# Beta diversity ITS2 DINO analyses for Pocillopora species across the Indo-Pacific, 29 Sep 2021

```
rm(list = ls())
library(tidyr)
library(purrr)
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
library(metagMisc)
```

```
##
## Attaching package: 'metagMisc'

## The following object is masked from 'package:purrr':
##
##     some
```

```
library(kableExtra)
```

```
##
## Attaching package: 'kableExtra'

## The following object is masked from 'package:dplyr':
##
##     group_rows
```

```
library(reshape2)
```

```
##
## Attaching package: 'reshape2'

## The following object is masked from 'package:tidyr':
##
##     smiths
```

```
library(stringr)
library(tidyverse)
```

```
## -- Attaching packages --------------------------------------- tidyverse 1.3.1 --
```

```
## v ggplot2 3.3.5     v readr   2.0.2
## v tibble  3.1.4     v forcats 0.5.1
```

```
## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter()          masks stats::filter()
## x kableExtra::group_rows() masks dplyr::group_rows()
## x dplyr::lag()             masks stats::lag()
## x metagMisc::some()        masks purrr::some()
```

```
library(phyloseq)
library(magrittr)
```

```
##
## Attaching package: 'magrittr'
```

```
## The following object is masked from 'package:purrr':
##
##     set_names
```

```
## The following object is masked from 'package:tidyr':
##
##     extract
```

```
library(metagMisc)
library(randomForest)
```

```
## randomForest 4.6-14
```

```
## Type rfNews() to see new features/changes/bug fixes.
```

```
##
## Attaching package: 'randomForest'
```

```
## The following object is masked from 'package:ggplot2':
##
##     margin
```

```
## The following object is masked from 'package:dplyr':
##
##     combine
```

```
library(knitr)
library(seqinr)
```

```
##
## Attaching package: 'seqinr'

## The following object is masked from 'package:dplyr':
##
##     count
```

```
library(ggplot2)
library(gridExtra)
```

```
##
## Attaching package: 'gridExtra'

## The following object is masked from 'package:randomForest':
##
##     combine

## The following object is masked from 'package:dplyr':
##
##     combine
```

```
library(vegan)
```

```
## Loading required package: permute

##
## Attaching package: 'permute'

## The following object is masked from 'package:seqinr':
##
##     getType

## Loading required package: lattice

## This is vegan 2.5-7
```

```
library(DESeq2)
```

```
## Loading required package: S4Vectors

## Loading required package: stats4

## Loading required package: BiocGenerics

## Loading required package: parallel

##
## Attaching package: 'BiocGenerics'
```

```
## The following objects are masked from 'package:parallel':
##
##     clusterApply, clusterApplyLB, clusterCall, clusterEvalQ,
##     clusterExport, clusterMap, parApply, parCapply, parLapply,
##     parLapplyLB, parRapply, parSapply, parSapplyLB

## The following object is masked from 'package:gridExtra':
##
##     combine

## The following object is masked from 'package:randomForest':
##
##     combine

## The following objects are masked from 'package:dplyr':
##
##     combine, intersect, setdiff, union

## The following objects are masked from 'package:stats':
##
##     IQR, mad, sd, var, xtabs

## The following objects are masked from 'package:base':
##
##     anyDuplicated, append, as.data.frame, basename, cbind, colnames,
##     dirname, do.call, duplicated, eval, evalq, Filter, Find, get, grep,
##     grepl, intersect, is.unsorted, lapply, Map, mapply, match, mget,
##     order, paste, pmax, pmax.int, pmin, pmin.int, Position, rank,
##     rbind, Reduce, rownames, sapply, setdiff, sort, table, tapply,
##     union, unique, unsplit, which.max, which.min

##
## Attaching package: 'S4Vectors'

## The following objects are masked from 'package:dplyr':
##
##     first, rename

## The following object is masked from 'package:tidyr':
##
##     expand

## The following objects are masked from 'package:base':
##
##     expand.grid, I, unname

## Loading required package: IRanges

##
## Attaching package: 'IRanges'
```

```
## The following object is masked from 'package:phyloseq':
##
##     distance

## The following objects are masked from 'package:dplyr':
##
##     collapse, desc, slice

## The following object is masked from 'package:purrr':
##
##     reduce

## Loading required package: GenomicRanges

## Loading required package: GenomeInfoDb

## Loading required package: SummarizedExperiment

## Loading required package: MatrixGenerics

## Loading required package: matrixStats

##
## Attaching package: 'matrixStats'

## The following object is masked from 'package:seqinr':
##
##     count

## The following object is masked from 'package:dplyr':
##
##     count

##
## Attaching package: 'MatrixGenerics'

## The following objects are masked from 'package:matrixStats':
##
##     colAlls, colAnyNAs, colAnys, colAvgsPerRowSet, colCollapse,
##     colCounts, colCummaxs, colCummins, colCumprods, colCumsums,
##     colDiffs, colIQRDiffs, colIQRs, colLogSumExps, colMadDiffs,
##     colMads, colMaxs, colMeans2, colMedians, colMins, colOrderStats,
##     colProds, colQuantiles, colRanges, colRanks, colSdDiffs, colSds,
##     colSums2, colTabulates, colVarDiffs, colVars, colWeightedMads,
##     colWeightedMeans, colWeightedMedians, colWeightedSds,
##     colWeightedVars, rowAlls, rowAnyNAs, rowAnys, rowAvgsPerColSet,
##     rowCollapse, rowCounts, rowCummaxs, rowCummins, rowCumprods,
##     rowCumsums, rowDiffs, rowIQRDiffs, rowIQRs, rowLogSumExps,
##     rowMadDiffs, rowMads, rowMaxs, rowMeans2, rowMedians, rowMins,
##     rowOrderStats, rowProds, rowQuantiles, rowRanges, rowRanks,
##     rowSdDiffs, rowSds, rowSums2, rowTabulates, rowVarDiffs, rowVars,
##     rowWeightedMads, rowWeightedMeans, rowWeightedMedians,
##     rowWeightedSds, rowWeightedVars
```

```
## Loading required package: Biobase

## Welcome to Bioconductor
##
##     Vignettes contain introductory material; view with
##     'browseVignettes()'. To cite Bioconductor, see
##     'citation("Biobase")', and for packages 'citation("pkgname")'.

##
## Attaching package: 'Biobase'

## The following object is masked from 'package:MatrixGenerics':
##
##     rowMedians

## The following objects are masked from 'package:matrixStats':
##
##     anyMissing, rowMedians

## The following object is masked from 'package:phyloseq':
##
##     sampleNames
```

```
library(picante)
```

```
## Loading required package: ape

##
## Attaching package: 'ape'

## The following objects are masked from 'package:seqinr':
##
##     as.alignment, consensus

## Loading required package: nlme

##
## Attaching package: 'nlme'

## The following object is masked from 'package:IRanges':
##
##     collapse

## The following object is masked from 'package:seqinr':
##
##     gls

## The following object is masked from 'package:dplyr':
##
##     collapse
```

```r
library(remotes)
```

```
##
## Attaching package: 'remotes'

## The following object is masked from 'package:metagMisc':
##
##     add_metadata
```

```r
library(ggrepel)
library(igraph)
```

```
##
## Attaching package: 'igraph'

## The following objects are masked from 'package:ape':
##
##     edges, mst, ring

## The following object is masked from 'package:GenomicRanges':
##
##     union

## The following object is masked from 'package:IRanges':
##
##     union

## The following object is masked from 'package:S4Vectors':
##
##     union

## The following objects are masked from 'package:BiocGenerics':
##
##     normalize, path, union

## The following object is masked from 'package:vegan':
##
##     diversity

## The following object is masked from 'package:permute':
##
##     permute

## The following object is masked from 'package:tibble':
##
##     as_data_frame

## The following objects are masked from 'package:dplyr':
##
##     as_data_frame, groups, union
```

```
## The following objects are masked from 'package:purrr':
##
##     compose, simplify

## The following object is masked from 'package:tidyr':
##
##     crossing

## The following objects are masked from 'package:stats':
##
##     decompose, spectrum

## The following object is masked from 'package:base':
##
##     union
```

```
library(ellipse)
```

```
##
## Attaching package: 'ellipse'

## The following object is masked from 'package:graphics':
##
##     pairs
```

```
library(dplyr)
library(indicspecies)
```

```
##
## Attaching package: 'indicspecies'

## The following object is masked from 'package:SummarizedExperiment':
##
##     coverage

## The following object is masked from 'package:GenomicRanges':
##
##     coverage

## The following object is masked from 'package:IRanges':
##
##     coverage
```

```
library(yhat)
```

```
## Registered S3 methods overwritten by 'yacca':
##   method             from
##   plot.cca           vegan
##   print.cca          vegan
##   print.summary.cca vegan
##   summary.cca        vegan
```

```r
library("dunn.test")
library(metagenomeSeq)
```

```
## Loading required package: limma

##
## Attaching package: 'limma'

## The following object is masked from 'package:DESeq2':
##
##     plotMA

## The following object is masked from 'package:BiocGenerics':
##
##     plotMA

## The following object is masked from 'package:seqinr':
##
##     zscore

## Loading required package: glmnet

## Loading required package: Matrix

##
## Attaching package: 'Matrix'

## The following object is masked from 'package:S4Vectors':
##
##     expand

## The following objects are masked from 'package:tidyr':
##
##     expand, pack, unpack

## Loaded glmnet 4.1-2

## Loading required package: RColorBrewer
```

```r
library(phyloseq)
```

```r
## Remember to setwd to where rds files are found
##setwd("~/Users/victoriamarieglynn/Desktop/Desktop_May2021/CC_11May2021_DINOenv")

##Read rds file generated from DADA2
ps <- readRDS("/Users/victoriamarieglynn/Desktop/Desktop_May2021/CC_11May2021_DINOenv/symITSps_may2021.
ps
```

```
## phyloseq-class experiment-level object
## otu_table()   OTU Table:         [ 11374 taxa and 416 samples ]
## sample_data() Sample Data:       [ 416 samples by 21 sample variables ]
## phy_tree()    Phylogenetic Tree: [ 11374 tips and 11372 internal nodes ]
```

```r
taxa_names(ps) <- paste0("asv", seq(ntaxa(ps)))
# explicitly rename taxas to asvs

otu <- otu_table(ps)
tre <- phy_tree(ps)
sam <- sample_data(ps)
```

```r
##Taxa import, below is for the NCBI search, which was as follows on our Compute Canada clusters:

###blastn \
###-query uniqueSeqs_F-asv.fasta \
###-db nt \
###-out SymPortal_NCBIcrossref_Fb5.csv \
###-evalue 1e-5 \
###-outfmt "6 qseqid sseqid sscinames scomnames sskingdoms stitle qstart qend mismatch evalue length" \
###-max_target_seqs 5

## For NCBI, I manually looked through the generated table to assign clade and type level identificatio

##I also used SymPortal for taxonomic assignment, but this did not result in ITS clades being grouped t

###vsearch --usearch_global uniqueSeqs_DINO_Stewart.fasta --db refSeqDB.fa --blast6out DINOSt_taxa.txt
```

```r
taxtable<-read.csv("/Users/victoriamarieglynn/Desktop/Desktop_May2021/CC_11May2021_DINOenv/DINO_NCBI_26
summary(taxtable)
```

```
##      ASV              ITSclade           ITStype
##  Length:882         Length:882         Length:882
##  Class :character   Class :character   Class :character
##  Mode  :character   Mode  :character   Mode  :character
```

```r
##This CSVs has all N sequences removed, as not informative
```

```r
## taxonomy table into matrix
taxmat<-as.matrix(taxtable[,2:3])
rownames(taxmat)<-taxtable$ASV
```

```r
##Combine the taxonomy matrix and the otu_table (otus) into a phyloseq object

TAX = tax_table(taxmat)

## Check if any duplicated row names

duplicated(TAX)
```

```
## asv1001 asv1074 asv1188 asv1235 asv1261 asv1341  asv137  asv148 asv1488  asv149
##   FALSE   FALSE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1617 asv1660 asv1689 asv1997 asv2005  asv221  asv224  asv228 asv2280 asv2357
##    TRUE    TRUE   FALSE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv2378   asv25 asv2553 asv2754 asv2830 asv3083 asv3798 asv4369 asv4370  asv448
##    TRUE    TRUE    TRUE    TRUE   FALSE    TRUE    TRUE    TRUE    TRUE    TRUE
```

```
##  asv449  asv454  asv492  asv547  asv604  asv606  asv618  asv625  asv640  asv693
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv756  asv765  asv779  asv790  asv793  asv809  asv831  asv838  asv860    asv1
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE   FALSE
## asv1005  asv101 asv1019  asv102 asv1023 asv1033 asv1037 asv1039 asv1042 asv1046
##   FALSE    TRUE   FALSE    TRUE    TRUE    TRUE   FALSE    TRUE    TRUE    TRUE
##  asv105 asv1055  asv106 asv1060 asv1067  asv107 asv1078  asv108 asv1085 asv1090
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1093 asv1098 asv1108 asv1110  asv112 asv1124  asv114 asv1144 asv1149 asv1153
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1156 asv1158 asv1167  asv117 asv1172 asv1175 asv1185  asv119   asv12  asv120
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1202 asv1205 asv1209  asv121 asv1216 asv1227 asv1228  asv123 asv1236 asv1239
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1247  asv125 asv1252 asv1256 asv1265  asv127  asv128 asv1284 asv1285 asv1293
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1295 asv1296   asv13 asv1302 asv1309  asv131 asv1310  asv132  asv133  asv134
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv135  asv136 asv1360 asv1363 asv1378  asv138 asv1389  asv139 asv1405 asv1408
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1426 asv1436  asv144 asv1441 asv1448 asv1457  asv146  asv147 asv1476 asv1482
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1497   asv15  asv150 asv1502 asv1505 asv1511 asv1517 asv1519  asv152 asv1523
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv153  asv154 asv1544 asv1545  asv155 asv1561  asv157  asv159 asv1594 asv1595
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1599  asv160 asv1601  asv161 asv1610 asv1616  asv163 asv1633  asv164 asv1653
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1668  asv167 asv1678 asv1686 asv1687 asv1690 asv1693 asv1696   asv17 asv1704
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv171 asv1711 asv1715 asv1719 asv1729  asv173 asv1737  asv175  asv176 asv1762
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1768  asv177  asv178 asv1784 asv1786  asv179 asv1792 asv1799   asv18  asv180
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1809 asv1810  asv182 asv1827 asv1828 asv1843  asv185 asv1854 asv1858 asv1863
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv187 asv1870 asv1875  asv188 asv1886 asv1896 asv1897   asv19 asv1903 asv1904
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1905 asv1906  asv191 asv1913  asv192 asv1920 asv1921  asv193 asv1938  asv194
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1952 asv1960 asv1969 asv1970 asv1982 asv1983 asv1990 asv1995    asv2  asv200
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv2013  asv202 asv2023  asv204 asv2043 asv2049 asv2051 asv2052  asv206 asv2071
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv2075 asv2076  asv209 asv2095  asv211 asv2117  asv215 asv2151 asv2157 asv2158
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv218 asv2187   asv22 asv2226  asv223 asv2248 asv2255  asv226 asv2268  asv227
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv229 asv2309  asv232 asv2329  asv233 asv2330 asv2339 asv2340 asv2341  asv235
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv2356  asv236 asv2367 asv2368 asv2377  asv239 asv2399   asv24  asv240 asv2400
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv2402 asv2403  asv241  asv242 asv2427  asv243 asv2441  asv246  asv248 asv2486
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
```

```
## asv2488  asv250  asv254 asv2552 asv2564  asv257  asv258   asv26 asv2600 asv2608
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv2609 asv2610 asv2622 asv2629 asv2631 asv2632  asv264 asv2648 asv2649  asv265
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv2662 asv2663 asv2665  asv267 asv2682  asv269 asv2698 asv2699 asv2701  asv271
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv2717 asv2718  asv272  asv273 asv2744 asv2755  asv276  asv280 asv2804 asv2805
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv2806  asv281 asv2815 asv2825 asv2826 asv2827  asv283  asv284  asv288 asv2881
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##   asv29  asv290 asv2915 asv2916 asv2918 asv2938  asv295  asv296 asv2965  asv298
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv2987    asv3   asv30  asv300 asv3003  asv301  asv302 asv3033 asv3049  asv305
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv3068   asv31  asv310 asv3104 asv3106 asv3107  asv312 asv3134 asv3135 asv3138
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv314 asv3160  asv317 asv3180 asv3181 asv3200 asv3201  asv321 asv3217 asv3219
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv322  asv323 asv3245 asv3246 asv3247 asv3249  asv325 asv3251  asv328   asv33
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv3304 asv3306 asv3307  asv332 asv3329 asv3331  asv334  asv335 asv3357 asv3358
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv336  asv337  asv340  asv341 asv3413 asv3414  asv343 asv3442 asv3443 asv3444
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv347 asv3474  asv348   asv35  asv351 asv3512 asv3539  asv355 asv3577 asv3578
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv3580 asv3581 asv3582 asv3583 asv3584 asv3608  asv361  asv362 asv3638 asv3640
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv365  asv367 asv3670  asv368 asv3698   asv37 asv3705  asv371  asv375 asv3753
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv377  asv378 asv3795 asv3796 asv3799   asv38  asv381 asv3828 asv3829  asv383
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv3830 asv3831 asv3832 asv3871  asv388   asv39 asv3925  asv393  asv395  asv399
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##    asv4 asv4005 asv4006  asv402  asv404 asv4048 asv4049  asv405  asv406 asv4094
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv4095 asv4096 asv4097   asv41  asv410  asv411  asv414 asv4154 asv4157 asv4159
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##   asv42 asv4204 asv4208 asv4209  asv423  asv424 asv4253 asv4254  asv426  asv427
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv428   asv43 asv4307 asv4308 asv4310 asv4311  asv433 asv4367 asv4368 asv4371
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##   asv44  asv440 asv4428 asv4429 asv4430 asv4433 asv4434  asv444  asv445  asv446
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##   asv45  asv450   asv46  asv460  asv462  asv468   asv47  asv471  asv472  asv475
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv476  asv477  asv479   asv48  asv486  asv490  asv491  asv493  asv495  asv498
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv499   asv50  asv500  asv505  asv507   asv51  asv514  asv516  asv519   asv52
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##   asv53  asv531  asv532  asv535  asv537   asv54  asv540  asv543  asv554  asv556
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##   asv56  asv561  asv562  asv563  asv565  asv587   asv60  asv605  asv607  asv609
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
```

```
##  asv611  asv613   asv63  asv630  asv632  asv633  asv638  asv649  asv653  asv654
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv657  asv660  asv661  asv666   asv67   asv68  asv691  asv699   asv70  asv700
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv703  asv706   asv71  asv714  asv715  asv718   asv73  asv732  asv735  asv742
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv746   asv75  asv752  asv753   asv76  asv764   asv77  asv770  asv772  asv774
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv777   asv78  asv784  asv787  asv788  asv789   asv79  asv792  asv799    asv8
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##   asv80  asv801  asv806  asv807  asv808  asv818   asv82  asv825  asv827   asv83
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv834  asv837   asv85  asv859   asv86  asv863  asv864   asv87  asv873  asv874
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv877   asv88  asv884  asv887   asv89  asv899    asv9   asv90  asv902  asv905
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv911  asv914  asv916   asv92  asv922  asv925  asv929  asv934   asv94  asv940
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv943  asv945  asv946  asv948  asv950  asv956  asv961  asv967  asv968  asv970
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv976  asv977  asv985  asv989  asv992  asv999 asv1031  asv104 asv1049 asv1050
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE   FALSE    TRUE   FALSE    TRUE
##  asv109  asv110  asv111 asv1131 asv1171 asv1194 asv1203 asv1204 asv1221 asv1258
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1286  asv129 asv1319 asv1342 asv1354 asv1359 asv1364 asv1391   asv14  asv142
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1420  asv145 asv1460 asv1465 asv1466 asv1471 asv1475 asv1498 asv1532 asv1533
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv156 asv1581 asv1589   asv16 asv1600 asv1609  asv166 asv1661 asv1667 asv1738
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1749 asv1757 asv1763 asv1777 asv1778 asv1785 asv1791 asv1805  asv183 asv1852
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv1853 asv1864 asv1874 asv1879 asv1931 asv1948 asv1973  asv201 asv2026 asv2032
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv2044  asv205 asv2063 asv2105 asv2124 asv2150 asv2169 asv2213 asv2290   asv23
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv231 asv2310 asv2312 asv2328  asv237  asv238 asv2401  asv245 asv2487  asv249
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE   FALSE    TRUE    TRUE
## asv2523 asv2524 asv2525  asv259 asv2599  asv260 asv2621 asv2630 asv2664   asv27
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv270 asv2700  asv279 asv2828 asv2829  asv286 asv2862  asv293 asv2937  asv294
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv297 asv2985 asv2986 asv3008 asv3084 asv3105 asv3136 asv3137  asv318 asv3248
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv327 asv3279 asv3305 asv3328  asv345  asv357 asv3579  asv359 asv3639 asv3702
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
## asv3797  asv390 asv3926  asv396   asv40 asv4003 asv4004  asv415 asv4155 asv4156
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv417  asv422  asv429 asv4309  asv431  asv437 asv4431 asv4432  asv447  asv453
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv459  asv463  asv467  asv474   asv49  asv501  asv504  asv529  asv533  asv538
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv542   asv55  asv553  asv558  asv559  asv567  asv571  asv574  asv575  asv585
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
```

```
##  asv598    asv6   asv62  asv639   asv66  asv674  asv675  asv680  asv682    asv7
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv702  asv730  asv738   asv74  asv767  asv780   asv81  asv816  asv820  asv822
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv836   asv84  asv848  asv857  asv862  asv904   asv91  asv920   asv95  asv952
##    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE    TRUE
##  asv955  asv984 asv1059 asv1305 asv2311 asv2342 asv3330  asv385  asv461  asv489
##    TRUE    TRUE   FALSE    TRUE    TRUE   FALSE    TRUE    TRUE    TRUE    TRUE
##  asv791  asv928
##    TRUE    TRUE
```

```
taxa_are_rows(TAX)
```

```
## NULL
```

```
any(duplicated(rownames(TAX)))
```

```
## [1] FALSE
```

```
which(duplicated(rownames(TAX)))
```

```
## integer(0)
```

```
## If no duplicated row names:

ps_tax = phyloseq(otu, TAX, sam, tre)

ps_tax
```

```
## phyloseq-class experiment-level object
## otu_table()   OTU Table:         [ 882 taxa and 416 samples ]
## sample_data() Sample Data:       [ 416 samples by 21 sample variables ]
## tax_table()   Taxonomy Table:    [ 882 taxa by 2 taxonomic ranks ]
## phy_tree()    Phylogenetic Tree: [ 882 tips and 881 internal nodes ]
```

```
# Compare phyloseq's raw and now SymPortal amended ps's
ps_tax
```

```
## phyloseq-class experiment-level object
## otu_table()   OTU Table:         [ 882 taxa and 416 samples ]
## sample_data() Sample Data:       [ 416 samples by 21 sample variables ]
## tax_table()   Taxonomy Table:    [ 882 taxa by 2 taxonomic ranks ]
## phy_tree()    Phylogenetic Tree: [ 882 tips and 881 internal nodes ]
```

```
ps
```

```
## phyloseq-class experiment-level object
## otu_table()   OTU Table:         [ 11374 taxa and 416 samples ]
## sample_data() Sample Data:       [ 416 samples by 21 sample variables ]
## phy_tree()    Phylogenetic Tree: [ 11374 tips and 11372 internal nodes ]
```

```
## Only 52.6% of taxa kept from ps to ps_tax
```

```
#Remove samples less 1000 reads

ps1 = prune_samples(sample_sums(ps_tax) > 1000, ps_tax)
ps1
```

```
## phyloseq-class experiment-level object
## otu_table()   OTU Table:         [ 882 taxa and 343 samples ]
## sample_data() Sample Data:       [ 343 samples by 21 sample variables ]
## tax_table()   Taxonomy Table:    [ 882 taxa by 2 taxonomic ranks ]
## phy_tree()    Phylogenetic Tree: [ 882 tips and 881 internal nodes ]
```

```
#Remove taxa not seen more than 1 times in at least 5% of the samples

ps2 = filter_taxa(ps1, function(x) sum(x > 1) > (0.05*length(x)), TRUE)
ps2
```

```
## phyloseq-class experiment-level object
## otu_table()   OTU Table:         [ 435 taxa and 343 samples ]
## sample_data() Sample Data:       [ 343 samples by 21 sample variables ]
## tax_table()   Taxonomy Table:    [ 435 taxa by 2 taxonomic ranks ]
## phy_tree()    Phylogenetic Tree: [ 435 tips and 434 internal nodes ]
```

```
# keep only taxa that were observed at least twice
ps3 = prune_taxa(taxa_sums(ps2) >= 2, ps2)
ps3
```

```
## phyloseq-class experiment-level object
## otu_table()   OTU Table:         [ 435 taxa and 343 samples ]
## sample_data() Sample Data:       [ 343 samples by 21 sample variables ]
## tax_table()   Taxonomy Table:    [ 435 taxa by 2 taxonomic ranks ]
## phy_tree()    Phylogenetic Tree: [ 435 tips and 434 internal nodes ]
```

```
# remove taxonomy samples that were Ns

ps4 = subset_samples(ps3, Spec != "P_spp")

## Remove Fr Poly as ASVs all = 0

ps5 = subset_samples(ps4, Loc != "FrenPoly")
```

```
## Assign ASV numeric values to replace sequences
##n_seqs <- seq(ntaxa(ps5))
##len_n_seqs <- nchar(max(n_seqs))
##taxa_seqs <- taxa_names(ps5)
##asvs <- paste("ASV", formatC(n_seqs,
##width = len_n_seqs,
##flag = "0"), sep = "_")
##taxa_names(ps5) <- asvs
```

```r
## remove samples with otu = 0
ps6 <- prune_samples(sample_sums(ps5) >= 1, ps5)
ps6
```

```
## phyloseq-class experiment-level object
## otu_table()   OTU Table:         [ 435 taxa and 338 samples ]
## sample_data() Sample Data:       [ 338 samples by 21 sample variables ]
## tax_table()   Taxonomy Table:    [ 435 taxa by 2 taxonomic ranks ]
## phy_tree()    Phylogenetic Tree: [ 435 tips and 434 internal nodes ]
```

```r
##dfASV_seq <- data.frame(asv=asvs, seq=taxa_seqs, stringsAsFactors = FALSE)
##write.csv(dfASV_seq, file="dfASV_seq.csv", row.names = FALSE)
##write.fasta(as.list(taxa_seqs), asvs, "asv_seq.fasta", open = "w", nbchar = 60, as.string =TRUE)

##saveRDS(dfASV_seq, file="dfASV_Seq.rds")
```

```r
## Remove singletons
ps6_filt <- filter_taxa(ps6, function(x) sum(x > 1) > 1, TRUE)
ps6_filt
```

```
## phyloseq-class experiment-level object
## otu_table()   OTU Table:         [ 435 taxa and 338 samples ]
## sample_data() Sample Data:       [ 338 samples by 21 sample variables ]
## tax_table()   Taxonomy Table:    [ 435 taxa by 2 taxonomic ranks ]
## phy_tree()    Phylogenetic Tree: [ 435 tips and 434 internal nodes ]
```

```r
## CSS transformation

ps6_filt_css <- phyloseq_transform_css(ps6_filt, norm = TRUE, log = FALSE)
ps_normalized <- list()
normalization <- 'css'
ps_normalized[[normalization]] <- ps6_filt_css
ps_normalized[[normalization]]
```

```
## phyloseq-class experiment-level object
## otu_table()   OTU Table:         [ 435 taxa and 338 samples ]
## sample_data() Sample Data:       [ 338 samples by 21 sample variables ]
## tax_table()   Taxonomy Table:    [ 435 taxa by 2 taxonomic ranks ]
## phy_tree()    Phylogenetic Tree: [ 435 tips and 434 internal nodes ]
```

```r
colnames(sample_data(ps6_filt_css))
```

```
##  [1] "Loc"        "Yr"         "Spec"       "Exp_cond"   "Code"
##  [6] "Repro"      "Month"      "Season"     "S_region"   "L_region"
## [11] "Exact.date" "Tbl_bin"    "T_bleach"   "DHW"        "DHW_cat"
## [16] "SST_a"      "Coord_X"    "Coord_Y"    "Primer"     "Pub"
## [21] "Note"
```

```r
saveRDS(ps6_filt_css, file="ps6_filt_css.rds")
```

```r
## Set random seed for reproducibility

set.seed(8765)

##Alpha div

#Remove Panama
ps7 <- subset_samples(ps6_filt_css, Loc != "Panam")

#Remove P. me
ps8 <- subset_samples(ps7, Spec != "P_me")

ps9 = subset_samples(ps8, Spec == "P_dam")

ps10 = subset_samples(ps9, Loc != "Aus_GBR_Heron")
ps11 = subset_samples(ps10, Season != "Summer")
ps12 = subset_samples(ps11, Tbl_bin != "Bleaching")
ps13 = subset_samples(ps12, Loc != "NewCal")

ps13
```

```
## phyloseq-class experiment-level object
## otu_table()   OTU Table:         [ 435 taxa and 91 samples ]
## sample_data() Sample Data:       [ 91 samples by 21 sample variables ]
## tax_table()   Taxonomy Table:    [ 435 taxa by 2 taxonomic ranks ]
## phy_tree()    Phylogenetic Tree: [ 435 tips and 434 internal nodes ]
```

```r
colnames(sample_data(ps13))
```

```
##  [1] "Loc"        "Yr"         "Spec"       "Exp_cond"   "Code"
##  [6] "Repro"      "Month"      "Season"     "S_region"   "L_region"
## [11] "Exact.date" "Tbl_bin"    "T_bleach"   "DHW"        "DHW_cat"
## [16] "SST_a"      "Coord_X"    "Coord_Y"    "Primer"     "Pub"
## [21] "Note"
```

```r
head(sample_data(ps13))
```

```
##              Loc   Yr  Spec Exp_cond Code Repro Month Season S_region L_region
## SRR5963024 Oman 2014 P_dam      31C  Om2     B  June Winter IndianOc IndianOc
## SRR5963025 Oman 2014 P_dam      31C  Om2     B  June Winter IndianOc IndianOc
## SRR5963026 Oman 2014 P_dam      31C  Om3     B  June Winter IndianOc IndianOc
## SRR5963027 Oman 2014 P_dam      31C  Om2     B  June Winter IndianOc IndianOc
## SRR5963028 Oman 2014 P_dam      31C  Om3     B  June Winter IndianOc IndianOc
## SRR5963029 Oman 2014 P_dam      31C  Om3     B  June Winter IndianOc IndianOc
##            Exact.date Tbl_bin T_bleach  DHW DHW_cat SST_a Coord_X Coord_Y
## SRR5963024       <NA>    Long      15y 4.24     Mod  30.8   23.52   58.74
## SRR5963025       <NA>    Long      15y 4.24     Mod  30.8   23.52   58.74
## SRR5963026       <NA>    Long      15y 3.79     Mod  30.8   23.62   58.60
## SRR5963027       <NA>    Long      15y 4.24     Mod  30.8   23.52   58.74
```

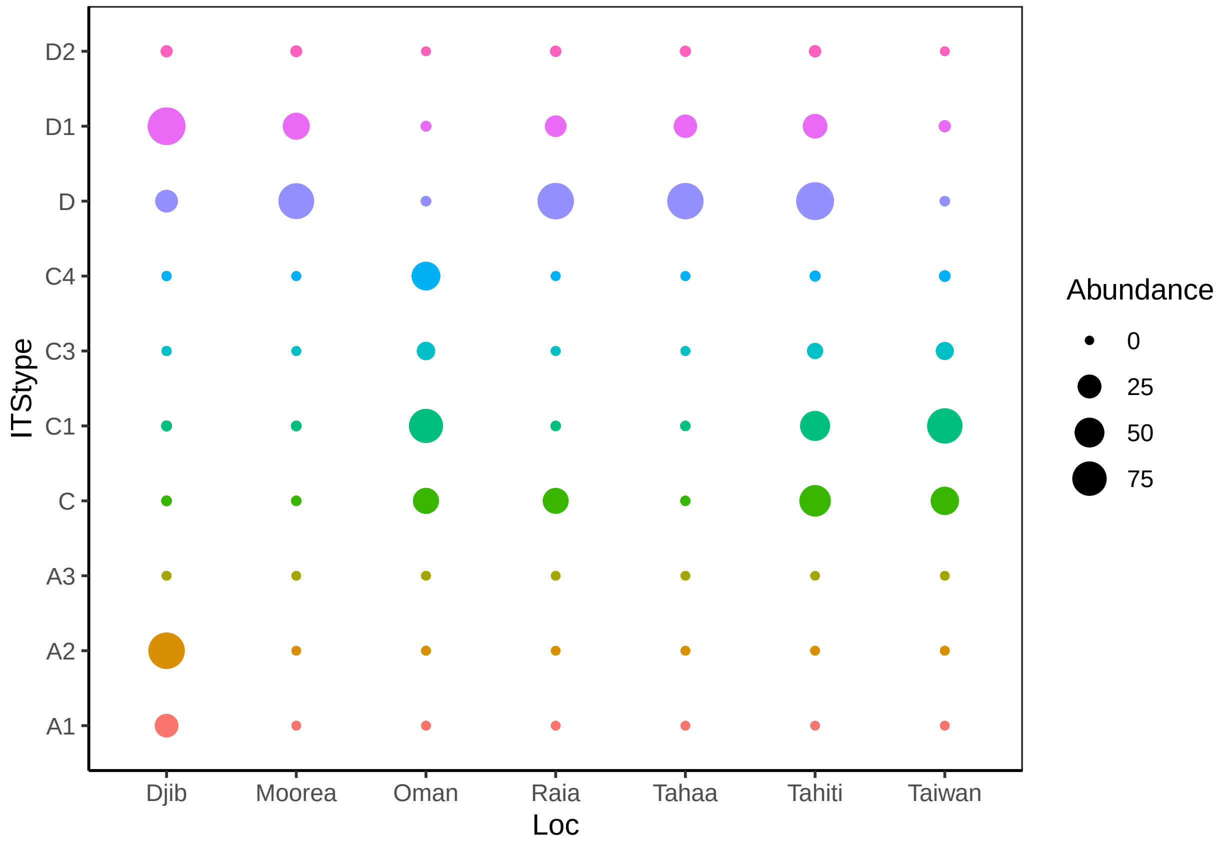
```
## SRR5963028       <NA>    Long      15y 3.79     Mod  30.8    23.62   58.60
## SRR5963029       <NA>    Long      15y 3.79     Mod  30.8    23.62   58.60
##              Primer                                                       Pub
## SRR5963024 ITS-DINO https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963025 ITS-DINO https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963026 ITS-DINO https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963027 ITS-DINO https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963028 ITS-DINO https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963029 ITS-DINO https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
##
## SRR5963024 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963025 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963026 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963027 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963028 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963029 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
```

```r
Locs <- c("Djib", "Oman", "Aus_GBR_Heron", "NewCal","Taiwan", "Moorea", "Tahiti", "Tahaa", "Raia")

DHW <-  c("N", "Mod")

T_bl <- c("Recent", "Long")

Season <- c("Winter", "Spring")

S_region <- c("IndianOc", "Taiwan", "Aus", "NewCal", "FrPoly")

L_region <- c("IndianOc", "WPac", "NPac", "EPac")
```

```r
##Dot plots

##Dot plots ITS type

library(ggplot2)

## Get relative abundances

ps.rel = transform_sample_counts(ps13, function(x) x/sum(x)*100)

# agglomerate taxa
glom <- tax_glom(ps.rel, taxrank = "ITStype", NArm = FALSE)
ps.melt <- psmelt(glom)

# change to character for easy-adjusted level
ps.melt$ITStype <- as.character(ps.melt$ITStype)

ps.melt <- ps.melt %>%
  group_by(Loc, ITStype) %>%
  mutate(median=median(Abundance))
```

```r
##ITS type across locations

ITStype_loc <- ggplot(ps.melt, aes(x = Loc, y = ITStype, color = ITStype)) + geom_point(aes(size = Abun
```

```
ITStype_loc
```



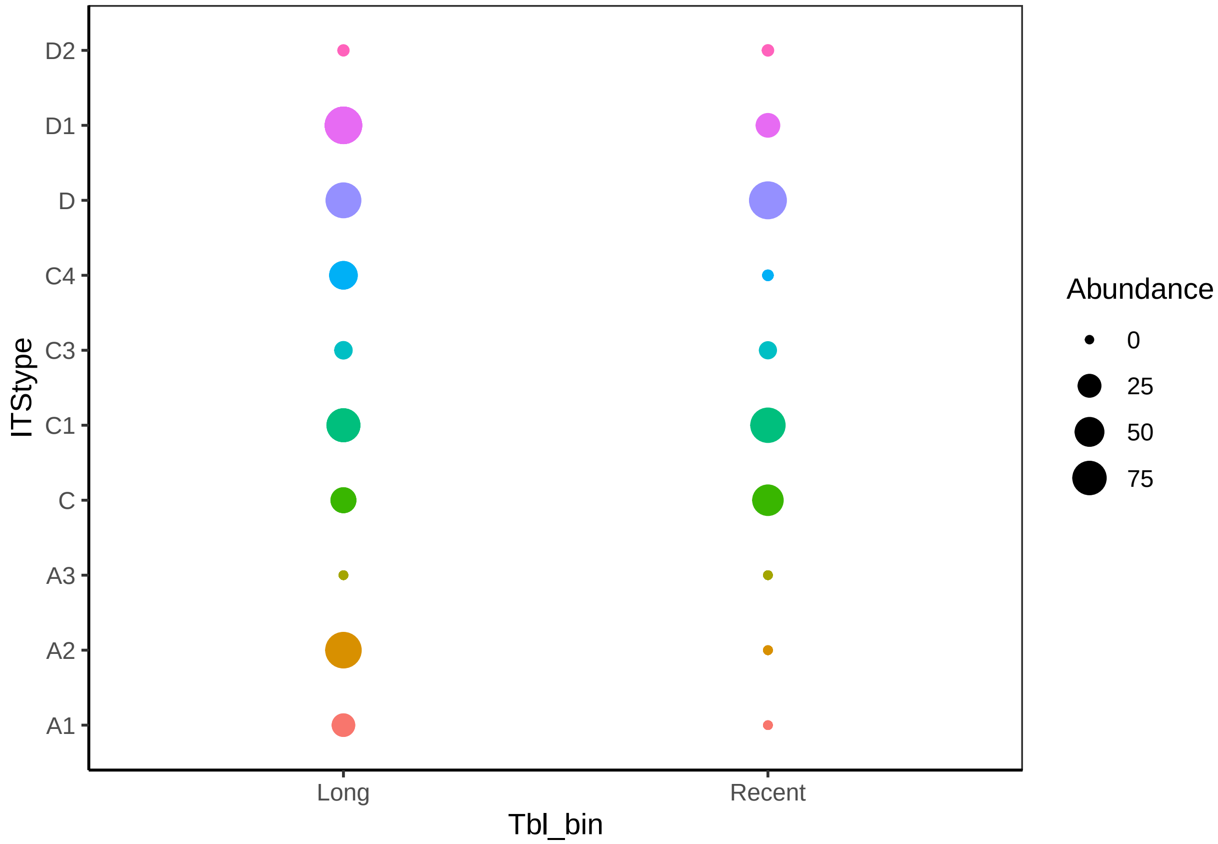

```
ggsave("ITStype_loc_pdam_16Sept2021.pdf")
```

```
## Saving 6.5 x 4.5 in image
```

```
##ITS type across seasons

 ##ITStype_Season <- ggplot(ps13, aes(x = Season, y = ITStype, color = ITStype)) + geom_point(aes(size =
 ##panel.background = element_blank(), axis.line = element_line(colour = "black")) + scale_x_discrete(l

 ##print(ITStype_Season)
 ##ggsave("ITStype_Season_pdam.png")
```

```
##ITS type across DHW

 ##ITStype_DHW <- ggplot(ps13, aes(x = DHW_cat, y = ITStype, color = ITStype)) + geom_point(aes(size =
 ##panel.background = element_blank(), axis.line = element_line(colour = "black"))

 ##print(ITStype_DHW)
 ##ggsave("ITStype_DHW_pdam.png")
```

```r
##ITS type across time mass bleaching

ITStype_blc <- ggplot(ps.melt, aes(x = Tbl_bin, y = ITStype, color = ITStype)) + geom_point(aes(size = A

ITStype_blc
```




```r
ggsave("ITStype_blc_pdam_16Sep2021.pdf")
```

```
## Saving 6.5 x 4.5 in image
```

```r
#Set random seed for reproducibility, calculate distance metrics
set.seed(423542)

bray.dist = phyloseq::distance(ps13, "bray")
jacc.dist = phyloseq::distance(ps13, "jaccard")
wuni.dist = phyloseq::distance(ps13, "wunifrac")
```

```r
#Move into Vegan
asv_css <- t(otu_table(ps13))
asv_css_hell <- decostand((asv_css), "hell") #not sure we are going to do this.
meta = as(sample_data(ps13), "data.frame")
```

```r
perm_css = adonis(asv_css ~ S_region/Loc + SST_a + Tbl_bin, meta) #uses bray internally.
perm_css$aov.tab
```

```
## Permutation: free
## Number of permutations: 999
##
## Terms added sequentially (first to last)
##
##               Df SumsOfSqs MeanSqs F.Model      R2 Pr(>F)
## S_region      2    12.991  6.4956  51.626 0.40081  0.001 ***
## SST_a         1     7.723  7.7234  61.384 0.23829  0.001 ***
## Tbl_bin       1     0.311  0.3113   2.474 0.00960  0.060 .
## S_region:Loc  3     0.943  0.3144   2.499 0.02910  0.007 **
## Residuals    83    10.443  0.1258         0.32220
## Total        90    32.412                 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
perm_css2 = adonis2(asv_css ~ S_region/Loc + SST_a + Tbl_bin,  meta, method = "bray", sqrt.dist = FALSE
perm_css2
```

```
## Permutation test for adonis under reduced model
## Terms added sequentially (first to last)
## Permutation: free
## Number of permutations: 999
##
## adonis2(formula = asv_css ~ S_region/Loc + SST_a + Tbl_bin, data = meta, method = "bray", sqrt.dist =
##              Df SumOfSqs      R2       F Pr(>F)
## S_region      2   12.991 0.40081 51.6259  0.001 ***
## SST_a         1    7.723 0.23829 61.3842  0.001 ***
## Tbl_bin       1    0.311 0.00960  2.4742  0.031 *
## S_region:Loc  3    0.943 0.02910  2.4986  0.003 **
## Residual     83   10.443 0.32220
## Total        90   32.412 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
#Remove loc as know may be masking abiotic differences, as per Mantel test showing a distance between l
perm_css3 = adonis2(asv_css ~ SST_a + Tbl_bin,  meta, method = "bray", sqrt.dist = FALSE, by = "terms")
perm_css3
```

```
## Permutation test for adonis under reduced model
## Terms added sequentially (first to last)
## Permutation: free
## Number of permutations: 999
##
## adonis2(formula = asv_css ~ SST_a + Tbl_bin, data = meta, method = "bray", sqrt.dist = FALSE, by = "
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1    8.678 0.26774 38.838  0.001 ***
## Tbl_bin   1    4.071 0.12561 18.221  0.001 ***
## Residual 88   19.663 0.60665
## Total    90   32.412 1.00000
```

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
# Pairwise differences - locations

library(pairwiseAdonis)
```

```
## Loading required package: cluster
```

```r
pairwise.adonis2(asv_css ~ Loc, data = meta, sim.method = "bray",  p.adjust.m = "BH",
  permutations = 999)
```

```
## $parent_call
## [1] "asv_css ~ Loc , strata = Null , permutations 999"
##
## $Oman_vs_Moorea
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   4.7766 0.62426 44.859  0.001 ***
## Residual 27   2.8750 0.37574
## Total    28   7.6515 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Oman_vs_Taiwan
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   0.3995 0.11634 4.0813   0.02 *
## Residual 31   3.0346 0.88366
## Total    32   3.4341 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Oman_vs_Djib
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   8.0918 0.51525 48.895  0.001 ***
## Residual 46   7.6127 0.48475
## Total    47  15.7046 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Oman_vs_Tahaa
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   5.6989 0.66865 58.519  0.001 ***
## Residual 29   2.8242 0.33135
## Total    30   8.5231 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Oman_vs_Tahiti
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   1.8377 0.32689 11.656  0.001 ***
## Residual 24   3.7839 0.67311
## Total    25   5.6216 1.00000
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Oman_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   4.9391 0.65069 50.296  0.001 ***
## Residual 27   2.6515 0.34931
## Total    28   7.5906 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Moorea_vs_Taiwan
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   4.2849 0.81122 77.348  0.001 ***
## Residual 18   0.9972 0.18878
## Total    19   5.2821 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Moorea_vs_Djib
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   3.8454 0.40819 22.761  0.001 ***
## Residual 33   5.5753 0.59181
## Total    34   9.4207 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Moorea_vs_Tahaa
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.25581 0.24537 5.2024  0.003 **
## Residual 16  0.78673 0.75463
## Total    17  1.04253 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Moorea_vs_Tahiti
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.40877 0.18966 2.5746  0.006 **
## Residual 11  1.74649 0.81034
## Total    12  2.15526 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Moorea_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.23498 0.27677 5.3577  0.002 **
## Residual 14  0.61402 0.72323
## Total    15  0.84899 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Taiwan_vs_Djib
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   6.2600 0.52189 40.387  0.001 ***
## Residual 37   5.7349 0.47811
```

```
## Total    38  11.9949 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Taiwan_vs_Tahaa
##          Df SumOfSqs     R2      F Pr(>F)
## Loc       1   4.9609 0.8398 104.84  0.001 ***
## Residual 20   0.9464 0.1602
## Total    21   5.9073 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Taiwan_vs_Tahiti
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   1.8160 0.48789 14.291  0.002 **
## Residual 15   1.9061 0.51211
## Total    16   3.7221 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Taiwan_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   4.4161 0.85093 102.75  0.001 ***
## Residual 18   0.7737 0.14907
## Total    19   5.1898 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Djib_vs_Tahaa
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   4.5582 0.45208 28.878  0.001 ***
## Residual 35   5.5245 0.54792
## Total    36  10.0827 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Djib_vs_Tahiti
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   1.8458 0.22158 8.5396  0.001 ***
## Residual 30   6.4843 0.77842
## Total    31   8.3300 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Djib_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   3.9998 0.42771 24.663  0.001 ***
## Residual 33   5.3518 0.57229
## Total    34   9.3516 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Tahaa_vs_Tahiti
##          Df SumOfSqs      R2      F Pr(>F)
```

```
## Loc       1  0.39949 0.19067 3.0627  0.005 **
## Residual 13  1.69569 0.80933
## Total    14  2.09518 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Tahaa_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.06429 0.10246 1.8265  0.126
## Residual 16  0.56322 0.89754
## Total    17  0.62751 1.00000
##
## $Tahiti_vs_Raia
##          Df SumOfSqs     R2      F Pr(>F)
## Loc       1  0.37316 0.1968 2.6952  0.011 *
## Residual 11  1.52298 0.8032
## Total    12  1.89614 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## attr(,"class")
## [1] "pwadstrata" "list"
```

```
pairwise.adonis2(asv_css ~ S_region, data = meta, sim.method = "bray",  p.adjust.m = "BH",
  permutations = 999)
```

```
## $parent_call
## [1] "asv_css ~ S_region , strata = Null , permutations 999"
##
## $IndianOc_vs_FrPoly
##          Df SumOfSqs      R2      F Pr(>F)
## S_region  1   9.0872 0.32536 37.135  0.001 ***
## Residual 77  18.8426 0.67464
## Total    78  27.9299 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $IndianOc_vs_Taiwan
##          Df SumOfSqs      R2      F Pr(>F)
## S_region  1   2.6704 0.14089 9.5118  0.001 ***
## Residual 58  16.2830 0.85911
## Total    59  18.9533 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $FrPoly_vs_Taiwan
##          Df SumOfSqs      R2      F Pr(>F)
## S_region  1   7.0719 0.65551 78.018  0.001 ***
## Residual 41   3.7165 0.34449
## Total    42  10.7884 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## attr(,"class")
```

```
## [1] "pwadstrata" "list"
```

```r
#Pairwise differences - SST
pairwise.adonis2(asv_css ~ SST_a, data = meta, sim.method = "bray",  p.adjust.m = "BH",
  permutations = 999)
```

```
## Set of permutations < 'minperm'. Generating entire set.

## 'nperm' >= set of all permutations: complete enumeration.

## Set of permutations < 'minperm'. Generating entire set.

## $parent_call
## [1] "asv_css ~ SST_a , strata = Null , permutations 999"
##
## $`30.8_vs_27.04`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   4.7766 0.62426 44.859  0.001 ***
## Residual 27   2.8750 0.37574
## Total    28   7.6515 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_28.59`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   0.3498 0.10705 3.4765  0.034 *
## Residual 29   2.9179 0.89295
## Total    30   3.2677 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_29.37`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   5.4194 0.54916 37.761  0.001 ***
## Residual 31   4.4491 0.45084
## Total    32   9.8684 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_27.19`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   3.9359 0.59642 36.946  0.001 ***
## Residual 25   2.6633 0.40358
## Total    26   6.5992 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_26.86`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.8377 0.32689 11.656  0.001 ***
## Residual 24   3.7839 0.67311
## Total    25   5.6216 1.00000
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   4.3225 0.55244 33.327  0.001 ***
## Residual 27   3.5019 0.44756
## Total    28   7.8244 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.19616 0.07359 1.6681  0.097 .
## Residual 21  2.46946 0.92641
## Total    22  2.66562 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   4.9391 0.65069 50.296  0.001 ***
## Residual 27   2.6515 0.34931
## Total    28   7.5906 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.8301 0.52118 25.034  0.001 ***
## Residual 23   2.6001 0.47882
## Total    24   5.4302 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_29.35`
##          Df SumOfSqs      R2     F Pr(>F)
## SST_a     1   3.2671 0.43589 20.09  0.001 ***
## Residual 26   4.2283 0.56411
## Total    27   7.4954 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_28.59`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   3.9759 0.81869 72.247  0.001 ***
## Residual 16   0.8805 0.18131
## Total    17   4.8564 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_29.37`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   3.1255 0.56446 23.328  0.001 ***
## Residual 18   2.4116 0.43554
```

```
## Total    19   5.5371 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_27.19`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.19517 0.23771 3.7421  0.014 *
## Residual 12  0.62587 0.76229
## Total    13  0.82104 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_26.86`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.40877 0.18966 2.5746   0.01 **
## Residual 11  1.74649 0.81034
## Total    12  2.15526 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.7223 0.65022 26.025  0.002 **
## Residual 14   1.4644 0.34978
## Total    15   4.1868 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  1.49594 0.77592 27.701  0.027 *
## Residual  8  0.43202 0.22408
## Total     9  1.92796 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.23498 0.27677 5.3577  0.001 ***
## Residual 14  0.61402 0.72323
## Total    15  0.84899 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_27.22`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1  0.16731 0.2292 2.9735   0.03 *
## Residual 10  0.56267 0.7708
## Total    11  0.72998 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
```

```
## SST_a     1   2.0860 0.48775 12.378  0.001 ***
## Residual 13   2.1908 0.51225
## Total    14   4.2768 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_29.37`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   4.2552 0.63418 34.671  0.001 ***
## Residual 20   2.4546 0.36582
## Total    21   6.7098 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_27.19`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   3.4256 0.83664 71.703  0.001 ***
## Residual 14   0.6689 0.16336
## Total    15   4.0944 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_26.86`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.7231 0.49055 12.518  0.002 **
## Residual 13   1.7895 0.50945
## Total    14   3.5125 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   3.6289 0.70652 38.518  0.001 ***
## Residual 16   1.5074 0.29348
## Total    17   5.1364 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.10339 0.17876 2.1766   0.13
## Residual 10  0.47501 0.82124
## Total    11  0.57840 1.00000
##
## $`28.59_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   4.1011 0.86192 99.874  0.001 ***
## Residual 16   0.6570 0.13808
## Total    17   4.7581 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_27.22`
##          Df SumOfSqs     R2      F Pr(>F)
```

```
## SST_a     1   2.6073 0.8115 51.659  0.002 **
## Residual 12   0.6057 0.1885
## Total    13   3.2129 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.8532 0.56088 19.159  0.001 ***
## Residual 15   2.2338 0.43912
## Total    16   5.0870 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_27.19`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.6283 0.54436 19.115  0.001 ***
## Residual 16   2.2000 0.45564
## Total    17   4.8283 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_26.86`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.6397 0.33057 7.4071  0.001 ***
## Residual 15   3.3206 0.66943
## Total    16   4.9603 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_29.11`
##          Df SumOfSqs      R2     F Pr(>F)
## SST_a     1  0.02178 0.00712 0.129  0.938
## Residual 18  3.03853 0.99288
## Total    19  3.06031 1.00000
##
## $`29.37_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.4059 0.41205 8.4097   0.01 **
## Residual 12   2.0061 0.58795
## Total    13   3.4120 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_27.25`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1   3.2455 0.5973 26.699  0.001 ***
## Residual 18   2.1881 0.4027
## Total    19   5.4336 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
```

```
## SST_a     1   1.9501 0.47717 12.777  0.002 **
## Residual 14   2.1368 0.52283
## Total    15   4.0869 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   0.2755 0.06818 1.2439  0.297
## Residual 17   3.7649 0.93182
## Total    18   4.0404 1.00000
##
## $`27.19_vs_26.86`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.32225 0.17352 1.8896   0.05 *
## Residual  9  1.53483 0.82648
## Total    10  1.85708 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.19_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.3545 0.65271 22.553  0.002 **
## Residual 12   1.2528 0.34729
## Total    13   3.6073 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.19_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  1.43066 0.86653 38.953  0.035 *
## Residual  6  0.22037 0.13347
## Total     7  1.65102 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.19_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.04146 0.09341 1.2364   0.25
## Residual 12  0.40236 0.90659
## Total    13  0.44382 1.00000
##
## $`27.19_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.01695 0.04607 0.3863  0.653
## Residual  8  0.35102 0.95393
## Total     9  0.36797 1.00000
##
## $`27.19_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.8220 0.47932 10.126  0.002 **
## Residual 11   1.9792 0.52068
## Total    12   3.8011 1.00000
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`26.86_vs_29.11`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1   1.5264 0.3914 7.0743  0.004 **
## Residual 11   2.3734 0.6086
## Total    12   3.8998 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`26.86_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.79182 0.37126 2.9524  0.048 *
## Residual  5  1.34099 0.62874
## Total     6  2.13281 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`26.86_vs_27.25`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1  0.37316 0.1968 2.6952   0.01 **
## Residual 11  1.52298 0.8032
## Total    12  1.89614 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`26.86_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.28137 0.16051 1.3384  0.192
## Residual  7  1.47164 0.83949
## Total     8  1.75301 1.00000
##
## $`26.86_vs_29.35`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1   1.0897 0.2601 3.5153  0.012 *
## Residual 10   3.0998 0.7399
## Total    11   4.1895 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.11_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.3702 0.56408 10.352  0.019 *
## Residual  8   1.0589 0.43592
## Total     9   2.4292 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.11_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.8215 0.69454 31.832  0.001 ***
## Residual 14   1.2409 0.30546
## Total    15   4.0625 1.00000
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.11_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.8185 0.60454 15.287  0.006 **
## Residual 10   1.1896 0.39546
## Total    11   3.0081 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.11_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.24474 0.07992 1.1291  0.345
## Residual 13  2.81774 0.92008
## Total    14  3.06248 1.00000
##
## $`28.67_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  1.53306 0.88027 58.818  0.019 *
## Residual  8  0.20851 0.11973
## Total     9  1.74158 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.67_vs_27.22`
##          Df SumOfSqs      R2      F  Pr(>F)
## SST_a     1  1.27017 0.88989 32.326 0.06667 .
## Residual  4  0.15717 0.11011
## Total     5  1.42734 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.67_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.1398 0.38966 4.4689  0.025 *
## Residual  7   1.7853 0.61034
## Total     8   2.9251 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.25_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.05938 0.14898 1.7507  0.173
## Residual 10  0.33916 0.85102
## Total    11  0.39854 1.00000
##
## $`27.25_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.1803 0.52568 14.408  0.001 ***
## Residual 13   1.9673 0.47432
## Total    14   4.1476 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## $`27.22_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.4169 0.42514 6.6559  0.006 **
## Residual  9   1.9160 0.57486
## Total    10   3.3329 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## attr(,"class")
## [1] "pwadstrata" "list"
```

```
#Pairwise differences - time since last mass bleaching event
pairwise.adonis2(asv_css ~ Tbl_bin, data = meta, sim.method = "bray",  p.adjust.m = "BH",
  permutations = 999)
```

```
## $parent_call
## [1] "asv_css ~ Tbl_bin , strata = Null , permutations 999"
##
## $Long_vs_Recent
##          Df SumOfSqs      R2      F Pr(>F)
## Tbl_bin   1    3.232 0.09971 9.8572  0.001 ***
## Residual 89   29.180 0.90029
## Total    90   32.412 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## attr(,"class")
## [1] "pwadstrata" "list"
```

```
ano = anosim(asv_css, meta$Loc, distance = "bray", permutations = 9999)
ano
```

```
##
## Call:
## anosim(x = asv_css, grouping = meta$Loc, permutations = 9999,      distance = "bray")
## Dissimilarity: bray
##
## ANOSIM statistic R: 0.7507
##       Significance: 1e-04
##
## Permutation: free
## Number of permutations: 9999
```

```
ano1 = anosim(asv_css, meta$Season, distance = "bray", permutations = 9999)
ano1
```

```
##
## Call:
## anosim(x = asv_css, grouping = meta$Season, permutations = 9999,      distance = "bray")
## Dissimilarity: bray
##
## ANOSIM statistic R: 0.162
```

```
##       Significance: 1e-04
##
## Permutation: free
## Number of permutations: 9999
```

```r
ano2 = anosim(asv_css, meta$Tbl_bin, distance = "bray", permutations = 9999)
ano2
```

```
##
## Call:
## anosim(x = asv_css, grouping = meta$Tbl_bin, permutations = 9999,      distance = "bray")
## Dissimilarity: bray
##
## ANOSIM statistic R: 0.08469
##       Significance: 0.005
##
## Permutation: free
## Number of permutations: 9999
```

```r
ano3 = anosim(asv_css, meta$DHW_cat, distance = "bray", permutations = 9999)
ano3
```

```
##
## Call:
## anosim(x = asv_css, grouping = meta$DHW_cat, permutations = 9999,      distance = "bray")
## Dissimilarity: bray
##
## ANOSIM statistic R: 0.4796
##       Significance: 1e-04
##
## Permutation: free
## Number of permutations: 9999
```

```r
ano4 = anosim(asv_css, meta$SST_a, distance = "bray", permutations = 9999)
ano4
```

```
##
## Call:
## anosim(x = asv_css, grouping = meta$SST_a, permutations = 9999,      distance = "bray")
## Dissimilarity: bray
##
## ANOSIM statistic R: 0.7304
##       Significance: 1e-04
##
## Permutation: free
## Number of permutations: 9999
```

```r
#BC and NMDs
MDSbray <- ordinate(ps13, "NMDS", "bray", autotransform = FALSE, parallel = 48)
```

```
## Run 0 stress 0.04456561
```

```
## Run 1 stress 0.04456555
## ... New best solution
## ... Procrustes: rmse 0.0001326623  max resid 0.00098373
## ... Similar to previous best
## Run 2 stress 0.04493539
## ... Procrustes: rmse 0.009844637  max resid 0.03846779
## Run 3 stress 0.04493573
## ... Procrustes: rmse 0.009850276  max resid 0.03847498
## Run 4 stress 0.04456577
## ... Procrustes: rmse 0.0001858612  max resid 0.001087807
## ... Similar to previous best
## Run 5 stress 0.04456562
## ... Procrustes: rmse 0.0001273412  max resid 0.0009093265
## ... Similar to previous best
## Run 6 stress 0.07847378
## Run 7 stress 0.04456577
## ... Procrustes: rmse 0.0001094518  max resid 0.0007431928
## ... Similar to previous best
## Run 8 stress 0.04493802
## ... Procrustes: rmse 0.009861326  max resid 0.03846342
## Run 9 stress 0.04456578
## ... Procrustes: rmse 0.0001089732  max resid 0.0007324545
## ... Similar to previous best
## Run 10 stress 0.0445656
## ... Procrustes: rmse 6.589543e-05  max resid 0.00044703
## ... Similar to previous best
## Run 11 stress 0.04493532
## ... Procrustes: rmse 0.009845916  max resid 0.03847095
## Run 12 stress 0.07750406
## Run 13 stress 0.0787962
## Run 14 stress 0.04493641
## ... Procrustes: rmse 0.009840101  max resid 0.03846092
## Run 15 stress 0.04493795
## ... Procrustes: rmse 0.009866225  max resid 0.03846492
## Run 16 stress 0.04493539
## ... Procrustes: rmse 0.00984494  max resid 0.0384683
## Run 17 stress 0.04456575
## ... Procrustes: rmse 0.0001815277  max resid 0.001107512
## ... Similar to previous best
## Run 18 stress 0.04493572
## ... Procrustes: rmse 0.009850437  max resid 0.03847517
## Run 19 stress 0.04456562
## ... Procrustes: rmse 0.000130659  max resid 0.0009597634
## ... Similar to previous best
## Run 20 stress 0.04606561
## Run 21 stress 0.04456561
## ... Procrustes: rmse 0.0001348173  max resid 0.001015346
## ... Similar to previous best
## Run 22 stress 0.04456584
## ... Procrustes: rmse 0.0001367073  max resid 0.0007568961
## ... Similar to previous best
## Run 23 stress 0.04456578
## ... Procrustes: rmse 0.0001103917  max resid 0.0007595952
## ... Similar to previous best
```

```
## Run 24 stress 0.04456577
## ... Procrustes: rmse 0.000193339  max resid 0.0010716
## ... Similar to previous best
## Run 25 stress 0.04493724
## ... Procrustes: rmse 0.009861967  max resid 0.03846777
## Run 26 stress 0.04493538
## ... Procrustes: rmse 0.009844909  max resid 0.03846785
## Run 27 stress 0.04493977
## ... Procrustes: rmse 0.009877413  max resid 0.03847094
## Run 28 stress 0.0445656
## ... Procrustes: rmse 6.521118e-05  max resid 0.0004420611
## ... Similar to previous best
## Run 29 stress 0.07899086
## Run 30 stress 0.04456563
## ... Procrustes: rmse 0.0001259577  max resid 0.0008873855
## ... Similar to previous best
## Run 31 stress 0.0445658
## ... Procrustes: rmse 0.000117221  max resid 0.0007523223
## ... Similar to previous best
## Run 32 stress 0.07900047
## Run 33 stress 0.04493532
## ... Procrustes: rmse 0.009846248  max resid 0.03847123
## Run 34 stress 0.0787594
## Run 35 stress 0.04456562
## ... Procrustes: rmse 0.0001325707  max resid 0.0009866156
## ... Similar to previous best
## Run 36 stress 0.04456566
## ... Procrustes: rmse 0.0001525704  max resid 0.001034378
## ... Similar to previous best
## Run 37 stress 0.04456565
## ... Procrustes: rmse 0.0001476982  max resid 0.0009861435
## ... Similar to previous best
## Run 38 stress 0.04456562
## ... Procrustes: rmse 0.0001292296  max resid 0.0009372756
## ... Similar to previous best
## Run 39 stress 0.04456556
## ... Procrustes: rmse 1.521678e-05  max resid 8.320319e-05
## ... Similar to previous best
## Run 40 stress 0.04456556
## ... Procrustes: rmse 1.254994e-05  max resid 7.93294e-05
## ... Similar to previous best
## Run 41 stress 0.04456576
## ... Procrustes: rmse 0.0001809359  max resid 0.001090513
## ... Similar to previous best
## Run 42 stress 0.04456581
## ... Procrustes: rmse 0.0001324979  max resid 0.0007544023
## ... Similar to previous best
## Run 43 stress 0.04456576
## ... Procrustes: rmse 0.0001789633  max resid 0.00106577
## ... Similar to previous best
## Run 44 stress 0.04456561
## ... Procrustes: rmse 0.0001321434  max resid 0.0009774651
## ... Similar to previous best
## Run 45 stress 0.04456576
```

```
## ... Procrustes: rmse 0.0001823114  max resid 0.00109351
## ... Similar to previous best
## Run 46 stress 0.04539162
## Run 47 stress 0.04456575
## ... Procrustes: rmse 0.0001809748  max resid 0.001101382
## ... Similar to previous best
## Run 48 stress 0.04456555
## ... New best solution
## ... Procrustes: rmse 2.931123e-06  max resid 1.412157e-05
## ... Similar to previous best
## *** Solution reached
```

```
##Wunifrac and NMDS

MDSwuni <- ordinate(ps13, "NMDS", "unifrac", weighted = TRUE)
```

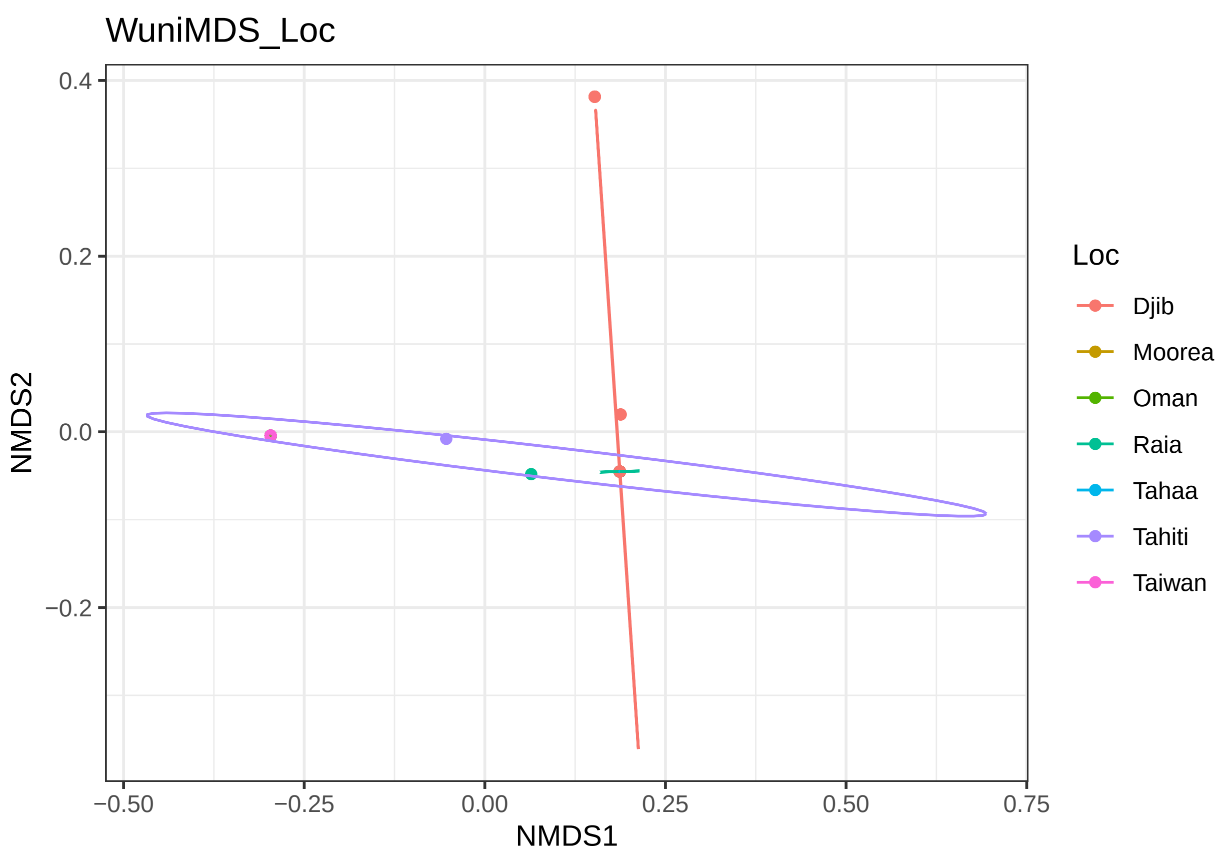
```
## Run 0 stress 9.931406e-05
## Run 1 stress 0.0002384287
## ... Procrustes: rmse 0.04922234  max resid 0.1645062
## Run 2 stress 0.0001793283
## ... Procrustes: rmse 0.04673508  max resid 0.152194
## Run 3 stress 0.0003249687
## ... Procrustes: rmse 0.04697159  max resid 0.1550795
## Run 4 stress 9.830611e-05
## ... New best solution
## ... Procrustes: rmse 0.04553518  max resid 0.1499965
## Run 5 stress 9.876233e-05
## ... Procrustes: rmse 0.001464196  max resid 0.006741422
## ... Similar to previous best
## Run 6 stress 9.797608e-05
## ... New best solution
## ... Procrustes: rmse 0.04044753  max resid 0.1352146
## Run 7 stress 0.0002525925
## ... Procrustes: rmse 0.03824358  max resid 0.1284796
## Run 8 stress 9.927441e-05
## ... Procrustes: rmse 0.04676491  max resid 0.1569664
## Run 9 stress 0.0001076674
## ... Procrustes: rmse 0.04630559  max resid 0.1554655
## Run 10 stress 0.0003764819
## ... Procrustes: rmse 0.04811834  max resid 0.1614708
## Run 11 stress 0.0007281039
## Run 12 stress 0.000507688
## ... Procrustes: rmse 0.04660333  max resid 0.1559861
## Run 13 stress 0.05411661
## Run 14 stress 0.0001478077
## ... Procrustes: rmse 0.04392056  max resid 0.1471097
## Run 15 stress 0.001315121
## Run 16 stress 0.0001962829
## ... Procrustes: rmse 0.04585003  max resid 0.1537805
## Run 17 stress 0.0001748006
## ... Procrustes: rmse 0.04268096  max resid 0.1429906
## Run 18 stress 0.0007254158
## Run 19 stress 0.0005738995
## ... Procrustes: rmse 0.04797309  max resid 0.1605292
```

```
## Run 20 stress 0.0006246007
## *** No convergence -- monoMDS stopping criteria:
##     11: no. of iterations >= maxit
##      4: stress < smin
##      1: stress ratio > sratmax
##      4: scale factor of the gradient < sfgrmin
```

```
## Warning in metaMDS(ps.dist): stress is (nearly) zero: you may have insufficient
## data
```

```
##Wunifrac NMDS trial
#Loc only

NMDSplot_loc <- plot_ordination(ps13, MDSwuni, type="samples", color="Loc") +
  theme_bw() +
  stat_ellipse() +
  ggtitle("WuniMDS_Loc")

NMDSplot_loc
```

```
## Warning in MASS::cov.trob(data[, vars]): Probable convergence failure

## Warning in MASS::cov.trob(data[, vars]): Probable convergence failure
```

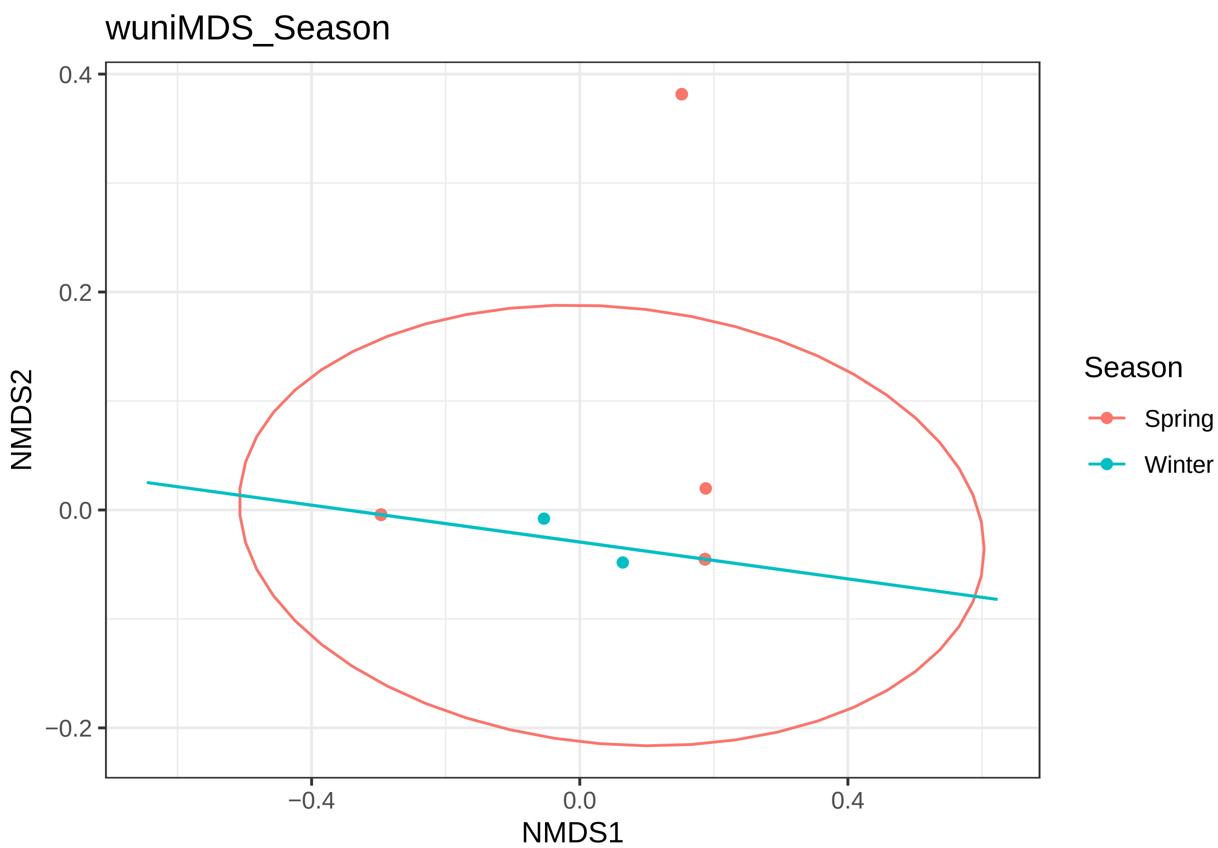


```r
ggsave("wuniNMDSplot_loc.png")
```

```
## Saving 6.5 x 4.5 in image

## Warning in MASS::cov.trob(data[, vars]): Probable convergence failure

## Warning in MASS::cov.trob(data[, vars]): Probable convergence failure
```

```r
# Wuni Season

NMDSplot_Season <- plot_ordination(ps13, MDSwuni, type="samples", color="Season") +
  theme_bw() +
  stat_ellipse() +
  ggtitle("wuniMDS_Season")

NMDSplot_Season
```

```
## Warning in MASS::cov.trob(data[, vars]): Probable convergence failure

## Warning in MASS::cov.trob(data[, vars]): Probable convergence failure
```




```r
ggsave("wuniNMDSplot_Season.png")
```

```
## Saving 6.5 x 4.5 in image
```

```
## Warning in MASS::cov.trob(data[, vars]): Probable convergence failure

## Warning in MASS::cov.trob(data[, vars]): Probable convergence failure
```

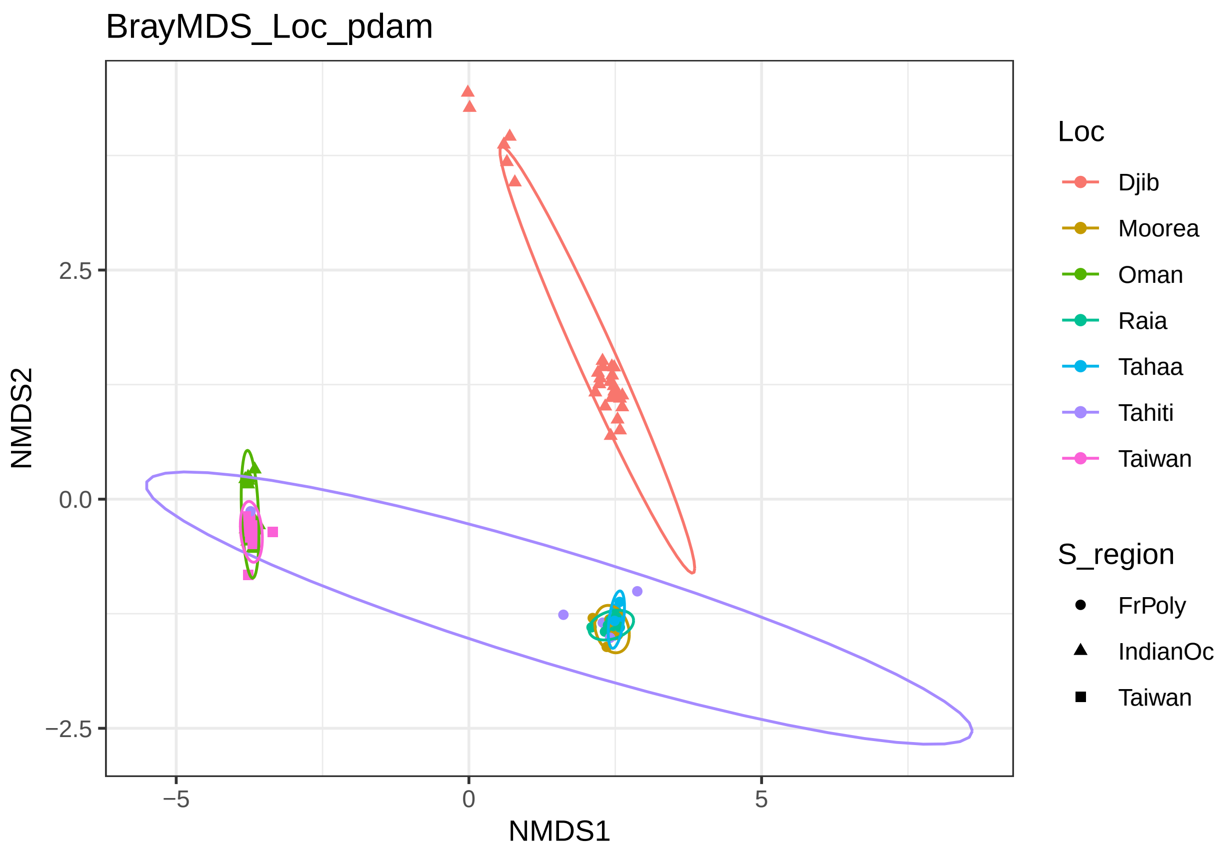
```
Locs <- c("Djib", "Oman","Taiwan", "Moorea", "Tahiti", "Tahaa", "Raia")
MDSbray$Loc <- factor(MDSbray$Loc, levels = c("Djib", "Oman","Taiwan", "Moorea", "Tahiti", "Tahaa", "Ra

DHW <-  c("N", "Mod")
MDSbray$DHW_cat <- factor(MDSbray$DHW_cat, levels = c("N", "Mod"))

T_bl <- c("Recent", "Long")
MDSbray$Tbl_bin <- factor(MDSbray$Tbl_bin, levels = c("Recent", "Long"))

Season <- c("Winter", "Spring")
MDSbray$Season <- factor(MDSbray$Season, levels = c("Winter", "Spring"))

S_region <- c("IndianOc", "Aus", "NewCal", "FrPoly")
MDSbray$S_region <- factor(MDSbray$S_region, levels = c("IndianOc", "Aus", "NewCal", "FrPoly"))

L_region <- c("IndianOc", "WPac", "NPac", "EPac")
MDSbray$L_region <- factor(MDSbray$L_region, levels = c("IndianOc", "WPac", "NPac", "EPac"))
```

```
NMDSplot_loc <- plot_ordination(ps13, MDSbray, type="samples", color="Loc", shape = "S_region") +
  theme_bw() +
  stat_ellipse() +
  ggtitle("BrayMDS_Loc_pdam")

summary (NMDSplot_loc)
```

```
## data: NMDS1, NMDS2, Loc, Yr, Spec, Exp_cond, Code, Repro, Month,
##   Season, S_region, L_region, Exact.date, Tbl_bin, T_bleach, DHW,
##   DHW_cat, SST_a, Coord_X, Coord_Y, Primer, Pub, Note [91x23]
## mapping:  colour = ~Loc, shape = ~S_region, na.rm = TRUE, x = ~NMDS1, y = ~NMDS2
## faceting: <ggproto object: Class FacetNull, Facet, gg>
##     compute_layout: function
##     draw_back: function
##     draw_front: function
##     draw_labels: function
##     draw_panels: function
##     finish_data: function
##     init_scales: function
##     map_data: function
##     params: list
##     setup_data: function
##     setup_params: function
##     shrink: TRUE
##     train_scales: function
##     vars: function
##     super:  <ggproto object: Class FacetNull, Facet, gg>
## -----------------------------------
## geom_point: na.rm = TRUE
## stat_identity: na.rm = TRUE
## position_identity
```

```
##
## geom_path: na.rm = FALSE
## stat_ellipse: type = t, level = 0.95, segments = 51, na.rm = FALSE
## position_identity
```

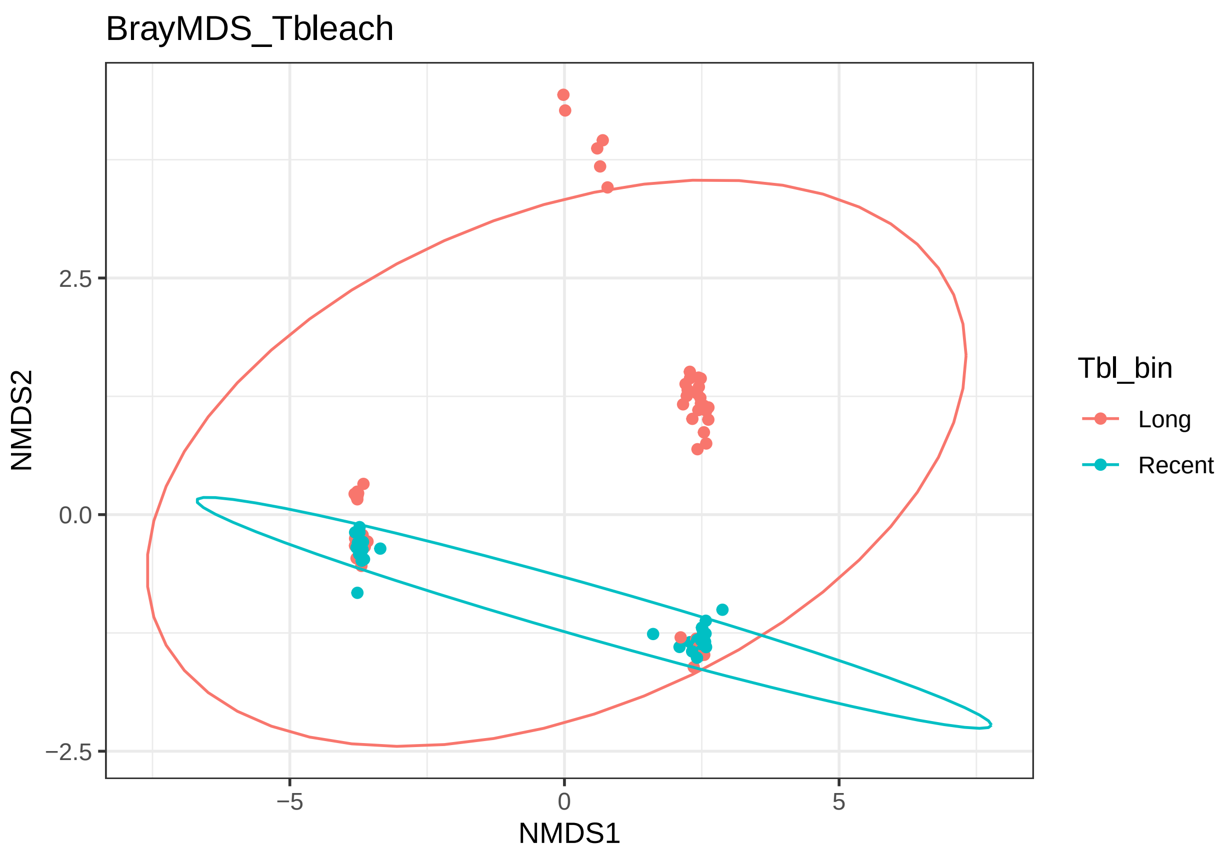
```r
NMDSplot_loc
```




```r
ggsave("NMDSplot_loc_pdam_1Nov2021.pdf")
```

```
## Saving 6.5 x 4.5 in image
```

```r
# Tbleach

NMDSplot_Tbleach <- plot_ordination(ps13, MDSbray, type="samples", color="Tbl_bin") +
  theme_bw() +
  stat_ellipse() +
  ggtitle("BrayMDS_Tbleach")

NMDSplot_Tbleach
```




```
ggsave("NMDSplot_Tbleach_pdam_1Nov2021.pdf")
```

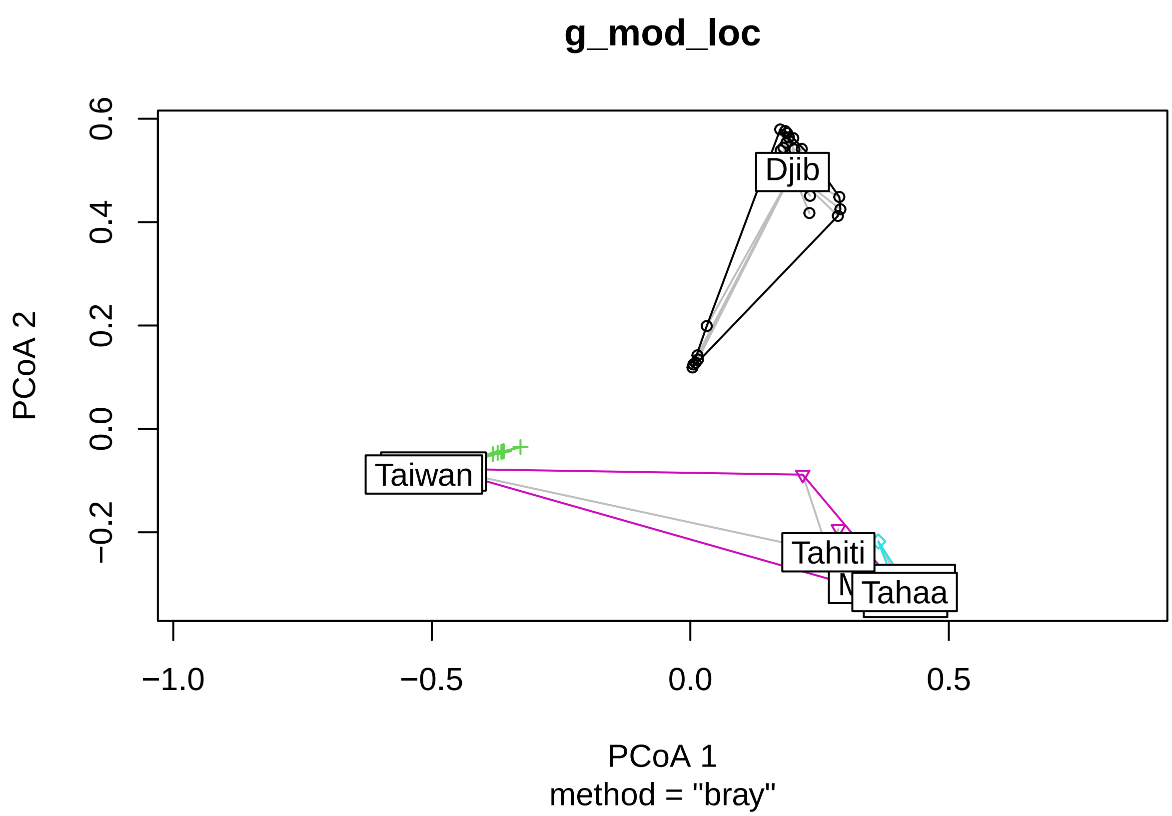
```
## Saving 6.5 x 4.5 in image
```

```
## Test dispersion/homoscedascity

##by location
g_mod_loc <- with(meta, betadisper(bray.dist, Loc))
g_mod_loc
```

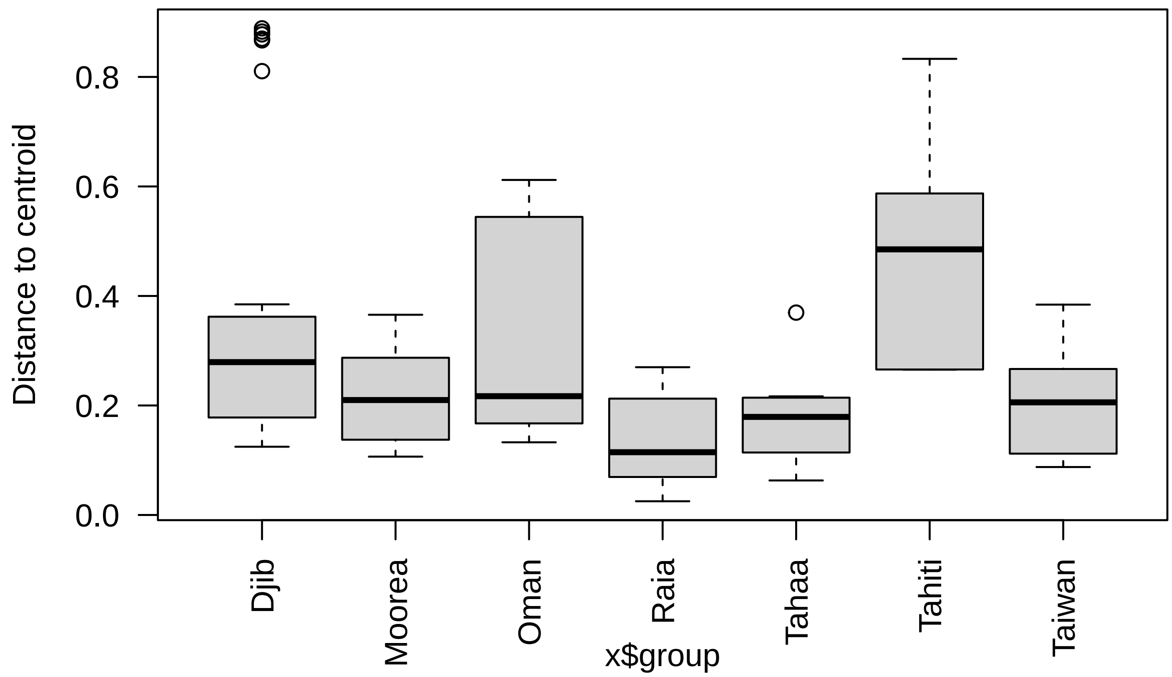
```
##
##  Homogeneity of multivariate dispersions
##
## Call: betadisper(d = bray.dist, group = Loc)
##
## No. of Positive Eigenvalues: 55
## No. of Negative Eigenvalues: 35
##
## Average distance to median:
##   Djib Moorea   Oman   Raia  Tahaa Tahiti Taiwan
## 0.3726 0.2176 0.3134 0.1360 0.1751 0.4873 0.2016
##
## Eigenvalues for PCoA axes:
## (Showing 8 of 90 eigenvalues)
##   PCoA1   PCoA2   PCoA3   PCoA4   PCoA5   PCoA6   PCoA7   PCoA8
```

```
## 13.6789  8.6777  3.4738  2.1797  0.8579  0.6863  0.4543  0.4404
```

```
plot(g_mod_loc)
```




```
boxplot(g_mod_loc,las=2)
```




```
anova(g_mod_loc)
```

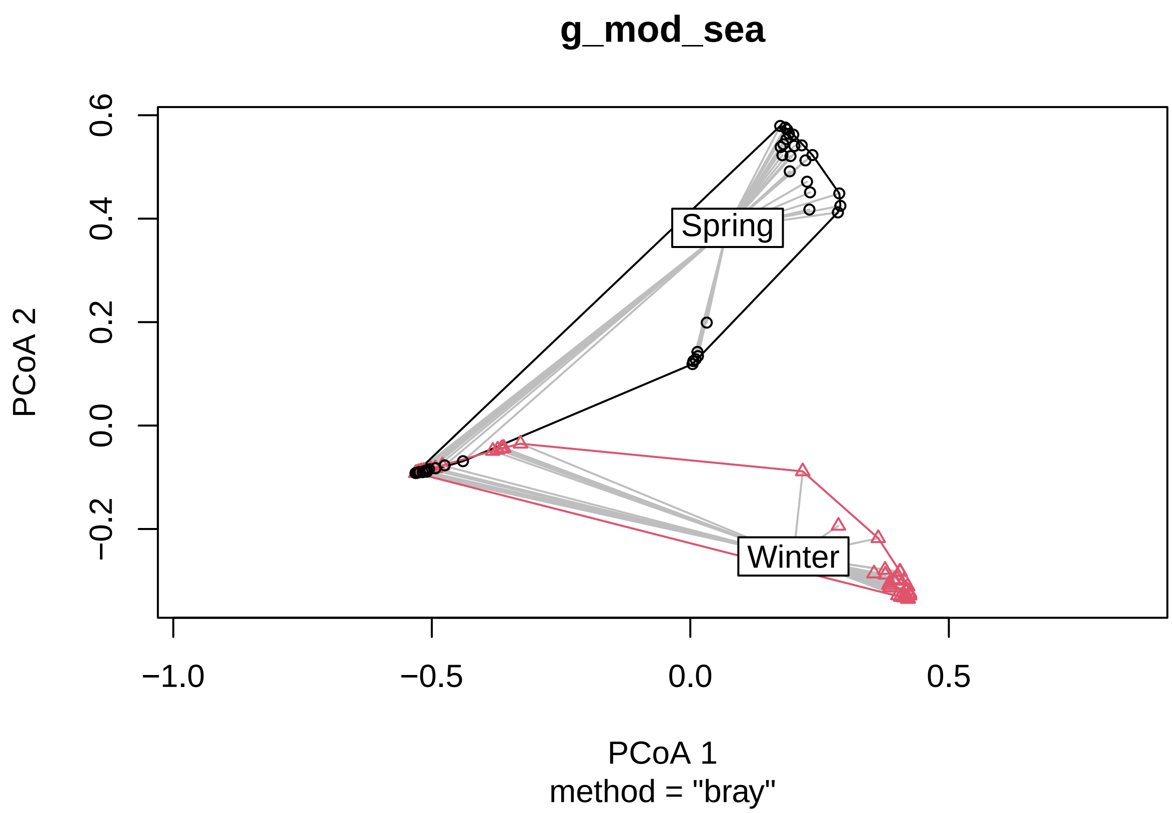
```
## Analysis of Variance Table
##
## Response: Distances
##           Df Sum Sq  Mean Sq F value   Pr(>F)
## Groups     6 0.8466 0.141095  3.7104 0.002546 **
## Residuals 84 3.1943 0.038027
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##by season
g_mod_sea <- with(meta, betadisper(bray.dist, Season))
g_mod_sea
```

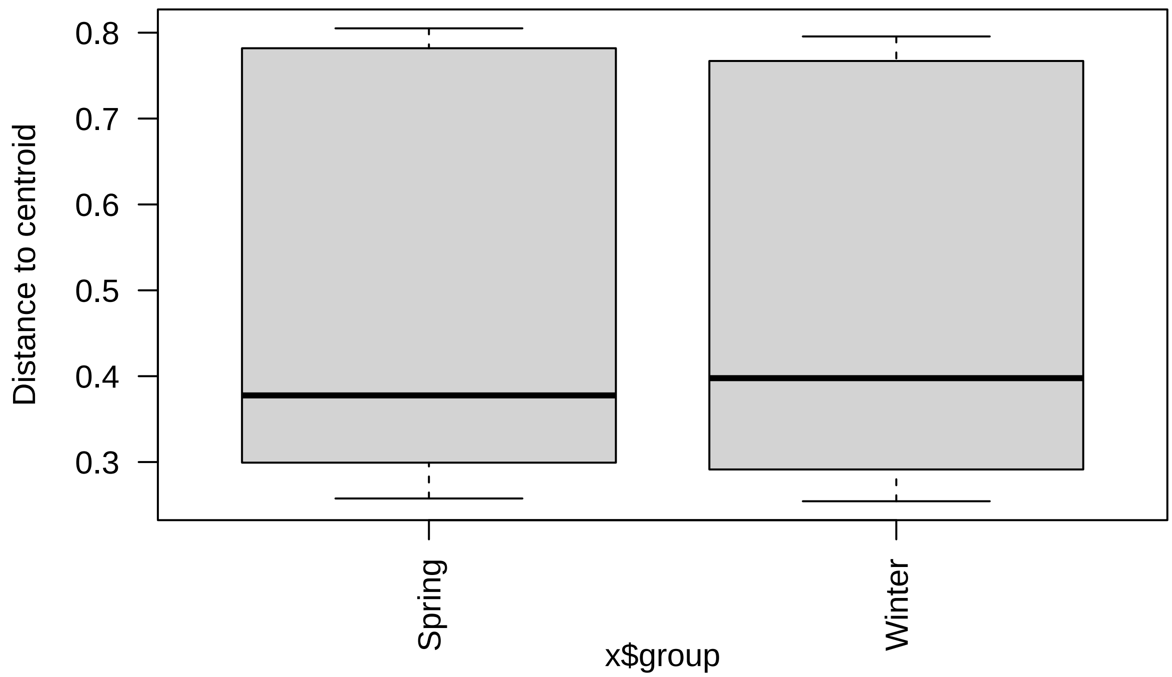
```
##
##  Homogeneity of multivariate dispersions
##
## Call: betadisper(d = bray.dist, group = Season)
##
## No. of Positive Eigenvalues: 55
## No. of Negative Eigenvalues: 35
##
## Average distance to median:
## Spring Winter
```

```
##  0.529  0.517
##
## Eigenvalues for PCoA axes:
## (Showing 8 of 90 eigenvalues)
##   PCoA1   PCoA2   PCoA3   PCoA4   PCoA5   PCoA6   PCoA7   PCoA8
## 13.6789  8.6777  3.4738  2.1797  0.8579  0.6863  0.4543  0.4404
```

```
plot(g_mod_sea)
```




```
boxplot(g_mod_sea,las=2)
```




```r
anova(g_mod_sea)
```

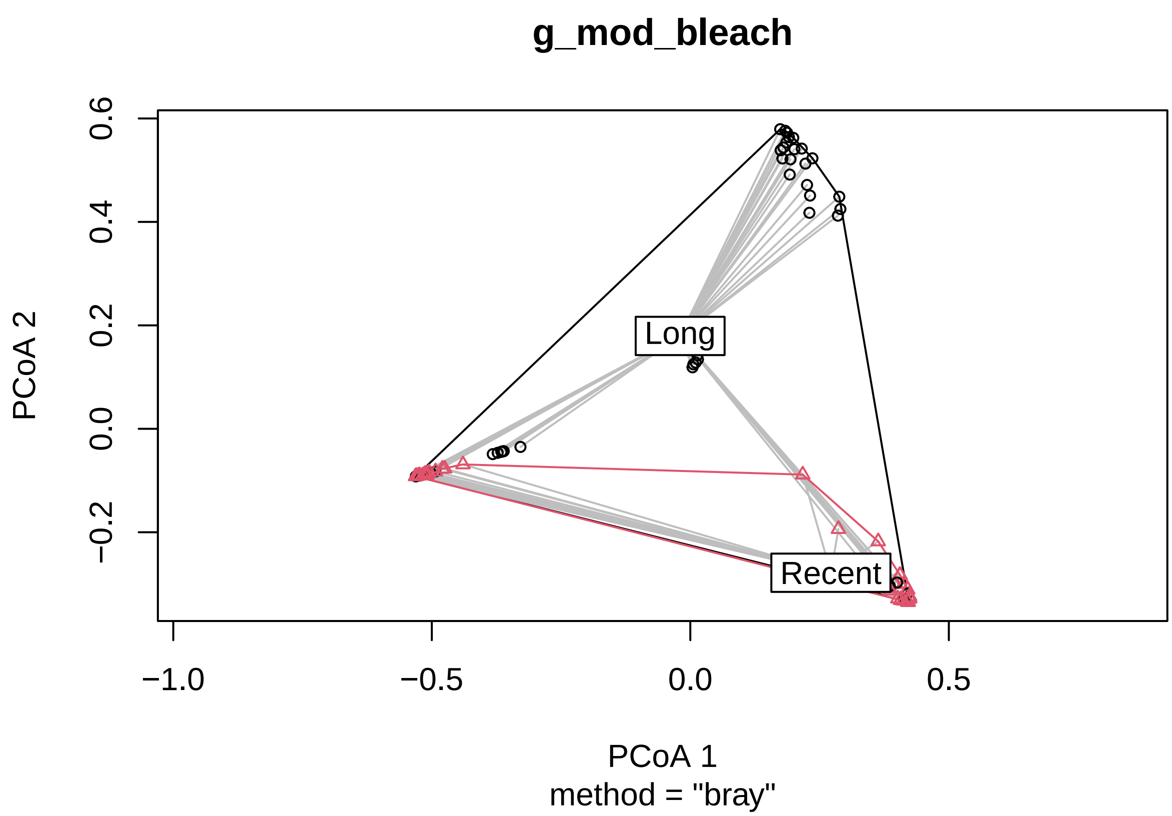
```
## Analysis of Variance Table
##
## Response: Distances
##           Df Sum Sq  Mean Sq F value Pr(>F)
## Groups     1 0.0032 0.003203  0.0575  0.811
## Residuals 89 4.9569 0.055695
```

```r
##by tbleaching
g_mod_bleach <- with(meta, betadisper(bray.dist, Tbl_bin))
g_mod_bleach
```

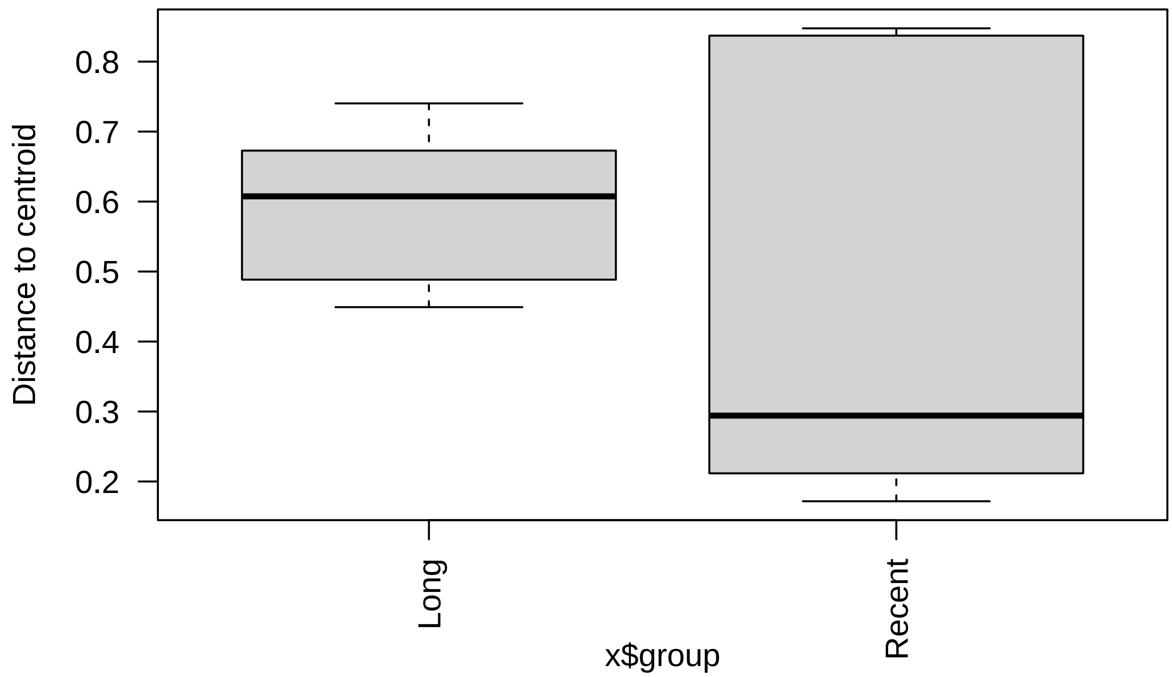
```
##
##  Homogeneity of multivariate dispersions
##
## Call: betadisper(d = bray.dist, group = Tbl_bin)
##
## No. of Positive Eigenvalues: 55
## No. of Negative Eigenvalues: 35
##
## Average distance to median:
##   Long Recent
## 0.5903 0.4801
##
```

```
## Eigenvalues for PCoA axes:
## (Showing 8 of 90 eigenvalues)
##    PCoA1   PCoA2   PCoA3   PCoA4   PCoA5   PCoA6   PCoA7   PCoA8
## 13.6789  8.6777  3.4738  2.1797  0.8579  0.6863  0.4543  0.4404
```

```
plot(g_mod_bleach)
```




```
boxplot(g_mod_bleach,las=2)
```




```
anova(g_mod_bleach)
```

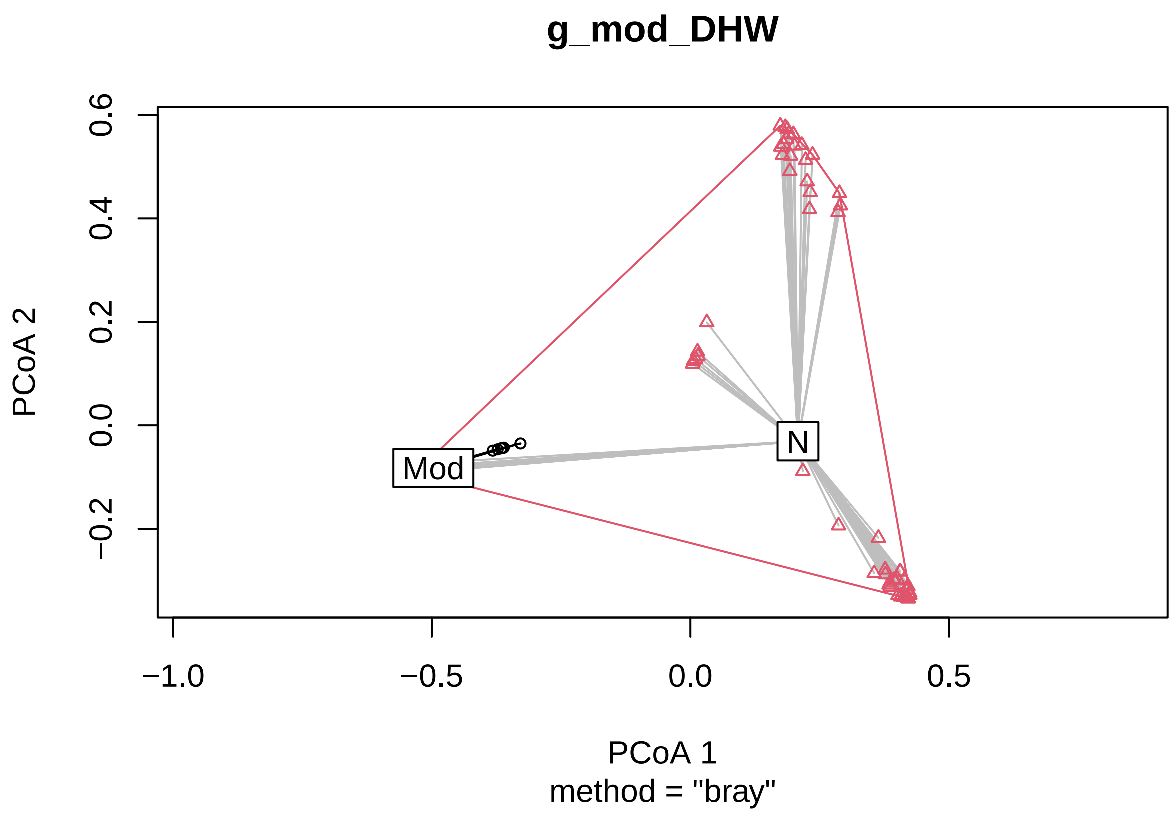
```
## Analysis of Variance Table
##
## Response: Distances
##           Df Sum Sq Mean Sq F value  Pr(>F)
## Groups     1 0.2619 0.26192  6.7142 0.01118 *
## Residuals 89 3.4719 0.03901
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##by DHW
g_mod_DHW <- with(meta, betadisper(bray.dist, DHW_cat))
g_mod_DHW
```

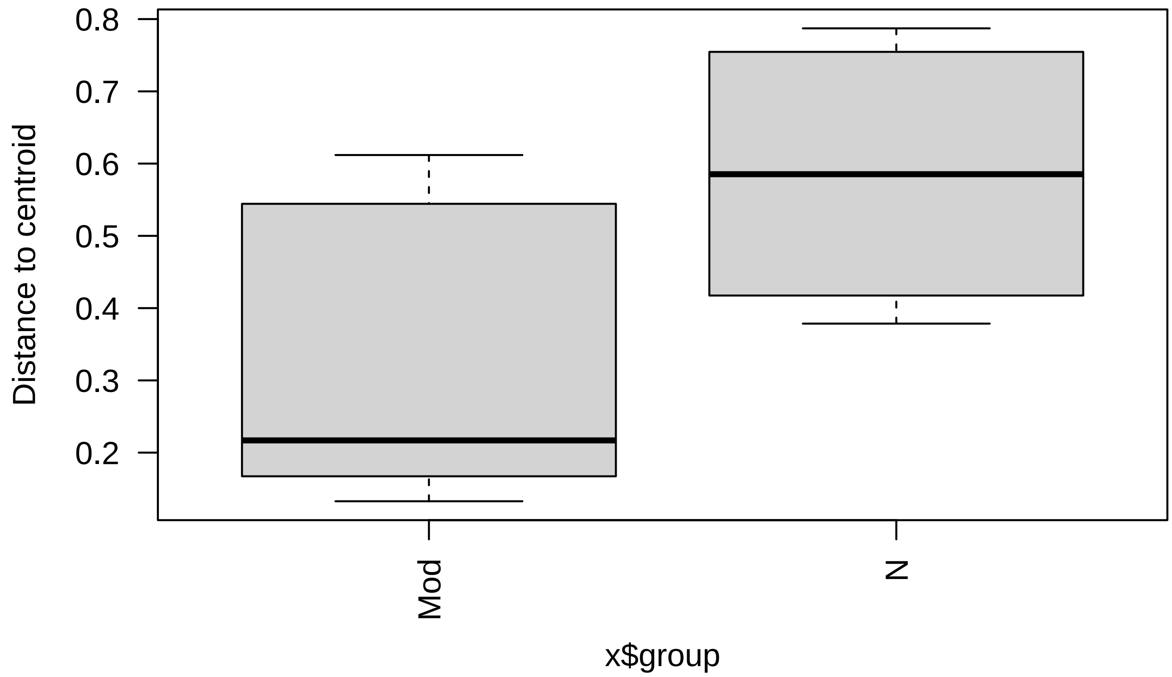
```
##
##  Homogeneity of multivariate dispersions
##
## Call: betadisper(d = bray.dist, group = DHW_cat)
##
## No. of Positive Eigenvalues: 55
## No. of Negative Eigenvalues: 35
##
## Average distance to median:
##    Mod      N
```

```
## 0.3134 0.5683
##
## Eigenvalues for PCoA axes:
## (Showing 8 of 90 eigenvalues)
##   PCoA1   PCoA2   PCoA3   PCoA4   PCoA5   PCoA6   PCoA7   PCoA8
## 13.6789  8.6777  3.4738  2.1797  0.8579  0.6863  0.4543  0.4404
```

```
plot(g_mod_DHW)
```




```
boxplot(g_mod_DHW,las=2)
```




```r
anova(g_mod_DHW)
```

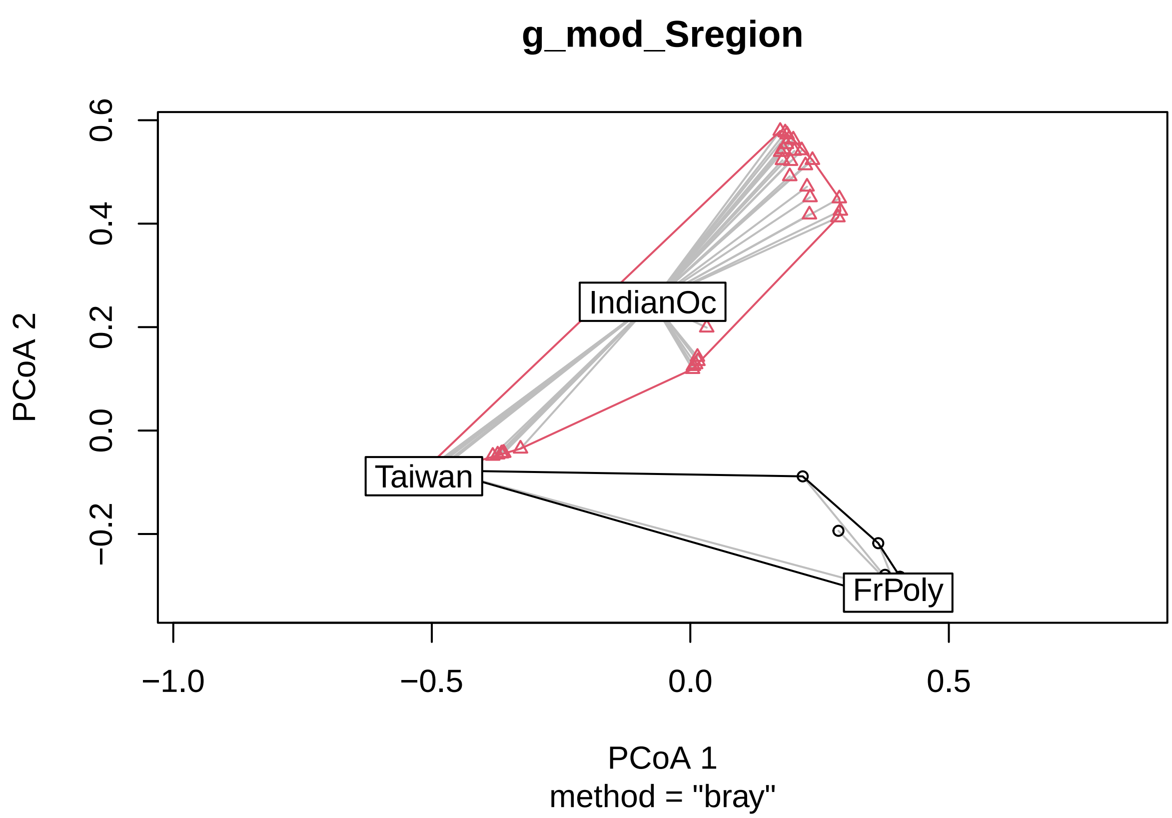
```
## Analysis of Variance Table
##
## Response: Distances
##           Df Sum Sq Mean Sq F value    Pr(>F)
## Groups     1 1.0492 1.04916  42.904 3.605e-09 ***
## Residuals 89 2.1764 0.02445
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
#by S_region
g_mod_Sregion <- with(meta, betadisper(bray.dist, S_region))
g_mod_Sregion
```

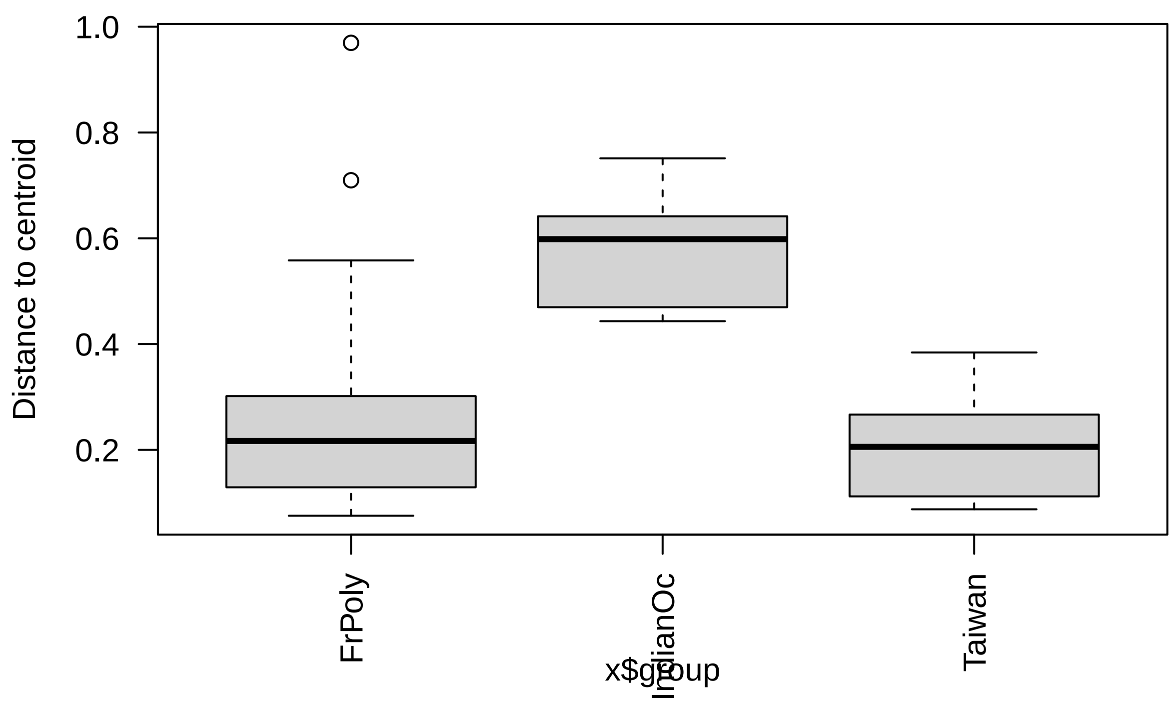
```
##
##  Homogeneity of multivariate dispersions
##
## Call: betadisper(d = bray.dist, group = S_region)
##
## No. of Positive Eigenvalues: 55
## No. of Negative Eigenvalues: 35
##
## Average distance to median:
##   FrPoly IndianOc   Taiwan
```

```
##    0.2598    0.5669    0.2016
##
## Eigenvalues for PCoA axes:
## (Showing 8 of 90 eigenvalues)
##    PCoA1    PCoA2    PCoA3    PCoA4    PCoA5    PCoA6    PCoA7    PCoA8
## 13.6789  8.6777  3.4738  2.1797  0.8579  0.6863  0.4543  0.4404
```

```
plot(g_mod_Sregion)
```




```
boxplot(g_mod_Sregion,las=2)
```




```
anova(g_mod_Sregion)
```

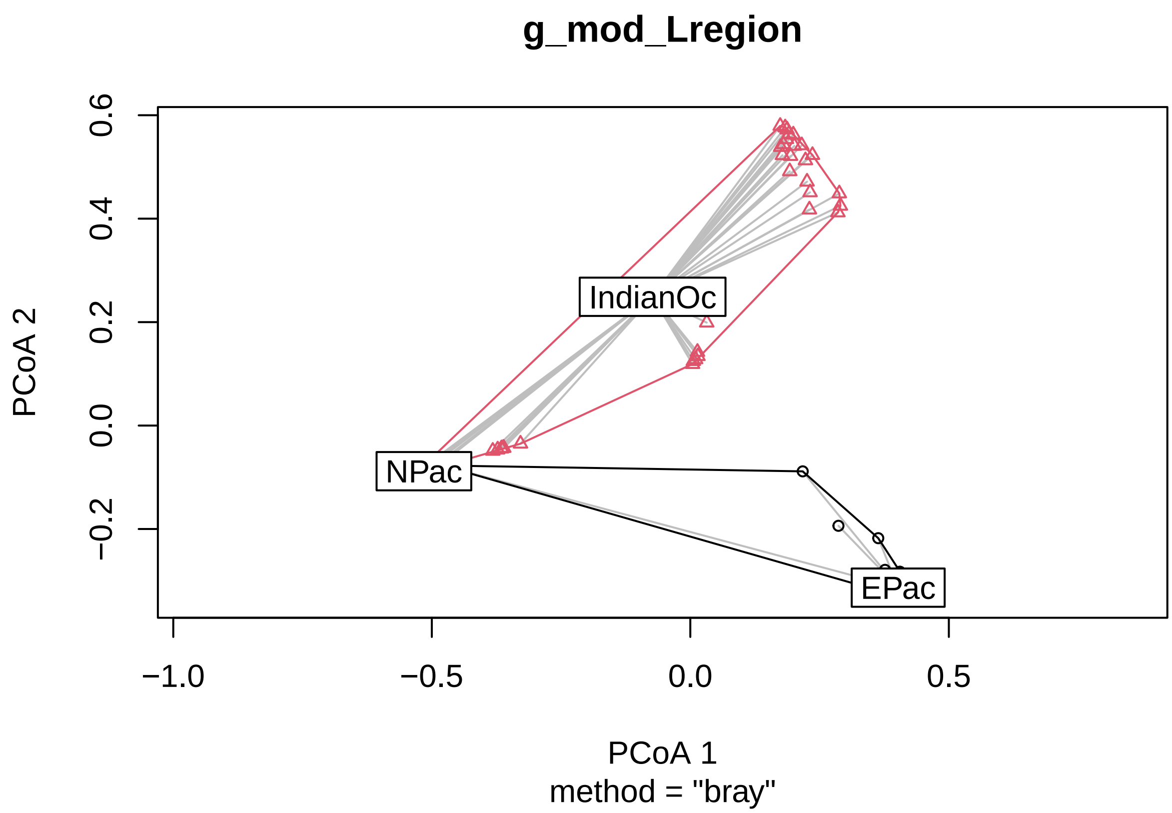
```
## Analysis of Variance Table
##
## Response: Distances
##           Df Sum Sq Mean Sq F value    Pr(>F)
## Groups     2 2.4002 1.20010  61.408 < 2.2e-16 ***
## Residuals 88 1.7198 0.01954
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
##by L_region
g_mod_Lregion <- with(meta, betadisper(bray.dist, L_region))
g_mod_Lregion
```

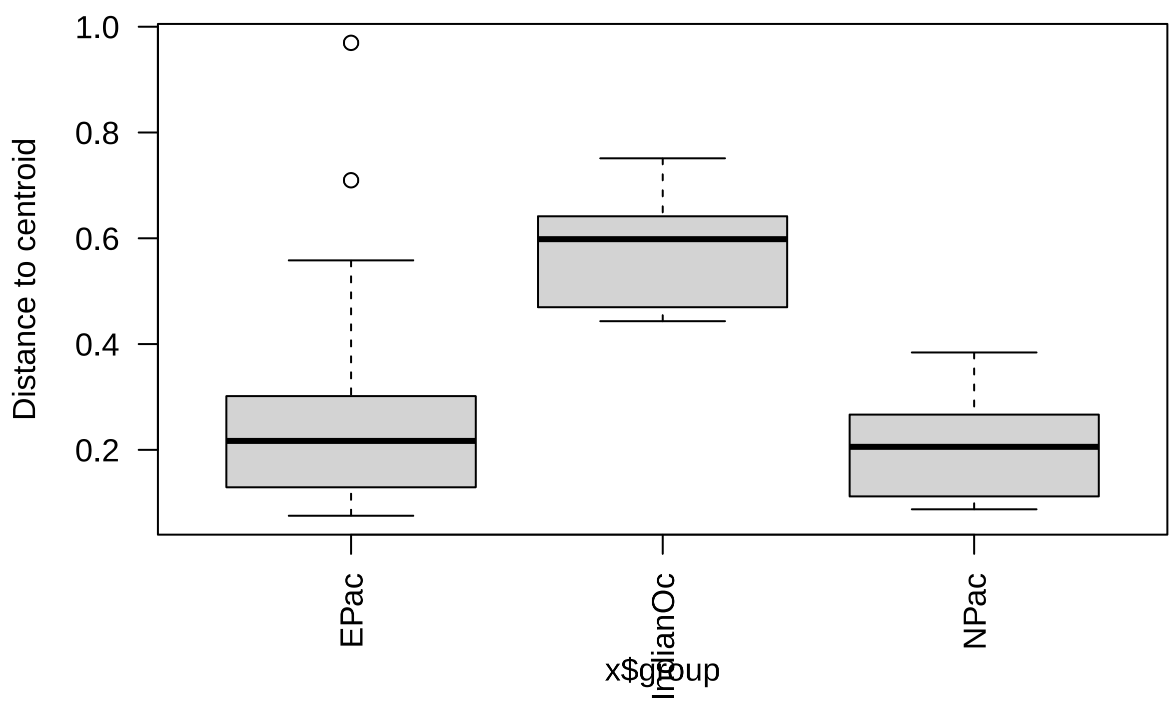
```
##
##  Homogeneity of multivariate dispersions
##
## Call: betadisper(d = bray.dist, group = L_region)
##
## No. of Positive Eigenvalues: 55
## No. of Negative Eigenvalues: 35
##
## Average distance to median:
##     EPac IndianOc     NPac
```

```
##    0.2598    0.5669    0.2016
##
## Eigenvalues for PCoA axes:
## (Showing 8 of 90 eigenvalues)
##    PCoA1    PCoA2    PCoA3    PCoA4    PCoA5    PCoA6    PCoA7    PCoA8
## 13.6789   8.6777   3.4738   2.1797   0.8579   0.6863   0.4543   0.4404
```

```
plot(g_mod_Lregion)
```




```
boxplot(g_mod_Lregion,las=2)
```

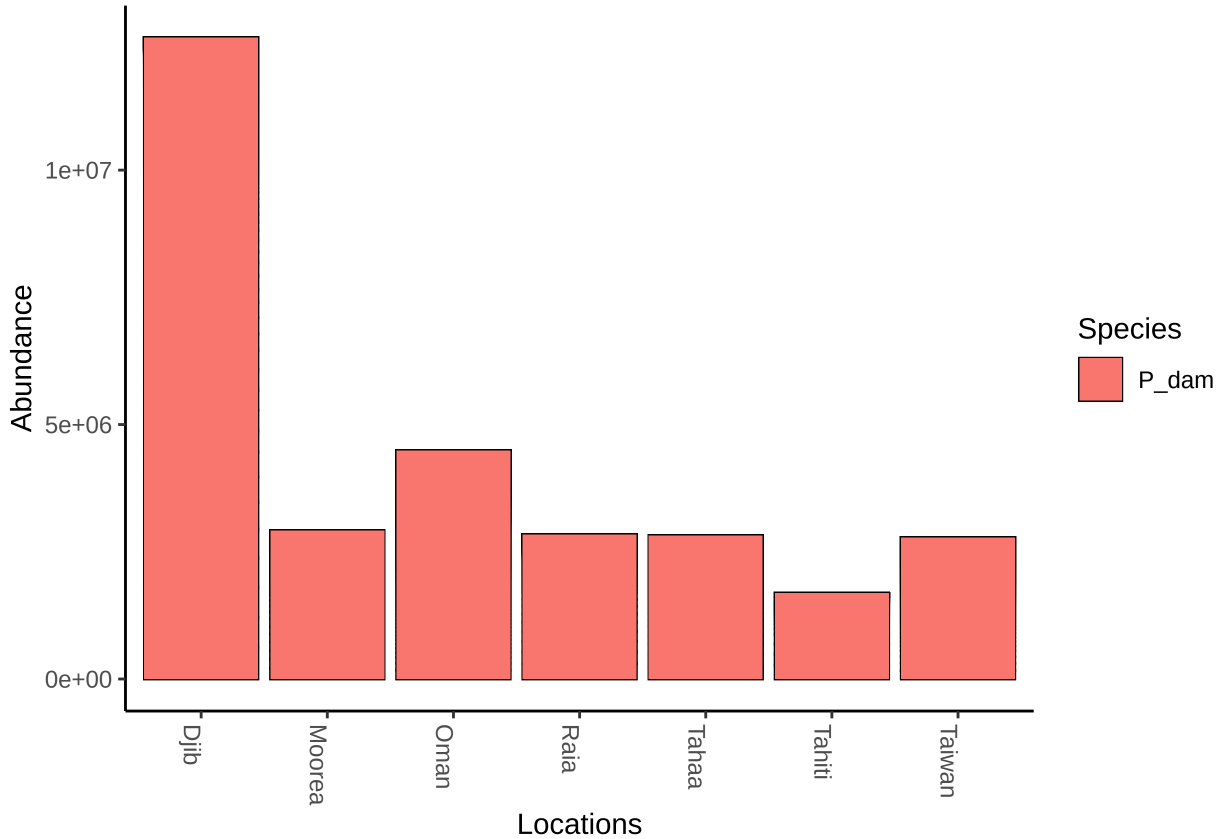



```
anova(g_mod_Lregion)
```

```
## Analysis of Variance Table
##
## Response: Distances
##           Df Sum Sq Mean Sq F value    Pr(>F)
## Groups     2 2.4002 1.20010  61.408 < 2.2e-16 ***
## Residuals 88 1.7198 0.01954
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
specloc <- plot_bar(ps13, x="Loc", fill="Spec") + labs(x = "Locations", y = "Abundance") + geom_bar(pos
panel.background = element_blank(), axis.line = element_line(colour = "black"))

specloc
```




```
ggsave("specloc.png")
```

```
## Saving 6.5 x 4.5 in image
```

```
##Mantel test
##Set random seed for reproducibility
set.seed(5462)

library(geosphere)

#longitude and latitude
sam_ps13 <- sample_data(ps13)
sam_ps13
```

```
##                Loc   Yr  Spec Exp_cond Code Repro Month Season S_region L_region
## SRR5963024    Oman 2014 P_dam      31C  Om2     B  June Winter IndianOc IndianOc
## SRR5963025    Oman 2014 P_dam      31C  Om2     B  June Winter IndianOc IndianOc
## SRR5963026    Oman 2014 P_dam      31C  Om3     B  June Winter IndianOc IndianOc
## SRR5963027    Oman 2014 P_dam      31C  Om2     B  June Winter IndianOc IndianOc
## SRR5963028    Oman 2014 P_dam      31C  Om3     B  June Winter IndianOc IndianOc
## SRR5963029    Oman 2014 P_dam      31C  Om3     B  June Winter IndianOc IndianOc
## SRR5963042    Oman 2014 P_dam      31C  Om1     B  June Winter IndianOc IndianOc
## SRR5963043    Oman 2014 P_dam      31C  Om1     B  June Winter IndianOc IndianOc
## SRR5963049    Oman 2014 P_dam      31C  Om1     B  June Winter IndianOc IndianOc
## SRR5963092    Oman 2014 P_dam      34C  Om2     B  June Winter IndianOc IndianOc
```

```
## SRR5963093   Oman 2014 P_dam     34C  Om2     B  June Winter IndianOc IndianOc
## SRR5963099   Oman 2014 P_dam     34C  Om1     B  June Winter IndianOc IndianOc
## SRR5963100   Oman 2014 P_dam     34C  Om1     B  June Winter IndianOc IndianOc
## SRR5963101   Oman 2014 P_dam     34C  Om1     B  June Winter IndianOc IndianOc
## SRR5963102   Oman 2014 P_dam surface  Om1     B  June Winter IndianOc IndianOc
## SRR5963106   Oman 2014 P_dam     34C  Om3     B  June Winter IndianOc IndianOc
## SRR5963107   Oman 2014 P_dam     34C  Om3     B  June Winter IndianOc IndianOc
## SRR5963108   Oman 2014 P_dam     34C  Om3     B  June Winter IndianOc IndianOc
## SRR5963109   Oman 2014 P_dam     34C  Om3     B  June Winter IndianOc IndianOc
## SRR5963110   Oman 2014 P_dam surface  Om3     B  June Winter IndianOc IndianOc
## SRR5963111   Oman 2014 P_dam surface  Om2     B  June Winter IndianOc IndianOc
## SRR5970158 Moorea 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970160 Taiwan 2012 P_dam     Nat <NA>     B   Sep Spring   Taiwan     NPac
## SRR5970162 Taiwan 2012 P_dam     Nat <NA>     B   Sep Spring   Taiwan     NPac
## SRR5970164 Taiwan 2012 P_dam     Nat <NA>     B   Sep Spring   Taiwan     NPac
## SRR5970166 Taiwan 2012 P_dam     Nat <NA>     B   Sep Spring   Taiwan     NPac
## SRR5970168 Taiwan 2012 P_dam     Nat <NA>     B   Sep Spring   Taiwan     NPac
## SRR5970169   Djib 2014 P_dam     Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970174  Tahaa 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970176  Tahaa 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970178  Tahaa 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970181  Tahaa 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970182 Tahiti 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970185 Taiwan 2012 P_dam     Nat <NA>     B   Sep Spring   Taiwan     NPac
## SRR5970187 Taiwan 2012 P_dam     Nat <NA>     B   Sep Spring   Taiwan     NPac
## SRR5970189 Taiwan 2012 P_dam     Nat <NA>     B   Sep Spring   Taiwan     NPac
## SRR5970191 Taiwan 2012 P_dam     Nat <NA>     B   Sep Spring   Taiwan     NPac
## SRR5970193 Tahiti 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970197  Tahaa 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970199 Tahiti 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970201  Tahaa 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970204   Djib 2014 P_dam     Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970206   Djib 2014 P_dam     Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970208   Djib 2014 P_dam     Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970210   Djib 2014 P_dam     Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970211 Taiwan 2012 P_dam     Nat <NA>     B   Sep Spring   Taiwan     NPac
## SRR5970213 Taiwan 2012 P_dam     Nat <NA>     B   Sep Spring   Taiwan     NPac
## SRR5970215 Taiwan 2012 P_dam     Nat <NA>     B   Sep Spring   Taiwan     NPac
## SRR5970221 Moorea 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970223   Djib 2014 P_dam     Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970230   Djib 2014 P_dam     Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970232   Raia 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970234 Moorea 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970236   Raia 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970238   Raia 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970241   Raia 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970243 Moorea 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970245 Moorea 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970247 Tahiti 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970250   Raia 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970252   Raia 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970254 Moorea 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970256 Moorea 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970259   Raia 2008 P_dam     Nat <NA>     B  June Winter   FrPoly     EPac
```

```
## SRR5970262   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970263 Tahiti 2008 P_dam      Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970264   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970266   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970274  Tahaa 2008 P_dam      Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970276  Tahaa 2008 P_dam      Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970278   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970280   Raia 2008 P_dam      Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970282   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970284   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970286   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970288   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970290   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970296  Tahaa 2008 P_dam      Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970300  Tahaa 2008 P_dam      Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970303   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970304   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970306   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970308   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970310   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970312   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970325 Moorea 2008 P_dam      Nat <NA>     B  June Winter   FrPoly     EPac
## SRR5970327   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970329   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970331   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970333   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
## SRR5970335   Djib 2014 P_dam      Nat <NA>     B   Nov Spring IndianOc IndianOc
##            Exact.date Tbl_bin T_bleach  DHW DHW_cat SST_a    Coord_X    Coord_Y
## SRR5963024       <NA>    Long      15y 4.24     Mod 30.80   23.52000   58.74000
## SRR5963025       <NA>    Long      15y 4.24     Mod 30.80   23.52000   58.74000
## SRR5963026       <NA>    Long      15y 3.79     Mod 30.80   23.62000   58.60000
## SRR5963027       <NA>    Long      15y 4.24     Mod 30.80   23.52000   58.74000
## SRR5963028       <NA>    Long      15y 3.79     Mod 30.80   23.62000   58.60000
## SRR5963029       <NA>    Long      15y 3.79     Mod 30.80   23.62000   58.60000
## SRR5963042       <NA>    Long      15y 4.28     Mod 30.80   23.50000   58.75000
## SRR5963043       <NA>    Long      15y 4.28     Mod 30.80   23.50000   58.75000
## SRR5963049       <NA>    Long      15y 4.28     Mod 30.80   23.50000   58.75000
## SRR5963092       <NA>    Long      15y 4.24     Mod 30.80   23.52000   58.74000
## SRR5963093       <NA>    Long      15y 4.24     Mod 30.80   23.52000   58.74000
## SRR5963099       <NA>    Long      15y 4.28     Mod 30.80   23.50000   58.75000
## SRR5963100       <NA>    Long      15y 4.28     Mod 30.80   23.50000   58.75000
## SRR5963101       <NA>    Long      15y 4.28     Mod 30.80   23.50000   58.75000
## SRR5963102       <NA>    Long      15y 4.28     Mod 30.80   23.50000   58.75000
## SRR5963106       <NA>    Long      15y 3.79     Mod 30.80   23.62000   58.60000
## SRR5963107       <NA>    Long      15y 3.79     Mod 30.80   23.62000   58.60000
## SRR5963108       <NA>    Long      15y 3.79     Mod 30.80   23.62000   58.60000
## SRR5963109       <NA>    Long      15y 3.79     Mod 30.80   23.62000   58.60000
## SRR5963110       <NA>    Long      15y 3.79     Mod 30.80   23.62000   58.60000
## SRR5963111       <NA>    Long      15y 4.24     Mod 30.80   23.52000   58.74000
## SRR5970158       <NA>    Long      10y 0.00       N 27.04 -17.48969 -149.89685
## SRR5970160     24_Sep  Recent       5y 0.00       N 28.59   21.93020  120.74497
## SRR5970162     24_Sep  Recent       5y 0.00       N 28.59   21.93010  120.74497
## SRR5970164     24_Sep  Recent       5y 0.00       N 28.59   21.93040  120.74497
## SRR5970166     24_Sep  Recent       5y 0.00       N 28.59   21.93030  120.74497
```

```
## SRR5970168     24_Sep  Recent       5y 0.00       N 28.59  21.93050  120.74497
## SRR5970169     23_Nov    Long     >15y 0.00       N 29.37  11.77949   42.92435
## SRR5970174       <NA>  Recent       5y 0.00       N 27.19 -16.67674 -151.45526
## SRR5970176       <NA>  Recent       5y 0.00       N 27.19 -16.61418 -151.54275
## SRR5970178       <NA>  Recent       5y 0.00       N 27.19 -16.61418 -151.54275
## SRR5970181       <NA>  Recent       5y 0.00       N 27.19 -16.67674 -151.45526
## SRR5970182       <NA>  Recent       5y 0.00       N 26.86 -17.57443 -149.61974
## SRR5970185     24_Sep  Recent       5y 0.00       N 28.59  21.94544  120.74802
## SRR5970187     24_Sep  Recent       5y 0.00       N 28.59  21.94544  120.74803
## SRR5970189     24_Sep  Recent       5y 0.00       N 28.59  21.94544  120.74803
## SRR5970191     24_Sep  Recent       5y 0.00       N 28.59  21.94544  120.74803
## SRR5970193       <NA>  Recent       5y 0.00       N 26.86 -17.57443 -149.61974
## SRR5970197       <NA>  Recent       5y 0.00       N 27.19 -16.61417 -151.54275
## SRR5970199       <NA>  Recent       5y 0.00       N 26.86 -17.57443 -149.61974
## SRR5970201       <NA>  Recent       5y 0.00       N 27.19 -16.61418 -151.54275
## SRR5970204     23_Nov    Long     >15y 0.00       N 29.11  11.73035   43.22408
## SRR5970206     23_Nov    Long     >15y 0.00       N 29.11  11.73035   43.22408
## SRR5970208     23_Nov    Long     >15y 0.00       N 29.11  11.73035   43.22408
## SRR5970210     23_Nov    Long     >15y 0.00       N 29.11  11.73035   43.22408
## SRR5970211     24_Sep  Recent       5y 0.00       N 28.67  21.99382  120.70630
## SRR5970213     24_Sep  Recent       5y 0.00       N 28.59  21.93060  120.74497
## SRR5970215     24_Sep  Recent       5y 0.00       N 28.67  21.99382  120.70650
## SRR5970221       <NA>    Long      10y 0.00       N 27.04 -17.49214 -149.86898
## SRR5970223     23_Nov    Long     >15y 0.00       N 29.37  11.77949   42.92435
## SRR5970230     23_Nov    Long     >15y 0.00       N 29.37  11.77949   42.92435
## SRR5970232       <NA>  Recent       5y 0.00       N 27.25 -16.78944 -151.39184
## SRR5970234       <NA>    Long      10y 0.00       N 27.04 -17.49214 -149.86898
## SRR5970236       <NA>  Recent       5y 0.00       N 27.25 -16.78945 -151.39184
## SRR5970238       <NA>  Recent       5y 0.00       N 27.25 -16.78944 -151.39184
## SRR5970241       <NA>  Recent       5y 0.00       N 27.25 -16.78945 -151.39184
## SRR5970243       <NA>    Long      10y 0.00       N 27.04 -17.49214 -149.86898
## SRR5970245       <NA>    Long      10y 0.00       N 27.04 -17.49214 -149.86898
## SRR5970247       <NA>  Recent       5y 0.00       N 26.86 -17.57443 -149.61974
## SRR5970250       <NA>  Recent       5y 0.00       N 27.25 -16.78944 -151.39184
## SRR5970252       <NA>  Recent       5y 0.00       N 27.25 -16.78944 -151.39184
## SRR5970254       <NA>    Long      10y 0.00       N 27.04 -17.48969 -149.89685
## SRR5970256       <NA>    Long      10y 0.00       N 27.04 -17.48969 -149.89685
## SRR5970259       <NA>  Recent       5y 0.00       N 27.25 -16.78944 -151.39184
## SRR5970262     23_Nov    Long     >15y 0.00       N 29.37  11.77949   42.92435
## SRR5970263       <NA>  Recent       5y 0.00       N 26.86 -17.57443 -149.61974
## SRR5970264     23_Nov    Long     >15y 0.00       N 29.37  11.77949   42.92435
## SRR5970266     23_Nov    Long     >15y 0.00       N 29.37  11.77949   42.92435
## SRR5970274       <NA>  Recent       5y 0.00       N 27.22 -16.67674 -151.45526
## SRR5970276       <NA>  Recent       5y 0.00       N 27.22 -16.67674 -151.45526
## SRR5970278     23_Nov    Long     >15y 0.00       N 29.37  11.77949   42.92435
## SRR5970280       <NA>  Recent       5y 0.00       N 27.25 -16.78944 -151.39184
## SRR5970282     23_Nov    Long     >15y 0.00       N 29.11  11.73035   43.22408
## SRR5970284     23_Nov    Long     >15y 0.00       N 29.35  11.58261   42.79607
## SRR5970286     23_Nov    Long     >15y 0.00       N 29.11  11.73035   43.22408
## SRR5970288     23_Nov    Long     >15y 0.00       N 29.11  11.73035   43.22408
## SRR5970290     23_Nov    Long     >15y 0.00       N 29.35  11.58261   42.79607
## SRR5970296       <NA>  Recent       5y 0.00       N 27.22 -16.67674 -151.45526
## SRR5970300       <NA>  Recent       5y 0.00       N 27.22 -16.67674 -151.45526
## SRR5970303     23_Nov    Long     >15y 0.00       N 29.11  11.73035   43.22408
```

```
## SRR5970304     23_Nov    Long     >15y 0.00       N 29.35  11.58261   42.79607
## SRR5970306     23_Nov    Long     >15y 0.00       N 29.35  11.58261   42.79607
## SRR5970308     23_Nov    Long     >15y 0.00       N 29.35  11.58261   42.79607
## SRR5970310     23_Nov    Long     >15y 0.00       N 29.35  11.58261   42.79607
## SRR5970312     23_Nov    Long     >15y 0.00       N 29.35  11.58261   42.79607
## SRR5970325       <NA>    Long      10y 0.00       N 27.04 -17.48969 -149.89685
## SRR5970327     23_Nov    Long     >15y 0.00       N 29.37  11.77949   42.92435
## SRR5970329     23_Nov    Long     >15y 0.00       N 29.37  11.77949   42.92435
## SRR5970331     23_Nov    Long     >15y 0.00       N 29.37  11.77949   42.92435
## SRR5970333     23_Nov    Long     >15y 0.00       N 29.37  11.77949   42.92435
## SRR5970335     23_Nov    Long     >15y 0.00       N 29.37  11.77949   42.92435
##              Primer
## SRR5963024 ITS-DINO
## SRR5963025 ITS-DINO
## SRR5963026 ITS-DINO
## SRR5963027 ITS-DINO
## SRR5963028 ITS-DINO
## SRR5963029 ITS-DINO
## SRR5963042 ITS-DINO
## SRR5963043 ITS-DINO
## SRR5963049 ITS-DINO
## SRR5963092 ITS-DINO
## SRR5963093 ITS-DINO
## SRR5963099 ITS-DINO
## SRR5963100 ITS-DINO
## SRR5963101 ITS-DINO
## SRR5963102 ITS-DINO
## SRR5963106 ITS-DINO
## SRR5963107 ITS-DINO
## SRR5963108 ITS-DINO
## SRR5963109 ITS-DINO
## SRR5963110 ITS-DINO
## SRR5963111 ITS-DINO
## SRR5970158 ITS-DINO
## SRR5970160 ITS-DINO
## SRR5970162 ITS-DINO
## SRR5970164 ITS-DINO
## SRR5970166 ITS-DINO
## SRR5970168 ITS-DINO
## SRR5970169 ITS-DINO
## SRR5970174 ITS-DINO
## SRR5970176 ITS-DINO
## SRR5970178 ITS-DINO
## SRR5970181 ITS-DINO
## SRR5970182 ITS-DINO
## SRR5970185 ITS-DINO
## SRR5970187 ITS-DINO
## SRR5970189 ITS-DINO
## SRR5970191 ITS-DINO
## SRR5970193 ITS-DINO
## SRR5970197 ITS-DINO
## SRR5970199 ITS-DINO
## SRR5970201 ITS-DINO
## SRR5970204 ITS-DINO
```

```
## SRR5970206 ITS-DINO
## SRR5970208 ITS-DINO
## SRR5970210 ITS-DINO
## SRR5970211 ITS-DINO
## SRR5970213 ITS-DINO
## SRR5970215 ITS-DINO
## SRR5970221 ITS-DINO
## SRR5970223 ITS-DINO
## SRR5970230 ITS-DINO
## SRR5970232 ITS-DINO
## SRR5970234 ITS-DINO
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## SRR5970331 ITS-DINO
## SRR5970333 ITS-DINO
## SRR5970335 ITS-DINO
##                                                                     Pub
## SRR5963024          https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963025          https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963026          https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963027          https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
```

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## SRR5963028           https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
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## SRR5963042           https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963043           https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963049           https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963092           https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963093           https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963099           https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963100           https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963101           https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963102           https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963106           https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963107           https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963108           https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963109           https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963110           https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
## SRR5963111           https://www.biorxiv.org/content/10.1101/398602v4.full.pdf
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## SRR5970335 https://pubmed-ncbi-nlm-nih-gov.proxy3.library.mcgill.ca/29463295/
##
## SRR5963024 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963025 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963026 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963027 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963028 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963029 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963042 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963043 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963049 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963092 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963093 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963099 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963100 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963101 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963102 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963106 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963107 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963108 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963109 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5963110 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
```

```
## SRR5963111 Colonies said to be "Pocillopora damicornis-like"; based on ORF and microsatellites, all
## SRR5970158
## SRR5970160
## SRR5970162
## SRR5970164
## SRR5970166
## SRR5970168
## SRR5970169                                         Last mass bleaching event in 1998 after ENSO; no
## SRR5970174                                                                                  Last mas
## SRR5970176                                                                                  Last mas
## SRR5970178                                                                                  Last mas
## SRR5970181                                                                                  Last mas
## SRR5970182                                                                                  Last mas
## SRR5970185
## SRR5970187
## SRR5970189
## SRR5970191
## SRR5970193                                                                                  Last mas
## SRR5970197                                                                                  Last mas
## SRR5970199                                                                                  Last mas
## SRR5970201                                                                                  Last mas
## SRR5970204                                         Last mass bleaching event in 1998 after ENSO; no
## SRR5970206                                         Last mass bleaching event in 1998 after ENSO; no
## SRR5970208                                         Last mass bleaching event in 1998 after ENSO; no
## SRR5970210                                         Last mass bleaching event in 1998 after ENSO; no
## SRR5970211
## SRR5970213
## SRR5970215
## SRR5970221
## SRR5970223                                         Last mass bleaching event in 1998 after ENSO; no
## SRR5970230                                         Last mass bleaching event in 1998 after ENSO; no
## SRR5970232                                                                                  Last mas
## SRR5970234
## SRR5970236                                                                                  Last mas
## SRR5970238                                                                                  Last mas
## SRR5970241                                                                                  Last mas
## SRR5970243
## SRR5970245
## SRR5970247                                                                                  Last mas
## SRR5970250                                                                                  Last mas
## SRR5970252                                                                                  Last mas
## SRR5970254
## SRR5970256
## SRR5970259                                                                                  Last mas
## SRR5970262                                         Last mass bleaching event in 1998 after ENSO; no
## SRR5970263                                                                                  Last mas
## SRR5970264                                         Last mass bleaching event in 1998 after ENSO; no
## SRR5970266                                         Last mass bleaching event in 1998 after ENSO; no
## SRR5970274                                                                                  Last mas
## SRR5970276                                                                                  Last mas
## SRR5970278                                         Last mass bleaching event in 1998 after ENSO; no
## SRR5970280                                                                                  Last mas
## SRR5970282                                         Last mass bleaching event in 1998 after ENSO; no
## SRR5970284                                         Last mass bleaching event in 1998 after ENSO; no
```

```
## SRR5970286                                        Last mass bleaching event in 1998 after ENSO; no p
## SRR5970288                                        Last mass bleaching event in 1998 after ENSO; no p
## SRR5970290                                        Last mass bleaching event in 1998 after ENSO; no p
## SRR5970296                                                                                Last mass
## SRR5970300                                                                                Last mass
## SRR5970303                                        Last mass bleaching event in 1998 after ENSO; no p
## SRR5970304                                        Last mass bleaching event in 1998 after ENSO; no p
## SRR5970306                                        Last mass bleaching event in 1998 after ENSO; no p
## SRR5970308                                        Last mass bleaching event in 1998 after ENSO; no p
## SRR5970310                                        Last mass bleaching event in 1998 after ENSO; no p
## SRR5970312                                        Last mass bleaching event in 1998 after ENSO; no p
## SRR5970325
## SRR5970327                                        Last mass bleaching event in 1998 after ENSO; no p
## SRR5970329                                        Last mass bleaching event in 1998 after ENSO; no p
## SRR5970331                                        Last mass bleaching event in 1998 after ENSO; no p
## SRR5970333                                        Last mass bleaching event in 1998 after ENSO; no p
## SRR5970335                                        Last mass bleaching event in 1998 after ENSO; no p
```

```
geo = data.frame(sam_ps13$Coord_Y, sam_ps13$Coord_X)
geo
```

```
##    sam_ps13.Coord_Y sam_ps13.Coord_X
## 1          58.74000         23.52000
## 2          58.74000         23.52000
## 3          58.60000         23.62000
## 4          58.74000         23.52000
## 5          58.60000         23.62000
## 6          58.60000         23.62000
## 7          58.75000         23.50000
## 8          58.75000         23.50000
## 9          58.75000         23.50000
## 10         58.74000         23.52000
## 11         58.74000         23.52000
## 12         58.75000         23.50000
## 13         58.75000         23.50000
## 14         58.75000         23.50000
## 15         58.75000         23.50000
## 16         58.60000         23.62000
## 17         58.60000         23.62000
## 18         58.60000         23.62000
## 19         58.60000         23.62000
## 20         58.60000         23.62000
## 21         58.74000         23.52000
## 22       -149.89685        -17.48969
## 23        120.74497         21.93020
## 24        120.74497         21.93010
## 25        120.74497         21.93040
## 26        120.74497         21.93030
## 27        120.74497         21.93050
## 28         42.92435         11.77949
## 29       -151.45526        -16.67674
## 30       -151.54275        -16.61418
## 31       -151.54275        -16.61418
## 32       -151.45526        -16.67674
```

```
## 33      -149.61974      -17.57443
## 34       120.74802       21.94544
## 35       120.74803       21.94544
## 36       120.74803       21.94544
## 37       120.74803       21.94544
## 38      -149.61974      -17.57443
## 39      -151.54275      -16.61417
## 40      -149.61974      -17.57443
## 41      -151.54275      -16.61418
## 42        43.22408       11.73035
## 43        43.22408       11.73035
## 44        43.22408       11.73035
## 45        43.22408       11.73035
## 46       120.70630       21.99382
## 47       120.74497       21.93060
## 48       120.70650       21.99382
## 49      -149.86898      -17.49214
## 50        42.92435       11.77949
## 51        42.92435       11.77949
## 52      -151.39184      -16.78944
## 53      -149.86898      -17.49214
## 54      -151.39184      -16.78945
## 55      -151.39184      -16.78944
## 56      -151.39184      -16.78945
## 57      -149.86898      -17.49214
## 58      -149.86898      -17.49214
## 59      -149.61974      -17.57443
## 60      -151.39184      -16.78944
## 61      -151.39184      -16.78944
## 62      -149.89685      -17.48969
## 63      -149.89685      -17.48969
## 64      -151.39184      -16.78944
## 65        42.92435       11.77949
## 66      -149.61974      -17.57443
## 67        42.92435       11.77949
## 68        42.92435       11.77949
## 69      -151.45526      -16.67674
## 70      -151.45526      -16.67674
## 71        42.92435       11.77949
## 72      -151.39184      -16.78944
## 73        43.22408       11.73035
## 74        42.79607       11.58261
## 75        43.22408       11.73035
## 76        43.22408       11.73035
## 77        42.79607       11.58261
## 78      -151.45526      -16.67674
## 79      -151.45526      -16.67674
## 80        43.22408       11.73035
## 81        42.79607       11.58261
## 82        42.79607       11.58261
## 83        42.79607       11.58261
## 84        42.79607       11.58261
## 85        42.79607       11.58261
## 86      -149.89685      -17.48969
```

```
## 87         42.92435         11.77949
## 88         42.92435         11.77949
## 89         42.92435         11.77949
## 90         42.92435         11.77949
## 91         42.92435         11.77949
```

```
#geographic data frame - haversine distance
d.geo = distm(geo, fun = distVincentyEllipsoid)
dist.geo = as.dist(d.geo)
```

```
##Bray-Curtis
bray.dist = phyloseq::distance(ps13, "bray")
```

```
#bray vs geographic
bray_geo  = mantel(bray.dist, dist.geo, method = "spearman", permutations = 9999, na.rm = TRUE)
bray_geo
```

```
##
## Mantel statistic based on Spearman's rank correlation rho
##
## Call:
## mantel(xdis = bray.dist, ydis = dist.geo, method = "spearman",      permutations = 9999, na.rm = TRUI
##
## Mantel statistic r: 0.3712
##       Significance: 1e-04
##
## Upper quantiles of permutations (null model):
##    90%    95%  97.5%    99%
## 0.0201 0.0313 0.0421 0.0570
## Permutation: free
## Number of permutations: 9999
```

```
#Bray vs environ

temp = sam_ps13$SST_a
##bleach = sam_ps13$Tbl_bin

#environmental vectors - euclidean distance
dist.temp = dist(temp, method = "euclidean")
##dist.bleach = dist(bleach, method = "euclidean")

bray_temp  = mantel(bray.dist, dist.temp, method = "spearman", permutations = 9999, na.rm = TRUE)
#bray_bleach  = mantel(bray.dist, dist.bleach, method = "spearman", permutations = 9999, na.rm = TRUE)
```

```
##summary results

bray_temp
```

```
##
## Mantel statistic based on Spearman's rank correlation rho
##
## Call:
```

```
## mantel(xdis = bray.dist, ydis = dist.temp, method = "spearman",      permutations = 9999, na.rm = TRU
##
## Mantel statistic r: 0.409
##       Significance: 1e-04
##
## Upper quantiles of permutations (null model):
##    90%    95%  97.5%    99%
## 0.0220 0.0326 0.0438 0.0582
## Permutation: free
## Number of permutations: 9999
```

```
#bray_Bleach
```

```
##Prepare for network analysis; plot only top20OTU as too complicated to visualize with full dataset

##Set random seed for reproducibility
set.seed(711L)

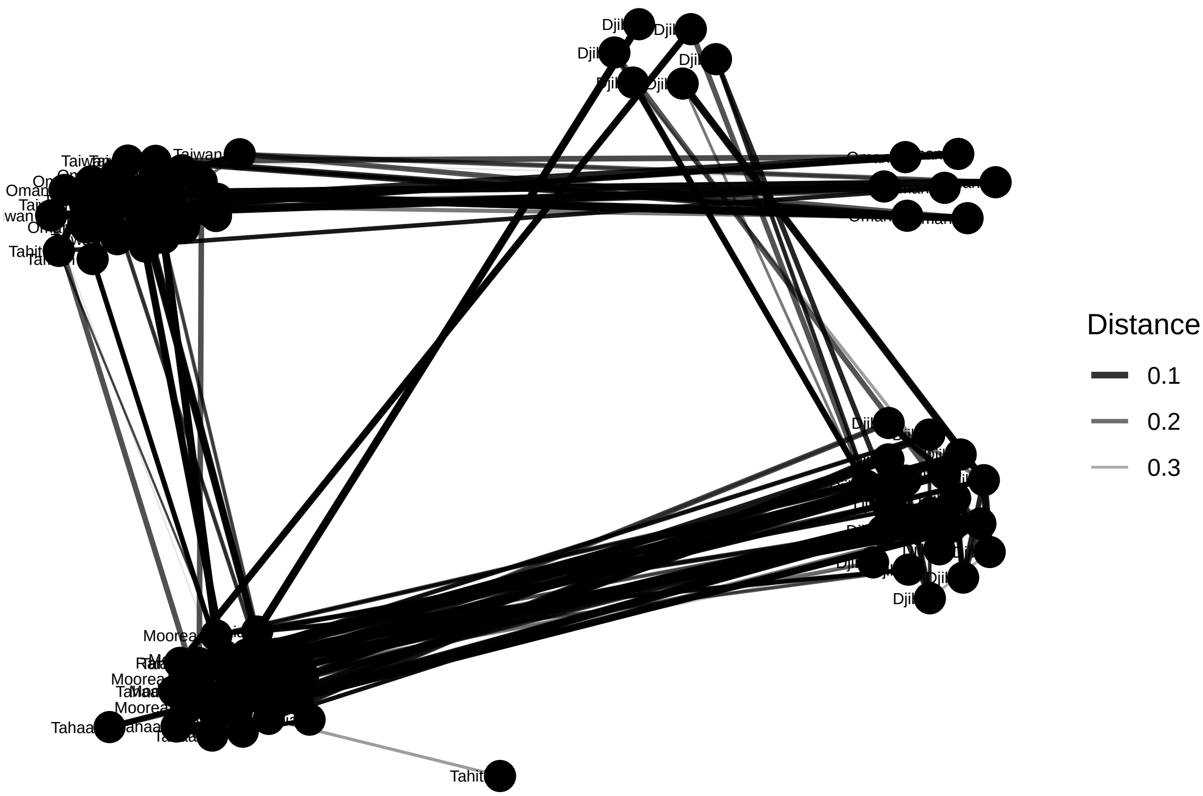
#Sort the OTUs by abundance and pick the top 20
top20OTU.names = names(sort(taxa_sums(ps13), TRUE)[1:20])

#Cut down the physeq.tree data to only the top 20
top20OTU = prune_taxa(top20OTU.names, ps13)

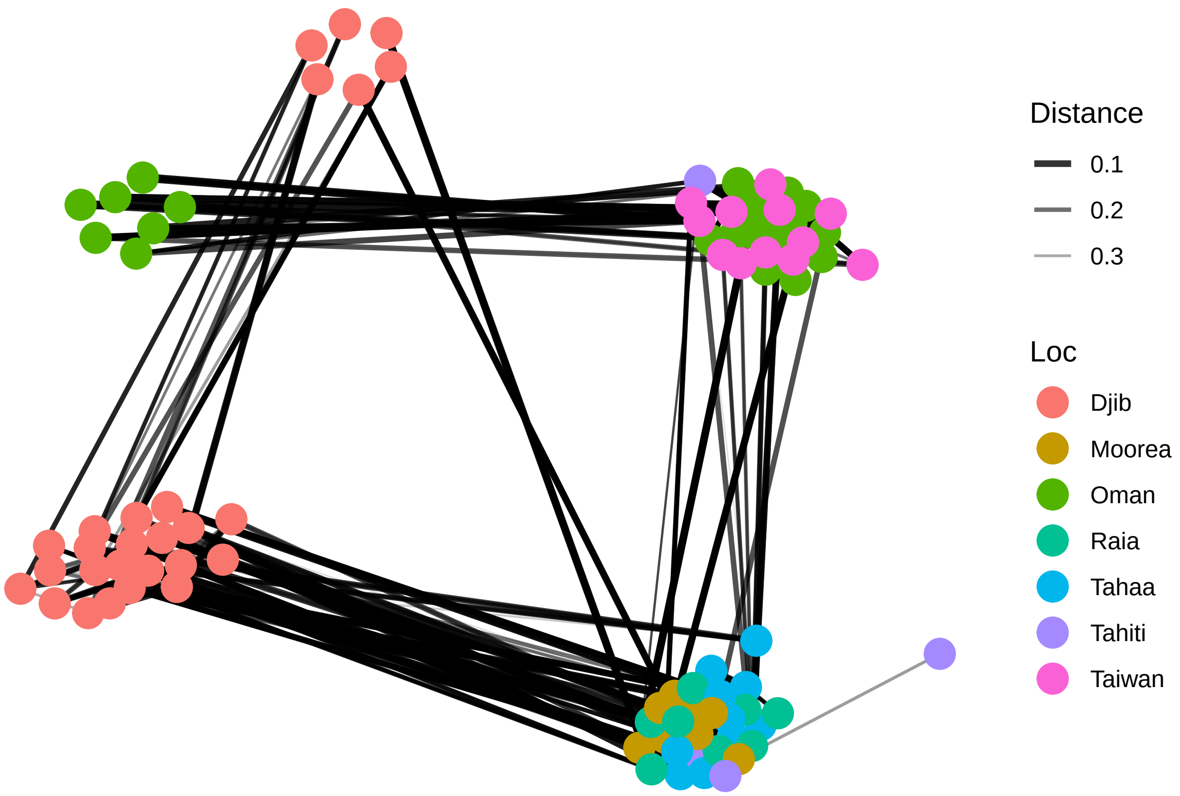
top20OTU
```

```
## phyloseq-class experiment-level object
## otu_table()   OTU Table:         [ 20 taxa and 91 samples ]
## sample_data() Sample Data:       [ 91 samples by 21 sample variables ]
## tax_table()   Taxonomy Table:    [ 20 taxa by 2 taxonomic ranks ]
## phy_tree()    Phylogenetic Tree: [ 20 tips and 19 internal nodes ]
```

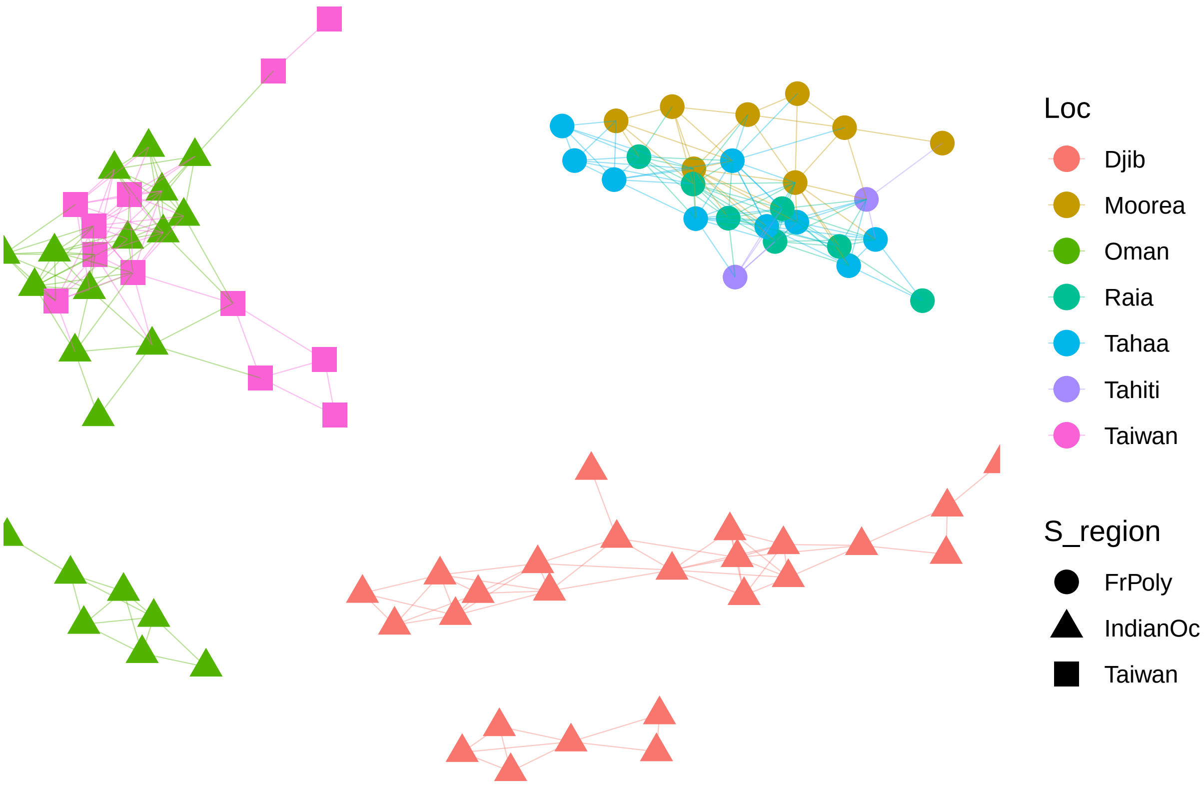
```
#Default settings as a trial
plot_net(top20OTU, maxdist = 0.4, point_label = "Loc")
```




```r
##Visualize species and location
plot_net(top20OTU, maxdist = 0.4, color = "Loc")
```

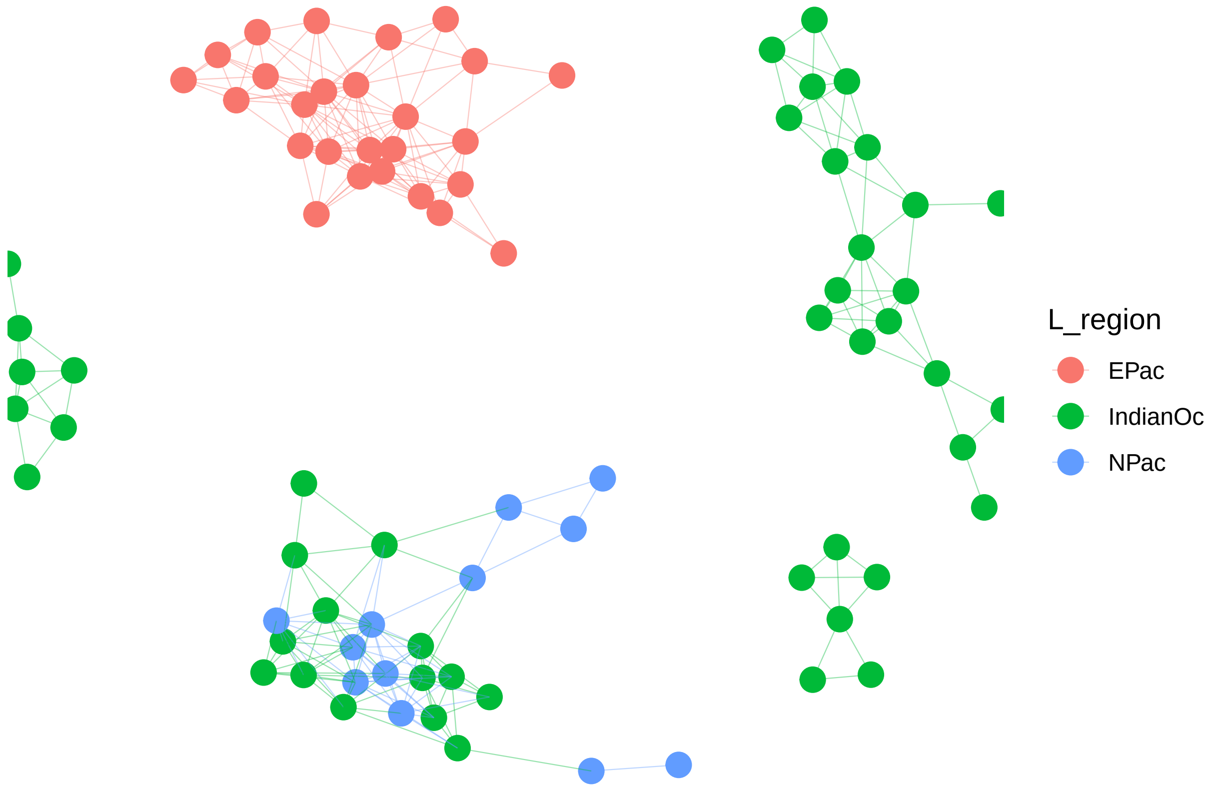



```
## Now explicitly include Bray-Curtis distances

ig <- make_network(top200TU, dist.fun="bray", max.dist=0.3)
ig2 <- plot_network(ig, top200TU, color="Loc", shape = "S_region", line_weight=0.2, label=NULL) +  scal
par(mar=c(1,1,1,1))
ig2
```




```
ggsave("network_pdam_16Sep2021.pdf", width = 30, height = 20, dpi = 300)
```

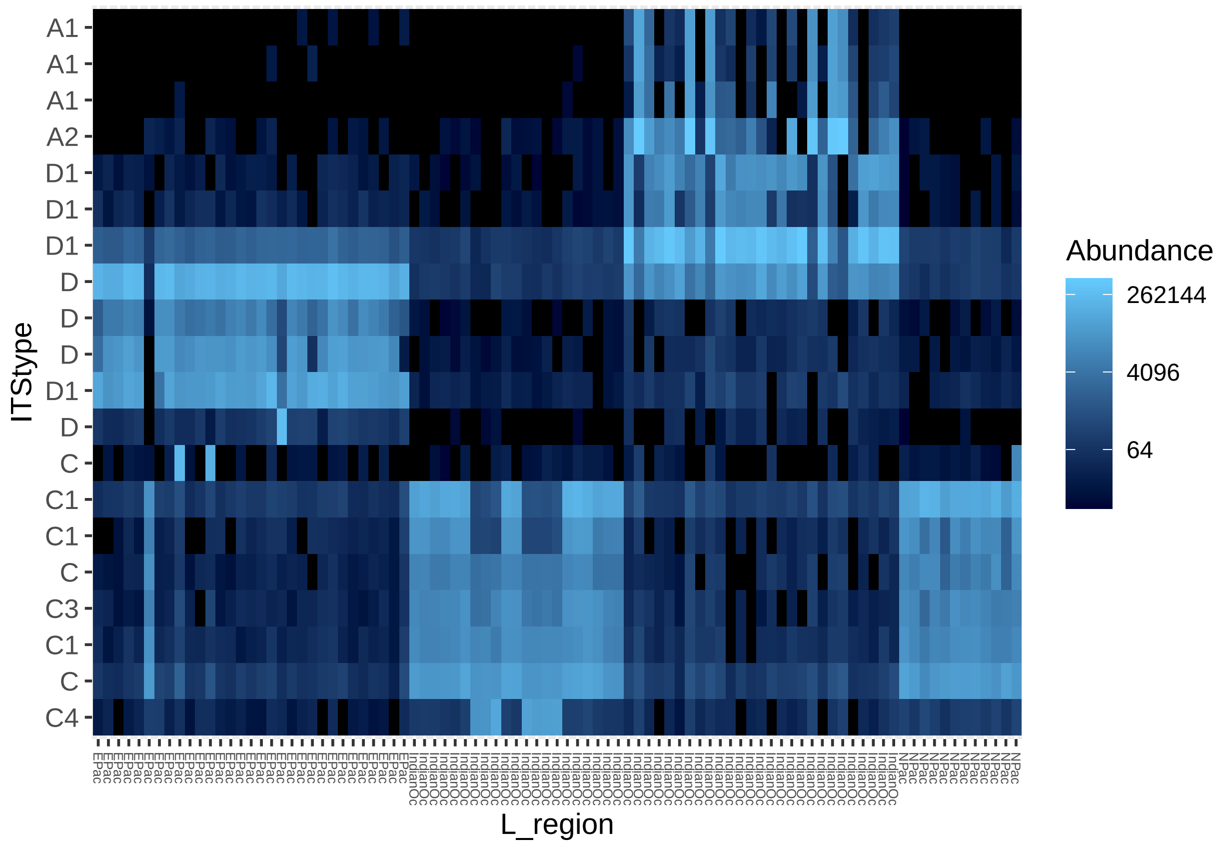
```
ig3 <- plot_network(ig, top20OTU, color="L_region", line_weight=0.2, label=NULL) +  scale_x_discrete(li
ig3
```




```
ggsave("network_pdam_lregion.pdf", width = 30, height = 20, dpi = 600)
```

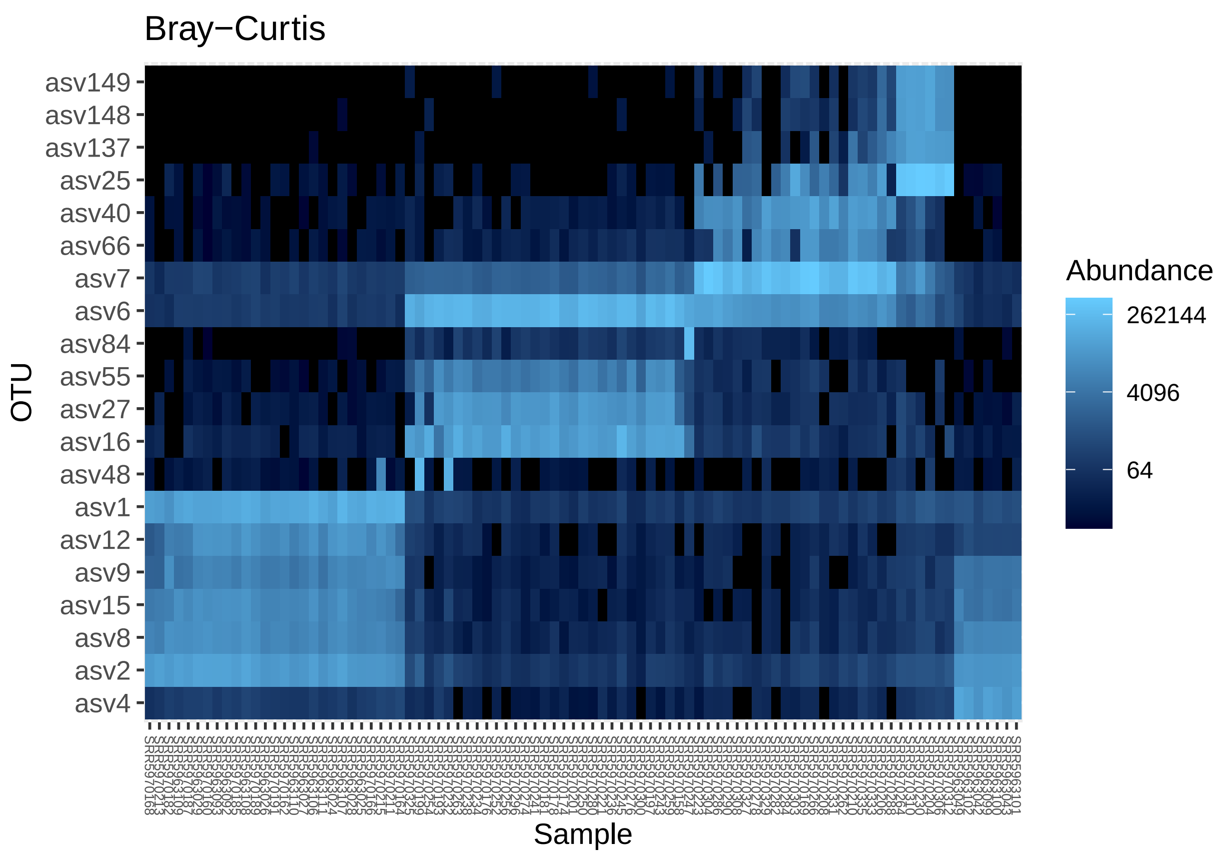
```
##Heatmap

plot_heatmap(top20OTU, sample.label="L_region", sample.order="L_region", taxa.label="ITStype")
```

```
## Warning: Transformation introduced infinite values in discrete y-axis
```




```r
plot_heatmap(top20OTU, "NMDS", "bray", title="Bray-Curtis")
```

```
## Warning: Transformation introduced infinite values in discrete y-axis
```




```
##IndicSpecies

##s_loc <- simper(asv_css, meta$Loc, permutations=100)
#3s_season <- simper(asv_css, meta$Season, permutations=100)
##s_dhw <- simper(asv_css, meta$DHW, permutations=100)
##s_sregion <- simper(asv_css, meta$Loc, permutations=100)
##s_lregion <- simper(asv_css, meta$Season, permutations=100)

set.seed(15673)
library(xlsx)
library(data.table)
```

```
##
## Attaching package: 'data.table'

## The following object is masked from 'package:SummarizedExperiment':
##
##     shift

## The following object is masked from 'package:GenomicRanges':
##
##     shift

## The following object is masked from 'package:IRanges':
##
##     shift
```

```
## The following objects are masked from 'package:S4Vectors':
##
##     first, second

## The following objects are masked from 'package:reshape2':
##
##     dcast, melt

## The following objects are masked from 'package:dplyr':
##
##     between, first, last

## The following object is masked from 'package:purrr':
##
##     transpose
```

```
inv_loc = multipatt(asv_css, meta$Loc, func = "IndVal.g", control = how(nperm=999))
summary(inv_loc)
```

```
##
##  Multilevel pattern analysis
##  ---------------------------
##
##  Association function: IndVal.g
##  Significance level (alpha): 0.05
##
##  Total number of species: 435
##  Selected number of species: 330
##  Number of species associated to 1 group: 108
##  Number of species associated to 2 groups: 114
##  Number of species associated to 3 groups: 62
##  Number of species associated to 4 groups: 39
##  Number of species associated to 5 groups: 5
##  Number of species associated to 6 groups: 2
##
##  List of species associated to each combination:
##
##  Group Djib  #sps.  23
##          stat p.value
## asv40   0.980   0.001 ***
## asv145  0.948   0.001 ***
## asv25   0.943   0.001 ***
## asv474  0.924   0.001 ***
## asv459  0.918   0.001 ***
## asv553  0.914   0.001 ***
## asv529  0.914   0.001 ***
## asv501  0.901   0.001 ***
## asv1471 0.899   0.001 ***
## asv1203 0.893   0.001 ***
## asv1050 0.890   0.001 ***
## asv453  0.888   0.001 ***
## asv1194 0.885   0.001 ***
## asv148  0.882   0.001 ***
```

```
## asv449  0.882   0.001 ***
## asv1600 0.875   0.001 ***
## asv2105 0.873   0.001 ***
## asv149  0.860   0.001 ***
## asv156  0.854   0.001 ***
## asv137  0.839   0.001 ***
## asv201  0.837   0.001 ***
## asv598  0.767   0.004 **
## asv780  0.766   0.001 ***
##
##  Group Moorea  #sps.  6
##          stat p.value
## asv74   0.999   0.001 ***
## asv533  0.961   0.001 ***
## asv1777 0.707   0.001 ***
## asv816  0.701   0.002 **
## asv857  0.700   0.003 **
## asv318  0.620   0.005 **
##
##  Group Oman  #sps.  51
##          stat p.value
## asv351  0.872   0.001 ***
## asv516  0.814   0.001 ***
## asv535  0.769   0.001 ***
## asv328  0.759   0.001 ***
## asv139  0.753   0.001 ***
## asv348  0.750   0.001 ***
## asv477  0.716   0.002 **
## asv191  0.706   0.003 **
## asv383  0.695   0.002 **
## asv1897 0.690   0.002 **
## asv3104 0.690   0.001 ***
## asv305  0.689   0.003 **
## asv3329 0.657   0.002 **
## asv177  0.648   0.003 **
## asv2341 0.647   0.004 **
## asv899  0.641   0.002 **
## asv121  0.617   0.003 **
## asv486  0.617   0.008 **
## asv161  0.614   0.010 **
## asv450  0.614   0.006 **
## asv784  0.613   0.004 **
## asv414  0.613   0.005 **
## asv160  0.610   0.009 **
## asv317  0.594   0.010 **
## asv150  0.577   0.006 **
## asv288  0.577   0.006 **
## asv295  0.577   0.005 **
## asv388  0.577   0.005 **
## asv462  0.577   0.006 **
## asv468  0.577   0.006 **
## asv1037 0.577   0.005 **
## asv1039 0.577   0.005 **
## asv1982 0.577   0.004 **
```

```
## asv428  0.576   0.011 *
## asv479  0.571   0.009 **
## asv1799 0.569   0.007 **
## asv460  0.563   0.009 **
## asv248  0.557   0.017 *
## asv47   0.535   0.015 *
## asv138  0.535   0.009 **
## asv1686 0.535   0.020 *
## asv1693 0.535   0.010 **
## asv335  0.533   0.009 **
## asv147  0.528   0.030 *
## asv1265 0.519   0.026 *
## asv426  0.488   0.029 *
## asv703  0.488   0.034 *
## asv2051 0.488   0.025 *
## asv2631 0.488   0.035 *
## asv3414 0.488   0.032 *
## asv280  0.436   0.038 *
##
##  Group Taiwan  #sps.  28
##          stat p.value
## asv105  0.996   0.001 ***
## asv164  0.986   0.001 ***
## asv78   0.966   0.001 ***
## asv70   0.962   0.001 ***
## asv159  0.947   0.001 ***
## asv235  0.933   0.001 ***
## asv187  0.929   0.001 ***
## asv223  0.926   0.001 ***
## asv60   0.912   0.001 ***
## asv154  0.905   0.001 ***
## asv233  0.904   0.001 ***
## asv236  0.904   0.001 ***
## asv68   0.902   0.001 ***
## asv232  0.900   0.001 ***
## asv200  0.898   0.001 ***
## asv243  0.897   0.001 ***
## asv39   0.887   0.001 ***
## asv444  0.876   0.001 ***
## asv80   0.722   0.001 ***
## asv1149 0.719   0.001 ***
## asv42   0.681   0.002 **
## asv101  0.645   0.001 ***
## asv1594 0.619   0.008 **
## asv943  0.589   0.003 **
## asv215  0.577   0.008 **
## asv1093 0.548   0.006 **
## asv192  0.500   0.008 **
## asv613  0.442   0.035 *
##
##  Group Djib+Raia  #sps.  1
##         stat p.value
## asv952 0.866   0.001 ***
##
```

```
##  Group Djib+Tahiti  #sps.  1
##        stat p.value
## asv848 0.828   0.002 **
##
##  Group Moorea+Tahiti  #sps.  5
##        stat p.value
## asv249 0.996   0.001 ***
## asv95  0.911   0.001 ***
## asv415 0.827   0.001 ***
## asv463 0.650   0.006 **
## asv585 0.452   0.041 *
##
##  Group Oman+Tahiti  #sps.  6
##         stat p.value
## asv531  0.782   0.006 **
## asv519  0.760   0.001 ***
## asv52   0.679   0.002 **
## asv1544 0.604   0.008 **
## asv2663 0.588   0.008 **
## asv254  0.542   0.049 *
##
##  Group Oman+Taiwan  #sps.  95
##         stat p.value
## asv133  0.991   0.001 ***
## asv67   0.990   0.001 ***
## asv19   0.987   0.001 ***
## asv89   0.987   0.001 ***
## asv30   0.986   0.001 ***
## asv117  0.983   0.001 ***
## asv38   0.982   0.001 ***
## asv112  0.982   0.001 ***
## asv267  0.981   0.001 ***
## asv176  0.980   0.001 ***
## asv35   0.979   0.001 ***
## asv152  0.977   0.001 ***
## asv88   0.976   0.001 ***
## asv26   0.974   0.001 ***
## asv211  0.972   0.001 ***
## asv46   0.971   0.001 ***
## asv54   0.970   0.001 ***
## asv476  0.969   0.001 ***
## asv239  0.968   0.001 ***
## asv106  0.965   0.001 ***
## asv119  0.962   0.001 ***
## asv611  0.962   0.001 ***
## asv332  0.954   0.001 ***
## asv271  0.954   0.001 ***
## asv399  0.953   0.001 ***
## asv605  0.953   0.001 ***
## asv73   0.952   0.001 ***
## asv94   0.951   0.001 ***
## asv498  0.951   0.001 ***
## asv153  0.947   0.001 ***
## asv312  0.946   0.001 ***
```

```
## asv163  0.944   0.001 ***
## asv302  0.942   0.001 ***
## asv127  0.941   0.001 ***
## asv41   0.941   0.001 ***
## asv85   0.935   0.001 ***
## asv123  0.935   0.001 ***
## asv51   0.934   0.001 ***
## asv746  0.928   0.001 ***
## asv440  0.927   0.001 ***
## asv22   0.926   0.001 ***
## asv2013 0.921   0.001 ***
## asv226  0.918   0.001 ***
## asv107  0.916   0.001 ***
## asv90   0.913   0.001 ***
## asv128  0.896   0.001 ***
## asv556  0.890   0.001 ***
## asv240  0.889   0.001 ***
## asv71   0.881   0.001 ***
## asv322  0.870   0.001 ***
## asv155  0.862   0.001 ***
## asv946  0.862   0.001 ***
## asv368  0.862   0.001 ***
## asv1252 0.856   0.001 ***
## asv543  0.853   0.001 ***
## asv1310 0.853   0.001 ***
## asv406  0.846   0.001 ***
## asv772  0.843   0.001 ***
## asv132  0.836   0.001 ***
## asv227  0.835   0.001 ***
## asv157  0.833   0.001 ***
## asv1601 0.824   0.001 ***
## asv202  0.822   0.001 ***
## asv1360 0.821   0.001 ***
## asv179  0.816   0.001 ***
## asv381  0.816   0.001 ***
## asv402  0.816   0.001 ***
## asv323  0.814   0.001 ***
## asv144  0.813   0.001 ***
## asv393  0.798   0.001 ***
## asv1886 0.787   0.001 ***
## asv2248 0.778   0.001 ***
## asv180  0.754   0.003 **
## asv1729 0.754   0.002 **
## asv827  0.748   0.001 ***
## asv940  0.739   0.001 ***
## asv1124 0.739   0.001 ***
## asv2157 0.739   0.001 ***
## asv1216 0.730   0.001 ***
## asv2075 0.718   0.002 **
## asv2356 0.718   0.001 ***
## asv2805 0.718   0.001 ***
## asv2486 0.696   0.002 **
## asv2916 0.696   0.001 ***
## asv654  0.651   0.001 ***
```

```
## asv2701 0.651   0.002 **
## asv82   0.603   0.005 **
## asv188  0.603   0.009 **
## asv1085 0.603   0.005 **
## asv3304 0.603   0.006 **
## asv265  0.577   0.010 **
## asv427  0.577   0.008 **
## asv321  0.550   0.014 *
## asv1256 0.550   0.014 *
## asv1019 0.492   0.027 *
##
##  Group Raia+Tahaa  #sps.  3
##          stat p.value
## asv286  0.996   0.001 ***
## asv270  0.969   0.001 ***
## asv1359 0.848   0.001 ***
##
##  Group Raia+Tahiti  #sps.  1
##          stat p.value
## asv1131 0.516   0.019 *
##
##  Group Tahiti+Taiwan  #sps.  2
##         stat p.value
## asv753 0.733   0.001 ***
## asv770 0.692   0.004 **
##
##  Group Djib+Moorea+Tahiti  #sps.  1
##         stat p.value
## asv639 0.842   0.001 ***
##
##  Group Djib+Raia+Tahaa  #sps.  1
##        stat p.value
## asv66 0.986   0.001 ***
##
##  Group Moorea+Raia+Tahaa  #sps.  6
##          stat p.value
## asv91   0.999   0.001 ***
## asv166  0.996   0.001 ***
## asv205  0.994   0.001 ***
## asv129  0.990   0.001 ***
## asv559  0.985   0.001 ***
## asv1864 0.858   0.001 ***
##
##  Group Moorea+Raia+Tahiti  #sps.  1
##         stat p.value
## asv836 0.535   0.029 *
##
##  Group Oman+Raia+Taiwan  #sps.  2
##          stat p.value
## asv4    0.995   0.001 ***
## asv3180 0.541   0.016 *
##
##  Group Oman+Tahiti+Taiwan  #sps.  50
##          stat p.value
```

```
## asv33   0.999   0.001 ***
## asv12   0.998   0.001 ***
## asv24   0.972   0.001 ***
## asv44   0.971   0.001 ***
## asv37   0.957   0.001 ***
## asv131  0.956   0.001 ***
## asv863  0.956   0.001 ***
## asv79   0.956   0.001 ***
## asv87   0.953   0.001 ***
## asv136  0.946   0.001 ***
## asv167  0.946   0.001 ***
## asv537  0.946   0.001 ***
## asv609  0.946   0.001 ***
## asv1476 0.932   0.001 ***
## asv607  0.926   0.001 ***
## asv108  0.913   0.001 ***
## asv229  0.903   0.001 ***
## asv563  0.903   0.001 ***
## asv347  0.889   0.001 ***
## asv13   0.882   0.001 ***
## asv1448 0.863   0.001 ***
## asv1156 0.843   0.001 ***
## asv283  0.843   0.001 ***
## asv859  0.843   0.001 ***
## asv1863 0.843   0.001 ***
## asv17   0.827   0.001 ***
## asv185  0.827   0.002 **
## asv269  0.827   0.001 ***
## asv788  0.827   0.001 ***
## asv134  0.811   0.001 ***
## asv125  0.798   0.001 ***
## asv182  0.778   0.002 **
## asv209  0.778   0.001 ***
## asv1108 0.775   0.001 ***
## asv371  0.769   0.001 ***
## asv264  0.761   0.001 ***
## asv922  0.743   0.001 ***
## asv2804 0.743   0.001 ***
## asv405  0.707   0.001 ***
## asv735  0.707   0.001 ***
## asv1247 0.707   0.001 ***
## asv1810 0.707   0.001 ***
## asv505  0.688   0.005 **
## asv825  0.669   0.005 **
## asv2329 0.669   0.003 **
## asv175  0.607   0.014 *
## asv1784 0.607   0.007 **
## asv2718 0.607   0.008 **
## asv446  0.513   0.015 *
## asv242  0.487   0.046 *
##
##  Group Raia+Tahiti+Taiwan  #sps.  1
##        stat p.value
## asv48 0.872    0.03 *
```

```
##
##  Group Djib+Moorea+Raia+Tahiti  #sps.  1
##        stat p.value
## asv49 0.959   0.001 ***
##
##  Group Djib+Oman+Tahiti+Taiwan  #sps.  1
##        stat p.value
## asv43 0.804    0.01 **
##
##  Group Moorea+Raia+Tahaa+Tahiti  #sps.  37
##          stat p.value
## asv81   1.000   0.001 ***
## asv55   0.999   0.001 ***
## asv62   0.999   0.001 ***
## asv84   0.984   0.017 *
## asv16   0.983   0.003 **
## asv27   0.983   0.001 ***
## asv110  0.983   0.001 ***
## asv417  0.983   0.001 ***
## asv260  0.980   0.001 ***
## asv558  0.975   0.001 ***
## asv431  0.972   0.001 ***
## asv245  0.972   0.001 ***
## asv237  0.968   0.001 ***
## asv862  0.967   0.001 ***
## asv429  0.967   0.001 ***
## asv447  0.967   0.001 ***
## asv467  0.967   0.001 ***
## asv109  0.966   0.001 ***
## asv1031 0.965   0.001 ***
## asv1258 0.964   0.001 ***
## asv327  0.964   0.001 ***
## asv1475 0.963   0.001 ***
## asv820  0.963   0.001 ***
## asv955  0.960   0.001 ***
## asv1778 0.957   0.001 ***
## asv293  0.955   0.001 ***
## asv1785 0.951   0.001 ***
## asv767  0.950   0.001 ***
## asv396  0.948   0.001 ***
## asv1931 0.944   0.001 ***
## asv1465 0.933   0.001 ***
## asv357  0.933   0.001 ***
## asv730  0.904   0.001 ***
## asv297  0.898   0.001 ***
## asv2828 0.880   0.001 ***
## asv142  0.880   0.001 ***
## asv2150 0.835   0.001 ***
##
##  Group Djib+Moorea+Raia+Tahaa+Tahiti  #sps.  3
##          stat p.value
## asv359  0.937   0.001 ***
## asv682  0.927   0.001 ***
## asv1749 0.861   0.001 ***
```

```
##
##  Group Oman+Raia+Tahaa+Tahiti+Taiwan  #sps.  2
##        stat p.value
## asv15 0.998   0.001 ***
## asv9  0.998   0.001 ***
##
##  Group Djib+Moorea+Raia+Tahaa+Tahiti+Taiwan  #sps.  1
##        stat p.value
## asv23 0.999   0.001 ***
##
##  Group Moorea+Oman+Raia+Tahaa+Tahiti+Taiwan  #sps.  1
##       stat p.value
## asv8 0.999   0.001 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
indisp.sign<-as.data.table(inv_loc$sign, keep.rownames=TRUE)
#add adjusted p-value
indisp.sign[ ,p.value.bh:=p.adjust(p.value, method="BH")]
#now can select only the indicators with adjusted significant p-values

IndVal_loc = indisp.sign[p.value.bh<=0.05, ]
IndVal_loc
```

```
##           rn s.Djib s.Moorea s.Oman s.Raia s.Tahaa s.Tahiti s.Taiwan index
##   1:    asv4      0        0      1      1       0        0        1    56
##   2:    asv8      0        1      1      1       1        1        1   126
##   3:    asv9      0        0      1      1       1        1        1   119
##   4:   asv12      0        0      1      0       0        1        1    59
##   5:   asv13      0        0      1      0       0        1        1    59
##  ---
## 324: asv3104      0        0      1      0       0        0        0     3
## 325: asv3180      0        0      1      1       0        0        1    56
## 326: asv3304      0        0      1      0       0        0        1    22
## 327: asv3329      0        0      1      0       0        0        0     3
## 328: asv3414      0        0      1      0       0        0        0     3
##           stat p.value  p.value.bh
##   1: 0.9953327   0.001 0.001574468
##   2: 0.9990148   0.001 0.001574468
##   3: 0.9980955   0.001 0.001574468
##   4: 0.9979479   0.001 0.001574468
##   5: 0.8816859   0.001 0.001574468
##  ---
## 324: 0.6900656   0.001 0.001574468
## 325: 0.5410018   0.016 0.019035370
## 326: 0.6030227   0.006 0.007844523
## 327: 0.6574373   0.002 0.002960000
## 328: 0.4879500   0.032 0.036656347
```

```r
write.xlsx(IndVal_loc, file = "IndVal_loc_16Sep2021.xlsx")
```

```r
inv_blc = multipatt(asv_css, meta$Tbl_bin, func = "IndVal.g", control = how(nperm=999))
summary(inv_blc)
```

```
##
##  Multilevel pattern analysis
##  ---------------------------
##
##  Association function: IndVal.g
##  Significance level (alpha): 0.05
##
##  Total number of species: 435
##  Selected number of species: 96
##  Number of species associated to 1 group: 96
##
##  List of species associated to each combination:
##
##  Group Long  #sps.  51
##          stat p.value
## asv40   0.896   0.002 **
## asv25   0.856   0.001 ***
## asv145  0.740   0.001 ***
## asv201  0.707   0.001 ***
## asv553  0.705   0.001 ***
## asv156  0.694   0.002 **
## asv639  0.682   0.002 **
## asv453  0.665   0.002 **
## asv952  0.664   0.002 **
## asv474  0.661   0.022 *
## asv1050 0.658   0.002 **
## asv148  0.655   0.001 ***
## asv1203 0.653   0.001 ***
## asv459  0.653   0.002 **
## asv529  0.652   0.003 **
## asv501  0.640   0.003 **
## asv88   0.638   0.023 *
## asv1471 0.635   0.001 ***
## asv1600 0.635   0.002 **
## asv2105 0.632   0.001 ***
## asv1194 0.622   0.003 **
## asv149  0.612   0.003 **
## asv449  0.612   0.002 **
## asv137  0.598   0.003 **
## asv598  0.566   0.006 **
## asv780  0.566   0.005 **
## asv351  0.554   0.018 *
## asv191  0.514   0.025 *
## asv516  0.499   0.005 **
## asv535  0.497   0.002 **
## asv139  0.481   0.030 *
## asv348  0.480   0.015 *
## asv519  0.471   0.011 *
## asv328  0.468   0.031 *
## asv477  0.439   0.023 *
```

```
## asv1897 0.423   0.011 *
## asv3104 0.423   0.008 **
## asv305  0.422   0.035 *
## asv160  0.401   0.020 *
## asv784  0.401   0.026 *
## asv899  0.398   0.033 *
## asv121  0.378   0.030 *
## asv460  0.378   0.031 *
## asv486  0.378   0.035 *
## asv150  0.354   0.041 *
## asv288  0.354   0.047 *
## asv462  0.354   0.049 *
## asv468  0.354   0.045 *
## asv1037 0.354   0.046 *
## asv1039 0.354   0.046 *
## asv1982 0.354   0.048 *
##
##  Group Recent  #sps.  45
##          stat p.value
## asv55   0.897   0.001 ***
## asv48   0.861   0.004 **
## asv84   0.827   0.030 *
## asv286  0.809   0.001 ***
## asv129  0.802   0.001 ***
## asv109  0.800   0.001 ***
## asv81   0.798   0.001 ***
## asv205  0.787   0.001 ***
## asv270  0.773   0.001 ***
## asv142  0.760   0.001 ***
## asv1465 0.746   0.001 ***
## asv1778 0.745   0.001 ***
## asv767  0.734   0.001 ***
## asv558  0.731   0.001 ***
## asv1931 0.705   0.001 ***
## asv396  0.704   0.002 **
## asv1031 0.704   0.002 **
## asv1785 0.696   0.001 ***
## asv2828 0.685   0.001 ***
## asv862  0.665   0.003 **
## asv357  0.662   0.004 **
## asv1359 0.634   0.001 ***
## asv297  0.614   0.003 **
## asv105  0.608   0.001 ***
## asv78   0.592   0.005 **
## asv70   0.588   0.002 **
## asv187  0.587   0.006 **
## asv235  0.586   0.002 **
## asv159  0.584   0.001 ***
## asv164  0.577   0.005 **
## asv232  0.570   0.009 **
## asv200  0.569   0.007 **
## asv154  0.563   0.025 *
## asv68   0.555   0.011 *
## asv444  0.552   0.011 *
```

```
## asv39   0.546   0.021 *
## asv223  0.538   0.023 *
## asv60   0.530   0.022 *
## asv753  0.510   0.010 **
## asv264  0.509   0.027 *
## asv42   0.477   0.002 **
## asv80   0.421   0.019 *
## asv101  0.378   0.009 **
## asv1131 0.350   0.024 *
## asv215  0.338   0.018 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
indisp.sign<-as.data.table(inv_blc$sign, keep.rownames=TRUE)
#add adjusted p-value
indisp.sign[ ,p.value.bh:=p.adjust(p.value, method="BH")]
#now can select only the indicators with adjusted significant p-values

IndVal_blc = indisp.sign[p.value.bh<=0.05, ]
IndVal_blc
```

```
##          rn s.Long s.Recent index      stat p.value  p.value.bh
##  1:   asv25      1        0     1 0.8556200   0.001 0.006000000
##  2:   asv39      0        1     2 0.5464411   0.021 0.046140845
##  3:   asv40      1        0     1 0.8960228   0.002 0.007609756
##  4:   asv42      0        1     2 0.4773189   0.002 0.007609756
##  5:   asv48      0        1     2 0.8614219   0.004 0.012480000
##  6:   asv55      0        1     2 0.8968675   0.001 0.006000000
##  7:   asv60      0        1     2 0.5297407   0.022 0.047013699
##  8:   asv68      0        1     2 0.5548573   0.011 0.026400000
##  9:   asv70      0        1     2 0.5879262   0.002 0.007609756
## 10:   asv78      0        1     2 0.5921531   0.005 0.014444444
## 11:   asv80      0        1     2 0.4208911   0.019 0.042956522
## 12:   asv81      0        1     2 0.7983603   0.001 0.006000000
## 13:   asv88      1        0     1 0.6376096   0.023 0.047210526
## 14:  asv101      0        1     2 0.3779645   0.009 0.023400000
## 15:  asv105      0        1     2 0.6077233   0.001 0.006000000
## 16:  asv109      0        1     2 0.8002843   0.001 0.006000000
## 17:  asv129      0        1     2 0.8022506   0.001 0.006000000
## 18:  asv137      1        0     1 0.5975967   0.003 0.009750000
## 19:  asv142      0        1     2 0.7598660   0.001 0.006000000
## 20:  asv145      1        0     1 0.7400631   0.001 0.006000000
## 21:  asv148      1        0     1 0.6546537   0.001 0.006000000
## 22:  asv149      1        0     1 0.6123310   0.003 0.009750000
## 23:  asv154      0        1     2 0.5630697   0.025 0.049367089
## 24:  asv156      1        0     1 0.6941641   0.002 0.007609756
## 25:  asv159      0        1     2 0.5841520   0.001 0.006000000
## 26:  asv160      1        0     1 0.4008919   0.020 0.044571429
## 27:  asv164      0        1     2 0.5768880   0.005 0.014444444
## 28:  asv187      0        1     2 0.5868317   0.006 0.016714286
## 29:  asv191      1        0     1 0.5142148   0.025 0.049367089
## 30:  asv200      0        1     2 0.5688478   0.007 0.019157895
## 31:  asv201      1        0     1 0.7067211   0.001 0.006000000
## 32:  asv205      0        1     2 0.7873764   0.001 0.006000000
```

```
## 33:  asv215      0        1     2 0.3380617   0.018 0.041294118
## 34:  asv223      0        1     2 0.5384108   0.023 0.047210526
## 35:  asv232      0        1     2 0.5704446   0.009 0.023400000
## 36:  asv235      0        1     2 0.5856639   0.002 0.007609756
## 37:  asv270      0        1     2 0.7728419   0.001 0.006000000
## 38:  asv286      0        1     2 0.8093620   0.001 0.006000000
## 39:  asv297      0        1     2 0.6138627   0.003 0.009750000
## 40:  asv348      1        0     1 0.4802149   0.015 0.035454545
## 41:  asv351      1        0     1 0.5539321   0.018 0.041294118
## 42:  asv357      0        1     2 0.6617079   0.004 0.012480000
## 43:  asv396      0        1     2 0.7041406   0.002 0.007609756
## 44:  asv444      0        1     2 0.5522738   0.011 0.026400000
## 45:  asv449      1        0     1 0.6122777   0.002 0.007609756
## 46:  asv453      1        0     1 0.6648085   0.002 0.007609756
## 47:  asv459      1        0     1 0.6529337   0.002 0.007609756
## 48:  asv474      1        0     1 0.6613430   0.022 0.047013699
## 49:  asv477      1        0     1 0.4389702   0.023 0.047210526
## 50:  asv501      1        0     1 0.6402061   0.003 0.009750000
## 51:  asv516      1        0     1 0.4989422   0.005 0.014444444
## 52:  asv519      1        0     1 0.4712941   0.011 0.026400000
## 53:  asv529      1        0     1 0.6523065   0.003 0.009750000
## 54:  asv535      1        0     1 0.4968256   0.002 0.007609756
## 55:  asv553      1        0     1 0.7052576   0.001 0.006000000
## 56:  asv558      0        1     2 0.7312706   0.001 0.006000000
## 57:  asv598      1        0     1 0.5664184   0.006 0.016714286
## 58:  asv639      1        0     1 0.6822422   0.002 0.007609756
## 59:  asv753      0        1     2 0.5104382   0.010 0.025573770
## 60:  asv767      0        1     2 0.7343698   0.001 0.006000000
## 61:  asv780      1        0     1 0.5660152   0.005 0.014444444
## 62:  asv862      0        1     2 0.6651863   0.003 0.009750000
## 63:  asv952      1        0     1 0.6641044   0.002 0.007609756
## 64: asv1031      0        1     2 0.7035375   0.002 0.007609756
## 65: asv1050      1        0     1 0.6583165   0.002 0.007609756
## 66: asv1131      0        1     2 0.3504492   0.024 0.048623377
## 67: asv1194      1        0     1 0.6218406   0.003 0.009750000
## 68: asv1203      1        0     1 0.6532600   0.001 0.006000000
## 69: asv1359      0        1     2 0.6339334   0.001 0.006000000
## 70: asv1465      0        1     2 0.7455714   0.001 0.006000000
## 71: asv1471      1        0     1 0.6351243   0.001 0.006000000
## 72: asv1600      1        0     1 0.6347221   0.002 0.007609756
## 73: asv1778      0        1     2 0.7450212   0.001 0.006000000
## 74: asv1785      0        1     2 0.6959315   0.001 0.006000000
## 75: asv1897      1        0     1 0.4225771   0.011 0.026400000
## 76: asv1931      0        1     2 0.7045757   0.001 0.006000000
## 77: asv2105      1        0     1 0.6324148   0.001 0.006000000
## 78: asv2828      0        1     2 0.6851706   0.001 0.006000000
## 79: asv3104      1        0     1 0.4225771   0.008 0.021517241
##           rn s.Long s.Recent index      stat p.value  p.value.bh
```

```
write.xlsx(IndVal_blc, file = "IndVal_blc_16Sep2021.xlsx")
```

```
inv_sregion = multipatt(asv_css, meta$S_region, func = "IndVal.g", control = how(nperm=999))
summary(inv_sregion)
```

```
##
##  Multilevel pattern analysis
##  ---------------------------
##
##  Association function: IndVal.g
##  Significance level (alpha): 0.05
##
##  Total number of species: 435
##  Selected number of species: 278
##  Number of species associated to 1 group: 204
##  Number of species associated to 2 groups: 74
##
##  List of species associated to each combination:
##
##  Group FrPoly  #sps.  56
##          stat p.value
## asv81   0.999   0.001 ***
## asv55   0.998   0.001 ***
## asv62   0.997   0.001 ***
## asv84   0.983   0.001 ***
## asv16   0.983   0.001 ***
## asv27   0.983   0.001 ***
## asv110  0.981   0.001 ***
## asv205  0.981   0.001 ***
## asv129  0.979   0.001 ***
## asv260  0.974   0.001 ***
## asv862  0.967   0.001 ***
## asv109  0.965   0.001 ***
## asv166  0.965   0.001 ***
## asv558  0.963   0.001 ***
## asv417  0.963   0.001 ***
## asv431  0.959   0.001 ***
## asv237  0.951   0.001 ***
## asv559  0.950   0.001 ***
## asv767  0.950   0.001 ***
## asv429  0.948   0.001 ***
## asv447  0.948   0.001 ***
## asv467  0.947   0.001 ***
## asv1778 0.946   0.001 ***
## asv1031 0.945   0.001 ***
## asv1475 0.942   0.001 ***
## asv327  0.941   0.001 ***
## asv1258 0.941   0.001 ***
## asv293  0.940   0.001 ***
## asv820  0.938   0.001 ***
## asv245  0.937   0.001 ***
## asv955  0.935   0.001 ***
## asv1465 0.933   0.001 ***
## asv91   0.932   0.001 ***
## asv357  0.932   0.001 ***
## asv1785 0.928   0.001 ***
## asv396  0.924   0.001 ***
## asv1931 0.918   0.001 ***
## asv533  0.916   0.001 ***
```

```
## asv297  0.898   0.001 ***
## asv95   0.898   0.001 ***
## asv2828 0.880   0.001 ***
## asv142  0.879   0.001 ***
## asv270  0.878   0.001 ***
## asv730  0.871   0.001 ***
## asv249  0.860   0.001 ***
## asv286  0.860   0.001 ***
## asv682  0.843   0.001 ***
## asv2150 0.806   0.001 ***
## asv1864 0.777   0.001 ***
## asv74   0.761   0.009 **
## asv415  0.752   0.001 ***
## asv1359 0.673   0.001 ***
## asv463  0.569   0.009 **
## asv816  0.468   0.010 **
## asv836  0.440   0.020 *
## asv1777 0.432   0.034 *
##
##  Group IndianOc  #sps.  36
##          stat p.value
## asv25   0.890   0.001 ***
## asv145  0.772   0.002 **
## asv553  0.733   0.001 ***
## asv201  0.721   0.002 **
## asv1050 0.711   0.002 **
## asv459  0.705   0.001 ***
## asv156  0.702   0.002 **
## asv501  0.692   0.004 **
## asv529  0.689   0.003 **
## asv453  0.688   0.001 ***
## asv1471 0.686   0.001 ***
## asv2105 0.683   0.001 ***
## asv148  0.677   0.004 **
## asv1203 0.673   0.001 ***
## asv1194 0.671   0.001 ***
## asv1600 0.667   0.001 ***
## asv449  0.661   0.004 **
## asv137  0.645   0.003 **
## asv149  0.645   0.003 **
## asv598  0.594   0.023 *
## asv780  0.594   0.013 *
## asv191  0.552   0.029 *
## asv516  0.538   0.015 *
## asv535  0.537   0.010 **
## asv139  0.518   0.039 *
## asv348  0.518   0.017 *
## asv519  0.510   0.017 *
## asv477  0.468   0.028 *
## asv1897 0.456   0.026 *
## asv3104 0.456   0.024 *
## asv305  0.456   0.049 *
## asv160  0.433   0.047 *
## asv784  0.433   0.042 *
```

```
## asv899  0.430   0.044 *
## asv121  0.408   0.049 *
## asv486  0.408   0.048 *
##
##  Group Taiwan  #sps.  112
##          stat p.value
## asv105  0.998   0.001 ***
## asv164  0.994   0.001 ***
## asv78   0.987   0.001 ***
## asv70   0.984   0.001 ***
## asv235  0.978   0.001 ***
## asv187  0.968   0.001 ***
## asv223  0.965   0.001 ***
## asv154  0.962   0.001 ***
## asv22   0.962   0.001 ***
## asv60   0.958   0.001 ***
## asv68   0.958   0.001 ***
## asv236  0.956   0.001 ***
## asv226  0.955   0.001 ***
## asv159  0.955   0.001 ***
## asv232  0.955   0.001 ***
## asv233  0.954   0.001 ***
## asv200  0.954   0.001 ***
## asv243  0.951   0.001 ***
## asv85   0.948   0.001 ***
## asv67   0.948   0.001 ***
## asv136  0.941   0.001 ***
## asv211  0.940   0.001 ***
## asv39   0.928   0.001 ***
## asv444  0.903   0.001 ***
## asv71   0.898   0.001 ***
## asv33   0.891   0.001 ***
## asv46   0.876   0.001 ***
## asv605  0.871   0.001 ***
## asv112  0.869   0.001 ***
## asv35   0.865   0.001 ***
## asv127  0.860   0.001 ***
## asv332  0.860   0.001 ***
## asv41   0.858   0.001 ***
## asv1310 0.856   0.001 ***
## asv537  0.843   0.001 ***
## asv17   0.838   0.001 ***
## asv283  0.836   0.001 ***
## asv240  0.832   0.001 ***
## asv264  0.830   0.001 ***
## asv1360 0.827   0.001 ***
## asv611  0.814   0.001 ***
## asv153  0.814   0.001 ***
## asv179  0.812   0.001 ***
## asv167  0.811   0.001 ***
## asv128  0.810   0.001 ***
## asv607  0.806   0.001 ***
## asv772  0.806   0.001 ***
## asv753  0.805   0.001 ***
```

```
## asv609  0.805   0.001 ***
## asv498  0.802   0.001 ***
## asv90   0.799   0.001 ***
## asv157  0.794   0.001 ***
## asv863  0.793   0.001 ***
## asv543  0.783   0.001 ***
## asv229  0.783   0.001 ***
## asv38   0.782   0.002 **
## asv770  0.778   0.001 ***
## asv371  0.775   0.002 **
## asv393  0.773   0.001 ***
## asv1476 0.771   0.001 ***
## asv1149 0.769   0.001 ***
## asv51   0.769   0.001 ***
## asv119  0.766   0.001 ***
## asv134  0.765   0.002 **
## asv155  0.761   0.002 **
## asv922  0.750   0.001 ***
## asv271  0.747   0.001 ***
## asv123  0.746   0.001 ***
## asv80   0.745   0.001 ***
## asv180  0.736   0.001 ***
## asv827  0.727   0.001 ***
## asv2013 0.726   0.001 ***
## asv132  0.725   0.001 ***
## asv125  0.723   0.002 **
## asv322  0.723   0.001 ***
## asv399  0.720   0.001 ***
## asv381  0.715   0.001 ***
## asv1601 0.715   0.001 ***
## asv1886 0.706   0.001 ***
## asv940  0.705   0.002 **
## asv42   0.702   0.001 ***
## asv2916 0.690   0.001 ***
## asv2329 0.687   0.001 ***
## asv227  0.678   0.001 ***
## asv2356 0.671   0.001 ***
## asv1156 0.670   0.004 **
## asv1594 0.664   0.001 ***
## asv144  0.646   0.001 ***
## asv209  0.646   0.001 ***
## asv101  0.645   0.001 ***
## asv202  0.640   0.001 ***
## asv735  0.637   0.002 **
## asv788  0.637   0.006 **
## asv1729 0.635   0.001 ***
## asv1784 0.628   0.001 ***
## asv82   0.621   0.002 **
## asv943  0.619   0.001 ***
## asv1093 0.597   0.001 ***
## asv215  0.577   0.002 **
## asv1216 0.574   0.011 *
## asv1810 0.570   0.012 *
## asv1124 0.562   0.011 *
```

```
## asv175  0.518   0.013 *
## asv192  0.500   0.005 **
## asv3304 0.489   0.015 *
## asv613  0.472   0.009 **
## asv1256 0.446   0.026 *
## asv806  0.444   0.015 *
## asv265  0.443   0.040 *
## asv404  0.441   0.017 *
## asv493  0.408   0.018 *
## asv1952 0.362   0.037 *
##
##  Group FrPoly+IndianOc  #sps.  8
##          stat p.value
## asv66   0.927   0.001 ***
## asv49   0.905   0.003 **
## asv40   0.893   0.005 **
## asv359  0.819   0.003 **
## asv1749 0.738   0.002 **
## asv474  0.703   0.015 *
## asv952  0.701   0.004 **
## asv639  0.675   0.014 *
##
##  Group IndianOc+Taiwan  #sps.  66
##          stat p.value
## asv12   0.942   0.003 **
## asv19   0.937   0.001 ***
## asv26   0.870   0.001 ***
## asv30   0.862   0.015 *
## asv24   0.859   0.001 ***
## asv43   0.832   0.001 ***
## asv44   0.826   0.001 ***
## asv106  0.820   0.001 ***
## asv87   0.818   0.003 **
## asv94   0.806   0.001 ***
## asv89   0.794   0.001 ***
## asv133  0.793   0.001 ***
## asv267  0.771   0.001 ***
## asv176  0.771   0.001 ***
## asv73   0.766   0.003 **
## asv88   0.762   0.001 ***
## asv37   0.759   0.010 **
## asv312  0.754   0.002 **
## asv440  0.751   0.001 ***
## asv117  0.749   0.002 **
## asv239  0.746   0.001 ***
## asv152  0.736   0.001 ***
## asv54   0.735   0.001 ***
## asv476  0.719   0.001 ***
## asv302  0.718   0.007 **
## asv746  0.717   0.001 ***
## asv163  0.716   0.009 **
## asv13   0.715   0.002 **
## asv79   0.709   0.011 *
## asv347  0.705   0.005 **
```

```
## asv108  0.705   0.006 **
## asv131  0.704   0.005 **
## asv563  0.695   0.001 ***
## asv107  0.694   0.002 **
## asv1448 0.668   0.001 ***
## asv556  0.668   0.003 **
## asv368  0.659   0.005 **
## asv1252 0.658   0.005 **
## asv946  0.653   0.004 **
## asv859  0.647   0.006 **
## asv1863 0.643   0.003 **
## asv406  0.640   0.008 **
## asv351  0.631   0.012 *
## asv185  0.622   0.007 **
## asv323  0.615   0.006 **
## asv402  0.606   0.014 *
## asv269  0.591   0.017 *
## asv1108 0.579   0.027 *
## asv2248 0.577   0.010 **
## asv182  0.572   0.018 *
## asv2804 0.561   0.014 *
## asv2157 0.548   0.014 *
## asv383  0.540   0.025 *
## asv405  0.538   0.024 *
## asv1247 0.533   0.017 *
## asv2075 0.532   0.012 *
## asv2805 0.532   0.014 *
## asv505  0.524   0.042 *
## asv328  0.516   0.031 *
## asv2486 0.516   0.023 *
## asv825  0.506   0.034 *
## asv654  0.483   0.019 *
## asv2701 0.483   0.035 *
## asv3329 0.483   0.029 *
## asv2341 0.465   0.043 *
## asv1085 0.447   0.044 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
indisp.sign<-as.data.table(inv_sregion$sign, keep.rownames=TRUE)
#add adjusted p-value
indisp.sign[ ,p.value.bh:=p.adjust(p.value, method="BH")]
#now can select only the indicators with adjusted significant p-values
IndVal_sregion = indisp.sign[p.value.bh<=0.05, ]
IndVal_sregion
```

```
##            rn s.FrPoly s.IndianOc s.Taiwan index      stat p.value  p.value.bh
##   1:    asv12        0          1        1     6 0.9422385   0.003 0.005482234
##   2:    asv13        0          1        1     6 0.7149152   0.002 0.003850267
##   3:    asv16        1          0        0     1 0.9829279   0.001 0.002130178
##   4:    asv17        0          0        1     3 0.8380529   0.001 0.002130178
##   5:    asv19        0          1        1     6 0.9367926   0.001 0.002130178
##  ---
## 263: asv2828        1          0        0     1 0.8798827   0.001 0.002130178
```

```
## 264: asv2916        0          0        1     3 0.6903017    0.001 0.002130178
## 265: asv3104        0          1        0     2 0.4564355    0.024 0.033882353
## 266: asv3304        0          0        1     3 0.4885800    0.015 0.022314050
## 267: asv3329        0          1        1     6 0.4830459    0.029 0.039847328
```

```
write.xlsx(IndVal_sregion, file = "IndVal_sregion_16Sep2021.xlsx")
```

```
inv_lregion = multipatt(asv_css, meta$L_region, func = "IndVal.g", control = how(nperm=999))
summary(inv_lregion)
```

```
##
##  Multilevel pattern analysis
##  ---------------------------
##
##  Association function: IndVal.g
##  Significance level (alpha): 0.05
##
##  Total number of species: 435
##  Selected number of species: 279
##  Number of species associated to 1 group: 204
##  Number of species associated to 2 groups: 75
##
##  List of species associated to each combination:
##
##  Group EPac  #sps.  57
##          stat p.value
## asv81   0.999   0.001 ***
## asv55   0.998   0.001 ***
## asv62   0.997   0.001 ***
## asv84   0.983   0.001 ***
## asv16   0.983   0.001 ***
## asv27   0.983   0.001 ***
## asv110  0.981   0.001 ***
## asv205  0.981   0.001 ***
## asv129  0.979   0.001 ***
## asv260  0.974   0.001 ***
## asv862  0.967   0.001 ***
## asv109  0.965   0.001 ***
## asv166  0.965   0.001 ***
## asv558  0.963   0.001 ***
## asv417  0.963   0.001 ***
## asv431  0.959   0.001 ***
## asv237  0.951   0.001 ***
## asv559  0.950   0.001 ***
## asv767  0.950   0.001 ***
## asv429  0.948   0.001 ***
## asv447  0.948   0.001 ***
## asv467  0.947   0.001 ***
## asv1778 0.946   0.001 ***
## asv1031 0.945   0.001 ***
## asv1475 0.942   0.001 ***
## asv327  0.941   0.001 ***
## asv1258 0.941   0.001 ***
```

```
## asv293  0.940   0.001 ***
## asv820  0.938   0.001 ***
## asv245  0.937   0.001 ***
## asv955  0.935   0.001 ***
## asv1465 0.933   0.001 ***
## asv91   0.932   0.001 ***
## asv357  0.932   0.001 ***
## asv1785 0.928   0.001 ***
## asv396  0.924   0.001 ***
## asv1931 0.918   0.001 ***
## asv533  0.916   0.001 ***
## asv297  0.898   0.001 ***
## asv95   0.898   0.001 ***
## asv2828 0.880   0.001 ***
## asv142  0.879   0.001 ***
## asv270  0.878   0.001 ***
## asv730  0.871   0.001 ***
## asv249  0.860   0.001 ***
## asv286  0.860   0.001 ***
## asv682  0.843   0.001 ***
## asv2150 0.806   0.001 ***
## asv1864 0.777   0.001 ***
## asv74   0.761   0.013 *
## asv415  0.752   0.001 ***
## asv1359 0.673   0.002 **
## asv463  0.569   0.010 **
## asv816  0.468   0.010 **
## asv836  0.440   0.015 *
## asv1777 0.432   0.023 *
## asv1131 0.372   0.048 *
##
##  Group IndianOc  #sps.  35
##          stat p.value
## asv25   0.890   0.001 ***
## asv145  0.772   0.002 **
## asv553  0.733   0.001 ***
## asv201  0.721   0.004 **
## asv1050 0.711   0.001 ***
## asv459  0.705   0.001 ***
## asv156  0.702   0.001 ***
## asv501  0.692   0.003 **
## asv529  0.689   0.001 ***
## asv453  0.688   0.002 **
## asv1471 0.686   0.001 ***
## asv2105 0.683   0.002 **
## asv148  0.677   0.002 **
## asv1203 0.673   0.001 ***
## asv1194 0.671   0.001 ***
## asv1600 0.667   0.002 **
## asv449  0.661   0.004 **
## asv137  0.645   0.002 **
## asv149  0.645   0.006 **
## asv598  0.594   0.017 *
## asv780  0.594   0.014 *
```

```
## asv191  0.552   0.020 *
## asv516  0.538   0.015 *
## asv535  0.537   0.013 *
## asv139  0.518   0.042 *
## asv348  0.518   0.017 *
## asv519  0.510   0.023 *
## asv477  0.468   0.029 *
## asv1897 0.456   0.023 *
## asv3104 0.456   0.028 *
## asv305  0.456   0.044 *
## asv160  0.433   0.038 *
## asv784  0.433   0.035 *
## asv899  0.430   0.044 *
## asv486  0.408   0.045 *
##
##  Group NPac  #sps.  112
##          stat p.value
## asv105  0.998   0.001 ***
## asv164  0.994   0.001 ***
## asv78   0.987   0.001 ***
## asv70   0.984   0.001 ***
## asv235  0.978   0.001 ***
## asv187  0.968   0.001 ***
## asv223  0.965   0.001 ***
## asv154  0.962   0.001 ***
## asv22   0.962   0.001 ***
## asv60   0.958   0.001 ***
## asv68   0.958   0.001 ***
## asv236  0.956   0.001 ***
## asv226  0.955   0.001 ***
## asv159  0.955   0.001 ***
## asv232  0.955   0.001 ***
## asv233  0.954   0.001 ***
## asv200  0.954   0.001 ***
## asv243  0.951   0.001 ***
## asv85   0.948   0.001 ***
## asv67   0.948   0.001 ***
## asv136  0.941   0.001 ***
## asv211  0.940   0.001 ***
## asv39   0.928   0.001 ***
## asv444  0.903   0.001 ***
## asv71   0.898   0.001 ***
## asv33   0.891   0.001 ***
## asv46   0.876   0.001 ***
## asv605  0.871   0.001 ***
## asv112  0.869   0.001 ***
## asv35   0.865   0.001 ***
## asv127  0.860   0.001 ***
## asv332  0.860   0.001 ***
## asv41   0.858   0.001 ***
## asv1310 0.856   0.001 ***
## asv537  0.843   0.001 ***
## asv17   0.838   0.001 ***
## asv283  0.836   0.001 ***
```

```
## asv240  0.832   0.001 ***
## asv264  0.830   0.001 ***
## asv1360 0.827   0.001 ***
## asv611  0.814   0.001 ***
## asv153  0.814   0.001 ***
## asv179  0.812   0.001 ***
## asv167  0.811   0.001 ***
## asv128  0.810   0.001 ***
## asv607  0.806   0.001 ***
## asv772  0.806   0.001 ***
## asv753  0.805   0.001 ***
## asv609  0.805   0.001 ***
## asv498  0.802   0.001 ***
## asv90   0.799   0.001 ***
## asv157  0.794   0.001 ***
## asv863  0.793   0.001 ***
## asv543  0.783   0.001 ***
## asv229  0.783   0.001 ***
## asv38   0.782   0.001 ***
## asv770  0.778   0.001 ***
## asv371  0.775   0.001 ***
## asv393  0.773   0.001 ***
## asv1476 0.771   0.001 ***
## asv1149 0.769   0.001 ***
## asv51   0.769   0.001 ***
## asv119  0.766   0.001 ***
## asv134  0.765   0.001 ***
## asv155  0.761   0.001 ***
## asv922  0.750   0.001 ***
## asv271  0.747   0.001 ***
## asv123  0.746   0.001 ***
## asv80   0.745   0.001 ***
## asv180  0.736   0.003 **
## asv827  0.727   0.001 ***
## asv2013 0.726   0.001 ***
## asv132  0.725   0.001 ***
## asv125  0.723   0.001 ***
## asv322  0.723   0.001 ***
## asv399  0.720   0.001 ***
## asv381  0.715   0.001 ***
## asv1601 0.715   0.001 ***
## asv1886 0.706   0.001 ***
## asv940  0.705   0.001 ***
## asv42   0.702   0.001 ***
## asv2916 0.690   0.001 ***
## asv2329 0.687   0.001 ***
## asv227  0.678   0.001 ***
## asv2356 0.671   0.001 ***
## asv1156 0.670   0.001 ***
## asv1594 0.664   0.001 ***
## asv144  0.646   0.004 **
## asv209  0.646   0.001 ***
## asv101  0.645   0.001 ***
## asv202  0.640   0.004 **
```

```
## asv735  0.637   0.001 ***
## asv788  0.637   0.003 **
## asv1729 0.635   0.002 **
## asv1784 0.628   0.001 ***
## asv82   0.621   0.004 **
## asv943  0.619   0.002 **
## asv1093 0.597   0.001 ***
## asv215  0.577   0.001 ***
## asv1216 0.574   0.006 **
## asv1810 0.570   0.005 **
## asv1124 0.562   0.003 **
## asv175  0.518   0.022 *
## asv192  0.500   0.001 ***
## asv3304 0.489   0.020 *
## asv613  0.472   0.007 **
## asv1256 0.446   0.023 *
## asv806  0.444   0.010 **
## asv265  0.443   0.050 *
## asv404  0.441   0.015 *
## asv493  0.408   0.019 *
## asv1952 0.362   0.036 *
##
##  Group EPac+IndianOc  #sps.  8
##          stat p.value
## asv66   0.927   0.002 **
## asv49   0.905   0.002 **
## asv40   0.893   0.007 **
## asv359  0.819   0.002 **
## asv1749 0.738   0.003 **
## asv474  0.703   0.019 *
## asv952  0.701   0.009 **
## asv639  0.675   0.014 *
##
##  Group IndianOc+NPac  #sps.  67
##          stat p.value
## asv12   0.942   0.003 **
## asv19   0.937   0.001 ***
## asv26   0.870   0.001 ***
## asv30   0.862   0.009 **
## asv24   0.859   0.001 ***
## asv43   0.832   0.001 ***
## asv44   0.826   0.001 ***
## asv106  0.820   0.001 ***
## asv87   0.818   0.002 **
## asv94   0.806   0.001 ***
## asv89   0.794   0.001 ***
## asv133  0.793   0.001 ***
## asv267  0.771   0.002 **
## asv176  0.771   0.001 ***
## asv73   0.766   0.002 **
## asv88   0.762   0.001 ***
## asv37   0.759   0.012 *
## asv312  0.754   0.001 ***
## asv440  0.751   0.001 ***
```

```
## asv117  0.749   0.002 **
## asv239  0.746   0.002 **
## asv152  0.736   0.001 ***
## asv54   0.735   0.002 **
## asv476  0.719   0.001 ***
## asv302  0.718   0.003 **
## asv746  0.717   0.002 **
## asv163  0.716   0.012 *
## asv13   0.715   0.001 ***
## asv79   0.709   0.008 **
## asv347  0.705   0.002 **
## asv108  0.705   0.004 **
## asv131  0.704   0.003 **
## asv563  0.695   0.001 ***
## asv107  0.694   0.003 **
## asv1448 0.668   0.003 **
## asv556  0.668   0.002 **
## asv368  0.659   0.004 **
## asv1252 0.658   0.003 **
## asv946  0.653   0.002 **
## asv859  0.647   0.003 **
## asv1863 0.643   0.002 **
## asv406  0.640   0.003 **
## asv351  0.631   0.007 **
## asv185  0.622   0.006 **
## asv323  0.615   0.005 **
## asv402  0.606   0.012 *
## asv269  0.591   0.022 *
## asv1108 0.579   0.030 *
## asv2248 0.577   0.014 *
## asv182  0.572   0.013 *
## asv2804 0.561   0.013 *
## asv2157 0.548   0.017 *
## asv383  0.540   0.024 *
## asv405  0.538   0.019 *
## asv1247 0.533   0.025 *
## asv2075 0.532   0.012 *
## asv2805 0.532   0.018 *
## asv505  0.524   0.036 *
## asv328  0.516   0.031 *
## asv2486 0.516   0.021 *
## asv825  0.506   0.038 *
## asv654  0.483   0.024 *
## asv2701 0.483   0.036 *
## asv3329 0.483   0.023 *
## asv2341 0.465   0.035 *
## asv188  0.447   0.050 *
## asv1085 0.447   0.040 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
indisp.sign<-as.data.table(inv_lregion$sign, keep.rownames=TRUE)
#add adjusted p-value
indisp.sign[ ,p.value.bh:=p.adjust(p.value, method="BH")]
```

```r
#now can select only the indicators with adjusted significant p-values
IndVal_lregion = indisp.sign[p.value.bh<=0.05, ]
IndVal_lregion
```

```
##           rn s.EPac s.IndianOc s.NPac index      stat p.value  p.value.bh
##   1:   asv12      0          1      1     6 0.9422385   0.003 0.005268293
##   2:   asv13      0          1      1     6 0.7149152   0.001 0.002130178
##   3:   asv16      1          0      0     1 0.9829279   0.001 0.002130178
##   4:   asv17      0          0      1     3 0.8380529   0.001 0.002130178
##   5:   asv19      0          1      1     6 0.9367926   0.001 0.002130178
##  ---
## 265: asv2828      1          0      0     1 0.8798827   0.001 0.002130178
## 266: asv2916      0          0      1     3 0.6903017   0.001 0.002130178
## 267: asv3104      0          1      0     2 0.4564355   0.028 0.038620690
## 268: asv3304      0          0      1     3 0.4885800   0.020 0.028915663
## 269: asv3329      0          1      1     6 0.4830459   0.023 0.032217899
```

```r
write.xlsx(IndVal_lregion, file = "IndVal_lregion_16Sep2021.xlsx")
```

```r
inv_temp = multipatt(asv_css, meta$SST_a, func = "IndVal.g", control = how(nperm=999))
summary(inv_temp)
```

```
##
##  Multilevel pattern analysis
##  ---------------------------
##
##  Association function: IndVal.g
##  Significance level (alpha): 0.05
##
##  Total number of species: 435
##  Selected number of species: 312
##  Number of species associated to 1 group: 50
##  Number of species associated to 2 groups: 49
##  Number of species associated to 3 groups: 126
##  Number of species associated to 4 groups: 38
##  Number of species associated to 5 groups: 29
##  Number of species associated to 6 groups: 7
##  Number of species associated to 7 groups: 8
##  Number of species associated to 8 groups: 3
##  Number of species associated to 9 groups: 1
##  Number of species associated to 10 groups: 1
##
##  List of species associated to each combination:
##
##  Group 27.04  #sps.  4
##          stat p.value
## asv74   0.998   0.001 ***
## asv1777 0.707   0.005 **
## asv816  0.701   0.009 **
## asv857  0.698   0.008 **
##
##  Group 28.59  #sps.  3
```

```
##         stat p.value
## asv101  0.707   0.003 **
## asv943  0.655   0.007 **
## asv1093 0.615   0.012 *
##
##  Group 28.67  #sps.  15
##         stat p.value
## asv192  0.959   0.001 ***
## asv215  0.942   0.001 ***
## asv42   0.917   0.001 ***
## asv1594 0.905   0.001 ***
## asv806  0.904   0.001 ***
## asv371  0.900   0.001 ***
## asv264  0.828   0.002 **
## asv80   0.774   0.004 **
## asv940  0.765   0.001 ***
## asv3180 0.763   0.002 **
## asv175  0.720   0.007 **
## asv325  0.704   0.005 **
## asv2881 0.636   0.007 **
## asv1952 0.617   0.013 *
## asv404  0.613   0.009 **
##
##  Group 30.8  #sps.  28
##         stat p.value
## asv351  0.866   0.001 ***
## asv516  0.811   0.001 ***
## asv535  0.757   0.004 **
## asv139  0.752   0.009 **
## asv328  0.749   0.003 **
## asv348  0.747   0.009 **
## asv1897 0.690   0.008 **
## asv3104 0.690   0.013 *
## asv305  0.689   0.011 *
## asv899  0.641   0.013 *
## asv121  0.617   0.012 *
## asv486  0.617   0.010 **
## asv784  0.608   0.017 *
## asv160  0.601   0.040 *
## asv150  0.577   0.015 *
## asv288  0.577   0.017 *
## asv295  0.577   0.035 *
## asv388  0.577   0.030 *
## asv462  0.577   0.019 *
## asv468  0.577   0.017 *
## asv1037 0.577   0.019 *
## asv1039 0.577   0.020 *
## asv1982 0.577   0.019 *
## asv428  0.575   0.048 *
## asv479  0.570   0.036 *
## asv1799 0.568   0.039 *
## asv460  0.563   0.048 *
## asv138  0.535   0.048 *
##
```

```
##  Group 26.86+27.04  #sps.  1
##         stat p.value
## asv249 0.994   0.001 ***
##
##  Group 26.86+30.8  #sps.  3
##          stat p.value
## asv519  0.760   0.003 **
## asv52   0.679   0.018 *
## asv2663 0.588   0.015 *
##
##  Group 28.59+28.67  #sps.  25
##          stat p.value
## asv105  0.998   0.001 ***
## asv164  0.993   0.001 ***
## asv78   0.983   0.001 ***
## asv70   0.980   0.001 ***
## asv235  0.978   0.001 ***
## asv154  0.964   0.001 ***
## asv223  0.960   0.001 ***
## asv187  0.957   0.001 ***
## asv22   0.955   0.001 ***
## asv60   0.951   0.001 ***
## asv233  0.950   0.001 ***
## asv159  0.949   0.001 ***
## asv236  0.949   0.001 ***
## asv226  0.949   0.001 ***
## asv200  0.949   0.001 ***
## asv243  0.946   0.001 ***
## asv232  0.945   0.001 ***
## asv68   0.943   0.001 ***
## asv39   0.922   0.001 ***
## asv444  0.890   0.001 ***
## asv1360 0.829   0.001 ***
## asv753  0.772   0.001 ***
## asv1149 0.769   0.003 **
## asv770  0.745   0.003 **
## asv82   0.631   0.019 *
##
##  Group 28.59+30.8  #sps.  10
##          stat p.value
## asv227  0.861   0.001 ***
## asv2075 0.741   0.002 **
## asv2916 0.718   0.003 **
## asv383  0.705   0.013 *
## asv3329 0.672   0.010 **
## asv2341 0.648   0.017 *
## asv188  0.622   0.018 *
## asv265  0.596   0.025 *
## asv427  0.596   0.026 *
## asv1256 0.568   0.041 *
##
##  Group 28.67+30.8  #sps.  9
##          stat p.value
## asv2248 0.806   0.001 ***
```

```
## asv477  0.722   0.008 **
## asv191  0.695   0.015 *
## asv177  0.656   0.008 **
## asv414  0.626   0.012 *
## asv161  0.624   0.017 *
## asv450  0.623   0.016 *
## asv1265 0.616   0.022 *
## asv317  0.613   0.014 *
##
##  Group 29.11+29.37  #sps.  1
##         stat p.value
## asv201 0.846   0.004 **
##
##  Group 26.86+27.04+27.19  #sps.  1
##        stat p.value
## asv95 0.944   0.001 ***
##
##  Group 26.86+27.04+27.22  #sps.  2
##         stat p.value
## asv415 0.832   0.002 **
## asv463 0.629   0.030 *
##
##  Group 26.86+28.59+30.8  #sps.  6
##          stat p.value
## asv209  0.799   0.001 ***
## asv1108 0.793   0.001 ***
## asv1247 0.726   0.004 **
## asv505  0.707   0.014 *
## asv825  0.687   0.008 **
## asv2718 0.624   0.018 *
##
##  Group 26.86+28.67+30.8  #sps.  1
##         stat p.value
## asv531 0.778   0.026 *
##
##  Group 27.04+27.19+27.22  #sps.  1
##         stat p.value
## asv533 0.959   0.009 **
##
##  Group 27.19+27.22+27.25  #sps.  4
##          stat p.value
## asv286  0.996   0.001 ***
## asv270  0.968   0.001 ***
## asv142  0.900   0.001 ***
## asv1359 0.834   0.001 ***
##
##  Group 28.59+28.67+30.8  #sps.  90
##          stat p.value
## asv67   0.991   0.001 ***
## asv133  0.988   0.001 ***
## asv89   0.988   0.001 ***
## asv112  0.986   0.001 ***
## asv19   0.985   0.001 ***
## asv35   0.983   0.001 ***
```

```
## asv117  0.983   0.001 ***
## asv38   0.982   0.001 ***
## asv211  0.981   0.001 ***
## asv30   0.980   0.001 ***
## asv26   0.979   0.001 ***
## asv152  0.978   0.001 ***
## asv267  0.978   0.001 ***
## asv176  0.974   0.001 ***
## asv46   0.973   0.001 ***
## asv54   0.973   0.001 ***
## asv239  0.972   0.001 ***
## asv88   0.971   0.001 ***
## asv106  0.970   0.001 ***
## asv476  0.969   0.001 ***
## asv332  0.968   0.001 ***
## asv611  0.964   0.001 ***
## asv119  0.963   0.001 ***
## asv271  0.961   0.001 ***
## asv153  0.961   0.001 ***
## asv605  0.957   0.001 ***
## asv167  0.956   0.001 ***
## asv498  0.956   0.001 ***
## asv399  0.956   0.001 ***
## asv863  0.956   0.001 ***
## asv41   0.953   0.001 ***
## asv94   0.951   0.001 ***
## asv537  0.950   0.001 ***
## asv73   0.948   0.001 ***
## asv51   0.948   0.001 ***
## asv312  0.943   0.001 ***
## asv127  0.942   0.001 ***
## asv163  0.940   0.001 ***
## asv123  0.935   0.001 ***
## asv1476 0.935   0.001 ***
## asv85   0.933   0.001 ***
## asv607  0.930   0.001 ***
## asv302  0.928   0.001 ***
## asv746  0.923   0.001 ***
## asv2013 0.921   0.001 ***
## asv107  0.917   0.001 ***
## asv90   0.917   0.001 ***
## asv128  0.911   0.001 ***
## asv440  0.907   0.001 ***
## asv556  0.894   0.001 ***
## asv240  0.893   0.001 ***
## asv71   0.882   0.001 ***
## asv13   0.875   0.001 ***
## asv946  0.872   0.001 ***
## asv322  0.870   0.001 ***
## asv155  0.869   0.001 ***
## asv1448 0.868   0.001 ***
## asv283  0.855   0.001 ***
## asv543  0.853   0.001 ***
## asv1310 0.853   0.001 ***
```

```
## asv406  0.852   0.002 **
## asv772  0.847   0.001 ***
## asv859  0.845   0.001 ***
## asv132  0.838   0.001 ***
## asv1156 0.834   0.001 ***
## asv157  0.833   0.001 ***
## asv1252 0.833   0.001 ***
## asv202  0.825   0.001 ***
## asv323  0.821   0.001 ***
## asv1601 0.821   0.001 ***
## asv179  0.816   0.001 ***
## asv381  0.816   0.001 ***
## asv402  0.816   0.004 **
## asv144  0.813   0.001 ***
## asv393  0.798   0.001 ***
## asv125  0.795   0.001 ***
## asv1886 0.778   0.001 ***
## asv827  0.762   0.002 **
## asv1729 0.762   0.001 ***
## asv180  0.758   0.018 *
## asv1216 0.739   0.001 ***
## asv1124 0.739   0.003 **
## asv2157 0.739   0.007 **
## asv2356 0.718   0.006 **
## asv2805 0.718   0.002 **
## asv2486 0.696   0.012 *
## asv654  0.651   0.014 *
## asv2701 0.651   0.010 **
## asv1085 0.603   0.019 *
## asv3304 0.603   0.025 *
##
##  Group 29.11+29.35+29.37  #sps.  21
##          stat p.value
## asv145  0.956   0.001 ***
## asv25   0.943   0.001 ***
## asv459  0.921   0.001 ***
## asv529  0.920   0.001 ***
## asv553  0.919   0.001 ***
## asv1471 0.914   0.001 ***
## asv1050 0.908   0.001 ***
## asv501  0.902   0.001 ***
## asv1203 0.899   0.001 ***
## asv453  0.898   0.001 ***
## asv1194 0.896   0.001 ***
## asv1600 0.892   0.001 ***
## asv2105 0.890   0.001 ***
## asv148  0.882   0.002 **
## asv449  0.882   0.001 ***
## asv156  0.879   0.001 ***
## asv639  0.873   0.001 ***
## asv149  0.861   0.002 **
## asv137  0.839   0.005 **
## asv598  0.769   0.012 *
## asv780  0.768   0.008 **
```

```
##
##  Group 26.86+28.59+28.67+30.8  #sps.  27
##          stat p.value
## asv33   0.998   0.001 ***
## asv24   0.970   0.001 ***
## asv44   0.969   0.001 ***
## asv37   0.956   0.001 ***
## asv79   0.955   0.001 ***
## asv131  0.953   0.001 ***
## asv136  0.946   0.001 ***
## asv609  0.946   0.001 ***
## asv87   0.938   0.001 ***
## asv563  0.904   0.001 ***
## asv229  0.903   0.001 ***
## asv108  0.903   0.001 ***
## asv347  0.867   0.001 ***
## asv1863 0.843   0.001 ***
## asv17   0.827   0.001 ***
## asv185  0.827   0.001 ***
## asv269  0.827   0.001 ***
## asv788  0.827   0.001 ***
## asv134  0.811   0.001 ***
## asv182  0.778   0.001 ***
## asv922  0.743   0.002 **
## asv2804 0.743   0.001 ***
## asv405  0.707   0.005 **
## asv735  0.707   0.001 ***
## asv1810 0.707   0.004 **
## asv2329 0.669   0.011 *
## asv1784 0.607   0.026 *
##
##  Group 26.86+28.67+29.11+30.8  #sps.  1
##         stat p.value
## asv254 0.606   0.032 *
##
##  Group 26.86+29.11+29.35+29.37  #sps.  1
##         stat p.value
## asv848 0.828   0.013 *
##
##  Group 27.04+27.19+27.22+27.25  #sps.  6
##          stat p.value
## asv91   0.999   0.001 ***
## asv166  0.995   0.001 ***
## asv205  0.994   0.001 ***
## asv129  0.990   0.001 ***
## asv559  0.986   0.001 ***
## asv1864 0.810   0.002 **
##
##  Group 27.22+28.59+28.67+30.8  #sps.  1
##         stat p.value
## asv368 0.853   0.001 ***
##
##  Group 27.22+29.11+29.35+29.37  #sps.  1
##         stat p.value
```

```
## asv474 0.944   0.001 ***
##
##  Group 27.25+28.59+28.67+30.8  #sps.  1
##       stat p.value
## asv4 0.992   0.001 ***
##
##  Group 26.86+27.04+27.19+27.22+27.25  #sps.  26
##          stat p.value
## asv81   0.999   0.001 ***
## asv84   0.983   0.038 *
## asv110  0.980   0.001 ***
## asv260  0.971   0.001 ***
## asv862  0.967   0.001 ***
## asv109  0.966   0.001 ***
## asv558  0.962   0.001 ***
## asv767  0.950   0.001 ***
## asv1778 0.948   0.001 ***
## asv429  0.944   0.001 ***
## asv447  0.943   0.001 ***
## asv245  0.941   0.001 ***
## asv1475 0.940   0.001 ***
## asv1258 0.938   0.001 ***
## asv820  0.936   0.001 ***
## asv293  0.935   0.001 ***
## asv327  0.934   0.001 ***
## asv1465 0.933   0.001 ***
## asv357  0.932   0.001 ***
## asv955  0.930   0.001 ***
## asv396  0.928   0.001 ***
## asv1785 0.926   0.001 ***
## asv1931 0.912   0.001 ***
## asv297  0.898   0.001 ***
## asv2828 0.880   0.001 ***
## asv2150 0.804   0.001 ***
##
##  Group 26.86+27.22+28.59+28.67+30.8  #sps.  1
##        stat p.value
## asv12 0.998   0.001 ***
##
##  Group 27.19+28.67+29.11+29.35+29.37  #sps.  1
##        stat p.value
## asv40 0.985   0.001 ***
##
##  Group 27.22+27.25+29.11+29.35+29.37  #sps.  1
##        stat p.value
## asv952 0.89   0.001 ***
##
##  Group 26.86+27.04+27.19+27.22+27.25+28.67  #sps.  1
##        stat p.value
## asv55 0.998   0.001 ***
##
##  Group 26.86+27.04+27.19+27.22+27.25+29.11  #sps.  2
##         stat p.value
## asv431 0.955   0.001 ***
```

```
## asv467 0.943   0.001 ***
##
##  Group 26.86+27.04+27.19+27.22+27.25+29.35  #sps.  1
##          stat p.value
## asv1031 0.941   0.001 ***
##
##  Group 26.86+27.04+27.19+27.22+27.25+29.37  #sps.  1
##        stat p.value
## asv62 0.998   0.001 ***
##
##  Group 26.86+27.04+27.25+29.11+29.35+29.37  #sps.  1
##        stat p.value
## asv49 0.962   0.001 ***
##
##  Group 27.04+27.19+27.22+27.25+29.11+29.37  #sps.  1
##          stat p.value
## asv1749 0.879   0.001 ***
##
##  Group 26.86+27.04+27.19+27.22+27.25+28.67+29.37  #sps.  2
##        stat p.value
## asv27 0.988   0.001 ***
## asv16 0.988   0.001 ***
##
##  Group 26.86+27.04+27.19+27.22+27.25+29.11+29.37  #sps.  3
##         stat p.value
## asv417 0.963   0.001 ***
## asv237 0.959   0.001 ***
## asv359 0.944   0.001 ***
##
##  Group 26.86+27.19+27.22+27.25+28.59+28.67+30.8  #sps.  1
##       stat p.value
## asv9 0.997   0.001 ***
##
##  Group 26.86+28.59+28.67+29.11+29.35+29.37+30.8  #sps.  1
##        stat p.value
## asv43 0.817   0.016 *
##
##  Group 27.19+27.22+27.25+28.67+29.11+29.35+29.37  #sps.  1
##        stat p.value
## asv66 0.988   0.001 ***
##
##  Group 26.86+27.04+27.19+27.22+27.25+29.11+29.35+29.37  #sps.  2
##         stat p.value
## asv682 0.925   0.001 ***
## asv730 0.900   0.001 ***
##
##  Group 26.86+27.19+27.22+27.25+28.59+28.67+29.11+30.8  #sps.  1
##        stat p.value
## asv15 0.998   0.001 ***
##
##  Group 26.86+27.04+27.19+27.22+27.25+28.59+28.67+29.11+30.8  #sps.  1
##       stat p.value
## asv8 0.999   0.009 **
##
```

```
##  Group 26.86+27.04+27.19+27.22+27.25+28.59+28.67+29.11+29.35+29.37  #sps.  1
##       stat p.value
## asv23 0.999   0.001 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
indisp.sign<-as.data.table(inv_temp$sign, keep.rownames=TRUE)
#add adjusted p-value
indisp.sign[ ,p.value.bh:=p.adjust(p.value, method="BH")]
#now can select only the indicators with adjusted significant p-values
IndVal_temp = indisp.sign[p.value.bh<=0.05, ]
IndVal_temp
```

```
##            rn s.26.86 s.27.04 s.27.19 s.27.22 s.27.25 s.28.59 s.28.67 s.29.11
##   1:     asv4       0       0       0       0       1       1       1       0
##   2:     asv8       1       1       1       1       1       1       1       1
##   3:     asv9       1       0       1       1       1       1       1       0
##   4:    asv12       1       0       0       1       0       1       1       0
##   5:    asv13       0       0       0       0       0       1       1       0
##  ---
## 305:  asv2916       0       0       0       0       0       1       0       0
## 306:  asv3104       0       0       0       0       0       0       0       0
## 307:  asv3180       0       0       0       0       0       0       1       0
## 308:  asv3304       0       0       0       0       0       1       1       0
## 309:  asv3329       0       0       0       0       0       1       0       0
##      s.29.35 s.29.37 s.30.8 index      stat p.value  p.value.bh
##   1:       0       0      1   530 0.9919628   0.001 0.001758294
##   2:       0       0      1  1983 0.9986101   0.009 0.013042969
##   3:       0       0      1  1615 0.9974249   0.001 0.001758294
##   4:       0       0      1   720 0.9980285   0.001 0.001758294
##   5:       0       0      1   215 0.8746931   0.001 0.001758294
##  ---
## 305:       0       0      1    56 0.7184212   0.003 0.004860262
## 306:       0       0      1    11 0.6900656   0.013 0.017797048
## 307:       0       0      0     7 0.7628160   0.002 0.003342342
## 308:       0       0      1   215 0.6030227   0.025 0.031228956
## 309:       0       0      1    56 0.6720215   0.010 0.014324324
```

```
write.xlsx(IndVal_temp, file = "IndVal_temp_16Sep2021.xlsx")
```

```
##GLM by clade

ps13_CladeA = subset_taxa(ps13, ITSclade=="A")
ps13_CladeC = subset_taxa(ps13, ITSclade=="C")
ps13_CladeD = subset_taxa(ps13, ITSclade=="D")
```

```
set.seed(199932)

#Clade A
ps13_CladeA_n2 = prune_samples(sample_sums(ps13_CladeA) >= 1, ps13_CladeA)
asv_css_A <- t(otu_table(ps13_CladeA_n2))
meta_A = as(sample_data(ps13_CladeA_n2), "data.frame")
```

```r
#Clade C
asv_css_C <- t(otu_table(ps13_CladeC))
meta_C = as(sample_data(ps13_CladeC), "data.frame")

#Clade D
asv_css_D <- t(otu_table(ps13_CladeD))
meta_D = as(sample_data(ps13_CladeD), "data.frame")
```

```r
perm_css_A = adonis2(asv_css_A ~ S_region/Loc + SST_a + Tbl_bin, meta_A, method = "bray", sqrt.dist = F
perm_css_A
```

```
## Permutation test for adonis under reduced model
## Terms added sequentially (first to last)
## Permutation: free
## Number of permutations: 999
##
## adonis2(formula = asv_css_A ~ S_region/Loc + SST_a + Tbl_bin, data = meta_A, method = "bray", sqrt.di
##              Df SumOfSqs      R2       F Pr(>F)
## S_region      2   2.5064 0.11108  5.1774  0.001 ***
## SST_a         1   5.0493 0.22379 20.8606  0.001 ***
## Tbl_bin       1   0.2207 0.00978  0.9118  0.444
## S_region:Loc  3   1.4738 0.06532  2.0296  0.014 *
## Residual     55  13.3128 0.59003
## Total        62  22.5631 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
perm_css_C = adonis2(asv_css_C ~ S_region/Loc + SST_a + Tbl_bin,  meta_C, method = "bray", sqrt.dist = F
perm_css_C
```

```
## Permutation test for adonis under reduced model
## Terms added sequentially (first to last)
## Permutation: free
## Number of permutations: 999
##
## adonis2(formula = asv_css_C ~ S_region/Loc + SST_a + Tbl_bin, data = meta_C, method = "bray", sqrt.di
##              Df SumOfSqs      R2       F Pr(>F)
## S_region      2   7.2496 0.25521 25.7169  0.001 ***
## SST_a         1   7.8701 0.27706 55.8362  0.001 ***
## Tbl_bin       1   0.2128 0.00749  1.5097  0.180
## S_region:Loc  3   1.3747 0.04840  3.2511  0.005 **
## Residual     83  11.6989 0.41184
## Total        90  28.4061 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```r
perm_css_D = adonis2(asv_css_D ~ S_region/Loc + SST_a + Tbl_bin,  meta_D, method = "bray", sqrt.dist = F
perm_css_D
```

```
## Permutation test for adonis under reduced model
## Terms added sequentially (first to last)
```

```
## Permutation: free
## Number of permutations: 999
##
## adonis2(formula = asv_css_D ~ S_region/Loc + SST_a + Tbl_bin, data = meta_D, method = "bray", sqrt.di
##              Df SumOfSqs      R2       F Pr(>F)
## S_region      2  12.7427 0.40306 53.4274  0.001 ***
## SST_a         1   7.8263 0.24755 65.6281  0.001 ***
## Tbl_bin       1   0.3052 0.00965  2.5591  0.062 .
## S_region:Loc  3   0.8427 0.02665  2.3554  0.016 *
## Residual     83   9.8980 0.31308
## Total        90  31.6149 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Pairwise differences - Clade A
library(pairwiseAdonis)

pairwise.adonis2(asv_css_A ~ Loc, data = meta_A, sim.method = "bray",  p.adjust.m = "BH", permutations =
```

```
## $parent_call
## [1] "asv_css_A ~ Loc , strata = Null , permutations 999"
##
## $Oman_vs_Taiwan
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   0.1001 0.04843 0.9161  0.454
## Residual 18   1.9670 0.95157
## Total    19   2.0671 1.00000
##
## $Oman_vs_Djib
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   5.2509 0.36419 21.193  0.001 ***
## Residual 37   9.1671 0.63581
## Total    38  14.4180 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Oman_vs_Tahaa
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.16553 0.08748 1.6297  0.185
## Residual 17  1.72667 0.91252
## Total    18  1.89220 1.00000
##
## $Oman_vs_Tahiti
##          Df SumOfSqs     R2      F Pr(>F)
## Loc       1  0.61711 0.3841 9.3547  0.003 **
## Residual 15  0.98952 0.6159
## Total    16  1.60664 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Oman_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   0.9558 0.32586 8.2174  0.003 **
## Residual 17   1.9773 0.67414
```

```
## Total    18   2.9331 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Oman_vs_Moorea
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.60951 0.20722 4.4435  0.013 *
## Residual 17  2.33188 0.79278
## Total    18  2.94140 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Taiwan_vs_Djib
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   2.3240 0.19991 7.2458  0.001 ***
## Residual 29   9.3015 0.80009
## Total    30  11.6255 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Taiwan_vs_Tahaa
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.03635 0.01916 0.1758  0.668
## Residual  9  1.86103 0.98084
## Total    10  1.89738 1.00000
##
## $Taiwan_vs_Tahiti
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.46923 0.29454 2.9225  0.042 *
## Residual  7  1.12388 0.70546
## Total     8  1.59311 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Taiwan_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.59496 0.21981 2.5357  0.092 .
## Residual  9  2.11169 0.78019
## Total    10  2.70664 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Taiwan_vs_Moorea
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.36632 0.12933 1.3368  0.214
## Residual  9  2.46624 0.87067
## Total    10  2.83256 1.00000
##
## $Djib_vs_Tahaa
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   2.0453 0.18415 6.3201  0.001 ***
## Residual 28   9.0612 0.81585
## Total    29  11.1065 1.00000
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Djib_vs_Tahiti
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   1.5842 0.15988 4.9481  0.001 ***
## Residual 26   8.3241 0.84012
## Total    27   9.9082 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Djib_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   1.8306 0.16429 5.5044  0.001 ***
## Residual 28   9.3119 0.83571
## Total    29  11.1425 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Djib_vs_Moorea
##          Df SumOfSqs     R2      F Pr(>F)
## Loc       1   1.5307 0.1367 4.4338  0.001 ***
## Residual 28   9.6664 0.8633
## Total    29  11.1971 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Tahaa_vs_Tahiti
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.35332 0.28565 2.3992  0.038 *
## Residual  6  0.88360 0.71435
## Total     7  1.23692 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Tahaa_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.52743 0.21987 2.2547  0.131
## Residual  8  1.87141 0.78013
## Total     9  2.39883 1.00000
##
## $Tahaa_vs_Moorea
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.32509 0.12743 1.1684  0.371
## Residual  8  2.22596 0.87257
## Total     9  2.55104 1.00000
##
## $Tahiti_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.59336 0.34345 3.1387  0.091 .
## Residual  6  1.13426 0.65655
## Total     7  1.72761 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## $Tahiti_vs_Moorea
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.39944 0.21154 1.6098  0.199
## Residual  6  1.48881 0.78846
## Total     7  1.88824 1.00000
##
## $Raia_vs_Moorea
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.28056 0.10176 0.9063  0.526
## Residual  8  2.47661 0.89824
## Total     9  2.75718 1.00000
##
## attr(,"class")
## [1] "pwadstrata" "list"
```

```
pairwise.adonis2(asv_css_A ~ S_region, data = meta_A, sim.method = "bray",  p.adjust.m = "BH", permutati
```

```
## $parent_call
## [1] "asv_css_A ~ S_region , strata = Null , permutations 999"
##
## $IndianOc_vs_Taiwan
##          Df SumOfSqs      R2      F Pr(>F)
## S_region  1   0.9454 0.05759 2.6279  0.024 *
## Residual 43  15.4687 0.94241
## Total    44  16.4140 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $IndianOc_vs_FrPoly
##          Df SumOfSqs     R2      F Pr(>F)
## S_region  1   1.8865 0.0903 5.4593  0.003 **
## Residual 55  19.0060 0.9097
## Total    56  20.8925 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Taiwan_vs_FrPoly
##          Df SumOfSqs     R2     F Pr(>F)
## S_region  1   0.3263 0.0547 1.273  0.291
## Residual 22   5.6386 0.9453
## Total    23   5.9649 1.0000
##
## attr(,"class")
## [1] "pwadstrata" "list"
```

```
pairwise.adonis2(asv_css_A ~ SST_a, data = meta_A, sim.method = "bray",  p.adjust.m = "BH", permutations
```

```
## 'nperm' >= set of all permutations: complete enumeration.

## Set of permutations < 'minperm'. Generating entire set.
## Set of permutations < 'minperm'. Generating entire set.

## 'nperm' >= set of all permutations: complete enumeration.
```

```
## Set of permutations < 'minperm'. Generating entire set.
## Set of permutations < 'minperm'. Generating entire set.

## 'nperm' >= set of all permutations: complete enumeration.

## Set of permutations < 'minperm'. Generating entire set.

## 'nperm' >= set of all permutations: complete enumeration.

## Set of permutations < 'minperm'. Generating entire set.
## Set of permutations < 'minperm'. Generating entire set.
## Set of permutations < 'minperm'. Generating entire set.

## 'nperm' >= set of all permutations: complete enumeration.

## Set of permutations < 'minperm'. Generating entire set.

## 'nperm' >= set of all permutations: complete enumeration.

## Set of permutations < 'minperm'. Generating entire set.

## 'nperm' >= set of all permutations: complete enumeration.

## Set of permutations < 'minperm'. Generating entire set.
## Set of permutations < 'minperm'. Generating entire set.
## Set of permutations < 'minperm'. Generating entire set.

## 'nperm' >= set of all permutations: complete enumeration.

## Set of permutations < 'minperm'. Generating entire set.

## $parent_call
## [1] "asv_css_A ~ SST_a , strata = Null , permutations 999"
##
## $`30.8_vs_28.59`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.00749 0.00652 0.1049  0.963
## Residual 16  1.14261 0.99348
## Total    17  1.15011 1.00000
##
## $`30.8_vs_29.37`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   3.8602 0.49338 22.399  0.001 ***
## Residual 23   3.9637 0.50662
## Total    24   7.8239 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_27.19`
##          Df SumOfSqs      R2    F Pr(>F)
## SST_a     1   0.3996 0.22006 3.95  0.086 .
```

```
## Residual 14   1.4163 0.77994
## Total    15   1.8159 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_26.86`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1  0.61711 0.3841 9.3547  0.004 **
## Residual 15  0.98952 0.6159
## Total    16  1.60664 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   3.0572 0.46602 17.455  0.001 ***
## Residual 20   3.5030 0.53398
## Total    21   6.5602 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   0.4005 0.22044 3.9589  0.067 .
## Residual 14   1.4163 0.77956
## Total    15   1.8168 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   0.9558 0.32586 8.2174  0.002 **
## Residual 17   1.9773 0.67414
## Total    18   2.9331 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_27.04`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.60951 0.20722 4.4435  0.009 **
## Residual 17  2.33188 0.79278
## Total    18  2.94140 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.05387 0.05479 0.8695   0.43
## Residual 15  0.92922 0.94521
## Total    16  0.98309 1.00000
##
## $`30.8_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.5563 0.47626 16.369  0.001 ***
```

```
## Residual 18   2.8112 0.52374
## Total    19   5.3675 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_29.37`
##          Df SumOfSqs      R2     F Pr(>F)
## SST_a     1   1.8633 0.36272 7.399  0.002 **
## Residual 13   3.2737 0.63728
## Total    14   5.1370 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_27.19`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.30311 0.29445 1.6693 0.2667
## Residual  4  0.72631 0.70555
## Total     5  1.02943 1.00000
##
## $`28.59_vs_26.86`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.36313 0.54798 6.0615  0.029 *
## Residual  5  0.29954 0.45202
## Total     6  0.66267 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1    1.625 0.36615 5.7766  0.003 **
## Residual 10    2.813 0.63385
## Total    11    4.438 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_28.67`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1  0.32434 0.3087 1.7862 0.2667
## Residual  4  0.72631 0.6913
## Total     5  1.05066 1.0000
##
## $`28.59_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.56138 0.30366 3.0526   0.11
## Residual  7  1.28735 0.69634
## Total     8  1.84873 1.00000
##
## $`28.59_vs_27.04`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.36831 0.18322 1.5702  0.195
## Residual  7  1.64190 0.81678
## Total     8  2.01021 1.00000
##
## $`28.59_vs_27.22`
```

```
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1 0.018593 0.07211 0.3886  0.878
## Residual  5 0.239238 0.92789
## Total     6 0.257832 1.00000
##
## $`28.59_vs_29.35`
##          Df SumOfSqs      R2     F Pr(>F)
## SST_a     1   1.4965 0.41366 5.644  0.007 **
## Residual  8   2.1212 0.58634
## Total     9   3.6176 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_27.19`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1   0.7687 0.1781 2.3836  0.044 *
## Residual 11   3.5474 0.8219
## Total    12   4.3161 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_26.86`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.4704 0.32028 5.6543  0.004 **
## Residual 12   3.1206 0.67972
## Total    13   4.5911 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   0.2720 0.04606 0.8208  0.516
## Residual 17   5.6341 0.95394
## Total    18   5.9062 1.00000
##
## $`29.37_vs_28.67`
##          Df SumOfSqs      R2     F Pr(>F)
## SST_a     1   0.7814 0.18051 2.423  0.033 *
## Residual 11   3.5474 0.81949
## Total    12   4.3288 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.6556 0.28723 5.6416  0.001 ***
## Residual 14   4.1085 0.71277
## Total    15   5.7640 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_27.04`
##          Df SumOfSqs      R2     F Pr(>F)
## SST_a     1   1.4039 0.23929 4.404  0.001 ***
```

```
## Residual 14   4.4630 0.76071
## Total    15   5.8669 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.6123 0.34505 6.3219  0.005 **
## Residual 12   3.0603 0.65495
## Total    13   4.6726 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   0.4454 0.08268 1.3519  0.241
## Residual 15   4.9423 0.91732
## Total    16   5.3877 1.00000
##
## $`27.19_vs_26.86`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.40270 0.41263 2.1075    0.1
## Residual  3  0.57322 0.58737
## Total     4  0.97592 1.00000
##
## $`27.19_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   0.6667 0.17763 1.7279  0.048 *
## Residual  8   3.0867 0.82237
## Total     9   3.7534 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.19_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.03037 0.02948 0.0607      1
## Residual  2  1.00000 0.97052
## Total     3  1.03037 1.00000
##
## $`27.19_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.39664 0.20261 1.2705  0.426
## Residual  5  1.56103 0.79739
## Total     6  1.95767 1.00000
##
## $`27.19_vs_27.04`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.28707 0.13033 0.7493  0.712
## Residual  5  1.91558 0.86967
## Total     6  2.20265 1.00000
##
## $`27.19_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.29745 0.36705 1.7397    0.4
```

```
## Residual  3  0.51292 0.63295
## Total     4  0.81037 1.00000
##
## $`27.19_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.64552 0.21232 1.6173  0.157
## Residual  6  2.39485 0.78768
## Total     7  3.04037 1.00000
##
## $`26.86_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.3633 0.33886 4.6128  0.006 **
## Residual  9   2.6599 0.66114
## Total    10   4.0232 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`26.86_vs_28.67`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1  0.53083 0.4808 2.7781    0.1
## Residual  3  0.57322 0.5192
## Total     4  1.10405 1.0000
##
## $`26.86_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.59336 0.34345 3.1387  0.097 .
## Residual  6  1.13426 0.65655
## Total     7  1.72761 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`26.86_vs_27.04`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.39944 0.21154 1.6098  0.206
## Residual  6  1.48881 0.78846
## Total     7  1.88824 1.00000
##
## $`26.86_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.28424 0.76741 13.198    0.1
## Residual  4  0.08615 0.23259
## Total     5  0.37039 1.00000
##
## $`26.86_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.2156 0.38182 4.3235  0.029 *
## Residual  7   1.9681 0.61818
## Total     8   3.1837 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.11_vs_28.67`
##          Df SumOfSqs    R2      F Pr(>F)
## SST_a     1   0.6730 0.179 1.7442   0.06 .
```

```
## Residual  8   3.0867 0.821
## Total     9   3.7597 1.000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.11_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.3851 0.27521 4.1769  0.001 ***
## Residual 11   3.6477 0.72479
## Total    12   5.0329 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.11_vs_27.04`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.1724 0.22656 3.2221  0.001 ***
## Residual 11   4.0023 0.77344
## Total    12   5.1747 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.11_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.4410 0.35663 4.9888  0.006 **
## Residual  9   2.5996 0.64337
## Total    10   4.0407 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.11_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   0.3789 0.07796 1.0146    0.4
## Residual 12   4.4816 0.92204
## Total    13   4.8605 1.00000
##
## $`28.67_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.44482 0.22176 1.4248  0.362
## Residual  5  1.56103 0.77824
## Total     6  2.00585 1.00000
##
## $`28.67_vs_27.04`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.33378 0.14839 0.8712  0.422
## Residual  5  1.91558 0.85161
## Total     6  2.24936 1.00000
##
## $`28.67_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.34718 0.40365 2.0306    0.1
## Residual  3  0.51292 0.59635
## Total     4  0.86011 1.00000
##
## $`28.67_vs_29.35`
```

```
##          Df SumOfSqs      R2     F Pr(>F)
## SST_a     1   0.6478 0.21291 1.623  0.142
## Residual  6   2.3948 0.78709
## Total     7   3.0427 1.00000
##
## $`27.25_vs_27.04`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.28056 0.10176 0.9063  0.497
## Residual  8  2.47661 0.89824
## Total     9  2.75718 1.00000
##
## $`27.25_vs_27.22`
##          Df SumOfSqs      R2     F Pr(>F)
## SST_a     1  0.49813 0.31686 2.783  0.189
## Residual  6  1.07396 0.68314
## Total     7  1.57208 1.00000
##
## $`27.25_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.2756 0.30145 3.8839  0.002 **
## Residual  9   2.9559 0.69855
## Total    10   4.2315 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.34108 0.19275 1.4326  0.339
## Residual  6  1.42851 0.80725
## Total     7  1.76959 1.00000
##
## $`27.04_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.0751 0.24515 2.9229  0.008 **
## Residual  9   3.3104 0.75485
## Total    10   4.3856 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.22_vs_29.35`
##          Df SumOfSqs      R2     F Pr(>F)
## SST_a     1   1.3507 0.41452 4.956  0.015 *
## Residual  7   1.9078 0.58548
## Total     8   3.2585 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## attr(,"class")
## [1] "pwadstrata" "list"
```

```
# Pairwise differences - Clade C
library(pairwiseAdonis)

pairwise.adonis2(asv_css_C ~ Loc, data = meta_C, sim.method = "bray",  p.adjust.m = "BH",
```

```r
  permutations = 999)
```

```
## $parent_call
## [1] "asv_css_C ~ Loc , strata = Null , permutations 999"
##
## $Oman_vs_Moorea
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1    4.501 0.58326 37.788  0.001 ***
## Residual 27    3.216 0.41674
## Total    28    7.717 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Oman_vs_Taiwan
##          Df SumOfSqs     R2      F Pr(>F)
## Loc       1   0.3998 0.1164 4.0838  0.026 *
## Residual 31   3.0351 0.8836
## Total    32   3.4350 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Oman_vs_Djib
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   8.3368 0.55312 56.937  0.001 ***
## Residual 46   6.7354 0.44688
## Total    47  15.0722 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Oman_vs_Tahaa
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   5.2693 0.60431 44.289  0.001 ***
## Residual 29   3.4502 0.39569
## Total    30   8.7195 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Oman_vs_Tahiti
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   1.6991 0.30156 10.362  0.001 ***
## Residual 24   3.9352 0.69844
## Total    25   5.6343 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Oman_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   4.1027 0.52052 29.311  0.001 ***
## Residual 27   3.7793 0.47948
## Total    28   7.8820 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## $Moorea_vs_Taiwan
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   4.0682 0.75301 54.877  0.001 ***
## Residual 18   1.3344 0.24699
## Total    19   5.4027 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Moorea_vs_Djib
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   0.2209 0.04203 1.4479  0.165
## Residual 33   5.0347 0.95797
## Total    34   5.2556 1.00000
##
## $Moorea_vs_Tahaa
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   0.3280 0.15788 2.9997  0.016 *
## Residual 16   1.7495 0.84212
## Total    17   2.0775 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Moorea_vs_Tahiti
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.41951 0.15807 2.0652  0.029 *
## Residual 11  2.23449 0.84193
## Total    12  2.65400 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Moorea_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.14202 0.06396 0.9566  0.452
## Residual 14  2.07857 0.93604
## Total    15  2.22059 1.00000
##
## $Taiwan_vs_Djib
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   6.4576 0.57089 49.225  0.001 ***
## Residual 37   4.8538 0.42911
## Total    38  11.3114 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Taiwan_vs_Tahaa
##          Df SumOfSqs      R2     F Pr(>F)
## Loc       1   4.6236 0.74667 58.95  0.001 ***
## Residual 20   1.5687 0.25333
## Total    21   6.1922 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Taiwan_vs_Tahiti
##          Df SumOfSqs     R2      F Pr(>F)
```

```
## Loc       1   1.7001 0.4529 12.418  0.002 **
## Residual 15   2.0536 0.5471
## Total    16   3.7537 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Taiwan_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   3.7299 0.66279 35.378  0.001 ***
## Residual 18   1.8977 0.33721
## Total    19   5.6276 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Djib_vs_Tahaa
##          Df SumOfSqs     R2      F Pr(>F)
## Loc       1   0.9015 0.1461 5.9886  0.003 **
## Residual 35   5.2689 0.8539
## Total    36   6.1704 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Djib_vs_Tahiti
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   0.4158 0.06739 2.1677  0.063 .
## Residual 30   5.7539 0.93261
## Total    31   6.1696 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Djib_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   0.3646 0.06116 2.1496  0.042 *
## Residual 33   5.5980 0.93884
## Total    34   5.9626 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Tahaa_vs_Tahiti
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.61323 0.19897 3.2292  0.002 **
## Residual 13  2.46873 0.80103
## Total    14  3.08196 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Tahaa_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.18615 0.07449 1.2878  0.203
## Residual 16  2.31282 0.92551
## Total    17  2.49897 1.00000
##
## $Tahiti_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
```

```
## Loc       1  0.27608 0.08982 1.0855   0.37
## Residual 11  2.79779 0.91018
## Total    12  3.07387 1.00000
##
## attr(,"class")
## [1] "pwadstrata" "list"
```

```r
pairwise.adonis2(asv_css_C ~ S_region, data = meta_C, sim.method = "bray",  p.adjust.m = "BH",
  permutations = 999)
```

```
## $parent_call
## [1] "asv_css_C ~ S_region , strata = Null , permutations 999"
##
## $IndianOc_vs_FrPoly
##          Df SumOfSqs      R2      F Pr(>F)
## S_region  1   2.7804 0.11902 10.403  0.001 ***
## Residual 77  20.5797 0.88098
## Total    78  23.3602 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $IndianOc_vs_Taiwan
##          Df SumOfSqs      R2      F Pr(>F)
## S_region  1    2.750 0.14946 10.192  0.001 ***
## Residual 58   15.649 0.85054
## Total    59   18.399 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $FrPoly_vs_Taiwan
##          Df SumOfSqs      R2      F Pr(>F)
## S_region  1   6.3967 0.51251 43.105  0.001 ***
## Residual 41   6.0843 0.48749
## Total    42  12.4811 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## attr(,"class")
## [1] "pwadstrata" "list"
```

```r
pairwise.adonis2(asv_css_C ~ SST_a, data = meta_C, sim.method = "bray",  p.adjust.m = "BH",
  permutations = 999)
```

```
## Set of permutations < 'minperm'. Generating entire set.

## 'nperm' >= set of all permutations: complete enumeration.

## Set of permutations < 'minperm'. Generating entire set.

## $parent_call
## [1] "asv_css_C ~ SST_a , strata = Null , permutations 999"
##
```

```
## $`30.8_vs_27.04`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1    4.501 0.58326 37.788  0.001 ***
## Residual 27    3.216 0.41674
## Total    28    7.717 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_28.59`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   0.3500 0.10708 3.4776  0.053 .
## Residual 29   2.9184 0.89292
## Total    30   3.2684 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_29.37`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   5.3431 0.54668 37.384  0.001 ***
## Residual 31   4.4307 0.45332
## Total    32   9.7738 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_27.19`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   3.7394 0.56254 32.148  0.001 ***
## Residual 25   2.9080 0.43746
## Total    26   6.6474 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_26.86`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.6991 0.30156 10.362  0.001 ***
## Residual 24   3.9352 0.69844
## Total    25   5.6343 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   4.3705 0.56513 35.087  0.001 ***
## Residual 27   3.3632 0.43487
## Total    28   7.7337 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.19646 0.07364 1.6693  0.108
## Residual 21  2.47161 0.92636
## Total    22  2.66807 1.00000
##
```

```
## $`30.8_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   4.1027 0.52052 29.311  0.001 ***
## Residual 27   3.7793 0.47948
## Total    28   7.8820 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.6946 0.49368 22.426  0.001 ***
## Residual 23   2.7635 0.50632
## Total    24   5.4581 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   3.6638 0.50461 26.484  0.001 ***
## Residual 26   3.5968 0.49539
## Total    27   7.2606 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_28.59`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   3.7755 0.75613 49.609  0.002 **
## Residual 16   1.2177 0.24387
## Total    17   4.9932 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_29.37`
##          Df SumOfSqs      R2     F Pr(>F)
## SST_a     1   0.1861 0.06382 1.227  0.257
## Residual 18   2.7300 0.93618
## Total    19   2.9161 1.00000
##
## $`27.04_vs_27.19`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.18184 0.13091 1.8075  0.089 .
## Residual 12  1.20724 0.86909
## Total    13  1.38908 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_26.86`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.41951 0.15807 2.0652  0.036 *
## Residual 11  2.23449 0.84193
## Total    12  2.65400 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## $`27.04_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.11509 0.06475 0.9692  0.399
## Residual 14  1.66242 0.93525
## Total    15  1.77751 1.00000
##
## $`27.04_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  1.42332 0.64868 14.771  0.019 *
## Residual  8  0.77087 0.35132
## Total     9  2.19419 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.14202 0.06396 0.9566  0.443
## Residual 14  2.07857 0.93604
## Total    15  2.22059 1.00000
##
## $`27.04_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.43795 0.29183 4.1208  0.002 **
## Residual 10  1.06276 0.70817
## Total    11  1.50070 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_29.35`
##          Df SumOfSqs      R2     F Pr(>F)
## SST_a     1  0.28398 0.13026 1.947  0.103
## Residual 13  1.89611 0.86974
## Total    14  2.18009 1.00000
##
## $`28.59_vs_29.37`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   4.2174 0.63422 34.677  0.001 ***
## Residual 20   2.4324 0.36578
## Total    21   6.6498 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_27.19`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1   3.2745 0.7826 50.396  0.001 ***
## Residual 14   0.9097 0.2174
## Total    15   4.1842 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_26.86`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.6152 0.45471 10.841  0.002 **
## Residual 13   1.9369 0.54529
```

```
## Total    14   3.5521 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   3.6759 0.72924 43.092  0.001 ***
## Residual 16   1.3648 0.27076
## Total    17   5.0407 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.10349 0.17942 2.1865  0.114
## Residual 10  0.47329 0.82058
## Total    11  0.57678 1.00000
##
## $`28.59_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   3.4684 0.66072 31.159  0.001 ***
## Residual 16   1.7810 0.33928
## Total    17   5.2493 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.4960 0.76537 39.145  0.002 **
## Residual 12   0.7652 0.23463
## Total    13   3.2612 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   3.1793 0.66543 29.833  0.001 ***
## Residual 15   1.5985 0.33457
## Total    16   4.7778 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_27.19`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.37054 0.13269 2.4479  0.061 .
## Residual 16  2.42194 0.86731
## Total    17  2.79248 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_26.86`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1   0.3332 0.0881 1.4491  0.147
## Residual 15   3.4492 0.9119
```

```
## Total    16   3.7824 1.0000
##
## $`29.37_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.13439 0.04463 0.8408   0.46
## Residual 18  2.87712 0.95537
## Total    19  3.01151 1.00000
##
## $`29.37_vs_28.67`
##          Df SumOfSqs      R2    F Pr(>F)
## SST_a     1   1.3949 0.41263 8.43  0.011 *
## Residual 12   1.9856 0.58737
## Total    13   3.3804 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_27.25`
##          Df SumOfSqs      R2    F Pr(>F)
## SST_a     1   0.2964 0.08257 1.62  0.108
## Residual 18   3.2933 0.91743
## Total    19   3.5897 1.00000
##
## $`29.37_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.65946 0.22454 4.0538  0.008 **
## Residual 14  2.27746 0.77546
## Total    15  2.93692 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   0.0951 0.02967 0.5198  0.807
## Residual 17   3.1108 0.97033
## Total    18   3.2059 1.00000
##
## $`27.19_vs_26.86`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   0.4733 0.19723 2.2111  0.007 **
## Residual  9   1.9265 0.80277
## Total    10   2.3998 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.19_vs_29.11`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1  0.28095 0.1718 2.4892  0.015 *
## Residual 12  1.35440 0.8282
## Total    13  1.63535 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.19_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
```

```
## SST_a     1  1.36956 0.74741 17.754  0.035 *
## Residual  6  0.46285 0.25259
## Total     7  1.83241 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.19_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.10415 0.05555 0.7059  0.802
## Residual 12  1.77055 0.94445
## Total    13  1.87469 1.00000
##
## $`27.19_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.23714 0.23908 2.5137  0.033 *
## Residual  8  0.75474 0.76092
## Total     9  0.99188 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.19_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.46752 0.22744 3.2383  0.035 *
## Residual 11  1.58809 0.77256
## Total    12  2.05561 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`26.86_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.36729 0.13361 1.6964  0.053 .
## Residual 11  2.38165 0.86639
## Total    12  2.74894 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`26.86_vs_28.67`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1  0.74157 0.3323 2.4883  0.047 *
## Residual  5  1.49009 0.6677
## Total     6  2.23167 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`26.86_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.27608 0.08982 1.0855   0.38
## Residual 11  2.79779 0.91018
## Total    12  3.07387 1.00000
##
## $`26.86_vs_27.22`
##          Df SumOfSqs      R2    F Pr(>F)
## SST_a     1  0.57532 0.24406 2.26  0.011 *
## Residual  7  1.78198 0.75594
```

```
## Total     8  2.35730 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`26.86_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.34767 0.11734 1.3293  0.197
## Residual 10  2.61533 0.88266
## Total    11  2.96300 1.00000
##
## $`29.11_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  1.38762 0.60183 12.092  0.021 *
## Residual  8  0.91803 0.39817
## Total     9  2.30565 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.11_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.19715 0.08137 1.2401   0.21
## Residual 14  2.22573 0.91863
## Total    15  2.42288 1.00000
##
## $`29.11_vs_27.22`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1  0.57751 0.3231 4.7732  0.003 **
## Residual 10  1.20992 0.6769
## Total    11  1.78743 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.11_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   0.1709 0.07718 1.0873   0.32
## Residual 13   2.0433 0.92282
## Total    14   2.2142 1.00000
##
## $`28.67_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.2995 0.49342 7.7923   0.02 *
## Residual  8   1.3342 0.50658
## Total     9   2.6337 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.67_vs_27.22`
##          Df SumOfSqs      R2      F  Pr(>F)
## SST_a     1  1.21766 0.79273 15.299 0.06667 .
## Residual  4  0.31837 0.20727
## Total     5  1.53602 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## $`28.67_vs_29.35`
##          Df SumOfSqs      R2     F Pr(>F)
## SST_a     1   1.2641 0.52326 7.683  0.028 *
## Residual  7   1.1517 0.47674
## Total     8   2.4158 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.25_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.31581 0.16263 1.9422   0.04 *
## Residual 10  1.62606 0.83737
## Total    11  1.94188 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.25_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.38477 0.13528 2.0338  0.061 .
## Residual 13  2.45942 0.86472
## Total    14  2.84419 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.22_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.74647 0.34084 4.6538  0.015 *
## Residual  9  1.44361 0.65916
## Total    10  2.19008 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## attr(,"class")
## [1] "pwadstrata" "list"
```

```r
# Pairwise differences - Clade D

pairwise.adonis2(asv_css_D ~ Loc, data = meta_D, sim.method = "bray",  p.adjust.m = "BH",
  permutations = 999)
```

```
## $parent_call
## [1] "asv_css_D ~ Loc , strata = Null , permutations 999"
##
## $Oman_vs_Moorea
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   5.0305 0.71524 67.817  0.001 ***
## Residual 27   2.0028 0.28476
## Total    28   7.0333 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Oman_vs_Taiwan
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.09222 0.03296 1.0565   0.36
```

```
## Residual 31  2.70593 0.96704
## Total    32  2.79814 1.00000
##
## $Oman_vs_Djib
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   8.1598 0.54955 56.121  0.001 ***
## Residual 46   6.6883 0.45045
## Total    47  14.8481 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Oman_vs_Tahaa
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   5.9771 0.75382 88.801  0.001 ***
## Residual 29   1.9520 0.24618
## Total    30   7.9291 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Oman_vs_Tahiti
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   2.0569 0.42128 17.471  0.001 ***
## Residual 24   2.8255 0.57872
## Total    25   4.8824 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Oman_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   5.2334 0.75263 82.146  0.001 ***
## Residual 27   1.7201 0.24737
## Total    28   6.9535 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Moorea_vs_Taiwan
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   4.0749 0.72575 47.633  0.001 ***
## Residual 18   1.5398 0.27425
## Total    19   5.6147 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Moorea_vs_Djib
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   3.8188 0.40882 22.821  0.001 ***
## Residual 33   5.5222 0.59118
## Total    34   9.3410 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Moorea_vs_Tahaa
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.25554 0.24538 5.2026  0.002 **
```

```
## Residual 16  0.78589 0.75462
## Total    17  1.04144 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Moorea_vs_Tahiti
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.35915 0.17792 2.3807  0.009 **
## Residual 11  1.65943 0.82208
## Total    12  2.01858 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Moorea_vs_Raia
##          Df SumOfSqs     R2     F Pr(>F)
## Loc       1  0.22063 0.2848 5.575  0.001 ***
## Residual 14  0.55404 0.7152
## Total    15  0.77467 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Taiwan_vs_Djib
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   5.5678 0.47212 33.092  0.001 ***
## Residual 37   6.2253 0.52788
## Total    38  11.7931 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Taiwan_vs_Tahaa
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1    4.707 0.75968 63.223  0.001 ***
## Residual 20    1.489 0.24032
## Total    21    6.196 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Taiwan_vs_Tahiti
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   1.7371 0.42373 11.029  0.002 **
## Residual 15   2.3625 0.57627
## Total    16   4.0997 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Taiwan_vs_Raia
##          Df SumOfSqs      R2     F Pr(>F)
## Loc       1   4.2436 0.77146 60.76  0.001 ***
## Residual 18   1.2572 0.22854
## Total    19   5.5008 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Djib_vs_Tahaa
```

```
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   4.5028 0.45145 28.804  0.001 ***
## Residual 35   5.4713 0.54855
## Total    36   9.9741 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Djib_vs_Tahiti
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   1.8363 0.22445 8.6822  0.001 ***
## Residual 30   6.3449 0.77555
## Total    31   8.1811 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Djib_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1   3.9935 0.43252 25.152  0.001 ***
## Residual 33   5.2395 0.56748
## Total    34   9.2330 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Tahaa_vs_Tahiti
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.32408 0.16768 2.6191  0.023 *
## Residual 13  1.60860 0.83232
## Total    14  1.93268 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $Tahaa_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.04881 0.08841 1.5518  0.207
## Residual 16  0.50321 0.91159
## Total    17  0.55202 1.00000
##
## $Tahiti_vs_Raia
##          Df SumOfSqs      R2      F Pr(>F)
## Loc       1  0.33852 0.19736 2.7047  0.011 *
## Residual 11  1.37675 0.80264
## Total    12  1.71527 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## attr(,"class")
## [1] "pwadstrata" "list"
```

```
pairwise.adonis2(asv_css_D ~ S_region, data = meta_D, sim.method = "bray",  p.adjust.m = "BH",
  permutations = 999)
```

```
## $parent_call
## [1] "asv_css_D ~ S_region , strata = Null , permutations 999"
##
```

```
## $IndianOc_vs_FrPoly
##          Df SumOfSqs      R2      F Pr(>F)
## S_region  1   9.4525 0.34748 41.003  0.001 ***
## Residual 77  17.7507 0.65252
## Total    78  27.2031 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $IndianOc_vs_Taiwan
##          Df SumOfSqs      R2      F Pr(>F)
## S_region  1   2.0378 0.11317 7.4012  0.002 **
## Residual 58  15.9695 0.88683
## Total    59  18.0074 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $FrPoly_vs_Taiwan
##          Df SumOfSqs      R2     F Pr(>F)
## S_region  1   6.7576 0.62677 68.85  0.001 ***
## Residual 41   4.0241 0.37323
## Total    42  10.7817 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## attr(,"class")
## [1] "pwadstrata" "list"
```

```
pairwise.adonis2(asv_css_D ~ SST_a, data = meta_D, sim.method = "bray",  p.adjust.m = "BH",
  permutations = 999)
```

```
## Set of permutations < 'minperm'. Generating entire set.

## 'nperm' >= set of all permutations: complete enumeration.

## Set of permutations < 'minperm'. Generating entire set.

## $parent_call
## [1] "asv_css_D ~ SST_a , strata = Null , permutations 999"
##
## $`30.8_vs_27.04`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   5.0305 0.71524 67.817  0.001 ***
## Residual 27   2.0028 0.28476
## Total    28   7.0333 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_28.59`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.09316 0.03396 1.0195  0.375
## Residual 29  2.65000 0.96604
## Total    30  2.74317 1.00000
##
```

```
## $`30.8_vs_29.37`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   5.8092 0.63395 53.688  0.001 ***
## Residual 31   3.3543 0.36605
## Total    32   9.1636 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_27.19`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   4.1297 0.69746 57.634  0.001 ***
## Residual 25   1.7914 0.30254
## Total    26   5.9211 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_26.86`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.0569 0.42128 17.471  0.001 ***
## Residual 24   2.8255 0.57872
## Total    25   4.8824 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   4.5201 0.63543 47.061  0.001 ***
## Residual 27   2.5933 0.36457
## Total    28   7.1134 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_28.67`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1  0.03322 0.0202 0.4329  0.895
## Residual 21  1.61137 0.9798
## Total    22  1.64459 1.0000
##
## $`30.8_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   5.2334 0.75263 82.146  0.001 ***
## Residual 27   1.7201 0.24737
## Total    28   6.9535 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`30.8_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.9657 0.63181 39.468  0.001 ***
## Residual 23   1.7282 0.36819
## Total    24   4.6939 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## $`30.8_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.7789 0.44368 20.735  0.001 ***
## Residual 26   3.4844 0.55632
## Total    27   6.2633 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_28.59`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1   3.7138 0.7145 40.043  0.001 ***
## Residual 16   1.4839 0.2855
## Total    17   5.1977 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_29.37`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   3.1892 0.59307 26.234  0.001 ***
## Residual 18   2.1883 0.40693
## Total    19   5.3775 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_27.19`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.19506 0.23778 3.7436  0.016 *
## Residual 12  0.62528 0.76222
## Total    13  0.82034 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_26.86`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.35915 0.17792 2.3807  0.006 **
## Residual 11  1.65943 0.82208
## Total    12  2.01858 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.7111 0.65512 26.594  0.001 ***
## Residual 14   1.4272 0.34488
## Total    15   4.1383 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_28.67`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1  1.48819 0.7697 26.737  0.024 *
## Residual  8  0.44529 0.2303
## Total     9  1.93347 1.0000
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_27.25`
##          Df SumOfSqs     R2     F Pr(>F)
## SST_a     1  0.22063 0.2848 5.575  0.002 **
## Residual 14  0.55404 0.7152
## Total    15  0.77467 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.16696 0.22898 2.9699  0.026 *
## Residual 10  0.56216 0.77102
## Total    11  0.72911 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.04_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.9931 0.46228 11.176  0.001 ***
## Residual 13   2.3183 0.53772
## Total    14   4.3114 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_29.37`
##          Df SumOfSqs      R2  F Pr(>F)
## SST_a     1   3.9697 0.58334 28  0.001 ***
## Residual 20   2.8355 0.41666
## Total    21   6.8052 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_27.19`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   3.1956 0.71521 35.159  0.001 ***
## Residual 14   1.2725 0.28479
## Total    15   4.4681 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_26.86`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.6054 0.41037 9.0478  0.001 ***
## Residual 13   2.3066 0.58963
## Total    14   3.9120 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_29.11`
##          Df SumOfSqs      R2     F Pr(>F)
## SST_a     1   3.3204 0.61548 25.61  0.001 ***
## Residual 16   2.0744 0.38452
```

```
## Total    17   5.3948 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   0.0290 0.02586 0.2655  0.959
## Residual 10   1.0925 0.97414
## Total    11   1.1215 1.00000
##
## $`28.59_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   3.8702 0.76314 51.549  0.001 ***
## Residual 16   1.2012 0.23686
## Total    17   5.0714 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_27.22`
##          Df SumOfSqs      R2    F Pr(>F)
## SST_a     1   2.4288 0.66759 24.1  0.002 **
## Residual 12   1.2093 0.33241
## Total    13   3.6381 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.59_vs_29.35`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1   2.0404 0.4076 10.321  0.001 ***
## Residual 15   2.9655 0.5924
## Total    16   5.0060 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_27.19`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.6718 0.57476 21.625  0.001 ***
## Residual 16   1.9768 0.42524
## Total    17   4.6487 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_26.86`
##          Df SumOfSqs      R2     F Pr(>F)
## SST_a     1   1.7078 0.36192 8.508  0.002 **
## Residual 15   3.0110 0.63808
## Total    16   4.7188 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.02955 0.01052 0.1914  0.898
## Residual 18  2.77877 0.98948
```

```
## Total    19  2.80832 1.00000
##
## $`29.37_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.4080 0.43933 9.4029  0.015 *
## Residual 12   1.7968 0.56067
## Total    13   3.2048 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_27.25`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1   3.3252 0.6357 31.409  0.001 ***
## Residual 18   1.9056 0.3643
## Total    19   5.2308 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_27.22`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1   1.9783 0.5083 14.473  0.002 **
## Residual 14   1.9137 0.4917
## Total    15   3.8920 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.37_vs_29.35`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1   0.3335 0.0833 1.5449  0.203
## Residual 17   3.6699 0.9167
## Total    18   4.0034 1.0000
##
## $`27.19_vs_26.86`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.26412 0.15427 1.6417  0.094 .
## Residual  9  1.44798 0.84573
## Total    10  1.71210 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.19_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.3357 0.65767 23.054  0.001 ***
## Residual 12   1.2158 0.34233
## Total    13   3.5515 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.19_vs_28.67`
##          Df SumOfSqs     R2      F Pr(>F)
## SST_a     1  1.41985 0.8586 36.431  0.041 *
## Residual  6  0.23384 0.1414
## Total     7  1.65369 1.0000
## ---
```

```
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.19_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.02891 0.07783 1.0128  0.322
## Residual 12  0.34260 0.92217
## Total    13  0.37151 1.00000
##
## $`27.19_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.01682 0.04577 0.3838  0.645
## Residual  8  0.35071 0.95423
## Total     9  0.36753 1.00000
##
## $`27.19_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.7321 0.45118 9.0431  0.002 **
## Residual 11   2.1069 0.54882
## Total    12   3.8390 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`26.86_vs_29.11`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.5378 0.40599 7.5182  0.002 **
## Residual 11   2.2499 0.59401
## Total    12   3.7877 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`26.86_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.79941 0.38667 3.1523  0.041 *
## Residual  5  1.26799 0.61333
## Total     6  2.06740 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`26.86_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.33852 0.19736 2.7047  0.018 *
## Residual 11  1.37675 0.80264
## Total    12  1.71527 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`26.86_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.22666 0.14065 1.1457  0.325
## Residual  7  1.38486 0.85935
## Total     8  1.61152 1.00000
##
## $`26.86_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
```

```
## SST_a     1   0.9884 0.23936 3.1469  0.013 *
## Residual 10   3.1410 0.76064
## Total    11   4.1295 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.11_vs_28.67`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.3450 0.56494 10.388  0.026 *
## Residual  8   1.0358 0.43506
## Total     9   2.3808 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.11_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.8238 0.71158 34.541  0.001 ***
## Residual 14   1.1445 0.28842
## Total    15   3.9684 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.11_vs_27.22`
##          Df SumOfSqs      R2     F Pr(>F)
## SST_a     1   1.7993 0.60952 15.61  0.002 **
## Residual 10   1.1527 0.39048
## Total    11   2.9519 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`29.11_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   0.3033 0.09442 1.3554  0.204
## Residual 13   2.9088 0.90558
## Total    14   3.2121 1.00000
##
## $`28.67_vs_27.25`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.5441 0.90473 75.971  0.016 *
## Residual  8   0.1626 0.09527
## Total     9   1.7067 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.67_vs_27.22`
##          Df SumOfSqs      R2      F  Pr(>F)
## SST_a     1  1.25898 0.88059 29.499 0.06667 .
## Residual  4  0.17071 0.11941
## Total     5  1.42969 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`28.67_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
```

```
## SST_a     1   0.8977 0.31781 3.2611  0.029 *
## Residual  7   1.9269 0.68219
## Total     8   2.8246 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.25_vs_27.22`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1  0.05069 0.15353 1.8138  0.192
## Residual 10  0.27947 0.84647
## Total    11  0.33016 1.00000
##
## $`27.25_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   2.0991 0.50768 13.405  0.001 ***
## Residual 13   2.0357 0.49232
## Total    14   4.1348 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## $`27.22_vs_29.35`
##          Df SumOfSqs      R2      F Pr(>F)
## SST_a     1   1.3412 0.39623 5.9062  0.003 **
## Residual  9   2.0438 0.60377
## Total    10   3.3850 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## attr(,"class")
## [1] "pwadstrata" "list"
```

```
pairwise.adonis2(asv_css_D ~ Tbl_bin, data = meta_D, sim.method = "bray",  p.adjust.m = "BH",
  permutations = 999)
```

```
## $parent_call
## [1] "asv_css_D ~ Tbl_bin , strata = Null , permutations 999"
##
## $Long_vs_Recent
##          Df SumOfSqs     R2      F Pr(>F)
## Tbl_bin   1   3.1394 0.0993 9.8123  0.001 ***
## Residual 89  28.4755 0.9007
## Total    90  31.6149 1.0000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## attr(,"class")
## [1] "pwadstrata" "list"
```

```
#EXTRA CODE FOR MANTEL TESTS -- NOT USED

##scatterplots

##aa = as.vector(bray.dist)
```

```
##tt = as.vector(dist.temp)
##dd = as.vector(dist.DHW)
##gg = as.vector(dist.geo)

#new data frame with vectorized distance matrices
##mat = data.frame(aa,tt,dd, gg)
```

```
##mm_temp = ggplot(mat, aes(y = aa, x = tt)) +
   ## geom_point(size = 4, alpha = 0.75, colour = "black",shape = 21, aes(fill=tt)) +
   ## geom_smooth(method = "lm", colour = "black", alpha = 0.2) +
   ## labs(x = "Difference in Temperature (C)", y = "Bray-Curtis Dissimilarity", fill = "Difference in 
  ##  theme( axis.text.x = element_text(face = "bold",colour = "black", size = 12),
    ##          axis.text.y = element_text(face = "bold", size = 11, colour = "black"),
    ##          axis.title= element_text(face = "bold", size = 14, colour = "black"),
    ##          panel.background = element_blank(),
  ##            panel.border = element_rect(fill = NA, colour = "black"),
    ##          legend.position = "top",
   ##           legend.text = element_text(size = 10, face = "bold"),
 ##          legend.title = element_text(size = 11, face = "bold")) +
   ##    scale_fill_continuous(high = "navy", low = "skyblue")

 ##mm_temp

 ##mm_dhw = ggplot(mat, aes(y = aa, x = dd)) +
 ##    geom_point(size = 4, alpha = 0.75, colour = "black",shape = 21, aes(fill=dd)) +
 ##    geom_smooth(method = "lm", colour = "black", alpha = 0.2) +
  ##   labs(x = "Difference in DHW", y = "Bray-Curtis Dissimilarity", fill = "Difference in DHW") +
  ##   theme( axis.text.x = element_text(face = "bold",colour = "black", size = 12),
  ##          axis.text.y = element_text(face = "bold", size = 11, colour = "black"),
   ##         axis.title= element_text(face = "bold", size = 14, colour = "black"),
       ##     panel.background = element_blank(),
          ##  panel.border = element_rect(fill = NA, colour = "black"),
   ##         legend.position = "top",
    ##        legend.text = element_text(size = 10, face = "bold"),
        #  legend.title = element_text(size = 11, face = "bold")) +
   ##  scale_fill_continuous(high = "navy", low = "skyblue")

 ##mm_dhw

 ##mm_dist = ggplot(mat, aes(y = aa, x = gg)) +
 ##    geom_point(size = 4, alpha = 0.75, colour = "black",shape = 21, aes(fill = gg/1000)) +
 ##    geom_smooth(method = "lm", colour = "black", alpha = 0.2) +
 ##    labs(x = "Physical Separation (m)", y = "Bray-Curtis Dissimilarity", fill = "Physical Separation
 ##    theme( axis.text.x = element_text(face = "bold",colour = "black", size = 12),
 ##           axis.text.y = element_text(face = "bold", size = 11, colour = "black"),
 ##           axis.title= element_text(face = "bold", size = 14, colour = "black"),
  ##          panel.background = element_blank(),
 ##           panel.border = element_rect(fill = NA, colour = "black"),
  ##          legend.position = "top",
  ##          legend.text = element_text(size = 10, face = "bold"),
  ##          legend.title = element_text(size = 11, face = "bold")) +
  ##   scale_fill_continuous(high = "navy", low = "skyblue")
```

```
##mm_dist
```