = 294]
## | | | | | | | | --[dendrogram w/ 2 branches and 5 members at h = 242]
## | | | | | | | | | --[dendrogram w/ 2 branches and 3 members at h = 237]
## | | | | | | | | | | |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18064"
## | | | | | | | | | | `--[dendrogram w/ 2 branches and 2 members at h = 232]
## | | | | | | | | | | | |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18182"
## | | | | | | | | | | | `--leaf "Iceland_1-Nearshore_Ice.Near.NE_18097"
## | | | | | | | | | | `--[dendrogram w/ 2 branches and 2 members at h = 241]
## | | | | | | | | | | | |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18183"
## | | | | | | | | | | | `--leaf "Iceland_1-Nearshore_Ice.Near.SW_18184"
## | | | | | | | | | | `--[dendrogram w/ 2 branches and 5 members at h = 253]
## | | | | | | | | | | | --[dendrogram w/ 2 branches and 3 members at h = 231]
## | | | | | | | | | | | | |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18165"
## | | | | | | | | | | | | `--[dendrogram w/ 2 branches and 2 members at h = 228]
## | | | | | | | | | | | | | |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18166"
## | | | | | | | | | | | | | `--leaf "Iceland_1-Nearshore_Ice.Near.SW_18174"
## | | | | | | | | | | | | `--[dendrogram w/ 2 branches and 2 members at h = 239]
## | | | | | | | | | | | | | |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18172"
## | | | | | | | | | | | | | `--leaf "Iceland_1-Nearshore_Ice.Near.SW_18191"
## | | | | | | | | | | | | `--[dendrogram w/ 2 branches and 39 members at h = 316]
## | | | | | | | | | | | | | --[dendrogram w/ 2 branches and 7 members at h = 272]
## | | | | | | | | | | | | | | |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16229"
## | | | | | | | | | | | | | | `--[dendrogram w/ 2 branches and 6 members at h = 260]
## | | | | | | | | | | | | | | | |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_17286"
## | | | | | | | | | | | | | | | `--[dendrogram w/ 2 branches and 5 members at h = 248]
## | | | | | | | | | | | | | | | | |--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17224"
## | | | | | | | | | | | | | | | | `--[dendrogram w/ 2 branches and 4 members at h = 244]
## | | | | | | | | | | | | | | | | | |--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17260"
## | | | | | | | | | | | | | | | | | `--[dendrogram w/ 2 branches and 3 members at h = 238]
## | | | | | | | | | | | | | | | | | | |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17155"
## | | | | | | | | | | | | | | | | | | `--[dendrogram w/ 2 branches and 2 members at h = 235]
## | | | | | | | | | | | | | | | | | | | |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17314"
## | | | | | | | | | | | | | | | | | | | `--leaf "GoM_1-Nearshore_GoM.Cashes.Red_17281"
## | | | | | | | | | | | | | | | | | | `--[dendrogram w/ 2 branches and 32 members at h = 281]
## | | | | | | | | | | | | | | | | | | | --[dendrogram w/ 2 branches and 22 members at h = 257]
## | | | | | | | | | | | | | | | | | | | | |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16232"
## | | | | | | | | | | | | | | | | | | | | `--[dendrogram w/ 2 branches and 21 members at h = 252]
## | | | | | | | | | | | | | | | | | | | | | --[dendrogram w/ 2 branches and 19 members at h = 250]

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## | --[dendrogram w/ 2 branches and 5 members at h = 247]
## | | --[dendrogram w/ 2 branches and 2 members at h = 110]
## | | | --leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16233"
## | | | --leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17233"
## | `--[dendrogram w/ 2 branches and 3 members at h = 245]
## | | --leaf "GoM_1-Nearshore_GoM.Cashes.Red_17262"
## | `--[dendrogram w/ 2 branches and 2 members at h = 239]
## | | --leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17221"
## | | --leaf "GoM_1-Nearshore_GoM.Cashes.Red_17252"
## `--[dendrogram w/ 2 branches and 14 members at h = 249]
## | --[dendrogram w/ 2 branches and 4 members at h = 246]
## | | --leaf "GoM_1-Nearshore_GoM.Mass.Red_17031"
## | `--[dendrogram w/ 2 branches and 3 members at h = 245]
## | | --leaf "GoM_1-Nearshore_GoM.Cashes.Red_17254"
## | | `--[dendrogram w/ 2 branches and 2 members at h = 243]
## | | | --leaf "GoM_1-Nearshore_GoM.Mass.Red_17024"
## | | | --leaf "GoM_1-Nearshore_GoM.Mass.Olive.Unknown_16228"
## | `--[dendrogram w/ 2 branches and 10 members at h = 247]
## | | --leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16236"
## | `--[dendrogram w/ 2 branches and 9 members at h = 245]
## | | --[dendrogram w/ 2 branches and 3 members at h = 242]
## | | | --leaf "GoM_1-Nearshore_GoM.Cashes.Red_17268"
## | | `--[dendrogram w/ 2 branches and 2 members at h = 239]
## | | | --leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_17327"
## | | | --leaf "GoM_1-Nearshore_GoM.Mass.Red_17316"
## | `--[dendrogram w/ 2 branches and 6 members at h = 244]
## | | --leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16225"
## | `--[dendrogram w/ 2 branches and 5 members at h = 240]
## | | --[dendrogram w/ 2 branches and 3 members at h = 236]
## | | | --leaf "GoM_1-Nearshore_GoM.Mass.Red_17027"
## | | `--[dendrogram w/ 2 branches and 2 members at h =
## | | | --leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_
## | | | --leaf "GoM_1-Nearshore_GoM.Cashes.Red_17272"
## | `--[dendrogram w/ 2 branches and 2 members at h = 237]
## | | --leaf "GoM_1-Nearshore_GoM.Mass.Red_17313"
## | | --leaf "GoM_1-Nearshore_GoM.Cashes.Red_17279"
## | `--[dendrogram w/ 2 branches and 2 members at h = 251]
## | | --leaf "GoM_1-Nearshore_GoM.Mass.Red_17026"
## | | --leaf "GoM_1-Nearshore_GoM.Mass.Red_17153"
## `--[dendrogram w/ 2 branches and 10 members at h = 263]
## | --[dendrogram w/ 2 branches and 3 members at h = 247]
## | | --leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16247"
## | | `--[dendrogram w/ 2 branches and 2 members at h = 238]
## | | | --leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17230"
## | | | --leaf "GoM_1-Nearshore_GoM.Cashes.Red_17259"
## | `--[dendrogram w/ 2 branches and 7 members at h = 248]
## | --[dendrogram w/ 2 branches and 3 members at h = 244]
## | | --leaf "GoM_1-Nearshore_GoM.Cashes.Red_17271"
## | | `--[dendrogram w/ 2 branches and 2 members at h = 241]
## | | | --leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_17032"
## | | | --leaf "GoM_1-Nearshore_GoM.Mass.Red_17019"
## `--[dendrogram w/ 2 branches and 4 members at h = 247]
## | --leaf "GoM_1-Nearshore_GoM.Cashes.Red_17257"
## | `--[dendrogram w/ 2 branches and 3 members at h = 243]

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## | --leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17204"
## | `--[dendrogram w/ 2 branches and 2 members at h = 236]
## |   |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16239"
## |   `--leaf "GoM_1-Nearshore_GoM.Cashes.Red_17282"
##`--[dendrogram w/ 2 branches and 77 members at h = 384]
## | --[dendrogram w/ 2 branches and 30 members at h = 320]
## |   | --[dendrogram w/ 2 branches and 12 members at h = 268]
## |   |   |--[dendrogram w/ 2 branches and 5 members at h = 249]
## |   |   | --leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17238"
## |   |   | `--[dendrogram w/ 2 branches and 4 members at h = 245]
## |   |   |   |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Unknown_17287"
## |   |   |   `--[dendrogram w/ 2 branches and 3 members at h = 241]
## |   |   |       |--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17234"
## |   |   |       `--[dendrogram w/ 2 branches and 2 members at h = 236]
## |   |   |           |--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17236"
## |   |   |           `--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17249"
## |   |   `--[dendrogram w/ 2 branches and 7 members at h = 262]
## |   |       |--leaf "GoM_1-Nearshore_GoM.Cashes.Red_17261"
## |   |   `--[dendrogram w/ 2 branches and 6 members at h = 252]
## |   |       |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17011"
## |   |   `--[dendrogram w/ 2 branches and 5 members at h = 242]
## |   |       |--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17219"
## |   |       `--[dendrogram w/ 2 branches and 4 members at h = 237]
## |   |           |--[dendrogram w/ 2 branches and 2 members at h = 232]
## |   |           | |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Unknown_16245"
## |   |           | `--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17215"
## |   |           `--[dendrogram w/ 2 branches and 2 members at h = 235]
## |   |               |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_17326"
## |   |               `--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Unknown_17325"
## |   `--[dendrogram w/ 2 branches and 18 members at h = 277]
## |       |--[dendrogram w/ 2 branches and 11 members at h = 257]
## |       | --[dendrogram w/ 2 branches and 3 members at h = 232]
## |       |   |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18098"
## |       |   `--[dendrogram w/ 2 branches and 2 members at h = 223]
## |       |       |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18153"
## |       |       `--leaf "Iceland_1-Nearshore_Ice.Near.SW_18156"
## |       `--[dendrogram w/ 2 branches and 8 members at h = 243]
## |           |--leaf "Iceland_2-Offshore_Ice.Off.NE_18134"
## |           `--[dendrogram w/ 2 branches and 7 members at h = 238]
## |               |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18158"
## |               `--[dendrogram w/ 2 branches and 6 members at h = 236]
## |                   |--[dendrogram w/ 2 branches and 2 members at h = 233]
## |                   | |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18080"
## |                   | `--leaf "Iceland_1-Nearshore_Ice.Near.NE_18095"
## |                   `--[dendrogram w/ 2 branches and 4 members at h = 233]
## |                       |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18067"
## |                       `--[dendrogram w/ 2 branches and 3 members at h = 231]
## |                           |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18072"
## |                           `--[dendrogram w/ 2 branches and 2 members at h = 230]
## |                               |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18053"
## |                               `--leaf "Iceland_1-Nearshore_Ice.Near.NE_18101"
## |   `--[dendrogram w/ 2 branches and 7 members at h = 261]
## |       |--[dendrogram w/ 2 branches and 2 members at h = 237]
## |           |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18163"

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##          |   '--leaf "Iceland_1-Nearshore_Ice.Near.SW_18167"
##          |`--[dendrogram w/ 2 branches and 5 members at h = 242]
##          |   |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18085"
##          |`--[dendrogram w/ 2 branches and 4 members at h = 234]
##          |   |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18178"
##          |`--[dendrogram w/ 2 branches and 3 members at h = 234]
##          |   |--leaf "Iceland_2-Offshore_Ice.Off.SW_18035"
##          |`--[dendrogram w/ 2 branches and 2 members at h = 231]
##          |   |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18069"
##          |`--leaf "Iceland_1-Nearshore_Ice.Near.NE_18087"
##`--[dendrogram w/ 2 branches and 47 members at h = 356]
##   |--[dendrogram w/ 2 branches and 3 members at h = 287]
##   |   |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18076"
##   |`--[dendrogram w/ 2 branches and 2 members at h = 251]
##   |   |--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17203"
##   |`--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17218"
##`--[dendrogram w/ 2 branches and 44 members at h = 333]
##   |--[dendrogram w/ 2 branches and 6 members at h = 262]
##   |   |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18168"
##   |`--[dendrogram w/ 2 branches and 5 members at h = 244]
##   |   |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18176"
##   |`--[dendrogram w/ 2 branches and 4 members at h = 233]
##   |   |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18073"
##   |`--[dendrogram w/ 2 branches and 3 members at h = 229]
##   |   |--leaf "Iceland_1-Nearshore_Ice.Near.NE_18074"
##   |`--[dendrogram w/ 2 branches and 2 members at h = 224]
##   |   |--leaf "Iceland_1-Nearshore_Ice.Near.SW_18157"
##   |`--leaf "Iceland_1-Nearshore_Ice.Near.SW_18192"
##`--[dendrogram w/ 2 branches and 38 members at h = 312]
##   |--[dendrogram w/ 2 branches and 10 members at h = 259]
##   |   |--[dendrogram w/ 2 branches and 2 members at h = 240]
##   |   |   |--leaf "GoM_1-Nearshore_GoM.Mass.Red_16218"
##   |   |`--leaf "GoM_1-Nearshore_GoM.Cashes.Red_17278"
##   |`--[dendrogram w/ 2 branches and 8 members at h = 248]
##   |   |--[dendrogram w/ 2 branches and 3 members at h = 243]
##   |   |   |--leaf "GoM_1-Nearshore_GoM.Cashes.Red_17264"
##   |   |`--[dendrogram w/ 2 branches and 2 members at h = 233]
##   |   |   |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17017"
##   |   |`--leaf "GoM_1-Nearshore_GoM.Mass.Red_17156"
##   |`--[dendrogram w/ 2 branches and 5 members at h = 245]
##   |   |--[dendrogram w/ 2 branches and 2 members at h = 240]
##   |   |   |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17006"
##   |   |`--leaf "GoM_1-Nearshore_GoM.Mass.Red_17029"
##   |`--[dendrogram w/ 2 branches and 3 members at h = 243]
##   |   |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_17296"
##   |`--[dendrogram w/ 2 branches and 2 members at h = 104]
##   |   |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_17291"
##   |`--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Unknown_16221"
##`--[dendrogram w/ 2 branches and 28 members at h = 269]
##   |--[dendrogram w/ 2 branches and 5 members at h = 243]
##   |   |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17003"
##   |`--[dendrogram w/ 2 branches and 4 members at h = 242]
##   |   |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_17298"
##   |`--[dendrogram w/ 2 branches and 3 members at h = 239]

```

```

##           |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16249"
##           `--[dendrogram w/ 2 branches and 2 members at h = 236]
##               |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17001"
##               `--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17277"
##           `--[dendrogram w/ 2 branches and 23 members at h = 257]
##               |--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17216"
##               `--[dendrogram w/ 2 branches and 22 members at h = 254]
##                   |--[dendrogram w/ 2 branches and 2 members at h = 119]
##                       |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17022"
##                       `--leaf "GoM_1-Nearshore_GoM.Mass.Red_17023"
##               `--[dendrogram w/ 2 branches and 20 members at h = 251]
##                   |--[dendrogram w/ 2 branches and 8 members at h = 244]
##                       |--[dendrogram w/ 2 branches and 3 members at h = 241]
##                           |--leaf "GoM_1-Nearshore_GoM.Cashes.Red_17267"
##                           `--[dendrogram w/ 2 branches and 2 members at h = 240]
##                               |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_17289"
##                               `--leaf "GoM_1-Nearshore_GoM.Cashes.Red_17263"
##                   `--[dendrogram w/ 2 branches and 5 members at h = 244]
##                       |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_17303"
##                       `--[dendrogram w/ 2 branches and 4 members at h = 241]
##                           |--[dendrogram w/ 2 branches and 2 members at h = 234]
##                               |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17020"
##                               `--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Unknown_17290"
##                   `--[dendrogram w/ 2 branches and 2 members at h = 235]
##                       |--leaf "GoM_1-Nearshore_GoM.Mass.Red_16214"
##                       `--leaf "GoM_1-Nearshore_GoM.Mass.Red_17013"
##           `--[dendrogram w/ 2 branches and 12 members at h = 249]
##               |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17018"
##               `--[dendrogram w/ 2 branches and 11 members at h = 246]
##                   |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Unknown_17030"
##                   `--[dendrogram w/ 2 branches and 10 members at h = 243]
##                       |--[dendrogram w/ 2 branches and 4 members at h = 239]
##                           |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Unknown_16243"
##                           `--[dendrogram w/ 2 branches and 3 members at h = 237]
##                               |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17154"
##                               `--[dendrogram w/ 2 branches and 2 members at h = 232]
##                                   |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Unknown_16242"
##                                   `--leaf "GoM_1-Nearshore_GoM.Cashes.Olive_17235"
##           `--[dendrogram w/ 2 branches and 6 members at h = 243]
##               |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16224"
##               `--[dendrogram w/ 2 branches and 5 members at h = 240]
##                   |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17015"
##                   `--[dendrogram w/ 2 branches and 4 members at h = 238]
##                       |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17315"
##                       `--[dendrogram w/ 2 branches and 3 members at h = 235]
##                           |--leaf "GoM_1-Nearshore_GoM.Mass.Red_17005"
##                           `--[dendrogram w/ 2 branches and 2 members at h = 234]
##                               |--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16223"
##                               `--leaf "GoM_1-Nearshore_GoM.Mass.Olive.Winter_16222"

# https://www.datacamp.com/tutorial/hierarchical-clustering-R
pdf("../figures/Hclust-inversionSNPsonly.pdf", width=15, height=10)
plot(hc, cex=0.3)
rect.hclust(hc , k = 5, border=2:6)

```

```

dev.off()

## pdf
## 2

samp_full$InvHclustOrder <- hc$order
samp_full$InvHclustK5 <- as.numeric(cut_avg)

# this looks like SW near in Iceland is more closely related to GOM then NE NEar in Iceland
table(samp_full$PopID, samp_full$InvHclustK5)

##                                     1   2   3   4   5
## GoM.Mass.Olive.Winter    22   9   2   1   0
## GoM.Mass.Red             15  17   2   1   0
## GoM.Mass.Olive.Unknown   9   5   0   3   0
## GoM.Cashes.Olive         14   5   0   6   0
## GoM.Cashes.Red           19   4   1   1   0
## Ice.Off.SW                0   0   1   1  37
## Ice.Near.SW              14   4   8   6   8
## Ice.Off.NE                0   0   0   1  38
## Ice.Near.NE              6   3   7  10  14

pdf("../figures/Hclust-inversionSNPsonly-heatmap.pdf", width=15, height=15)
par(oma=c(8,4,4,8))
heatmap(as.matrix(dist), cexRow=0.2, cexCol=0.2, scale="none", ColSideColors=samp_full$PopID_color, Row
dev.off()

## pdf
## 2

```

save outputs

```

head(samp_full)

##   samp_full Pop          PopID Region      Ecotype
## 1       16216 Pop1 GoM.Mass.Olive.Winter     GoM 1-Nearshore
## 2       16220 Pop1 GoM.Mass.Olive.Winter     GoM 1-Nearshore
## 3       16224 Pop1 GoM.Mass.Olive.Winter     GoM 1-Nearshore
## 4       16225 Pop1 GoM.Mass.Olive.Winter     GoM 1-Nearshore
## 5       16229 Pop1 GoM.Mass.Olive.Winter     GoM 1-Nearshore
## 6       16231 Pop1 GoM.Mass.Olive.Winter     GoM 1-Nearshore
##                                         label Region_color Ecotype_color
## 1 GoM_1-Nearshore_GoM.Mass.Olive.Winter_16216     blue4    darkcyan
## 2 GoM_1-Nearshore_GoM.Mass.Olive.Winter_16220     blue4    darkcyan
## 3 GoM_1-Nearshore_GoM.Mass.Olive.Winter_16224     blue4    darkcyan
## 4 GoM_1-Nearshore_GoM.Mass.Olive.Winter_16225     blue4    darkcyan
## 5 GoM_1-Nearshore_GoM.Mass.Olive.Winter_16229     blue4    darkcyan
## 6 GoM_1-Nearshore_GoM.Mass.Olive.Winter_16231     blue4    darkcyan
##   PopID_color   Gsub_PC1   Gsub_PC2 G_AllInv_PC1 G_AllInv_PC2 InvHclustOrder
## 1 #006400FF -0.05893059  0.027334412  0.03531921 -0.007908553          146
## 2 #006400FF -0.06696424  0.001338206  0.06496404 -0.049032057          258
## 3 #006400FF -0.06511353  0.002449571  0.06134477 -0.053768027          230
## 4 #006400FF -0.06136966  0.004868653  0.05153129 -0.037532901          147
## 5 #006400FF -0.05381484  0.015398091  0.03185495  0.019557487          172

```

```

## 6   #006400FF -0.05952850 0.018067312  0.04147050  0.003228003      238
##   InvHclustK5
## 1       1
## 2       1
## 3       2
## 4       1
## 5       1
## 6       1

write.csv(samp_full,"../outputs/1-Samples.csv")
saveRDS(samp_full,"../outputs/1-Samples.rds")

```

breakpoints

Save individual inversion files

```

##      LG LGstartIndex LGendIndex      chrom LGstartPos LGendPos
## 1  LG1      33090     104012 NC_044048.1    11299038 28292263
## 2  LG2      111433     132871 NC_044049.1    481246 4466546
## 3  LG7      648745     696592 NC_044054.1   16828712 26336501
## 4 LG12     1098771     1141346 NC_044059.1   1809214 13690550
##      LGstartPos_minus1MB_index LGendPos_plus1MB_index
## 1                      29750          106154
## 2                      109720         135332
## 3                      645345         700639
## 4                      1096496        1142816

write.csv.breakpoints, "../outputs/1-breakpoints.csv", row.names = FALSE)

head(G_full[,1:5]) # make sure rows and columns are labeled

```

	NC_044048.1__268	NC_044048.1__280
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16216	0	2
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16220	1	2
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16224	1	2
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16225	0	0
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16229	1	0
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16231	1	1
##	NC_044048.1__378	NC_044048.1__539
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16216	0	1
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16220	0	0
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16224	0	0
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16225	0	0
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16229	0	0
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16231	0	0
##	NC_044048.1__1555	
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16216	0	
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16220	0	
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16224	0	
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16225	0	
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16229	0	
## GoM_1-Nearshore_GoM.Mass.Olive.Winter_16231	0	

```

saveRDS(G_LG, "../outputs/1-AllLGSNPs.rds")
saveRDS(G_full[,LG1start_minus1MB:LG1end_plus1MB], "../outputs/1-G_LG1.rds")

```

```
saveRDS(G_full[,LG2start_minus1MB:LG2end_plus1MB], " ../outputs/1-G_LG2.rds")
saveRDS(G_full[,LG7start_minus1MB:LG7end_plus1MB], " ../outputs/1-G_LG7.rds")
saveRDS(G_full[,LG12start_minus1MB:LG12end_plus1MB], " ../outputs/1-G_LG12.rds")
```