PR_project

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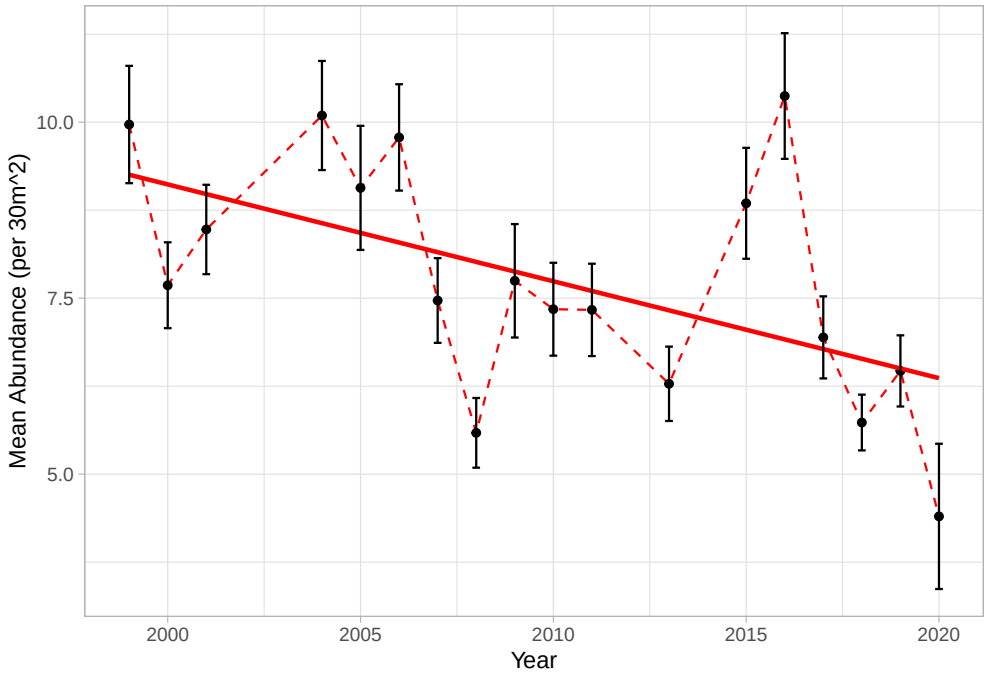
Parrot Fish

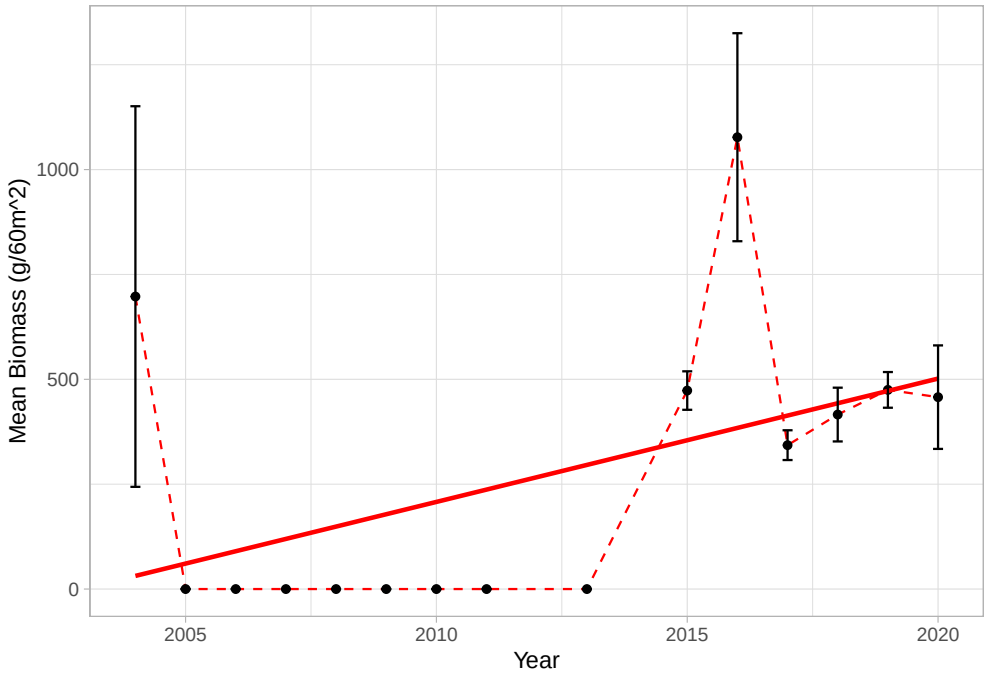
Mean parrotfish abundance over time w/ linear model:




```
##
## Call:
## lm(formula = total ~ YEAR, data = parrotfish_abundance)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -9.016 -4.487 -1.215  2.984 51.679
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 220.81847   53.50148   4.127 3.88e-05 ***
## YEAR         -0.10595    0.02661  -3.982 7.19e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```

```
## Residual standard error: 6.339 on 1430 degrees of freedom
## Multiple R-squared:  0.01096,    Adjusted R-squared:  0.01027
## F-statistic: 15.85 on 1 and 1430 DF,  p-value: 7.19e-05
```

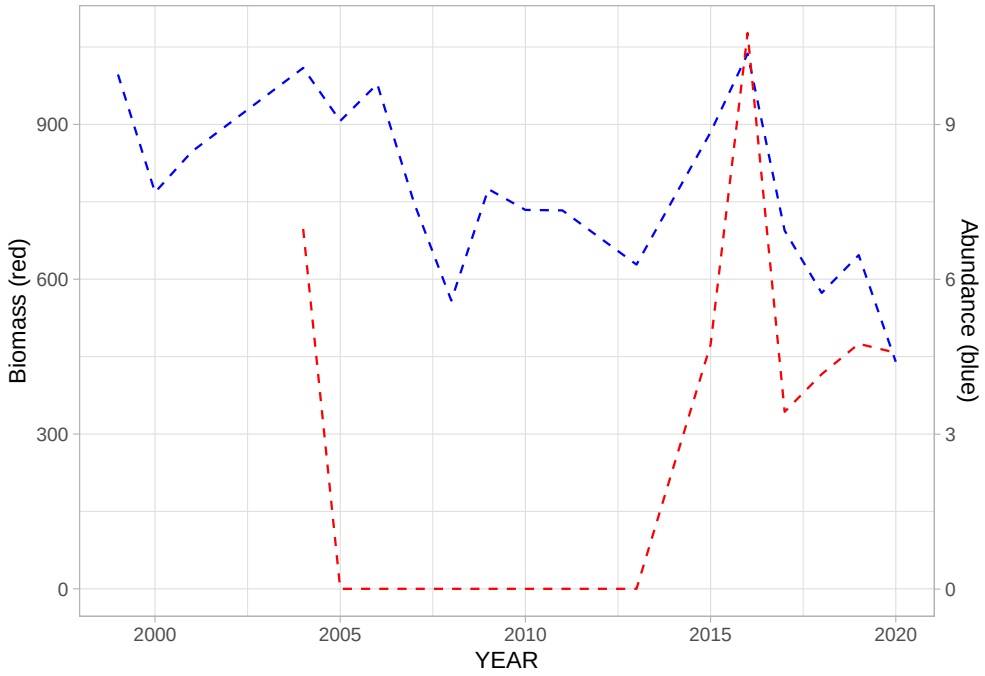
Mean parrotfish biomass over time w/ linear model:




```
model_parrotfish_biomass <- lm(total ~ YEAR, data = parrotfish_biomass)
summary(model_parrotfish_biomass)
```

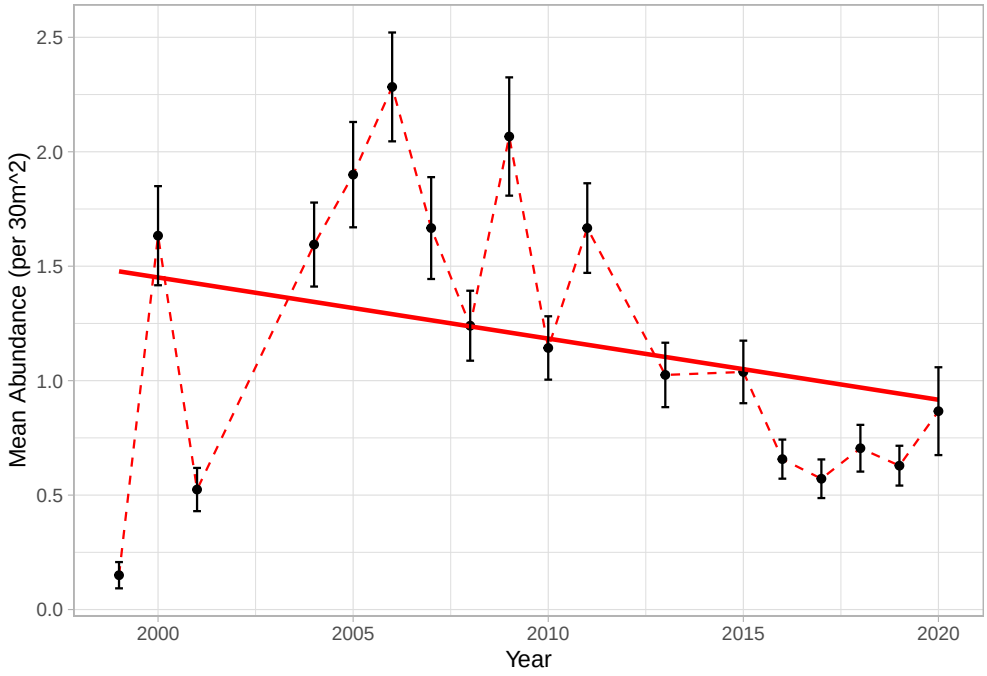
```
##
## Call:
## lm(formula = total ~ YEAR, data = parrotfish_biomass)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
##  -601.2  -386.9  -233.8    27.7 16715.6
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -61248.15   23057.50  -2.656  0.00809 **
## YEAR            30.62      11.44   2.676  0.00763 **
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1144 on 670 degrees of freedom
## Multiple R-squared:  0.01058,    Adjusted R-squared:  0.009101
## F-statistic: 7.163 on 1 and 670 DF,  p-value: 0.007626
```

Mean Parrotfish Biomass & abundance on same plot:



Grouper

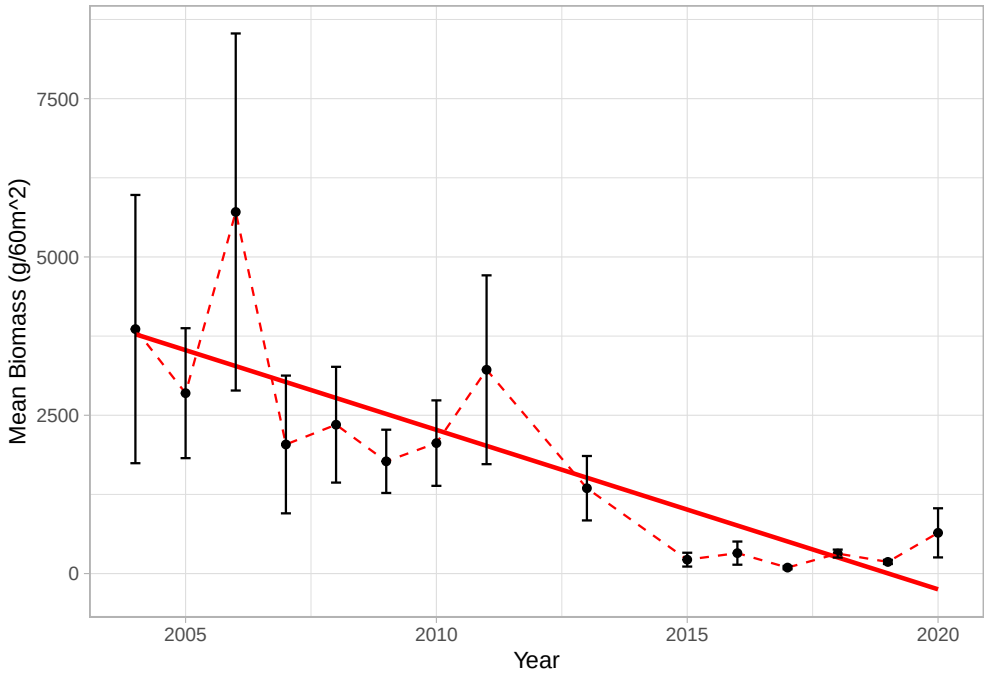
Mean grouper abundance over time w/ linear model:



```r
model_grouper_abundance <- lm(total ~ YEAR, data = grouper_abundance)
summary(model_grouper_abundance)
```

```
##
## Call:
## lm(formula = total ~ YEAR, data = grouper_abundance)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -1.4400 -1.0438 -0.2985  0.7298  7.9562
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 58.008952  12.379416   4.686 3.05e-06 ***
## YEAR        -0.028299   0.006157  -4.596 4.69e-06 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1.467 on 1430 degrees of freedom
## Multiple R-squared:  0.01456,    Adjusted R-squared:  0.01387
## F-statistic: 21.12 on 1 and 1430 DF,  p-value: 4.69e-06
```

Mean grouper biomass over time w/ linear model:

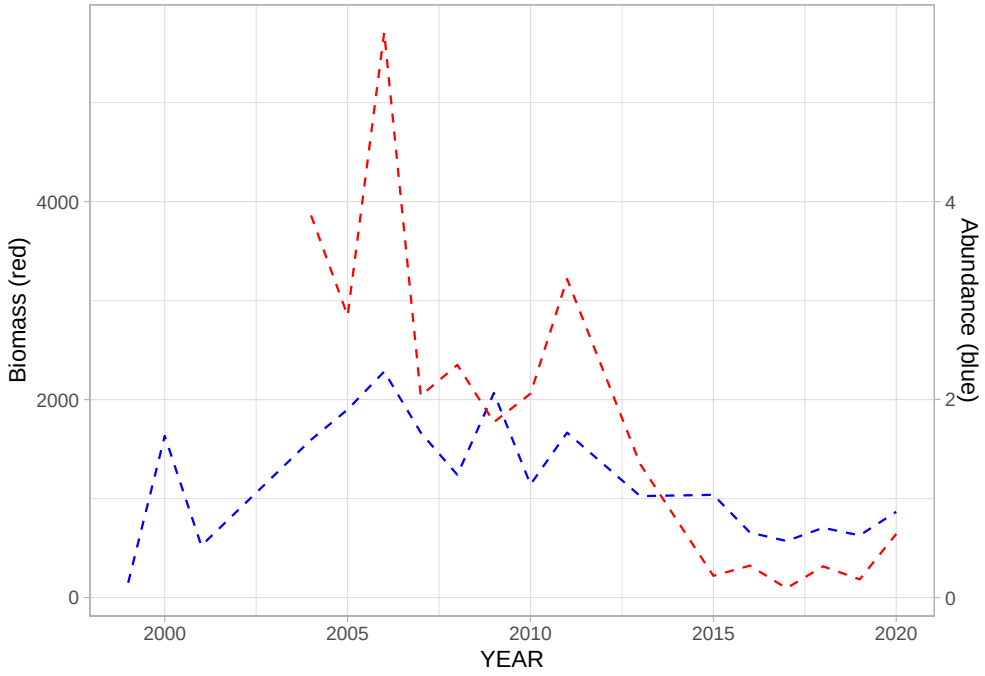



```r
model_grouper_biomass <- lm(total ~ YEAR, data = grouper_biomass)
summary(model_grouper_biomass)
```

```
##
## Call:
## lm(formula = total ~ YEAR, data = grouper_biomass)
##
```

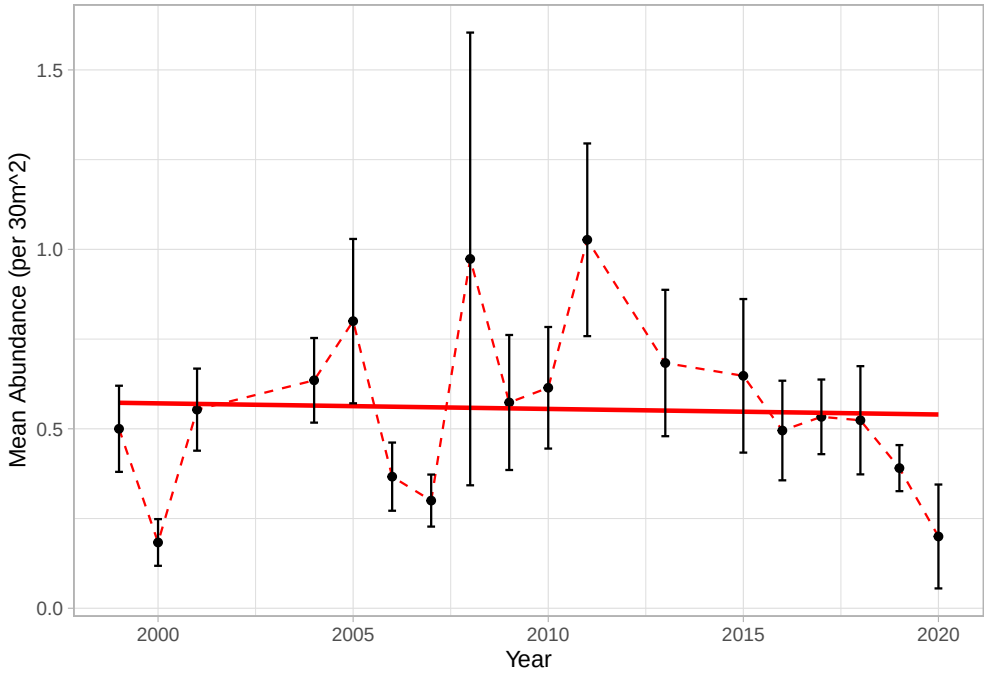
```
## Residuals:
##     Min      1Q  Median      3Q     Max
## -3454.3  -740.4  -321.7   174.4 30627.0
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 500674.16   48990.39   10.22   <2e-16 ***
## YEAR          -248.07      24.31  -10.21   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2431 on 670 degrees of freedom
## Multiple R-squared:  0.1345, Adjusted R-squared:  0.1332
## F-statistic: 104.1 on 1 and 670 DF,  p-value: < 2.2e-16
```

Mean Parrotfish Biomass & abundance on same plot:



Snapper

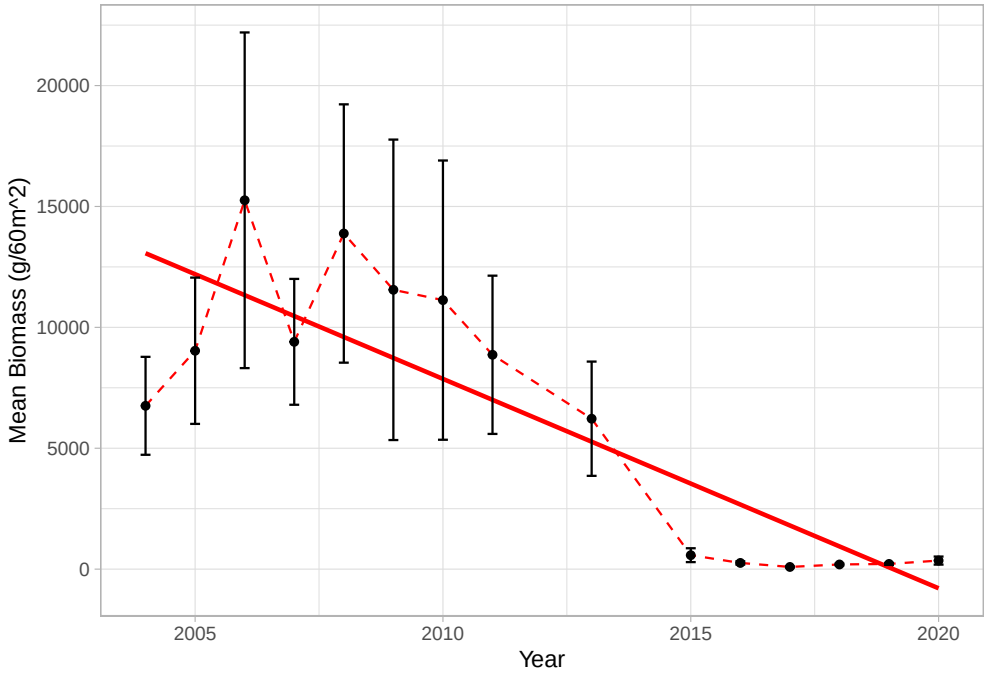
Mean snapper abundance over time w/ linear model:




```
model_snapper_abundance <- lm(total ~ YEAR, data = snapper_abundance)
summary(model_snapper_abundance)
```

```
##
## Call:
## lm(formula = total ~ YEAR, data = snapper_abundance)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -0.578 -0.577 -0.577  0.422 45.423
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 3.834e-01  1.615e+01   0.024    0.981
## YEAR        9.619e-05  8.031e-03   0.012    0.990
##
## Residual standard error: 1.913 on 1430 degrees of freedom
## Multiple R-squared:  1.003e-07,  Adjusted R-squared:  -0.0006992
## F-statistic: 0.0001434 on 1 and 1430 DF,  p-value: 0.9904
```

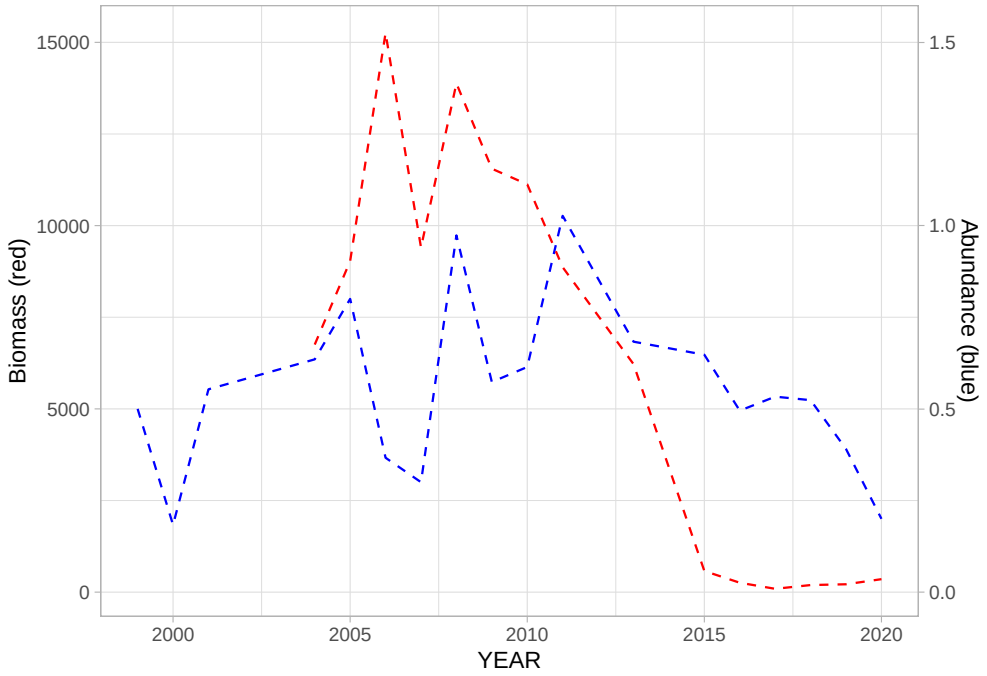
Mean snapper biomass over time w/ linear model:




```
model_snapper_biomass <- lm(total ~ YEAR, data = snapper_biomass)
summary(model_snapper_biomass)
```

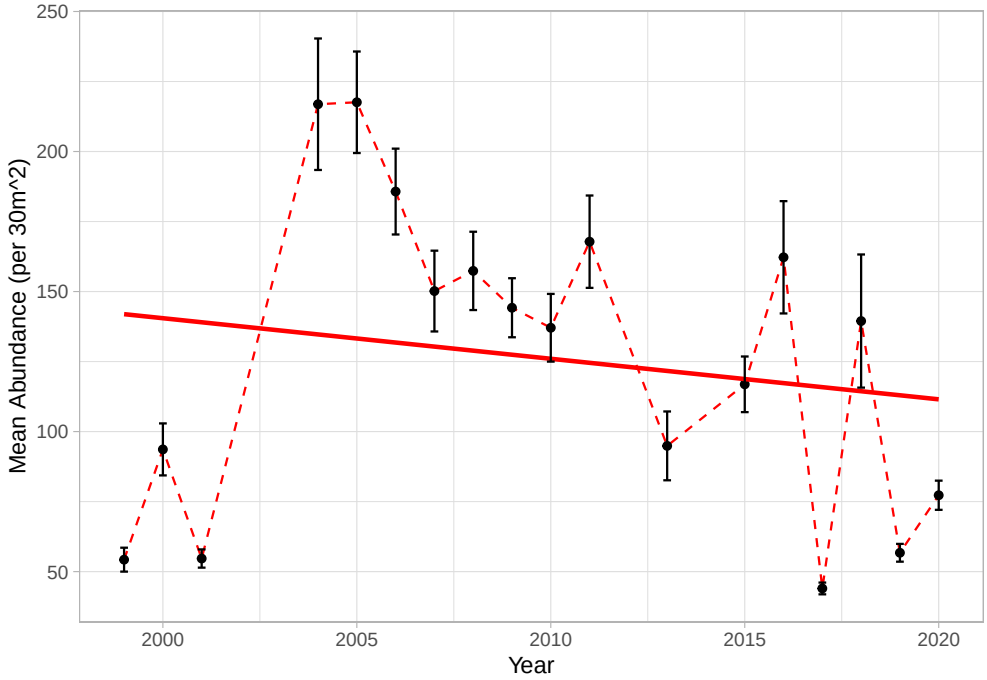
```
##
## Call:
## lm(formula = total ~ YEAR, data = snapper_biomass)
##
## Residuals:
##    Min     1Q Median     3Q    Max
## -11872  -2062   -718   1080  89131
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) 1814090.12  150164.28   12.08   <2e-16 ***
## YEAR           -899.04      74.51  -12.07   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 7452 on 670 degrees of freedom
## Multiple R-squared:  0.1785, Adjusted R-squared:  0.1773
## F-statistic: 145.6 on 1 and 670 DF,  p-value: < 2.2e-16
```

Mean Parrotfish Biomass & abundance on same plot:



All species

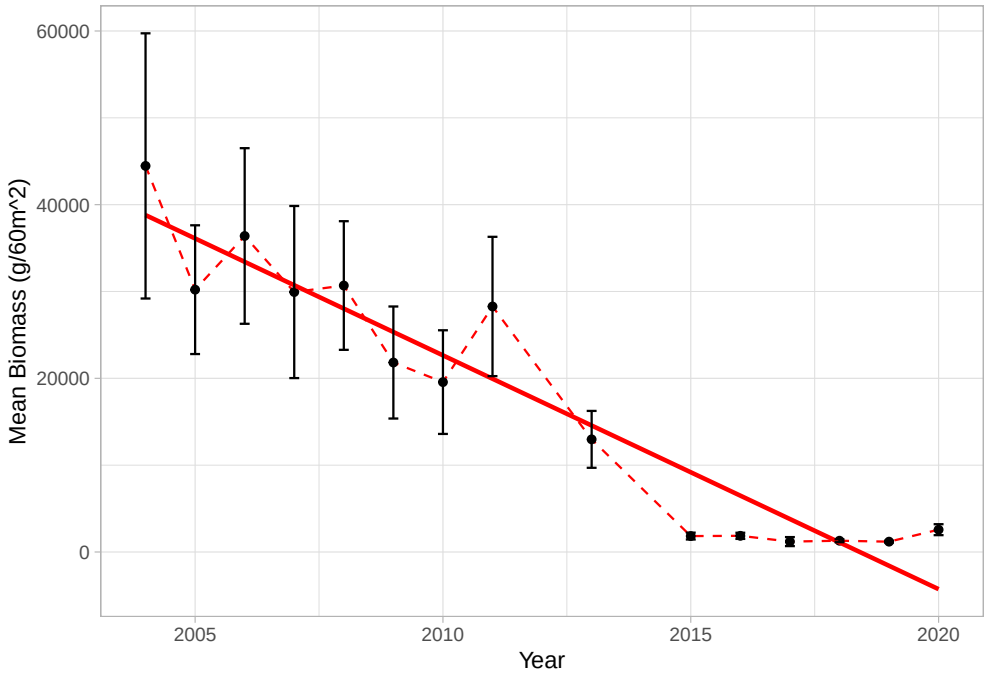
Mean abundance of all fish over time w/ linear model:



```r
model_fish_abundance <- lm(total ~ YEAR, data = fish_abundance)
summary(model_fish_abundance)
```

```
##
## Call:
## lm(formula = total ~ YEAR, data = fish_abundance)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -137.04  -79.41  -46.49   24.89 1142.51
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 2614.2771  1182.9212   2.210   0.0273 *
## YEAR          -1.2392     0.5884  -2.106   0.0354 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 140.3 on 1437 degrees of freedom
## Multiple R-squared:  0.003078,   Adjusted R-squared:  0.002384
## F-statistic: 4.436 on 1 and 1437 DF,  p-value: 0.03536
```

Mean Biomass of all fish over time w/ linear model:

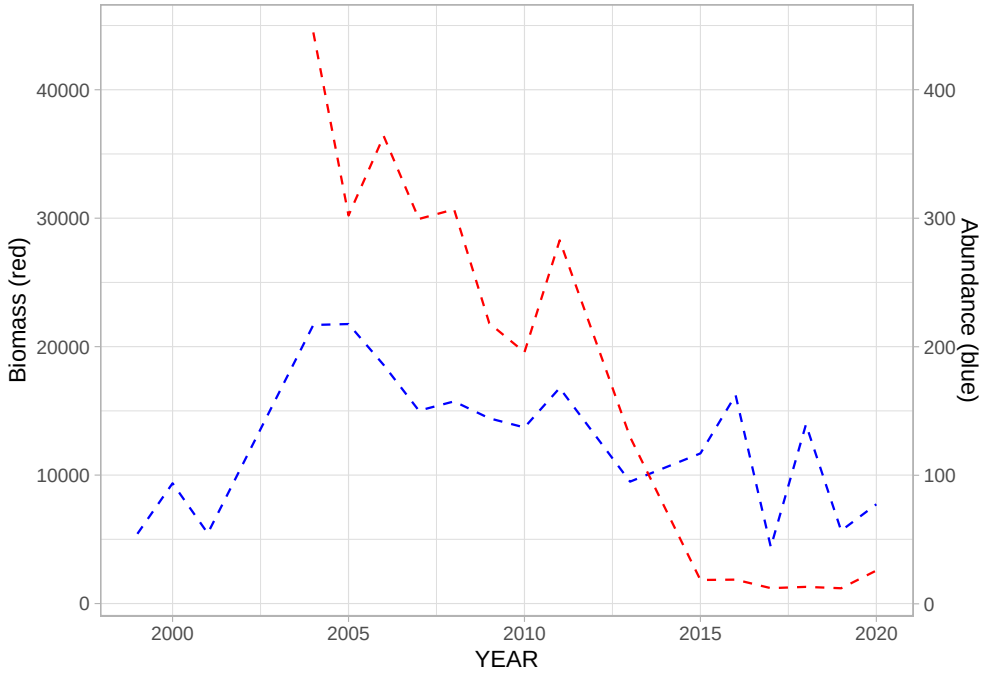



```r
model_fish_biomass <- lm(total ~ YEAR, data = fish_biomass)
summary(model_fish_biomass)
```

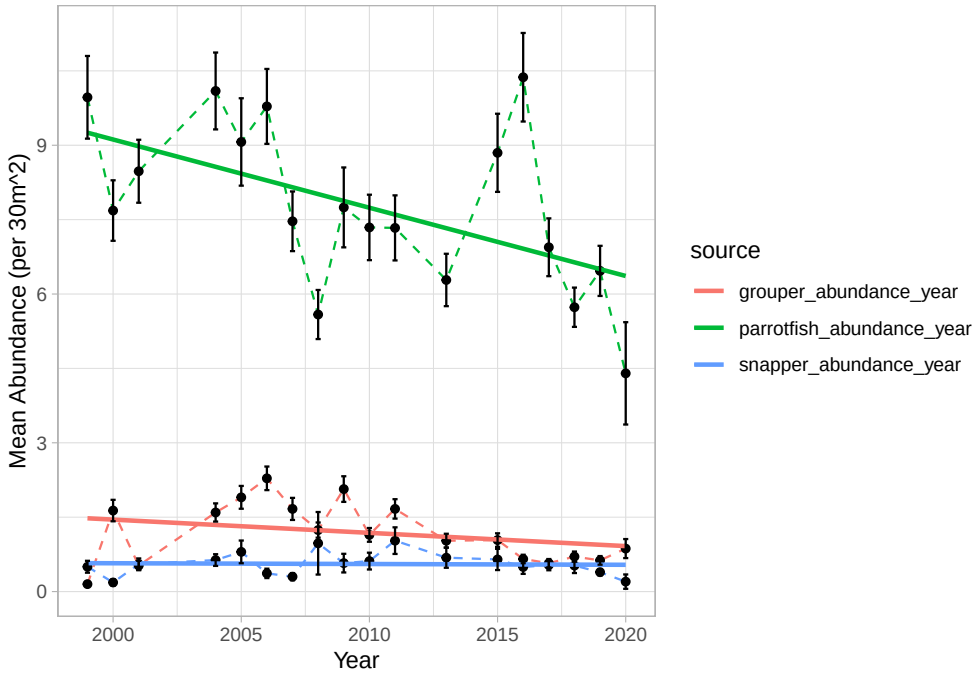
```
##
## Call:
## lm(formula = total ~ YEAR, data = fish_biomass)
##
```

```
## Residuals:
##    Min     1Q Median     3Q    Max
## -31945  -5829  -1758   3236 174884
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) 5316962.9   294476.8   18.06   <2e-16 ***
## YEAR          -2634.9      146.1  -18.03   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 14610 on 670 degrees of freedom
## Multiple R-squared:  0.3268, Adjusted R-squared:  0.3258
## F-statistic: 325.2 on 1 and 670 DF,  p-value: < 2.2e-16
```

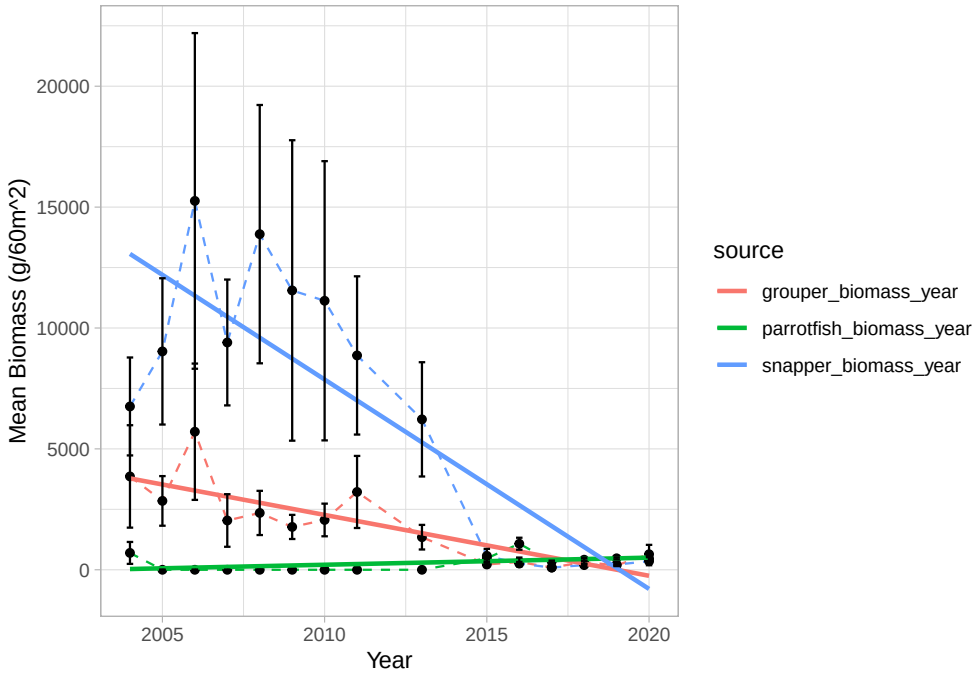
Mean Biomass & abundance of all fish over time plotted on same axis



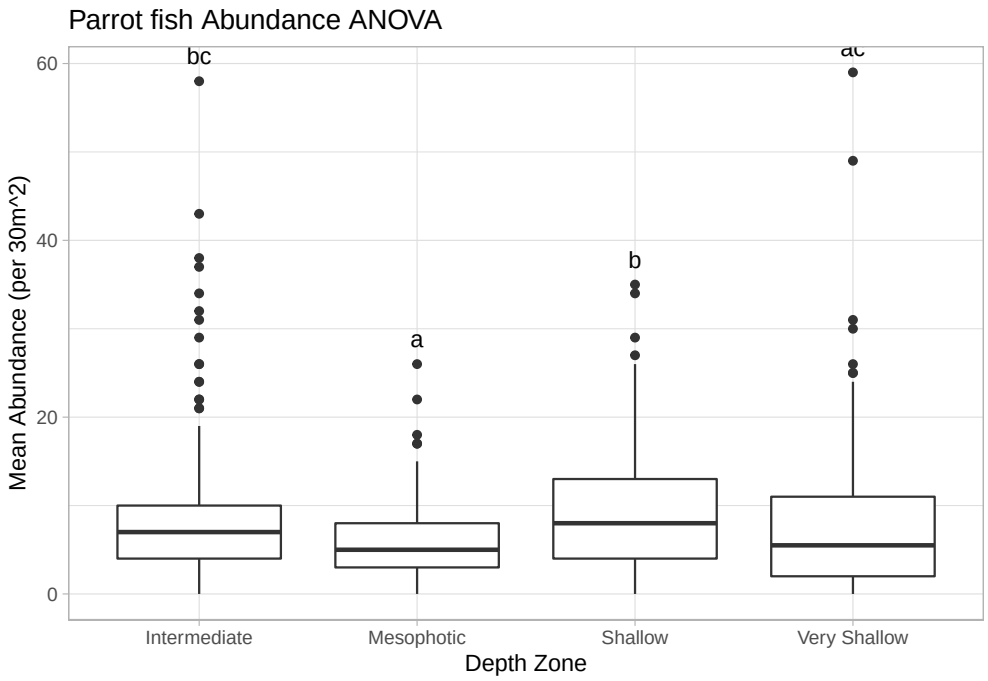
Snapper, Grouper & Parrotfish abundance on same axis:

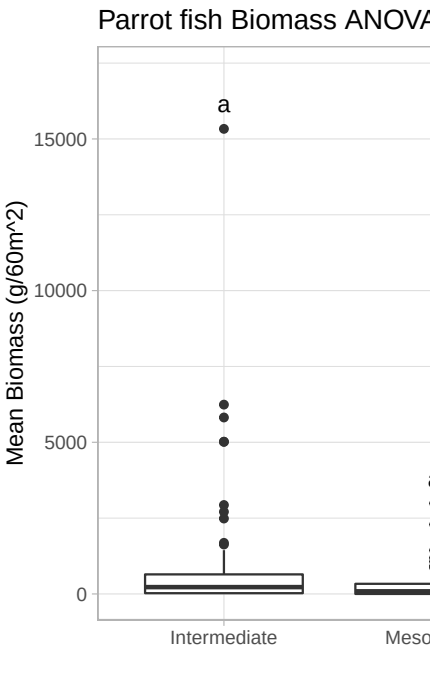


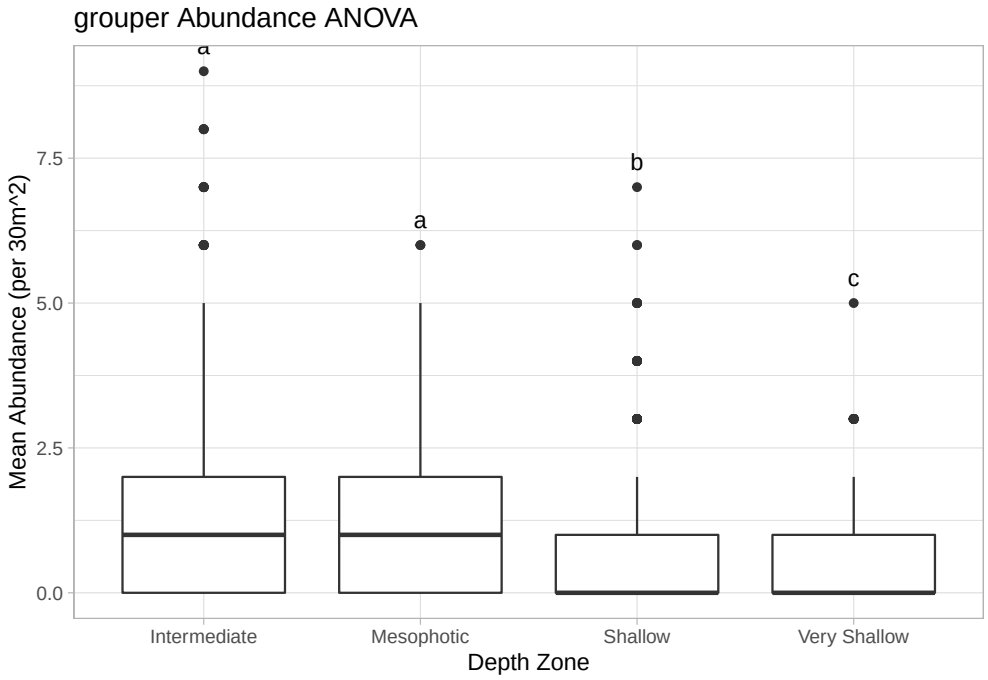
Snapper, Grouper & Parrotfish biomass on same axis:

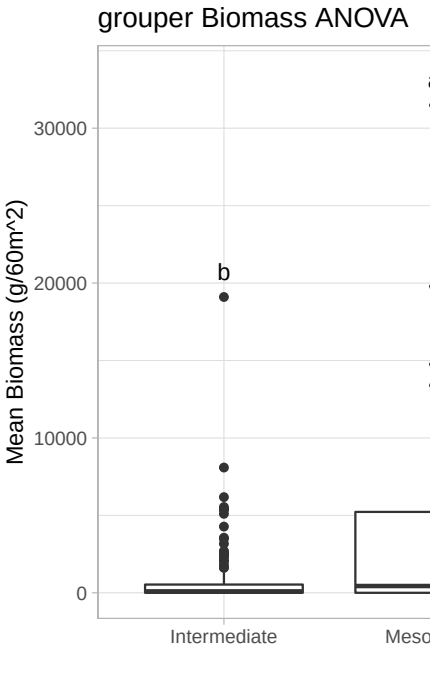


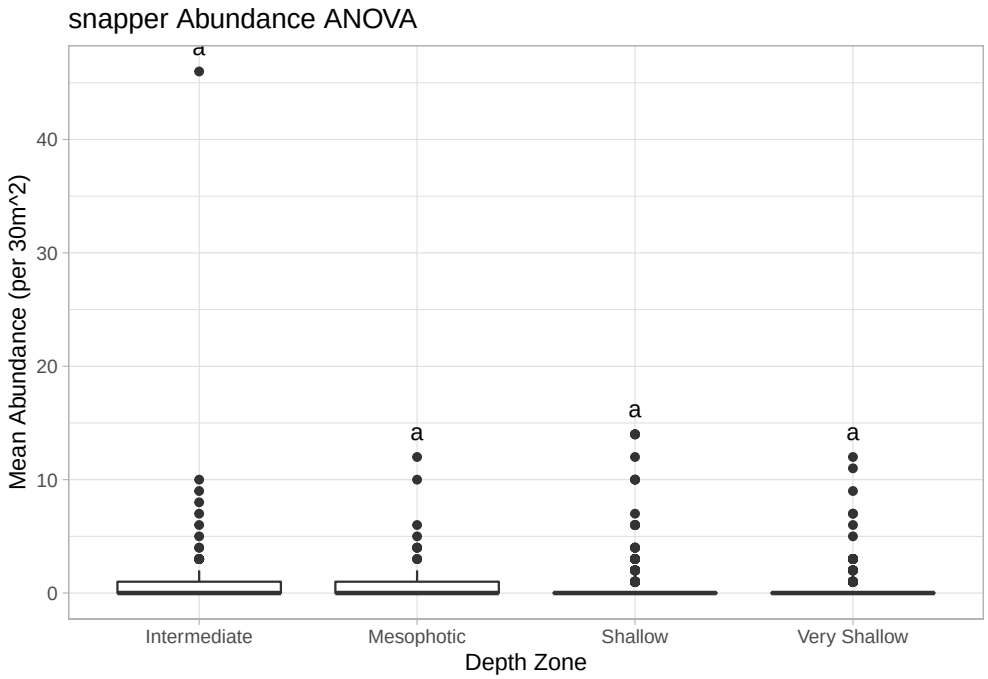
Exploring the effects of depth:

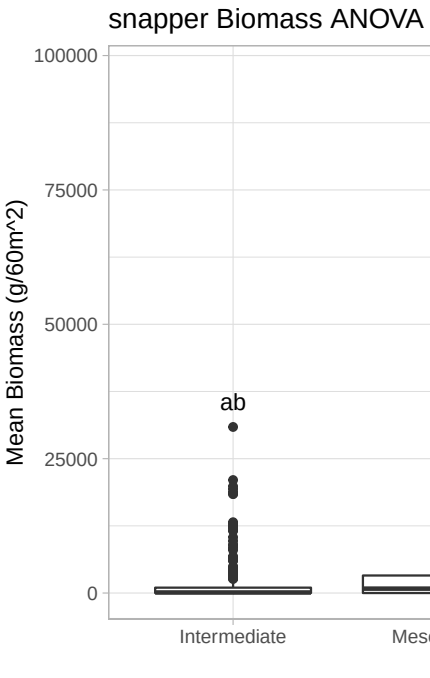












ANOVAS comapring depth, year, location

```
# Parrotfish Abundance:
parrotfish_abundance_multi.aov <- aov(total ~ DEPTH.ZONE*YEAR*LOCATION, data = parrotfish_abundance)
summary(parrotfish_abundance_multi.aov)
```

```
##                            Df Sum Sq Mean Sq F value   Pr(>F)
## DEPTH.ZONE                  3   1244   414.6  14.075 4.90e-09 ***
## YEAR                        1    440   439.7  14.929 0.000117 ***
## LOCATION                   17   8297   488.1  16.570  < 2e-16 ***
## DEPTH.ZONE:YEAR             3     24     8.1   0.275 0.843794
## DEPTH.ZONE:LOCATION        26   4972   191.2   6.492  < 2e-16 ***
## YEAR:LOCATION              14   1587   113.3   3.848 1.87e-06 ***
## DEPTH.ZONE:YEAR:LOCATION   22   1922    87.3   2.965 5.27e-06 ***
## Residuals                1345  39616    29.5
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Parrotfish Biomass:
parrotfish_biomass_multi.aov <- aov(total ~ DEPTH.ZONE*YEAR*LOCATION, data = parrotfish_biomass)
summary(parrotfish_biomass_multi.aov)
```

```
##                            Df    Sum Sq Mean Sq F value   Pr(>F)
## DEPTH.ZONE                  3   5294437 1764812   1.475  0.22014
## YEAR                        1   9502082 9502082   7.944  0.00499 **
## LOCATION                   16  64346385 4021649   3.362 1.06e-05 ***
## DEPTH.ZONE:YEAR             3    432933  144311   0.121  0.94795
## DEPTH.ZONE:LOCATION        22  45253679 2056985   1.720  0.02199 *
## YEAR:LOCATION              13  27972567 2151736   1.799  0.03994 *
## DEPTH.ZONE:YEAR:LOCATION   19  23262615 1224348   1.024  0.43094
## Residuals                 594 710528008 1196175
```

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

```
# Grouper Abundance:
grouper_abundance_multi.aov <- aov(total ~ DEPTH.ZONE*YEAR*LOCATION, data = grouper_abundance)
summary(grouper_abundance_multi.aov)
```

```
##                            Df Sum Sq Mean Sq F value   Pr(>F)
## DEPTH.ZONE                  3  366.8  122.25 104.017  < 2e-16 ***
## YEAR                        1   31.0   31.01  26.384 3.21e-07 ***
## LOCATION                   17  823.3   48.43  41.204  < 2e-16 ***
## DEPTH.ZONE:YEAR             3   11.6    3.85   3.278   0.0203 *
## DEPTH.ZONE:LOCATION        26  227.1    8.73   7.431  < 2e-16 ***
## YEAR:LOCATION              14   56.3    4.02   3.424 1.71e-05 ***
## DEPTH.ZONE:YEAR:LOCATION   22   25.2    1.14   0.973   0.4963
## Residuals                1345 1580.8    1.18
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Grouper Biomass:
grouper_biomass_multi.aov <- aov(total ~ DEPTH.ZONE*YEAR*LOCATION, data = grouper_biomass)
summary(grouper_biomass_multi.aov)
```

```
##                            Df    Sum Sq   Mean Sq F value   Pr(>F)
## DEPTH.ZONE                  3 5.131e+08 171035622  45.832  < 2e-16 ***
## YEAR                        1 4.868e+08 486760599 130.437  < 2e-16 ***
## LOCATION                   16 1.755e+08  10970443   2.940 0.000105 ***
## DEPTH.ZONE:YEAR             3 4.134e+08 137786149  36.923  < 2e-16 ***
## DEPTH.ZONE:LOCATION        22 2.119e+08   9633750   2.582 0.000113 ***
## YEAR:LOCATION              13 2.488e+08  19135014   5.128 1.11e-08 ***
## DEPTH.ZONE:YEAR:LOCATION   19 3.095e+08  16291172   4.366 3.07e-09 ***
## Residuals                 594 2.217e+09   3731754
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
# Snapper Abundance:
snapper_abundance_multi.aov <- aov(total ~ DEPTH.ZONE*YEAR*LOCATION, data = snapper_abundance)
summary(snapper_abundance_multi.aov)
```

```
##                            Df Sum Sq Mean Sq F value  Pr(>F)
## DEPTH.ZONE                  3      5   1.805   0.500 0.68206
## YEAR                        1      0   0.162   0.045 0.83203
## LOCATION                   17    141   8.274   2.294 0.00199 **
## DEPTH.ZONE:YEAR             3     29   9.720   2.695 0.04470 *
## DEPTH.ZONE:LOCATION        26    102   3.915   1.086 0.34943
## YEAR:LOCATION              14     79   5.633   1.562 0.08305 .
## DEPTH.ZONE:YEAR:LOCATION   22     27   1.228   0.340 0.99821
## Residuals                1345   4850   3.606
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

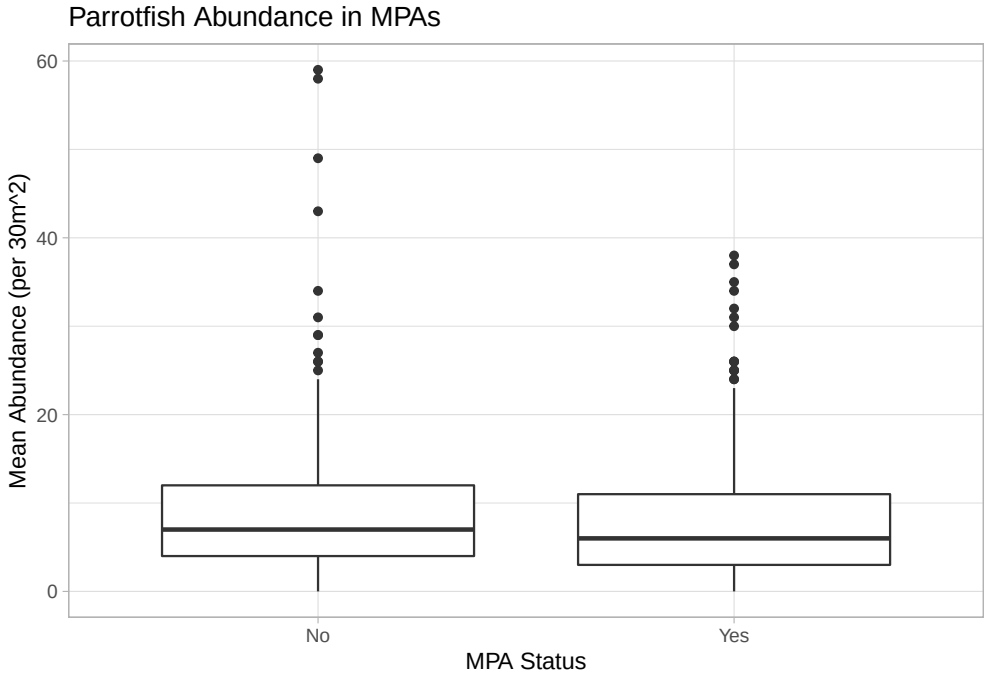
```
# Snapper Biomass:
snapper_biomass_multi.aov <- aov(total ~ DEPTH.ZONE*YEAR*LOCATION, data = snapper_biomass)
summary(snapper_biomass_multi.aov)
```

```
##                            Df    Sum Sq   Mean Sq F value   Pr(>F)
## DEPTH.ZONE                  3 9.406e+08 3.135e+08  10.280 1.32e-06 ***
```

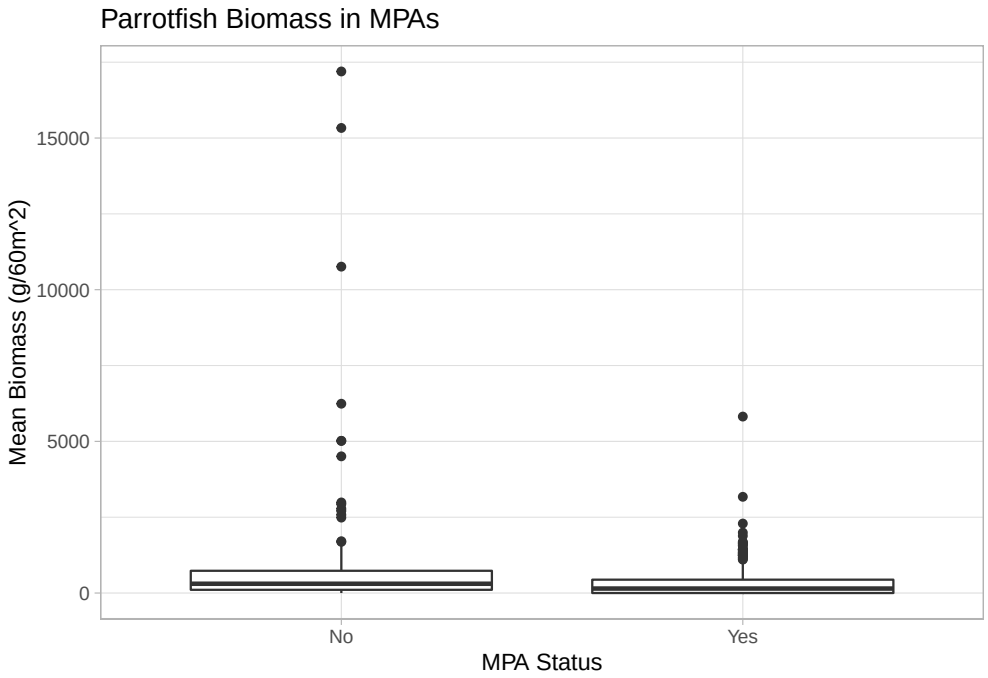
```
## YEAR                       1 7.743e+09 7.743e+09 253.854  < 2e-16 ***
## LOCATION                  16 4.934e+09 3.084e+08  10.109  < 2e-16 ***
## DEPTH.ZONE:YEAR            3 2.124e+09 7.079e+08  23.209 3.23e-14 ***
## DEPTH.ZONE:LOCATION       22 2.739e+09 1.245e+08   4.082 2.38e-09 ***
## YEAR:LOCATION             13 5.667e+09 4.359e+08  14.291  < 2e-16 ***
## DEPTH.ZONE:YEAR:LOCATION  19 3.027e+09 1.593e+08   5.223 9.44e-12 ***
## Residuals                594 1.812e+10 3.050e+07
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Exploring the effects of MPAs. ANOVA results appear above each graph

```
##                       Df Sum Sq Mean Sq F value   Pr(>F)
## Station.Within.MPA.    1    510   509.9   12.62 0.000394 ***
## Residuals           1425  57562    40.4
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

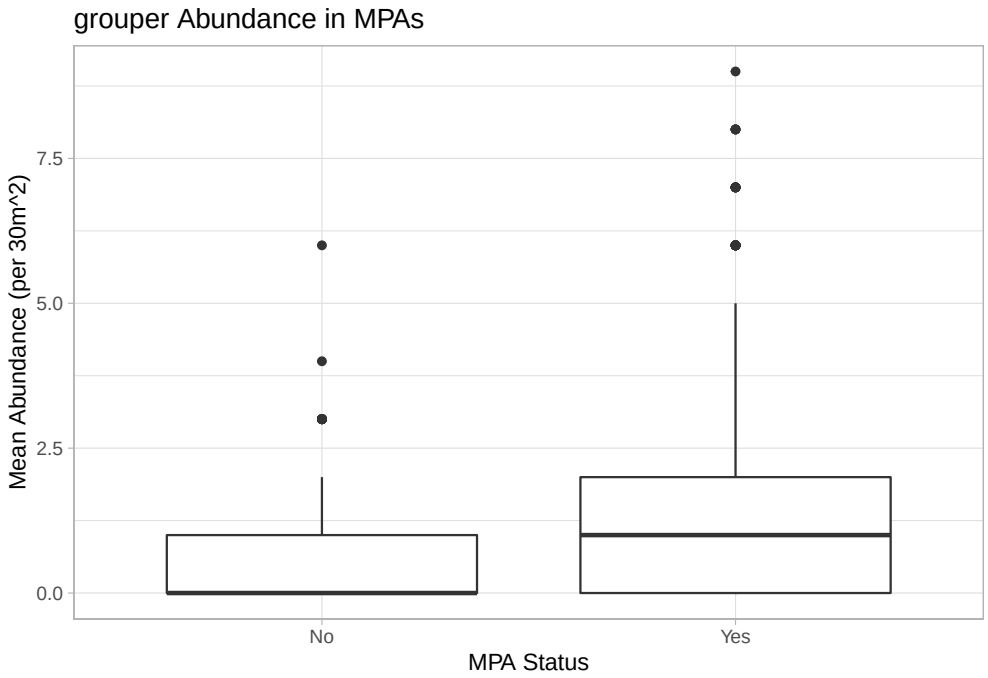



```
##                        Df    Sum Sq  Mean Sq F value   Pr(>F)
## Station.Within.MPA.     1  26782780 26782780   20.87 5.85e-06 ***
## Residuals             670 859809926  1283298
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

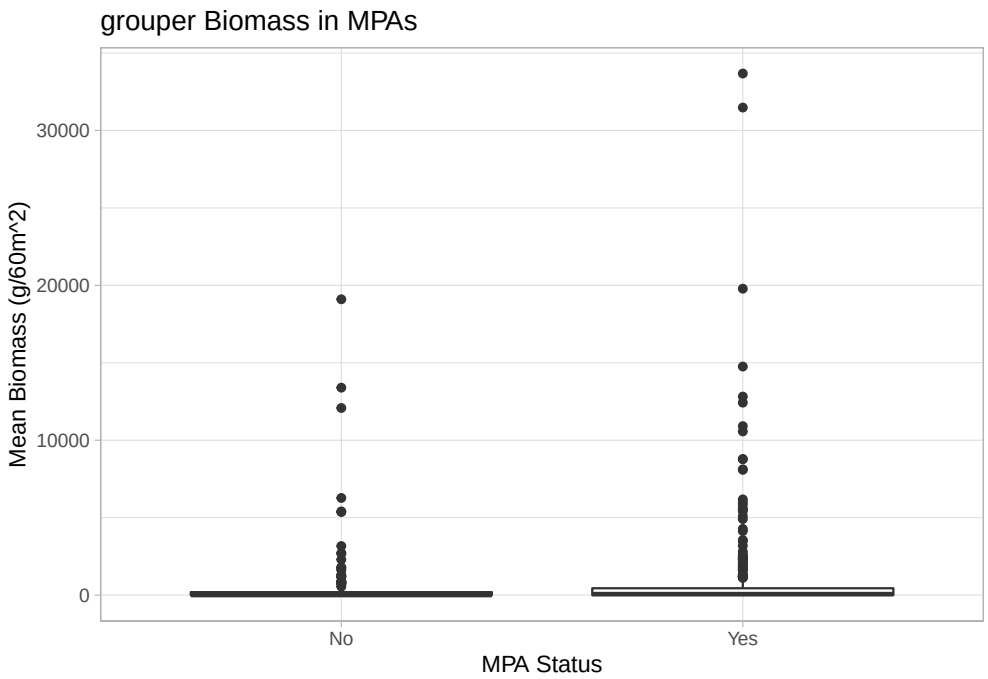



```
##                       Df Sum Sq Mean Sq F value Pr(>F)
## Station.Within.MPA.    1  201.1  201.10   98.32 <2e-16 ***
## Residuals           1425 2914.6    2.05
## ---
## Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1
```

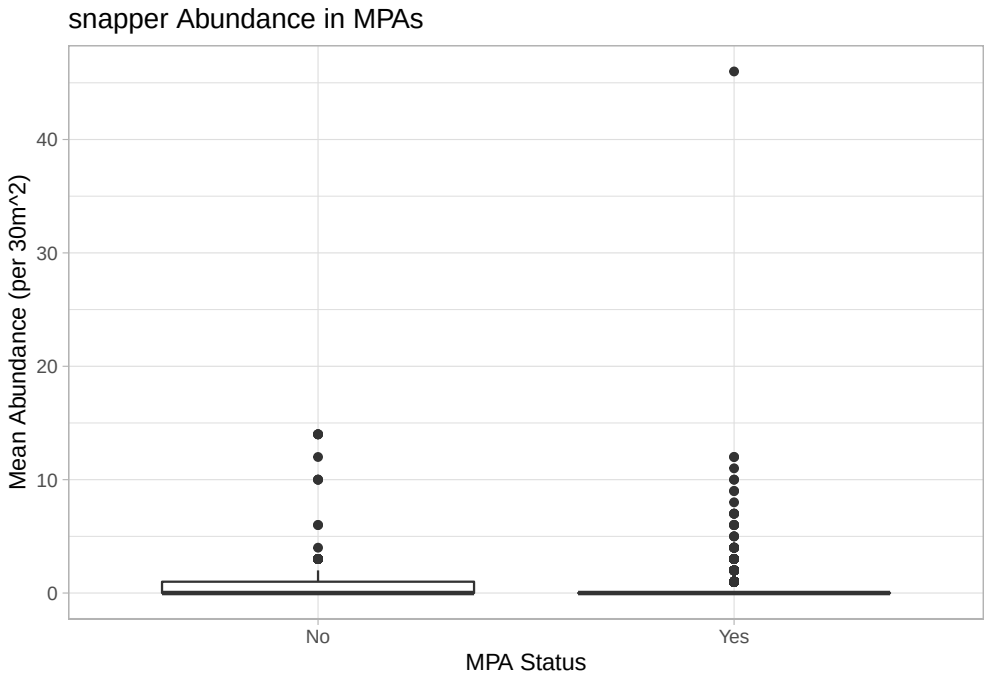
```
##                       Df    Sum Sq  Mean Sq F value Pr(>F)
## Station.Within.MPA.    1 1.889e+07 18886100   2.777 0.0961 .
## Residuals           670 4.557e+09  6801133
## ---
## Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1
```



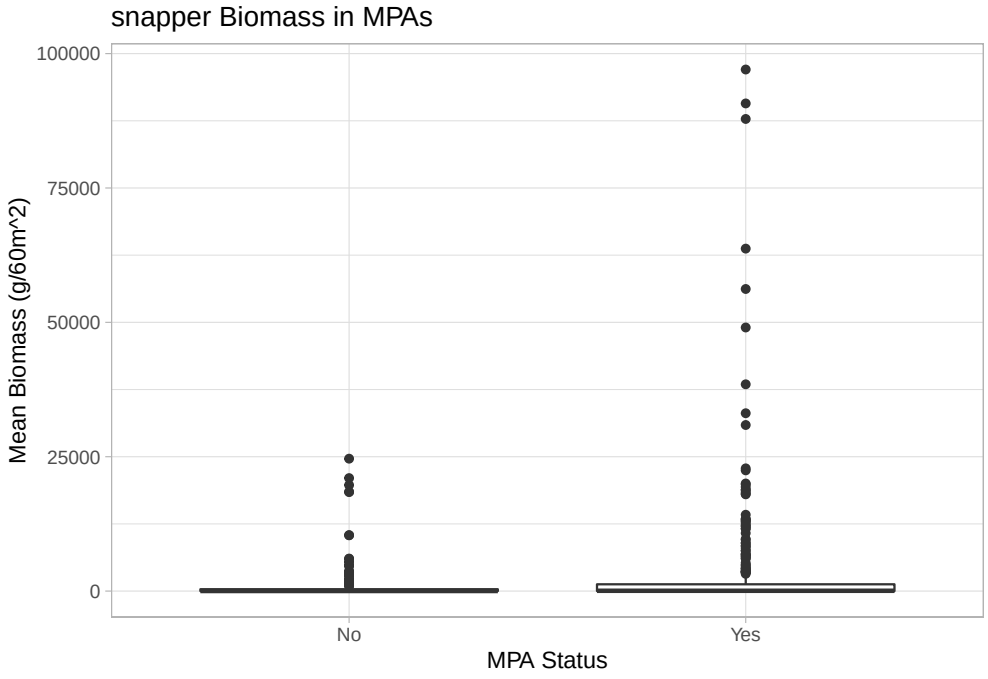

```
##                       Df    Sum Sq  Mean Sq F value Pr(>F)
## Station.Within.MPA.    1 1.889e+07 18886100   2.777 0.0961 .
## Residuals            670 4.557e+09  6801133
## ---
## Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1
```




```
##                       Df Sum Sq Mean Sq F value Pr(>F)
## Station.Within.MPA.     1      3   3.475   0.947  0.331
## Residuals            1425   5228   3.669
```

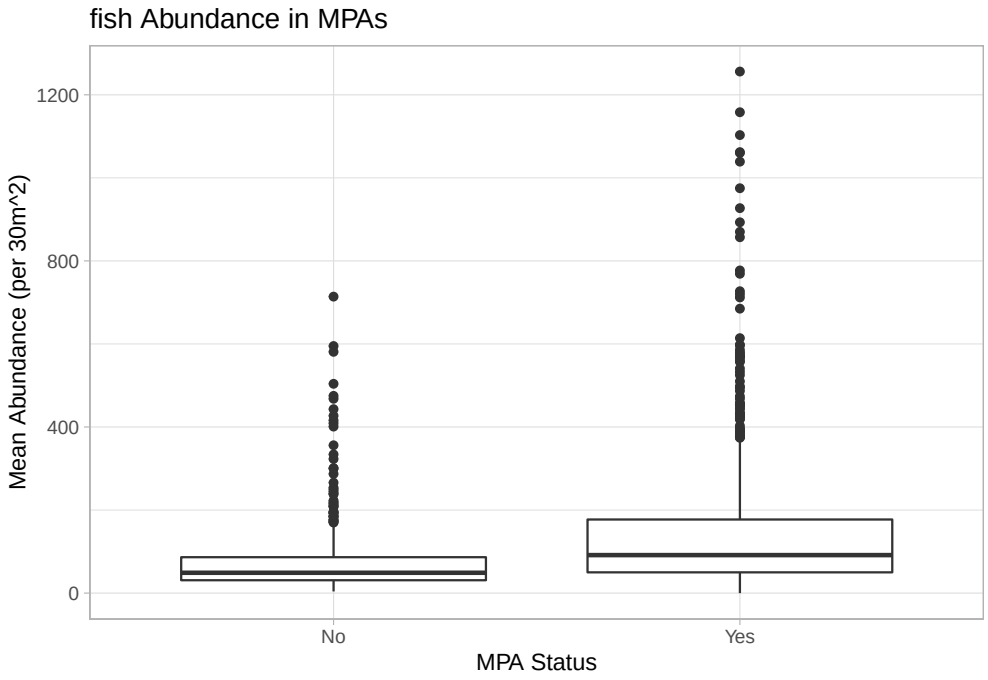



```
##                       Df    Sum Sq   Mean Sq F value Pr(>F)
## Station.Within.MPA.    1 4.419e+08 441899731   6.601 0.0104 *
## Residuals            670 4.485e+10  66939741
## ---
## Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1
```




```
##                       Df   Sum Sq Mean Sq F value   Pr(>F)
## Station.Within.MPA.    1  1218973 1218973   64.42 2.07e-15 ***
## Residuals           1432 27094472   18921
## ---
```

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




```
##                       Df    Sum Sq   Mean Sq F value Pr(>F)
## Station.Within.MPA.    1 1.059e+09 1.059e+09   3.354 0.0675 .
## Residuals            670 2.115e+11 3.156e+08
## ---
## Signif. codes:  0 ’***’ 0.001 ’**’ 0.01 ’*’ 0.05 ’.’ 0.1 ’ ’ 1
```