**Methods section for Anacapa Island Story**

**Methods**

Data was formatted in two data frames. One to display densities of species and taxonomic groups per m2 in the Anacapa Island SMR and SMCA each year, and the other to display counts with the same organization. Each data point in the analyses was from a single year in either the Anacapa Island SMCA or the SMR. Shannon index diversity in each MPA type each year was calculated using the diversity() function in the vegan package in R version 4.0.4. To test the effect of MPA type on Shannon diversity while controlling for the effects of years, a paired t-test was run using the t.test function.

To determine if fishing pressure in the SMCA significantly altered California spiny lobster *Panulirus interruptus* from their density in the SMR with no fishing pressure, a bootstrapped two-way t-test was run. A paired t-test could not be run due to the abnormal distribution of the data. To test if *P. interruptus* density m-2 was correlated with Shannon diversity off Anacapa Island, a Spearman’s rank correlation test was used using the cor.test() function. However, due to the abnormal abundance of white urchins (*L. anamesus*) in 2014 and 2015, white urchinswere removed from the data, the Shannon diversity re-calculated, and the Spearman test run a second time to remove abnormally low diversity. The Shannon diversity without white urchinsis subsequently referred to as “modified diversity” and the original calculation as “unmodified diversity”.

Because white urchins were determined to have a major impact to diversity, a bootstrapped 2-way t-test was run using *L. anamesus* as the independent variable, and unmodified Shannon diversity as the dependant variable. Due to the highest urchin density coinciding with the highest lobster density, a spearman test was run on lobster and urchin densities to determine a correlation, and a two-way ANOVA run to test for an interaction between the two populations and their effects on (normal) diversity.

To characterize SMCA and SMR sites, An NMDS was run in R using the vegan package to characterize the SMCA and SMR, using each year of data in each type of MPA as a data point, with points labelled by year. A species fit was run using the envfit() function in the vegan package. 10,000 permutations were run, and the critical p-value was 0.005.

Because California sea cucumbers (*Apostichopus californicus*) are fished in the SMCA, but not the SMR, a bootstrapped two-way t-test with type as the independent variable was run to test if density changes between the SMCA and SMR. Additionally, two spearman tests were run to test for correlations with both unmodified and modified diversity. For comparison, a spearman test was run in the same method to test for a correlation between another (non-fished) sea cucumber, *Parastichopus parvimensis* and modified diversity.

Due to their role in characterizing the SMR in the NMDS and forming reefs, a spearman rank test was run on orange gorgonian (*Adelogorgia phyllosclera*) and modified diversity in addition to a bootstrapped two-way t-test between gorgonian density and MPA type, and a two-way ANOVA to test between gorgonian density and modified diversity.

Lastly, the ggplot and cowplot packages were used to plot barcharts of normal diversity, modified diversity, *P. interruptus* density, *L. anamesus* density, *A. californicus* density, *P. parvimensis* density, and *A. phyllosclera* density across both year and MPA type.

**Results**

The effect of MPA type in the Anacapa Island region was found to have a significant impact on diversity, with the SMR having a higher average diversity than the SMCA (Paired t-test n = 8, df = 7, t = -5.8635, p = 0.000622).

The change in fishing pressure between the SMR and SMCA appears to have a significant impact on spiny lobster density (Bootstrap t-test p = 0.049), with higher density in the SMR. However, given the rarity and variance of spiny lobster sightings using the ROV, this result is vague at best. Using the Spearman test, no significant correlation could be ascertained between lobster density and unmodified Shannon diversity (Spearmans’s r= -0.0184219, p = 0.946). However, the removal of white urchins from the calculation of the diversity index made a great difference when the Spearman test was re-run and a significant correlation was found between lobster density and the modified Shannon diversity (Spearman’s r = 0.743, p = 0.0009741). This trend is contrasted by the negative correlation between white urchins and unmodified shannon diversity (Bootstrap t-test, p = 0.003). Interestingly, spiny lobster densityis positively correlated with white urchin density (Spearman’s r = 0.55162, p = 0.02675). However, the two-way ANOVA revealed no interaction between lobsters and urchins in their correlation with normal diversity despite their correlation with one another (ANOVA df = 1,12, F = 1.216, p = 0.292).

The NMDS and species fit of the Anacapa Island SMR and SMCA provided two distinct assemblages in the two types of MPA (non-linear stress = 0.994). The SMCA is relatively consistent between years and is characterized by a significantly higher density of the bat star *Patiria miniata*. The SMR by contrast is more highly variable and overall, the site is characterized by a higher abundance oforange gorgonians, but 2014, and to a lesser extent 2015 and 2019 characterize the SMR much more by the greater abundance ofwhite urchins, spiny lobsters, and an unidentified boot sponge.

Likethe California spiny lobster*,* the California sea cucumber is not correlated with unmodified diversity (Spearman’s r = -0.22059, p = 0.4103), but unlike its crustacean counterpart, it is not correlated with the modified diversity either (Spearman’s r =0.2352941, p = 0.379). Also unlike spiny lobsters the SMR was not found to significantly alter the density of California sea cucumbers compared with the densities reported in the SMCA (Bootstrapped 2-way t-test, p = 0.227). By contrast, the other abundant holothuroid, the warty sea cucumber, was found to be correlated with modified diversity (Spearman’s r = 0.5559, p = 0.02762).

Orange gorgonians, which play a role as reef-building organisms that characterize the SMR were also found to be correlated with modified diversity (Spearman’s r = 0.6696, p = 0.004547) and to be significantly correlated with the SMR (Bootstrapped 2-way t-test SN = 25.162, p = 0.001). However, there was no interaction found between MPA type and orange gorgonian density in the correlation with modified diversity (ANOVA df = 1,12, F = 1.651, p = 0.2231).