TL_Trans Detailed Analysis

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Summary & Terms

This document shows the results from a reciprocal transplant experiment in Puerto Rico

OFAV - *Orbicella faveolata*, OFRA - *Orbicella franksii*

PP - Deep to deep transplant, PS - Deep to shallow transplant, SS - Shallow to shallow transplant, SP - Shallow to deep transplant

Load libraries: Done

Remove outliers: Done

Each variable in this data set has been filtered for outliers > 3x z-score

Check for Normalcy: Done

Run Shapiro and Bartlett tests on all parameters to test for normality and homogeneity

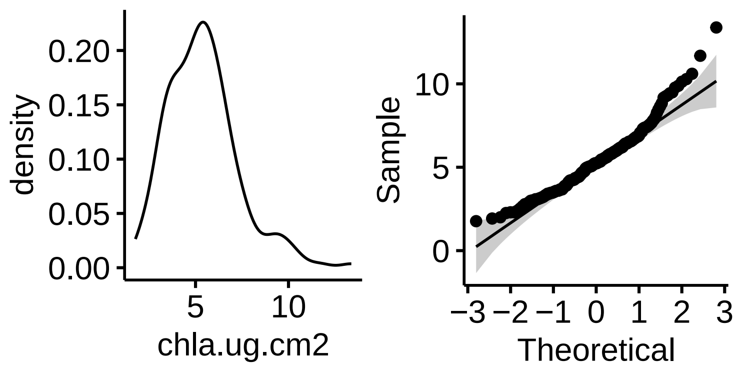
Results of Normalcy check All physiology metrics do not have parametric shapes or homogeneity, must use non-parametric tests on all analyses

t-test -> Wilcoxon's

Chlorophyll a

```
##
##  Shapiro-Wilk normality test
##
## data:  raw$chla.ug.cm2
## W = 0.95441, p-value = 5.419e-06
```

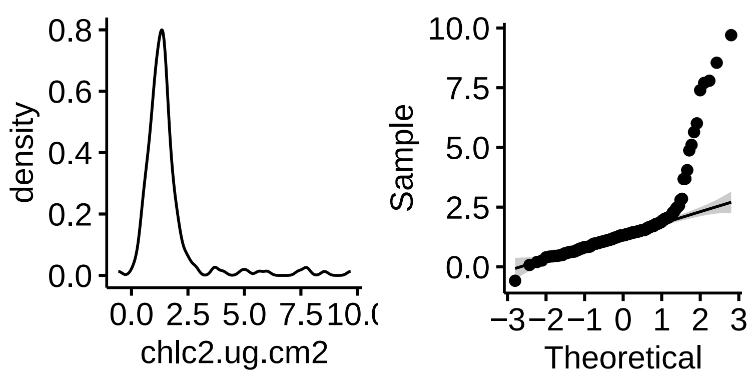
```
##
##  Bartlett test of homogeneity of variances
##
## data:  chla.ug.cm2 by full_treatment
## Bartlett's K-squared = 44.859, df = 5, p-value = 1.55e-08
```



Chlorophyll c2

```
##
##  Shapiro-Wilk normality test
##
## data:  raw$chlc2.ug.cm2
## W = 0.59857, p-value < 2.2e-16
```

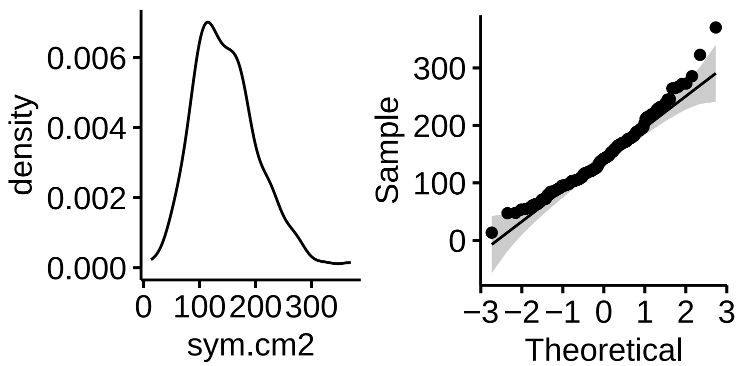
```
##
##  Bartlett test of homogeneity of variances
##
## data:  chlc2.ug.cm2 by full_treatment
## Bartlett's K-squared = 201.5, df = 5, p-value < 2.2e-16
```



Symbiont Density

```
##
##  Shapiro-Wilk normality test
##
## data:  raw$sym.cm2
## W = 0.9703, p-value = 0.001676
```

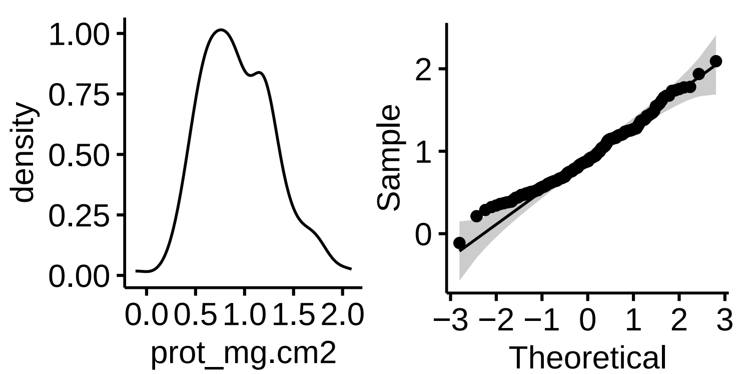
```
##
##  Bartlett test of homogeneity of variances
##
## data:  sym.cm2 by full_treatment
## Bartlett's K-squared = 18.153, df = 5, p-value = 0.002761
```



Protein Concentration

```
##
##  Shapiro-Wilk normality test
##
## data:  raw$prot_mg.cm2
## W = 0.98266, p-value = 0.01475
```

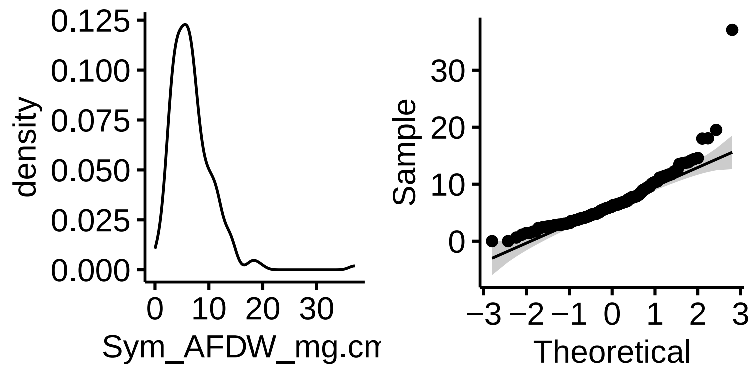
```
##
##  Bartlett test of homogeneity of variances
##
## data:  prot_mg.cm2 by full_treatment
## Bartlett's K-squared = 15.074, df = 5, p-value = 0.01005
```



Symbiont Ash Free Dry Weight

```
##
##  Shapiro-Wilk normality test
##
## data:  raw$Sym_AFDW_mg.cm2
## W = 0.83842, p-value = 1.455e-13
```

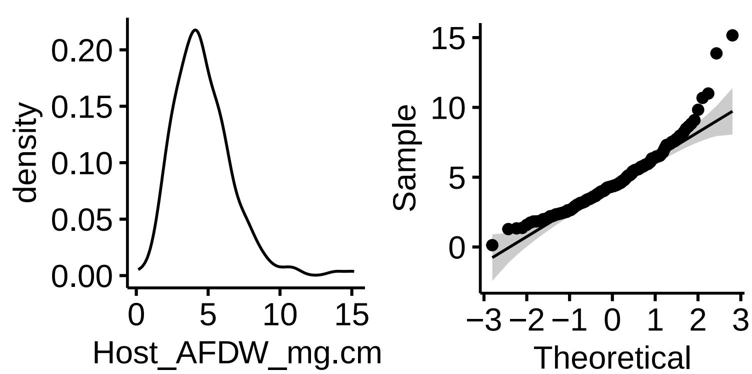
```
##
##  Bartlett test of homogeneity of variances
##
## data:  Sym_AFDW_mg.cm2 by full_treatment
## Bartlett's K-squared = 51.618, df = 5, p-value = 6.462e-10
```



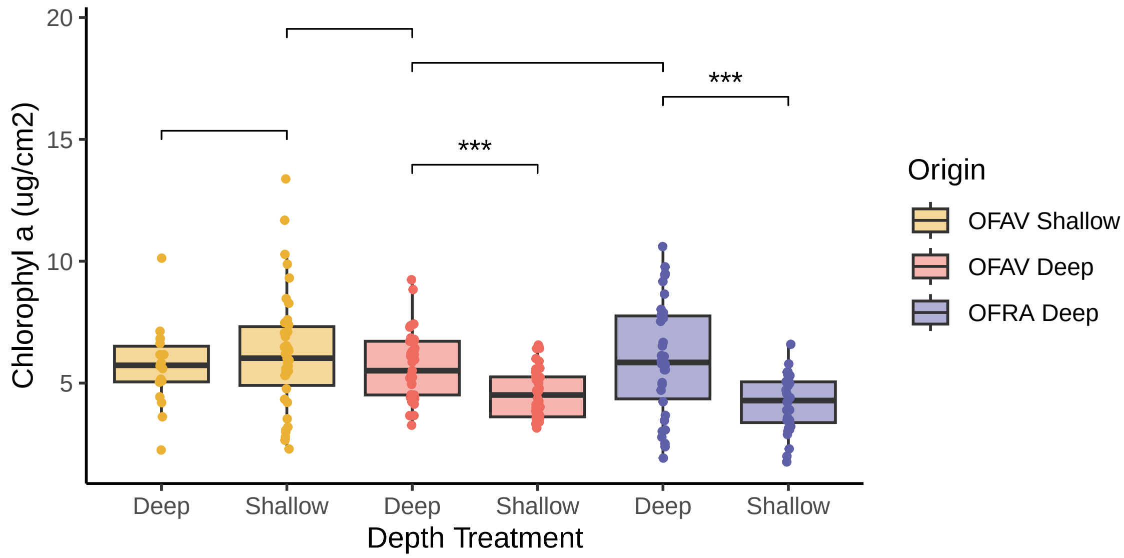
Host Ash Free Dry Weight

```
##
##  Shapiro-Wilk normality test
##
## data:  raw$Host_AFDW_mg.cm2
## W = 0.91961, p-value = 5.828e-09
```

```
##
##  Bartlett test of homogeneity of variances
##
## data:  Host_AFDW_mg.cm2 by full_treatment
## Bartlett's K-squared = 24.377, df = 5, p-value = 0.0001838
```



Chlorophyl a




```
##
##  Pairwise comparisons using Wilcoxon rank sum exact test
##
## data:  raw$chla.ug.cm2 and raw$full_treatment
##
##         OFAV_PP OFAV_PS OFAV_SP OFAV_SS OFRA_PP
## OFAV_PS 0.00047 -       -       -       -
## OFAV_SP 0.93629 0.00392 -       -       -
## OFAV_SS 0.35589 0.00065 0.40819 -       -
## OFRA_PP 0.64308 0.00710 0.72451 0.78359 -
## OFRA_PS 1.3e-05 0.18247 0.00023 2.0e-05 0.00046
##
## P value adjustment method: none
```

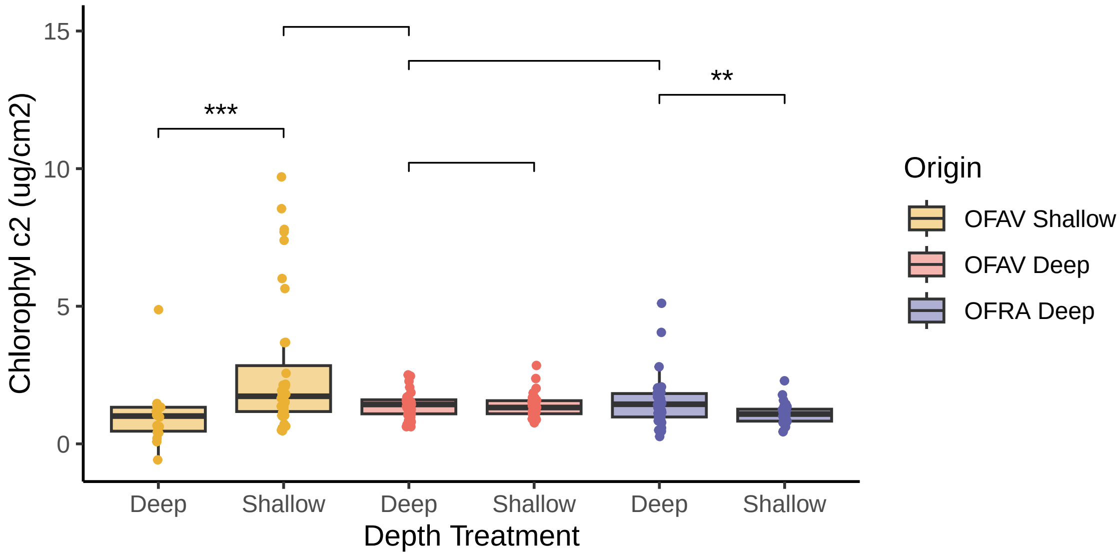
Results summary

Expected trend: low in shallow

There were no differences in chl a between species controls or deep and shallow controls of OFAV. *this is surprising*

For both OFAV and OFRA, there was a significant decrease in chl a concentration when samples were transplanted from deep to shallow. There was no effect of transplanting OFAV from shallow to deep. *this follows our expected trend, with the exception that OFAV transplanted to deep expressed no change*

Chlorophyll c2




```
##
##  Pairwise comparisons using Wilcoxon rank sum exact test
##
## data:  raw$chlc2.ug.cm2 and raw$full_treatment
##
##         OFAV_PP OFAV_PS OFAV_SP OFAV_SS OFRA_PP
## OFAV_PS 0.66190 -       -       -       -
## OFAV_SP 0.00164 0.00469 -       -       -
## OFAV_SS 0.05109 0.02219 0.00025 -       -
## OFRA_PP 0.78808 0.57877 0.00533 0.08518 -
## OFRA_PS 0.00150 0.00354 0.24718 0.00013 0.00855
##
## P value adjustment method: none
```

Results summary

Expected results: low in shallow

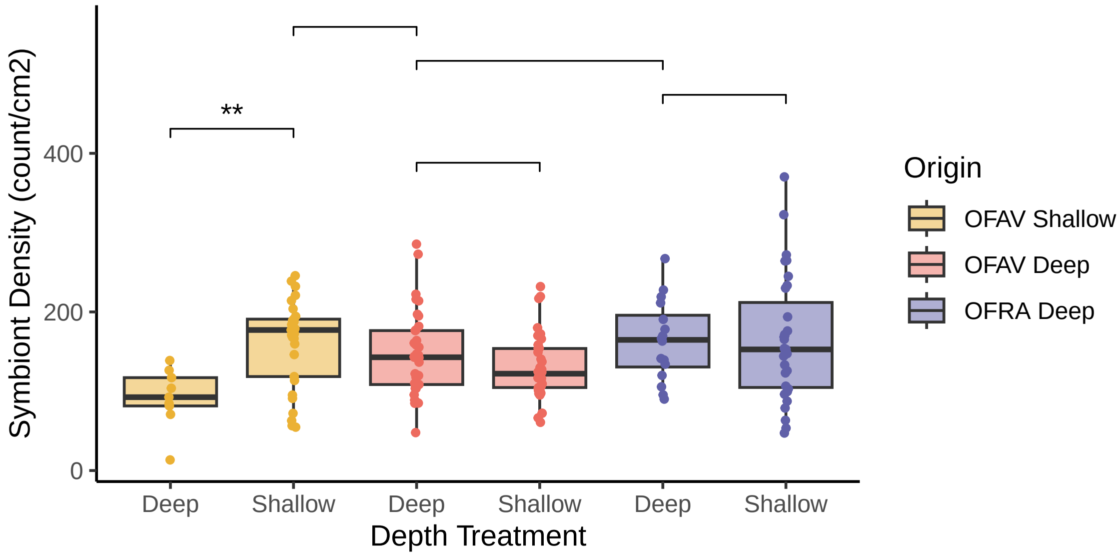
There were no differences in chl c2 between species controls or deep and shallow controls of OFAV. *surprising, we would expect depth related changes*

OFRA experienced a significant decrease in chl c2 when transplanted from deep to shallow. *this follows the expected trend*

OFAV experienced a significant decrease in chl c2 when transplanted from shallow to deep. *this is the opposite of the expected trend*

it doesn't seem like c2 follows the same trends that chl a follows

Symbiont density




```
##
##  Pairwise comparisons using Wilcoxon rank sum exact test
##
## data:  raw$sym.cm2 and raw$full_treatment
##
##         OFAV_PP OFAV_PS OFAV_SP OFAV_SS OFRA_PP
## OFAV_PS 0.23164 -       -       -       -
## OFAV_SP 0.00250 0.01964 -       -       -
## OFAV_SS 0.10384 0.00810 0.00236 -       -
## OFRA_PP 0.23614 0.02680 0.00063 0.78742 -
## OFRA_PS 0.39114 0.06632 0.00560 0.58673 0.83293
##
## P value adjustment method: none
```

Results summary

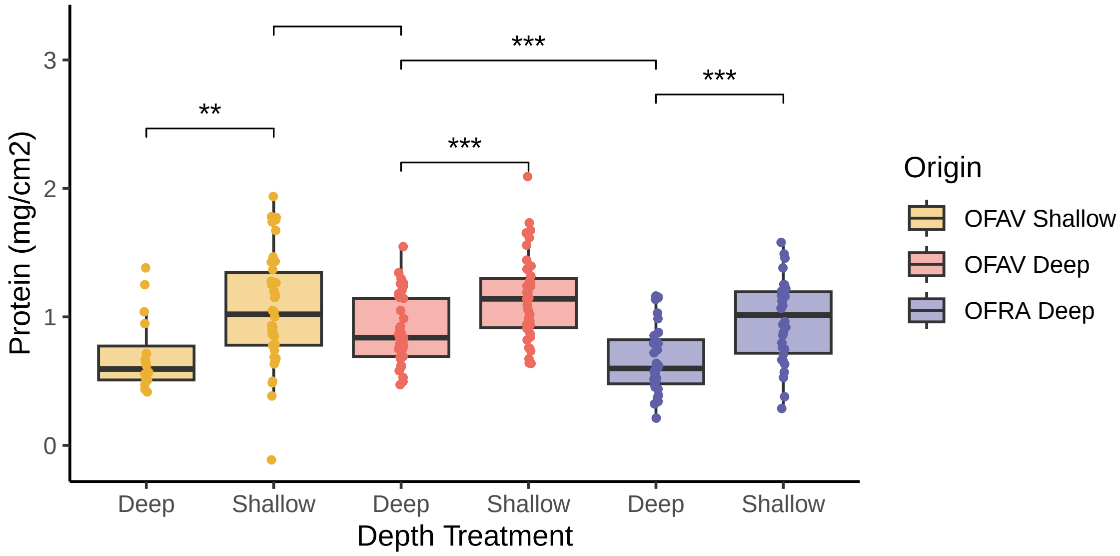
Expected results: studies have found mixed results, but most suggest that there are fewer symbionts in shallow environments

There were no differences in symbiont density between species controls or deep and shallow controls of OFAV.

For both OFAV and OFRA that were transplanted from deep to shallow, there was no effect on the symbiont density.

For OFAV transplanted from shallow to deep, there was a significant decrease in symbiont density. *this goes against expected results*

Protein




```
##
##  Pairwise comparisons using Wilcoxon rank sum exact test
##
## data:  raw$prot_mg.cm2 and raw$full_treatment
##
##         OFAV_PP OFAV_PS OFAV_SP OFAV_SS OFRA_PP
## OFAV_PS 0.00095 -       -       -       -
## OFAV_SP 0.00723 2.1e-05 -       -       -
## OFAV_SS 0.05408 0.45611 0.00170 -       -
## OFRA_PP 0.00014 9.0e-10 0.65117 4.4e-06 -
## OFRA_PS 0.33288 0.05467 0.00466 0.38428 2.6e-05
##
## P value adjustment method: none
```

Results summary

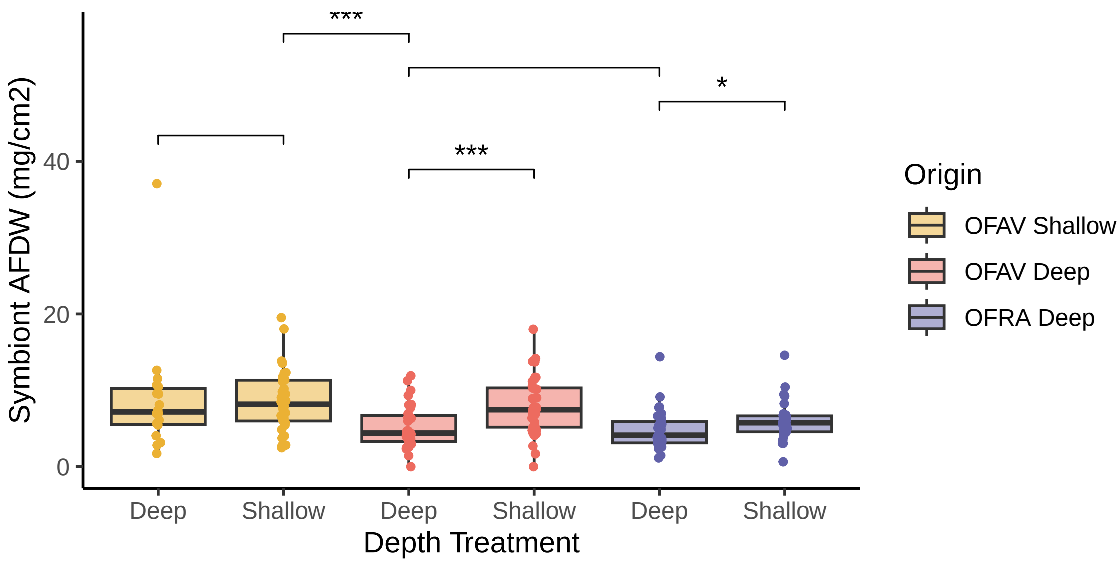
Expected results: higher protein concentrations in shallow environments

There was no difference in protein concentration between deep and shallow controls of OFAV. *this is suprising because our results showed a strong effect of depth on protein concentration. It is possible that this change in protein occurs quickly during the period of acclimation, then levels out over time*

In deep samples only, OFAV controls had a significantly higher concentration of protein than OFRA controls. *this makes sense because OFAV is a generalist that can survive in shallow environments, where we would expect the protein to be higher, while OFRA is a depth-specialist and therefore would usually have lower protein at depth*

All three treatment pairs experienced a significant change in protein concentration between shallow and deep. No matter which direction the transplant occurred, shallow samples always had higher protein concentrations than deep for both OFAV and OFRA. *this follows our expectations that shallow samples have higher levels of protein*

Symbiont Biomass




```
##
##  Pairwise comparisons using Wilcoxon rank sum test with continuity correction
##
## data:  raw$Sym_AFDW_mg.cm2 and raw$full_treatment
##
##         OFAV_PP OFAV_PS OFAV_SP OFAV_SS OFRA_PP
## OFAV_PS 0.00039 -       -       -       -
## OFAV_SP 0.01479 0.85830 -       -       -
## OFAV_SS 5.9e-05 0.45611 0.49188 -       -
## OFRA_PP 0.53590 2.1e-05 0.00270 2.0e-06 -
## OFRA_PS 0.07307 0.00514 0.05663 0.00136 0.01549
##
## P value adjustment method: none
```

Results summary

Expected results: dependent on symbiont density, which we expect to be higher at depth

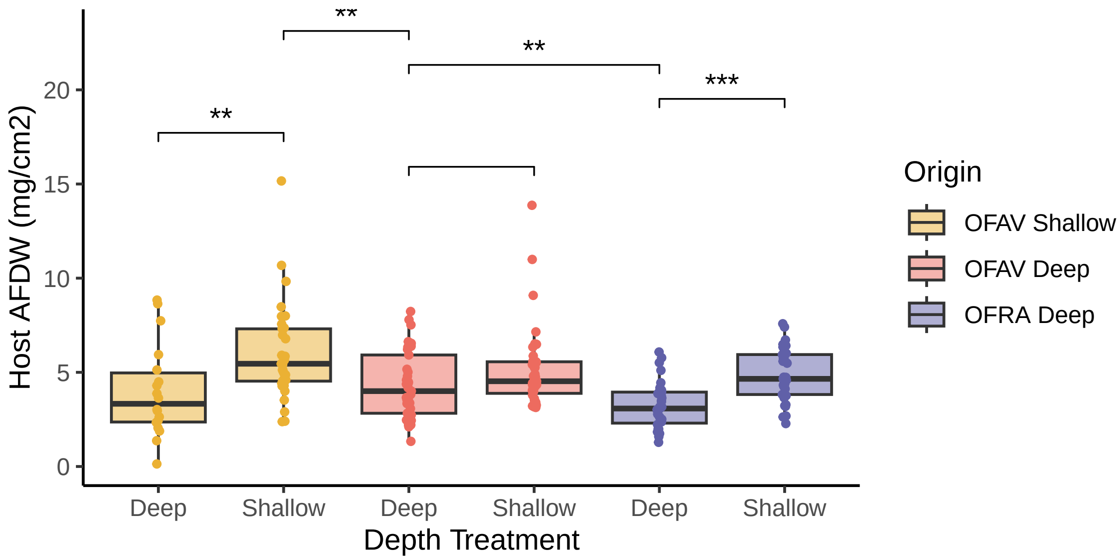
OFAV control samples had significantly higher biomass in shallow sites than deep. *goes against expectations*

OFRA and OFAV deep controls did not differ.

For both OFAV and OFRA, there was a significant increase in symbiont biomass when transplanted to shallow environments. *goes against expectations*

OFRA did not experience significant change in biomass when transplanted to shallow.

Host Biomass




```
##
##  Pairwise comparisons using Wilcoxon rank sum exact test
##
## data:  raw$Host_AFDW_mg.cm2 and raw$full_treatment
##
##         OFAV_PP OFAV_PS OFAV_SP OFAV_SS OFRA_PP
## OFAV_PS 0.0884  -       -       -       -
## OFAV_SP 0.3497  0.0199  -       -       -
## OFAV_SS 0.0016  0.0309  0.0038  -       -
## OFRA_PP 0.0068  3.1e-07 0.4176  2.4e-09 -
## OFRA_PS 0.1589  0.8135  0.0405  0.0680  2.3e-06
##
## P value adjustment method: none
```

Results summary

Expected trend: biomass is higher in shallow corals

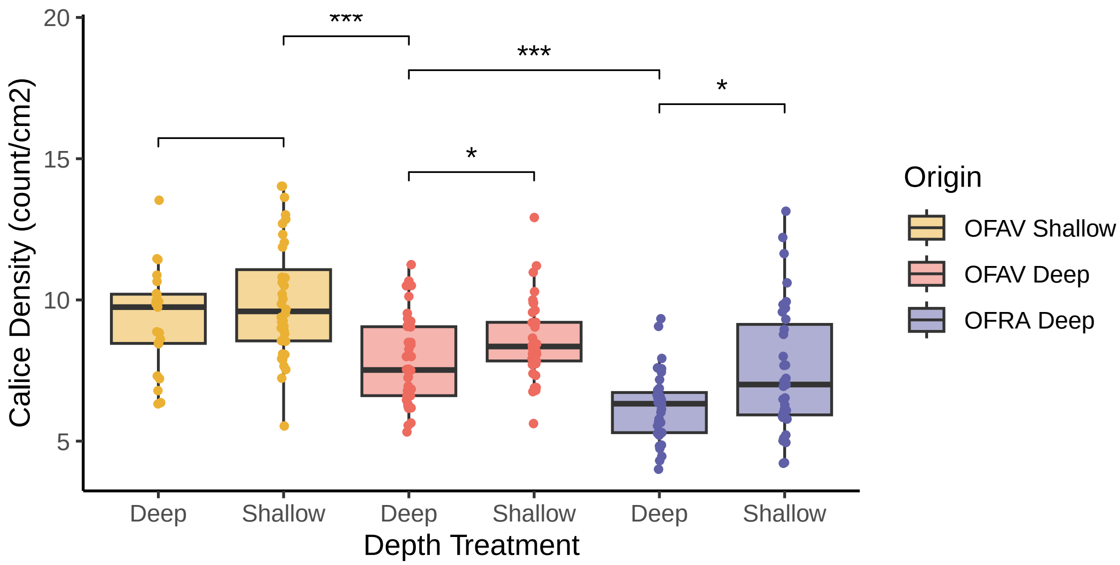
OFAV has higher biomass in their shallow control than their deep control. *this follows our expected trend*

OFRA has significantly lower biomass than OFAV. *this follows the expected trend with OFRA being a deepth specialist, and OFAV being more generalist*

OFRA transplanted from deep to shallow experienced an increase in biomass, while the same treatment on OFAV had no change. *this follows our expected trend, with OFAV sample size too low but still showing the trend*

OFAV transplanted from shallow to deep experienced a decrease in biomass. *this follows our expected trend*

Calice Density




```
##
##  Pairwise comparisons using Wilcoxon rank sum test with continuity correction
##
## data:  raw$D and raw$full_treatment
##
##         OFAV_PP OFAV_PS OFAV_SP OFAV_SS OFRA_PP
## OFAV_PS 0.0235  -       -       -       -
## OFAV_SP 0.0033  0.0704  -       -       -
## OFAV_SS 8.0e-06 0.0025  0.2801  -       -
## OFRA_PP 1.3e-05 1.6e-09 3.9e-09 6.7e-11 -
## OFRA_PS 0.2091  0.0056  0.0014  1.9e-05 0.0213
##
## P value adjustment method: none
```

Results summary

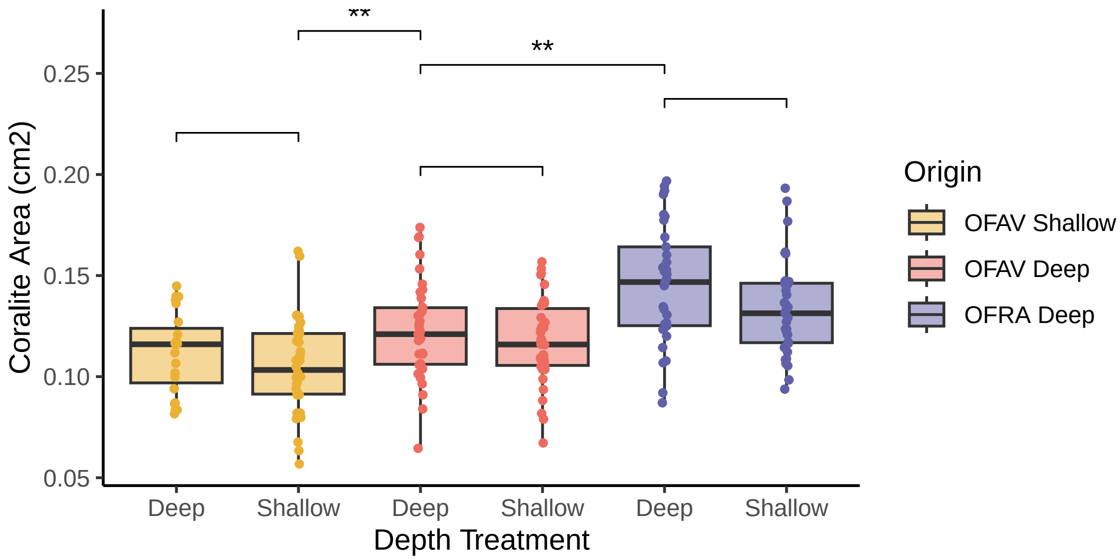
Expected trend: Calices are smaller in shallow environments, so higher density

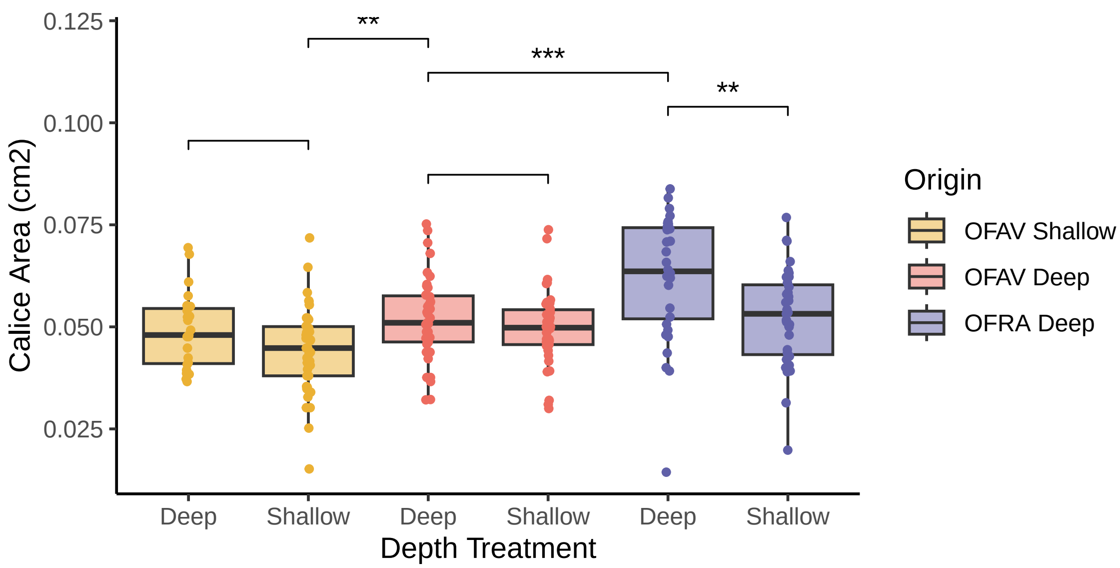
OFAV controls were significanly higher density in shallow environments *This follows our expected results.*

OFAV deep control was significantly higher density than OFRA deep control *This follows our expected results.*

For both OFAV and OFRA when transplanted from deep to shallow, there was an increase in calice density, while there was no change when transplanted from shallow to deep. *This follows our expected results.*

Calice Area






```
##
##  Pairwise comparisons using Wilcoxon rank sum test with continuity correction
##
## data:  raw$A and raw$full_treatment
##
##         OFAV_PP OFAV_PS OFAV_SP OFAV_SS OFRA_PP
## OFAV_PS 0.3180  -       -       -       -
## OFAV_SP 0.0829  0.4796  -       -       -
## OFAV_SS 0.0010  0.0186  0.2140  -       -
## OFRA_PP 0.0012  8.7e-05 4.8e-05 2.5e-07 -
## OFRA_PS 0.0633  0.0066  0.0016  4.7e-06 0.0742
##
## P value adjustment method: none
```

```
##
##  Pairwise comparisons using Wilcoxon rank sum test with continuity correction
##
```

```
## data:  raw$CA and raw$full_treatment
##
##         OFAV_PP OFAV_PS OFAV_SP OFAV_SS OFRA_PP
## OFAV_PS 0.26234 -       -       -       -
## OFAV_SP 0.23207 0.62334 -       -       -
## OFAV_SS 0.00185 0.01835 0.10797 -       -
## OFRA_PP 0.00056 5.7e-05 0.00024 8.1e-07 -
## OFRA_PS 0.76589 0.22028 0.16186 0.00337 0.00181
##
## P value adjustment method: none
```

Results summary

Expected trend: Calices are smaller in shallow environments, but morphology will change very slowly and therefore we won't be surprised by small change

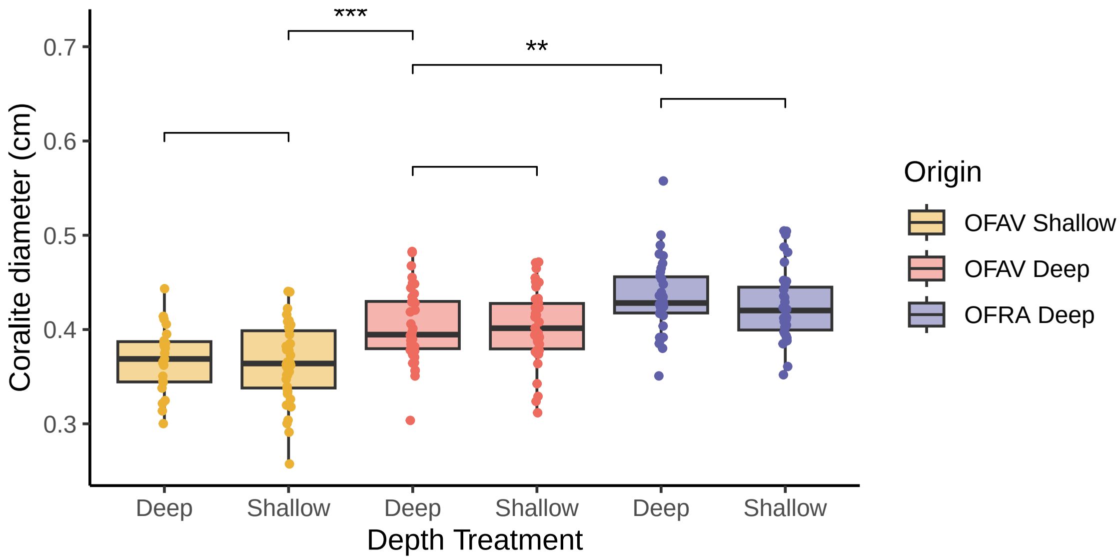
For both calice area and corallite area, OFAV controls were significanly smaller in shallow environments *This follows our expected results.*

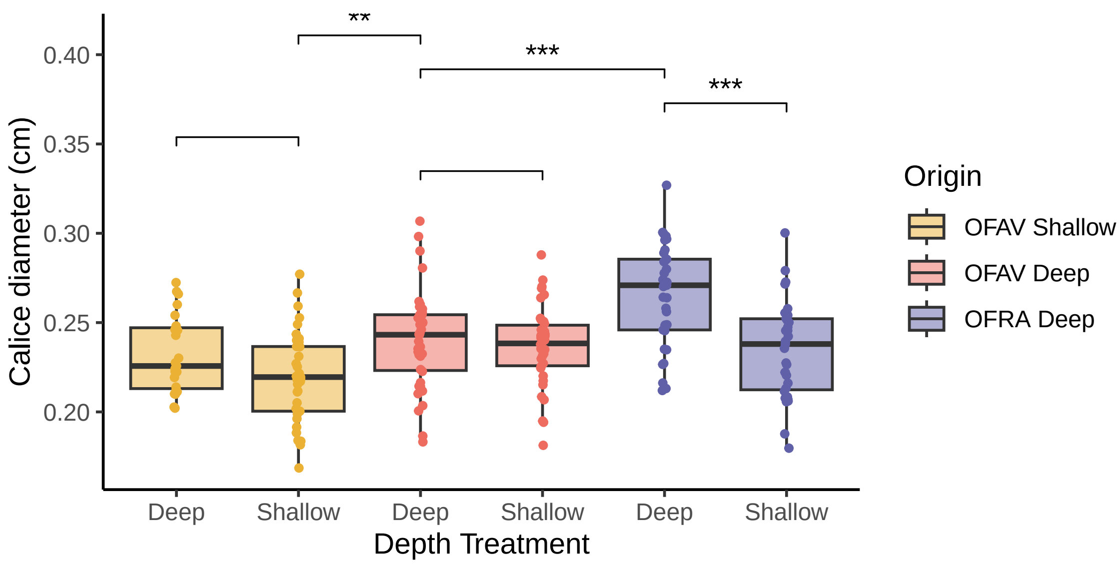
For both calice area and corallite area, OFAV deep control were significantly smaller than OFRA deep control *This follows our expected results.*

For each of the OFAV treatments, there was no change in corallite or calice area. *This is expected because these species are so slow growing*

For OFRA, there was no significant change in corallite area when transplanted from deep to shallow, but there was a significant decrease in the calice size. *This is surprising given how slow growing the species are, but follows expected patterns of smaller calices in shallow. We hypothesize that the corals acclimated to a foreign environment very quickly by reducing photoinhibition through reflectance of the calice.*

Calice diameter






```
##
##  Pairwise comparisons using Wilcoxon rank sum test with continuity correction
##
## data:  raw$di and raw$full_treatment
##
##         OFAV_PP OFAV_PS OFAV_SP OFAV_SS OFRA_PP
## OFAV_PS 0.85848 -       -       -       -
## OFAV_SP 0.00104 0.00075 -       -       -
## OFAV_SS 0.00017 0.00017 0.76214 -       -
## OFRA_PP 0.00249 0.00114 6.4e-09 1.4e-10 -
## OFRA_PS 0.02502 0.03689 2.7e-07 1.3e-07 0.16023
##
## P value adjustment method: none
```

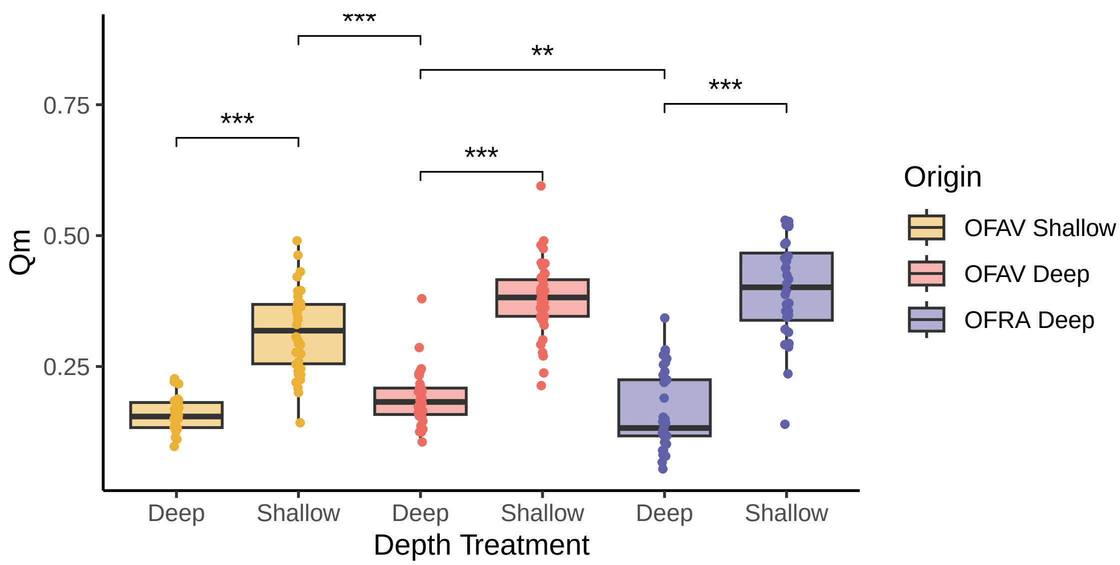
```
##
##  Pairwise comparisons using Wilcoxon rank sum test with continuity correction
##
```

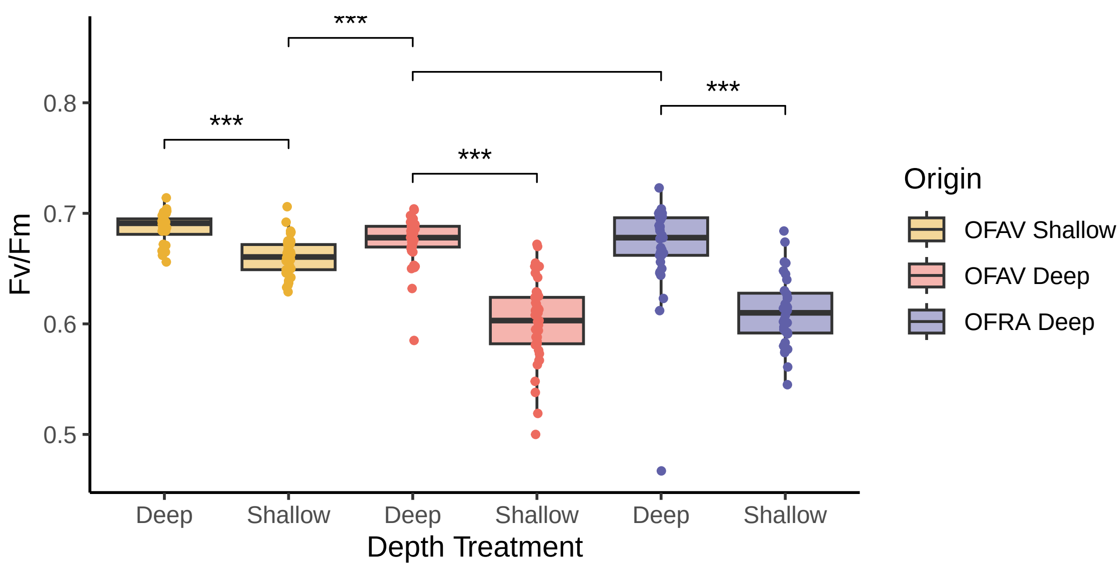
```
## data:  raw$Cdi and raw$full_treatment
##
##         OFAV_PP OFAV_PS OFAV_SP OFAV_SS OFRA_PP
## OFAV_PS 0.5857  -       -       -       -
## OFAV_SP 0.1848  0.3250  -       -       -
## OFAV_SS 0.0014  0.0017  0.0569  -       -
## OFRA_PP 0.0005  5.1e-05 1.6e-05 5.5e-09 -
## OFRA_PS 0.3924  0.7867  0.7992  0.0180  5.8e-05
##
## P value adjustment method: none
```

Results summary

These results are EXACTLY the same as the area results, see that info.

PAM





Results summary

Explanation of data: PAM measurements were taken and dawn and noon on Aug 4 and 13 2021. All fragments within 6 cages representing the 6 treatments were measured, but we do not have the ability to match the genotypes with this data. Thus, each of the 6 treatments are pooled.

Expected Trends

Photosynthetic efficiency - Fv/Fm:

- expected to be lower in high light and higher in low light
- associated with CHL and Sym density. having more sym or chl is less efficient.
- deep corals therefore expected to be more efficient than shallow

Maximum excitation pressure - Qm:

- expected to be inverse of Fv/Fm - higher in high-light and lower in low light
- calculated based on the difference between efficiency at dawn and noon to see the difference in extreme light conditions

For all treatment and control pairs, the maximum excitation pressure was significantly higher and the photosynthetic efficiency was significantly lower in shallow environments than in deep. This supports the hypothesis that deeper corals are more efficient at capturing light than shallow corals. We showed that all three sets of samples are able to acclimate to new environments by changing their photosynthetic efficiency. ***these results follow all expectations***

There is a significant difference in Maximum excitation pressure but not in photosynthetic efficiency between OFAV and OFRA. ***Not sure what this means***

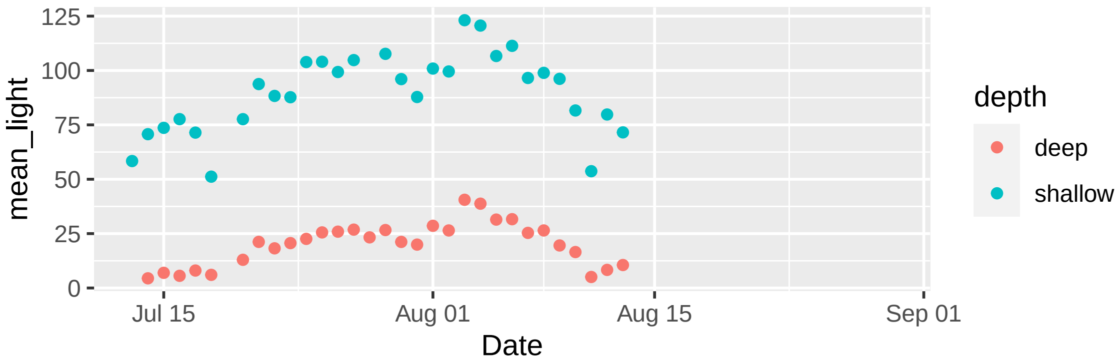
PE Curves

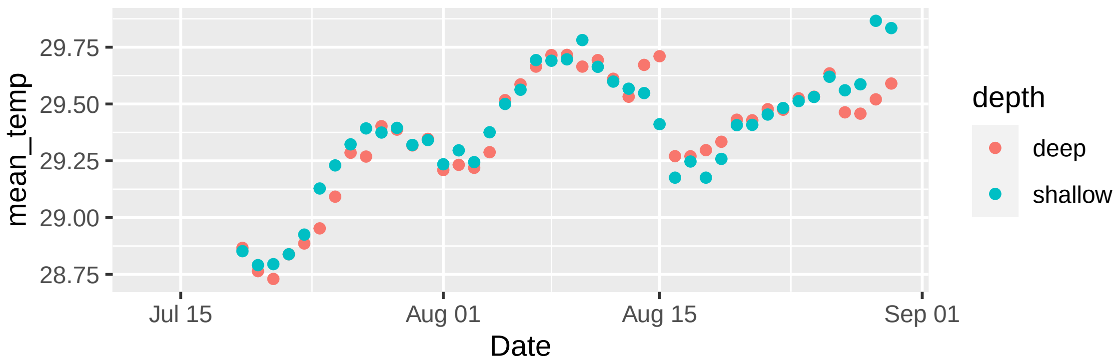
Survival

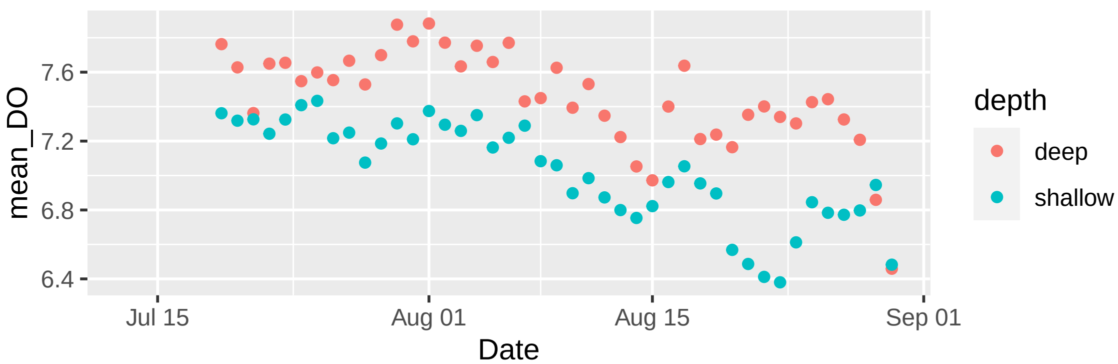
NAME

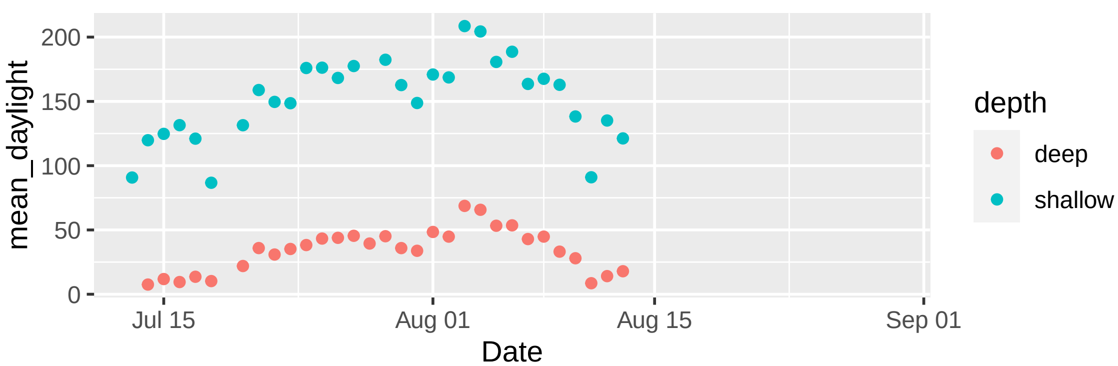
Survival

Environmental Data

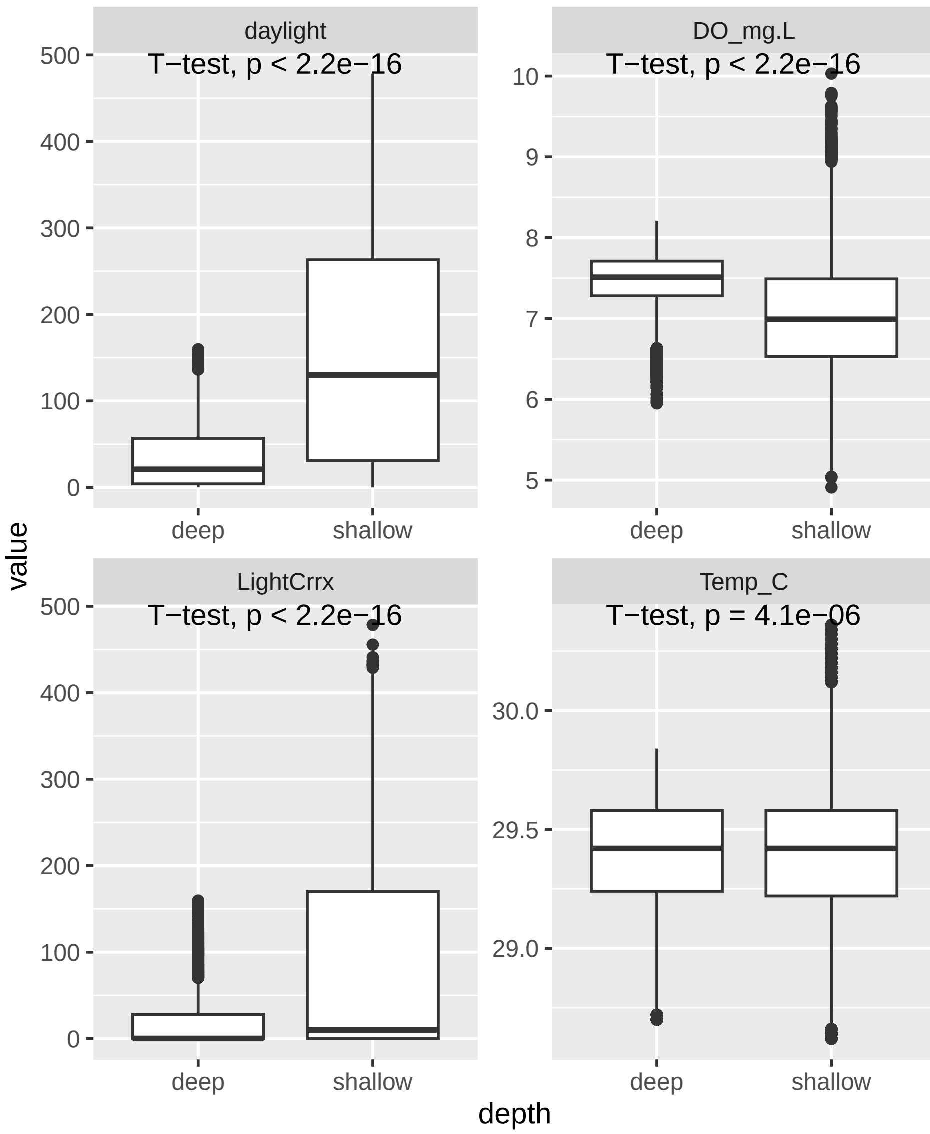








Why is oxygen higher in deep environments?




```
## # A tibble: 2 x 8
##   depth   datetime  Date  Time LightCrrx DO_mg.L Temp_C daylight
##   <chr>      <dbl> <dbl> <dbl>     <dbl>   <dbl>  <dbl>    <dbl>
## 1 deep           1     1 0.272     0.272   0.758  0.758    0.160
## 2 shallow        1     1 0.269     0.269   0.760  0.760    0.159
```