Initial OCNMS Community Analyses - SWATH INVERTEBRATES

INTRODUCTION

Some preliminary data analyses and interpretation follow for swath invertebrates.

For these analysis, I expanded the data by simply multiplying the count by the distance measured and dividing by 10. I know this is Ole's "detested method" but it is easy enough to change later.

ORDINATIONS BY TRANSECT

I started with some ordinations (nMDS) by transect. This analysis would then includes Year, Site, and Depth in the presentation, although the nMDS analyzes are unconstrained and do not formally recognize these groups.

For all the community analyses that follow, I sqrt transformed the data and used a Bray-Curtis distance matrix.

I limited the species to those see on at least 20 transects. I also removed transects with no sightings, since they mess up the distance matrices.

Stress was 0.2114206, which is high and not particularly good.

```
##
## Call:
## metaMDS(comm = benth_matrix, distance = "bray", k = 3, trymax = 100,      autotransform = TRUE)
##
## global Multidimensional Scaling using monoMDS
##
## Data:     wisconsin(sqrt(benth_matrix))
## Distance: bray
##
## Dimensions: 3
## Stress:     0.2114206
## Stress type 1, weak ties
## Two convergent solutions found after 24 tries
## Scaling: centring, PC rotation, halfchange scaling
## Species: expanded scores based on 'wisconsin(sqrt(benth_matrix))'
```

The nMDS ordination does not show any clear patterns initially. There is a lot of overap among points. I would suggest that this means that there is too much variation at the transect level to see any really obvious patterns. Below, I've done some alternate presentations and analyses by summarizing the data (taking averages). However, some transect-level results still follow.

The figure below separates years. The nMDS is the same as that above. I've just plotted years separately for clarity. There do not seem to be any obvious patters here either. Just too much variation at the transfect level to see.

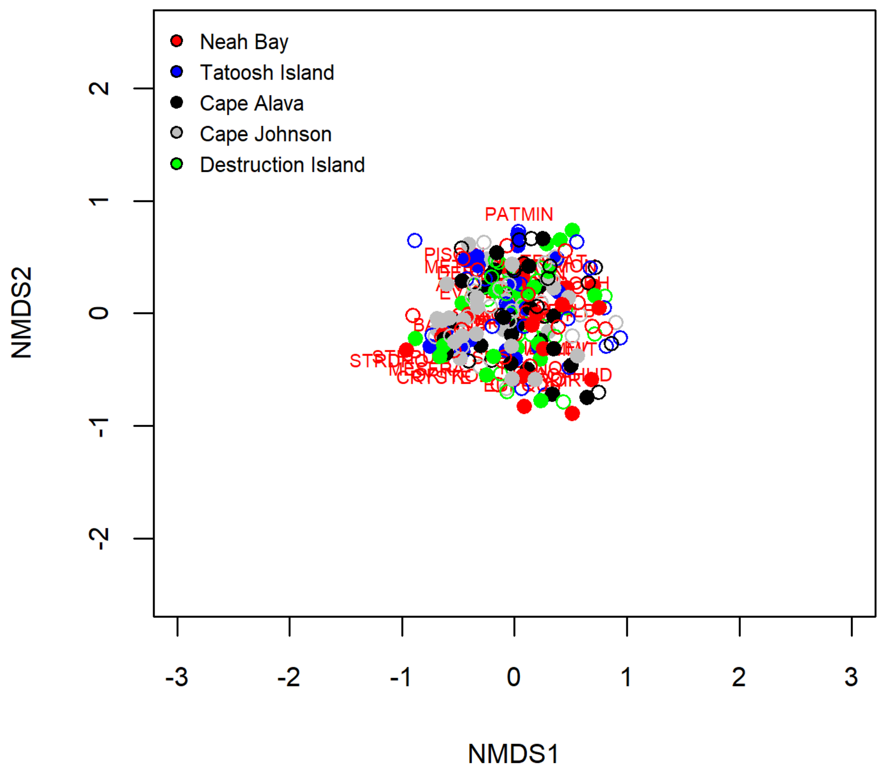


Figure 1: nMDS plot of benth assemblage structure. Colors indicate sites. Open circues = 5 m, closed circles = 10 m. Years are not differentiated in this figure.

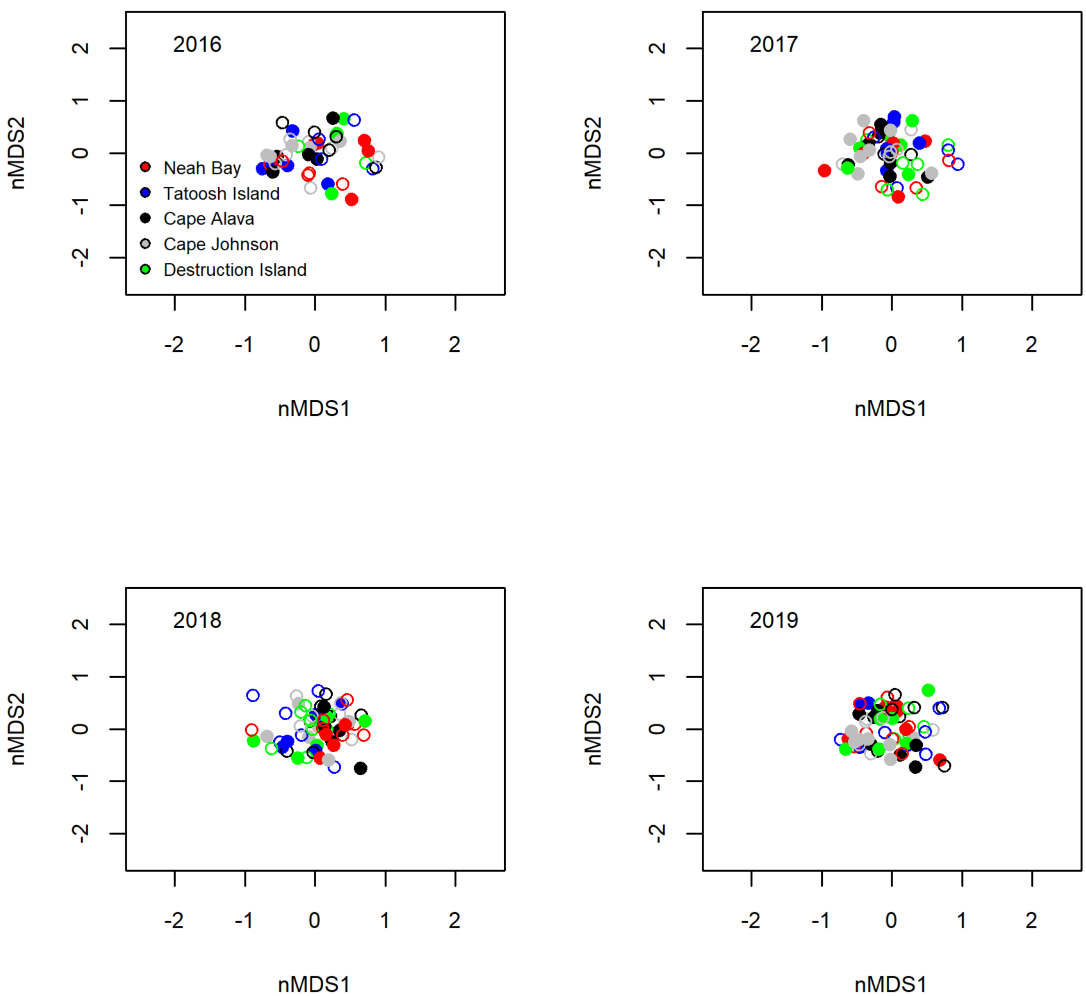


Figure 2: nMDS plot of benth assemblage structure. Colors indicate sites. Open circues = 5 m, closed circles = 10 m. Years are not differentiated in this figure.

AVERAGED BY YEAR, SITE, DEPTH ZONE

I averaged the observations by site, year, and depth to partly reduce the number of data points and to be better able to see any assemblage trends through time. First, some plots of abundance for each taxa by year, site, and depth.

One obvious pattern is the increase in purple urchins (STRDRO) over time.

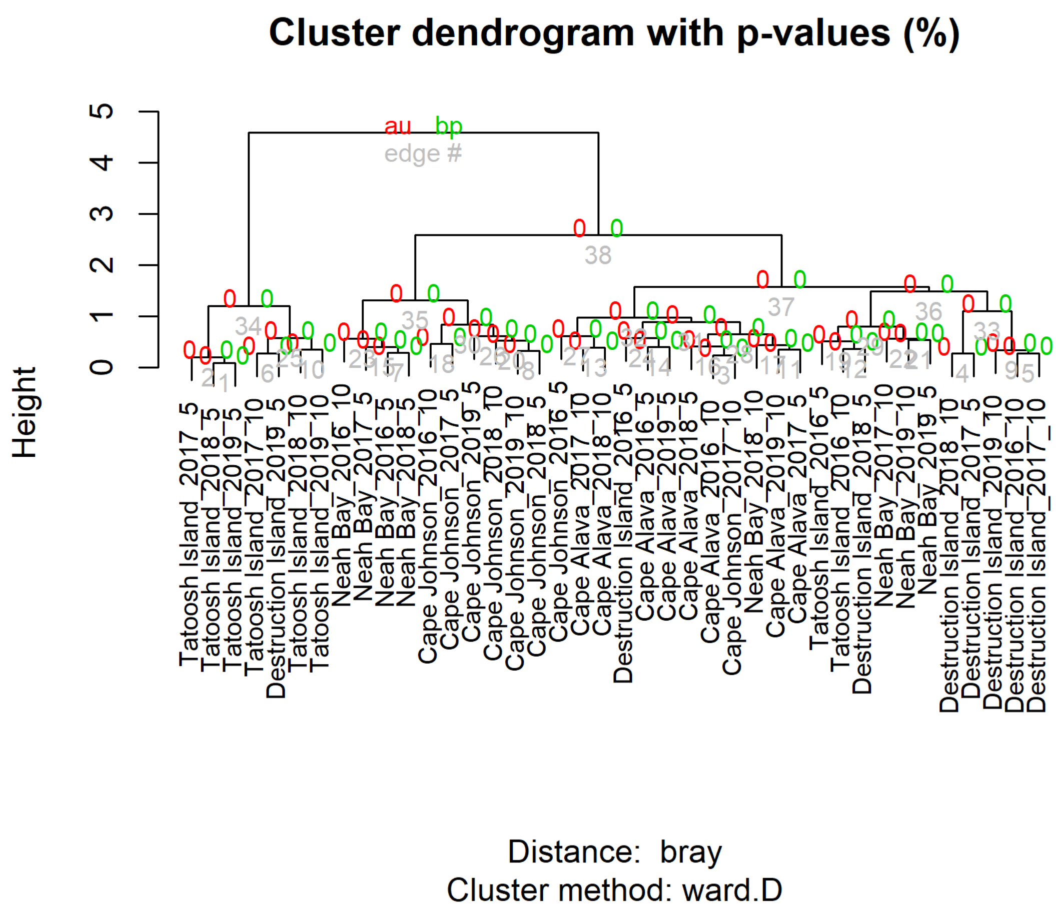
This model using averaged values by site, year, and depth converged and had a stress of 0.1498177, which is less than 0.2, so OK. So better, but I would stil say nothing obvious jumps out in terms of sites. There is a lot of overlap.

Plotting the nMDS by site x depth x year starts to show some differences among sites. But there is still a lot of data. Most sites show a bit of a difference between depths, especially the two more southern sites.

Nevertheless, the site differences start to appear and in the sub plots you can see some differences.

I also ran some cluster analyses, which is a typical add-on to an nMDS analysis. The cluster is not as clear, but Tatoosh is clearly different, and distruction is off by itself. Neah Bay and Cape Johnson tend to be similar.

This version does some bootstrapping to estimate the 'signficance' of branches.



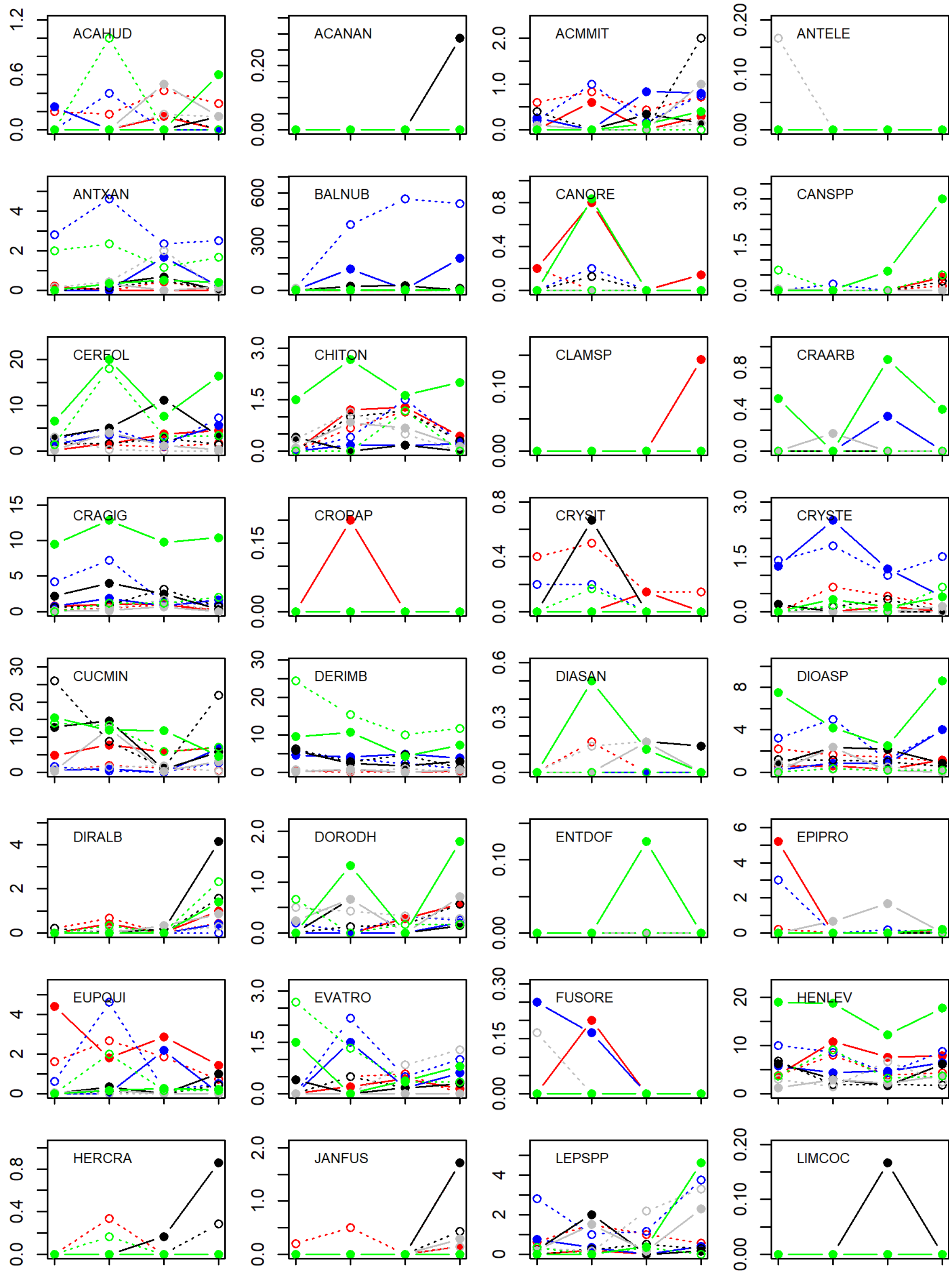


Figure 3: Taxon abundance by year, site, and depth. Open circles = 5 m, closed circles = 10 m.

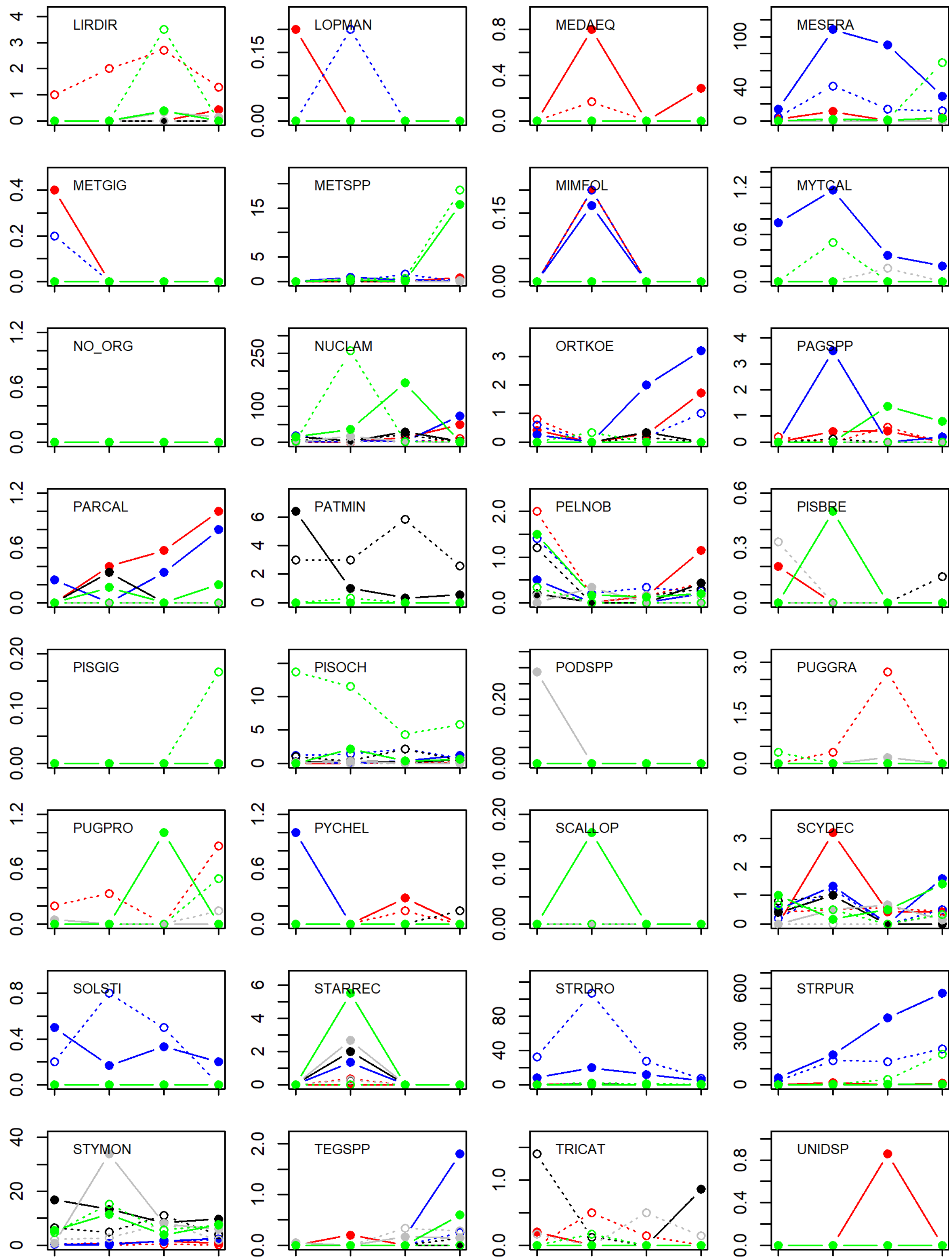


Figure 4: Taxon abundance by year, site, and depth. Open circles = 5 m, closed circles = 10 m.

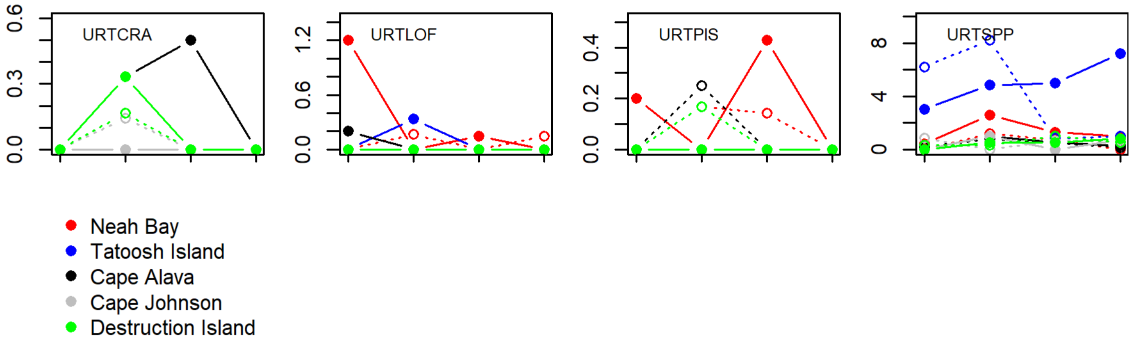


Figure 5: Taxon abundance by year, site, and depth. Open circles = 5 m, closed circles = 10 m.

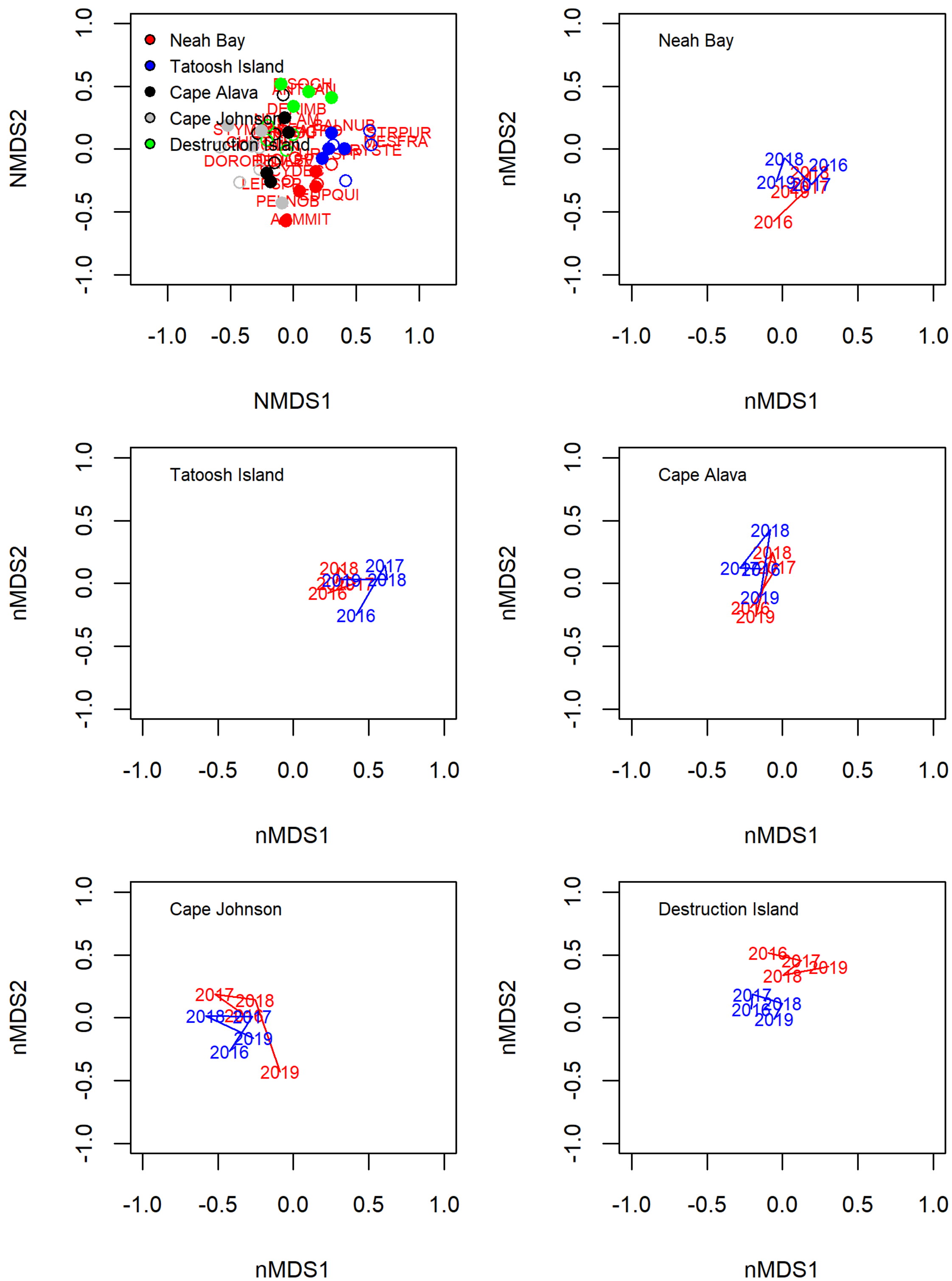


Figure 6: nMDS plot of benth assemblage structure. In the first, pane, colors indicate sites, open circues = 5 m, and closed circles = 10 m. In the additional planes, red = 5 m, blue = 10 m. All figures are from the same nMDS.

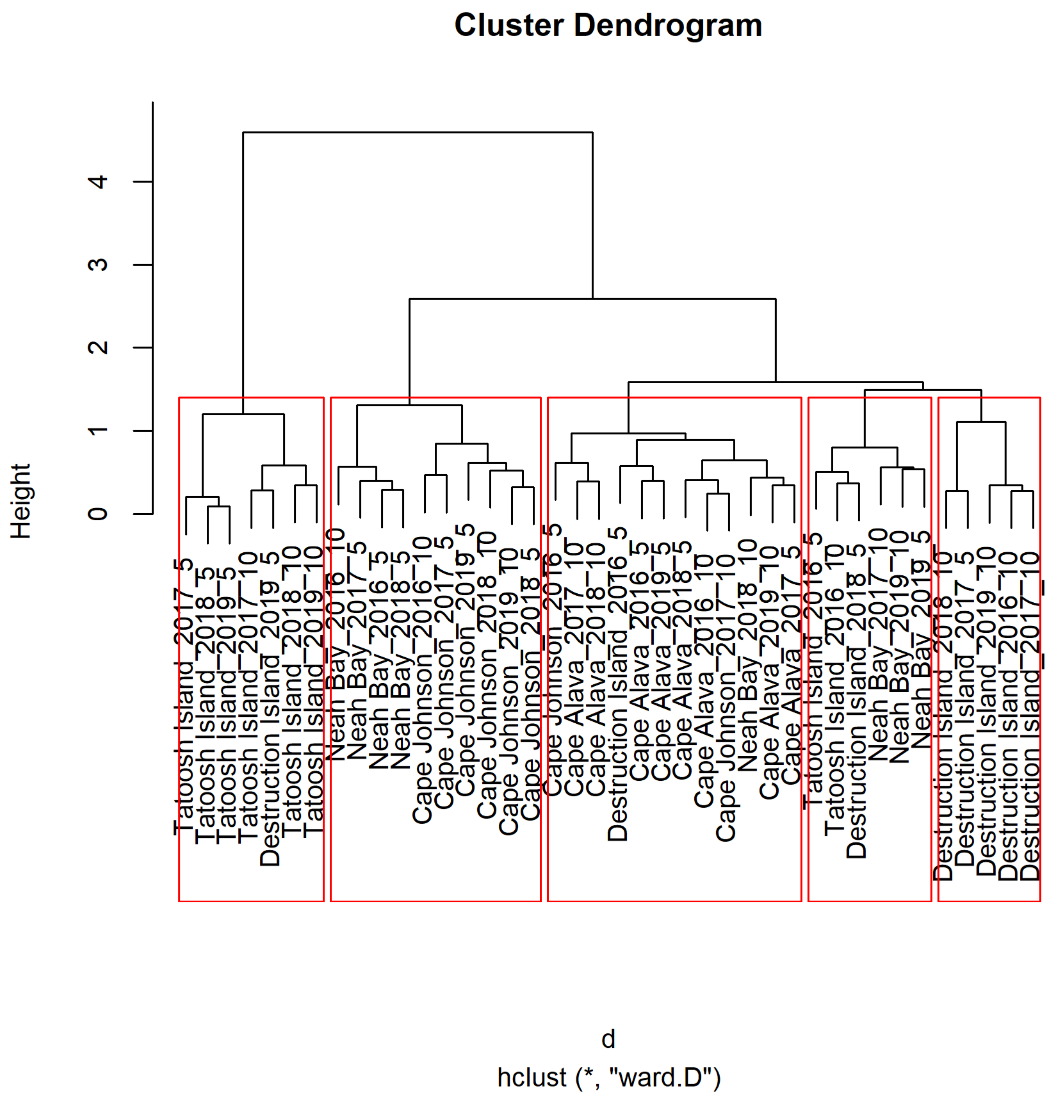


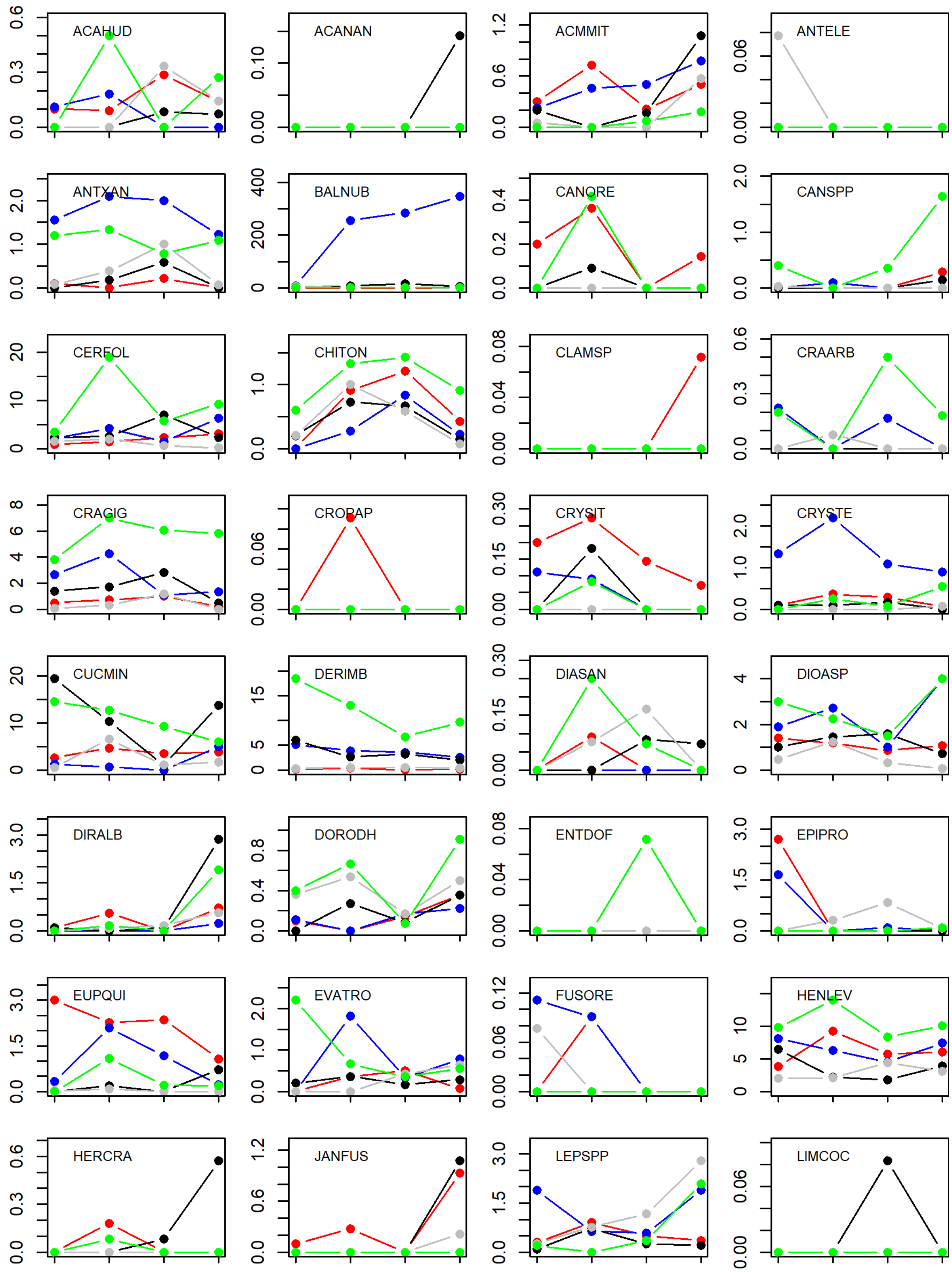
Figure 7: Cluster of inverts.

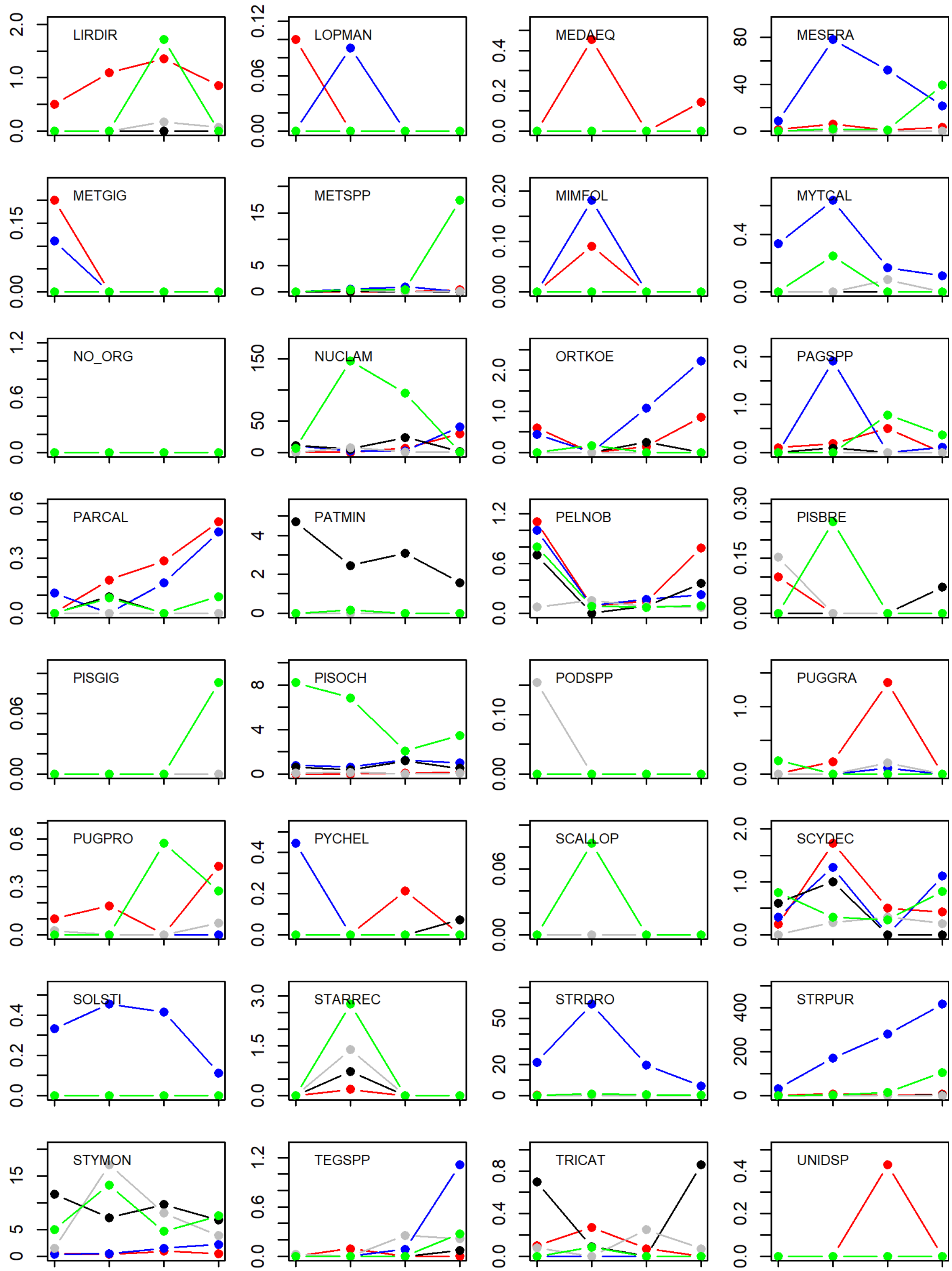
AVERAGED BY YEAR & SITE

Finally, I then just *AVERAGED DATA BY YEAR AND SITE*, partly to better see any temporal patterns. Looking at the univariate plots there are a few potentially interesting bits:

- Purple urchins steadily increaed over time primarily at Tatoosh but a little bit at Destruction in 2019.
- Sea stars (STARREC) had a pulse of recruitment up and down the coast in 2018. Ignoring Neah Bay, since it is in the strait, there appears to be a bit of a north-south pattern with higher recruitment in the south.
- Chitons increased everywhere and then decreased everywhere.
- There are taxa where patterns along the coast are more or less coherent through time (all sites go up in the same year) BUT
- Thera are a lot of taxa for which abudnance varies differently through time at the sites.

NOTE: I haven't run any stats on these univariate patterns yet. The above are just from visual observation.


ACAHUD
ACANAN
ACMMIT
ANTELE
ANTXAN
BALNUB
CANORE
CANSPP
CERFOL
CHITON
CLAMSP
CRAARB
CRAGIG
CROPAP
CRYSIT
CRYSTE
CUCMIN
DERIMB
DIASAN
DIOASP
DIRALB
DORODH
ENTDOF
EPIPRO
EUPQUI
EVATRO
FUSORE
HENLEV
HERCRA
JANFUS
LEPSPP
LIMCOC


LIRDIR
LOPMAN
MEDAEQ
MESFRA
METGIG
METSPP
MIMFOL
MYTCAL
NO_ORG
NUCLAM
ORTKOE
PAGSPP
PARCAL
PATMIN
PELNOB
PISBRE
PISGIG
PISOCH
PODSPP
PUGGRA
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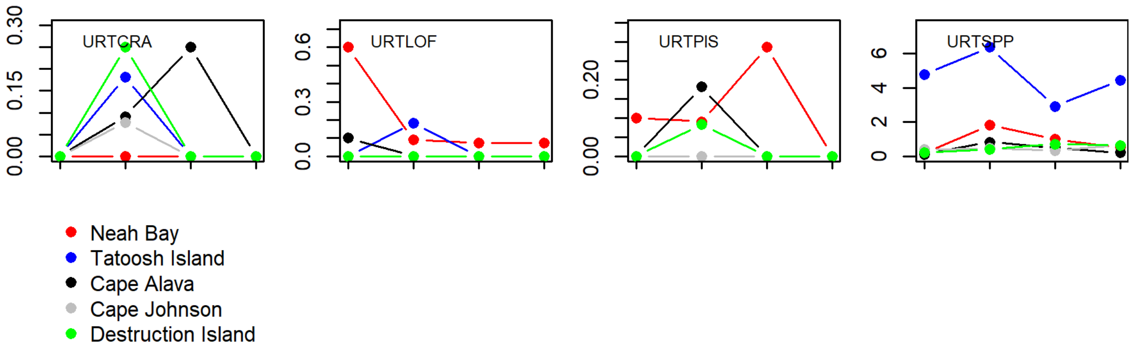
TEGSPP
TRICAT
UNIDSP



When taking the average for site x year, the ordination is good. The stress was 0.1718408. The model converged. The sites also are all clearly different from one another and cluster separately in the ordination and the clustergrams. My take on this is that there is a lot of transect level variation that makes the assemblage-level differences difficult to see among sites. However, assemblage structure for benthic inverts does differ among the sites.

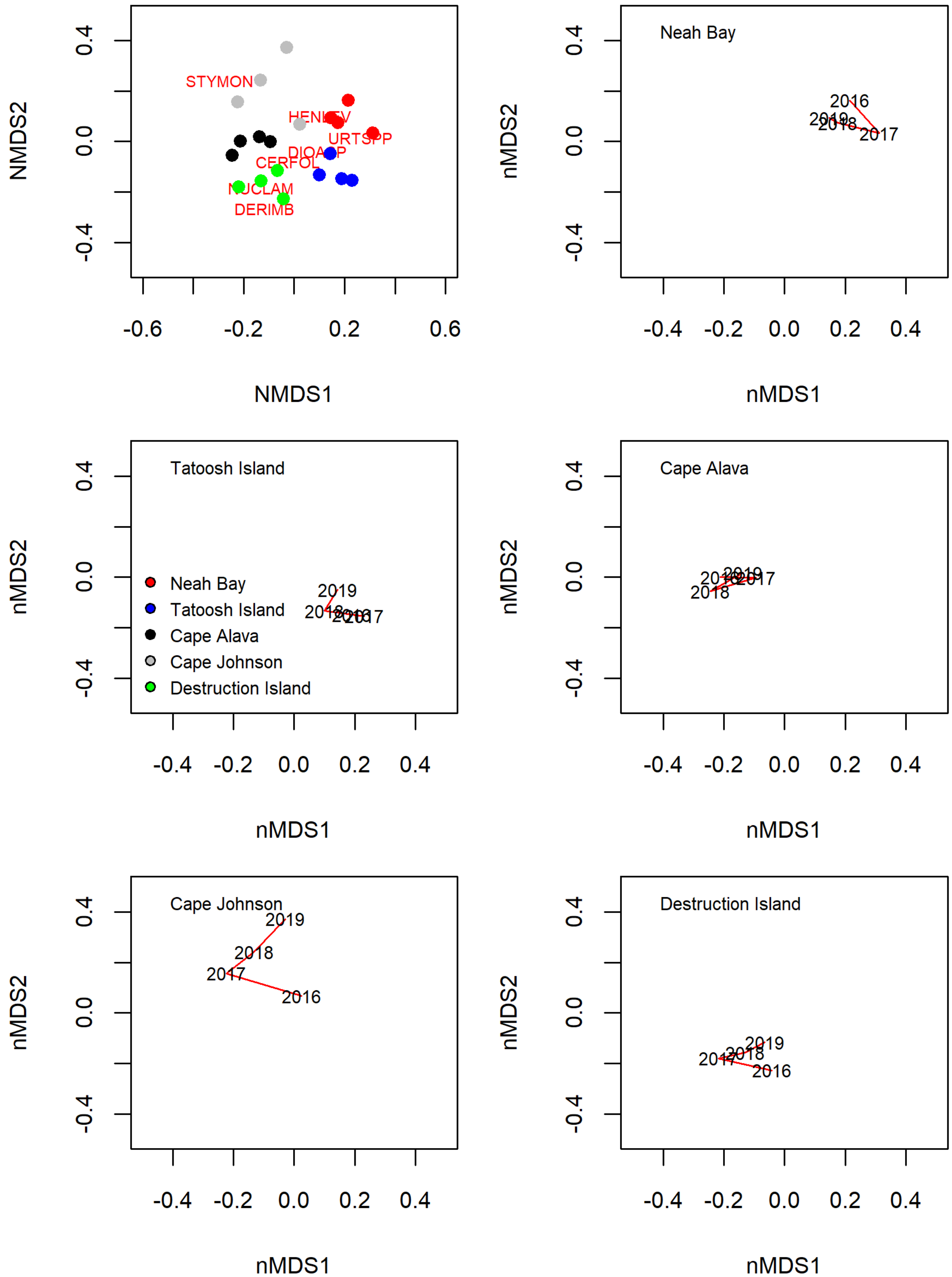
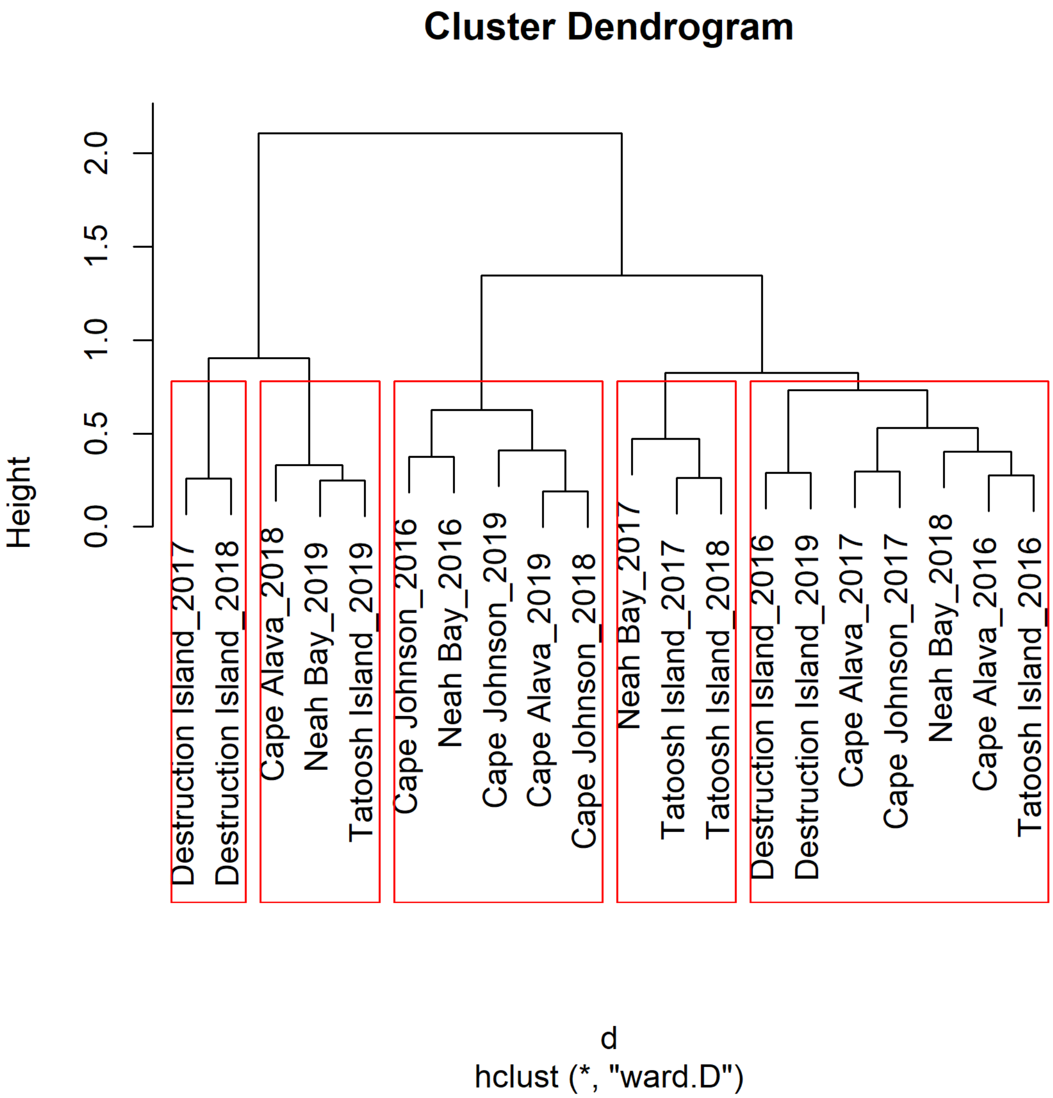
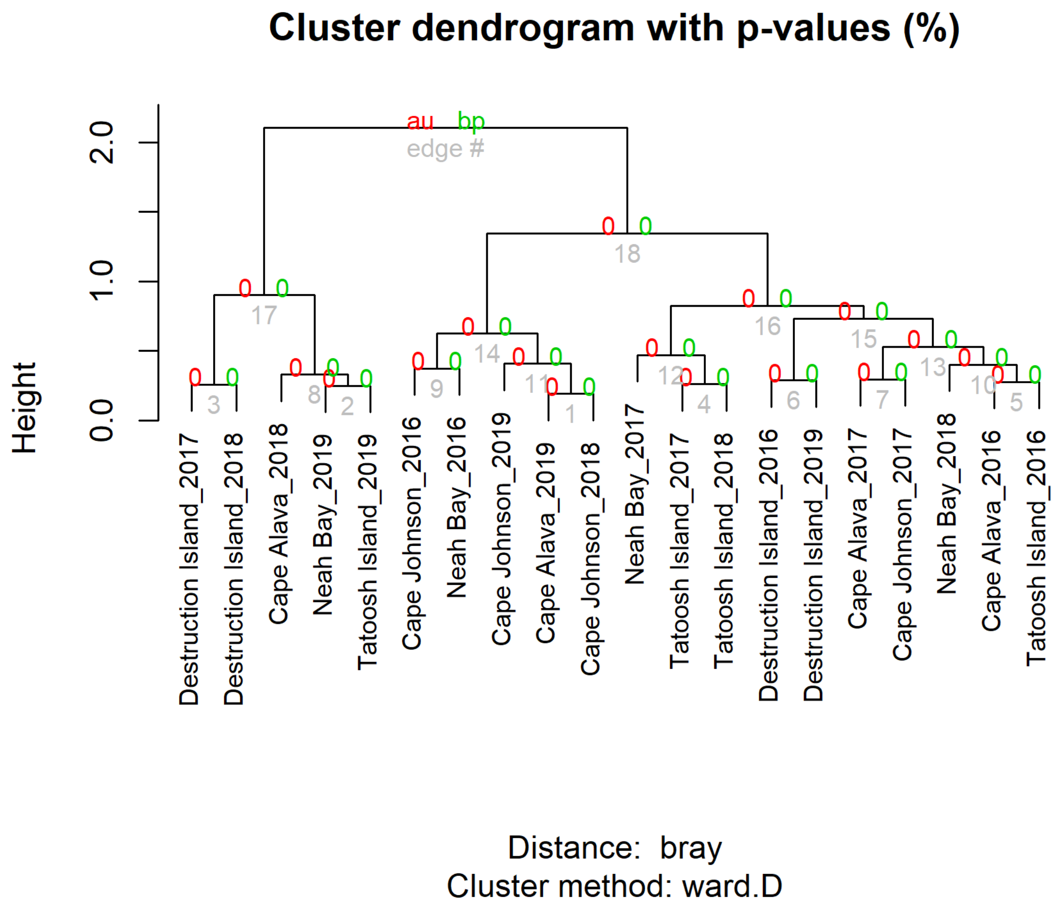


Figure 8: nMDS plot of benth assemblage structure. In the first, pane, colors indicate sites, open circues = 5 m, and closed circles = 10 m. In the additional planes, red = 5 m, blue = 10 m. All figures are from the same nMDS.

The cluster diagrams are also much better. Site cluster separately for the most part, but Cape Johnson and Cape Alava mix a bit. I want to double check some stuff here just because it doesn't look at clear as the nMDS



Bootstrap version.



Canonical/Constrained Analysis of Principal Cordinates and PerMANOVA

with Depth zone

nMDS is an unconstrained ordination. That is, it has not specific hypotheses and doesn't recognize existing groups. We (I) just add them later in terms of coloring the points.

I also did constrained ordinations and perMANOVAs to determine whether we could really tell apart the site,years, depths. Constrained ordinations start with hypothesis and then try to draw the factors axes in a way to separate the categories.

For the PerMANOVA, year and zone were significant in the first round. But lots of terms were not so I also did some back fitting.

```
## Permutation: free
## Number of permutations: 999
##
## Terms added sequentially (first to last)
##
##                   Df SumsOfSqs MeanSqs F.Model      R2 Pr(>F)
## year               3     1.157 0.38566  1.5750 0.01988  0.037 *
## site               4     1.268 0.31708  1.2949 0.02179  0.093 .
```

```
## zone             1     0.696 0.69586  2.8418 0.01196  0.002 **
## year:site       12     2.948 0.24565  1.0032 0.05066  0.447
## year:zone        3     0.808 0.26934  1.0999 0.01389  0.307
## site:zone        4     1.249 0.31231  1.2755 0.02147  0.089 .
## year:site:zone  12     3.297 0.27479  1.1222 0.05666  0.175
## Residuals      191    46.769 0.24486         0.80369
## Total          230    58.192                 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

But lots of terms were not so I also did some back fitting.

Again, year and zone were the only significant terms, which doens't match the nMDS, which is ok, I suppose. They do not always match. It is not uncommon for the PerMANOVA-CAP approach pick up stuff that the nMDS does not. So we might expect Depth (zone) to ordinate more clearly. I'm not sure why Site was unimportant in the PerMANOVA-CAP but not the nMDS.

```
## Permutation: free
## Number of permutations: 999
##
## Terms added sequentially (first to last)
##
##                 Df SumsOfSqs MeanSqs F.Model      R2 Pr(>F)
## year             3     1.157 0.38566  1.5750 0.01988  0.034 *
## site             4     1.268 0.31708  1.2949 0.02179  0.103
## zone             1     0.696 0.69586  2.8418 0.01196  0.003 **
## year:site       12     2.948 0.24565  1.0032 0.05066  0.482
## year:zone        3     0.808 0.26934  1.0999 0.01389  0.309
## site:zone        4     1.249 0.31231  1.2755 0.02147  0.108
## year:site:zone  12     3.297 0.27479  1.1222 0.05666  0.177
## Residuals      191    46.769 0.24486         0.80369
## Total          230    58.192                 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Permutation: free
## Number of permutations: 999
##
## Terms added sequentially (first to last)
##
##            Df SumsOfSqs MeanSqs F.Model      R2 Pr(>F)
## year        3     1.157 0.38566  1.5463 0.01988  0.033 *
## zone        1     0.669 0.66871  2.6812 0.01149  0.004 **
## Residuals 226    56.367 0.24941         0.96863
## Total     230    58.192                 1.00000
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
## Overall classification success (m=9) : 19.9134199134199 percent
## 2016_10 (n=23) correct: 0 percent
## 2016_5 (n=24) correct: 16.6666666666667 percent
## 2017_10 (n=26) correct: 19.2307692307692 percent
## 2017_5 (n=32) correct: 25 percent
## 2018_10 (n=33) correct: 30.3030303030303 percent
## 2018_5 (n=31) correct: 22.5806451612903 percent
## 2019_10 (n=31) correct: 29.0322580645161 percent
```

```
## 2019_5 (n=31) correct: 9.67741935483871 percent
```

```
##              Df  Pillai approx F num Df den Df   Pr(>F)
## y[, group]    7 0.33778   1.6152     49   1561 0.004866 **
## Residuals   223
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

The CAP using all the transects doesn't show huge differenes among transects based on site or year.

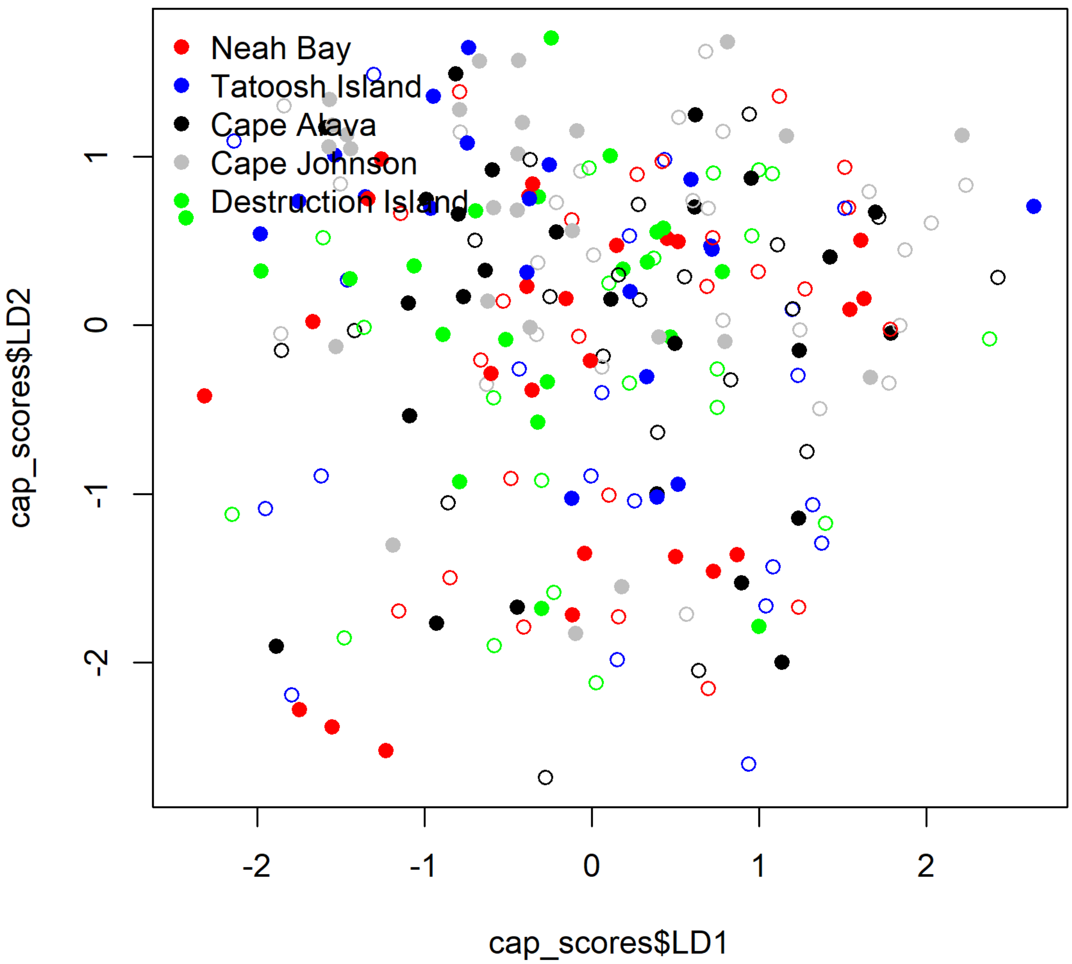


Figure 9: Plot of the first and second linear dimensions from a constrained analysis of principal coordinates. Sqrt transform, Bray-Curtis distance. Open circles = 5 m, Closed circles - 10 m.

Averaging the CAP scores by year x site does clean up the figure a bit, but it isn't great looking. The nMDS are much cleaner (fewer data though).

I haven't managed to really graph out the spp involved yet.

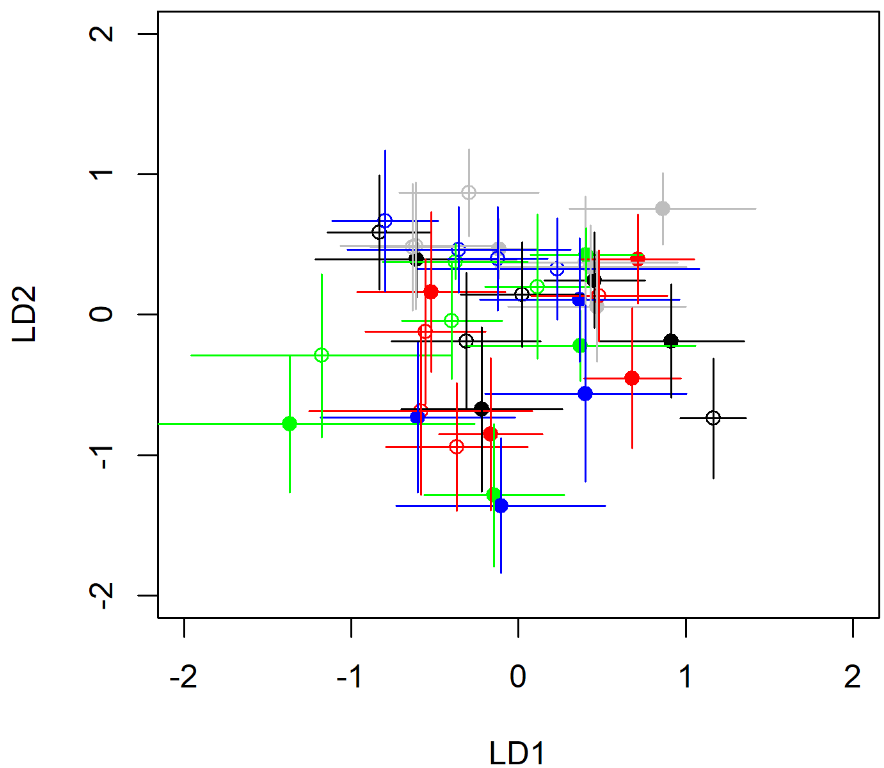


Figure 10: Means from CAP with year and depth. Open circles = 5 m, closed circles = 10 m.