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Comparative analyses of potential resilience in 51 coral patches from Apra Harbor, Guam using CoralPatchSim

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Coral Reef Simulation Lab

Introduction

- Coral reefs have a huge biodiversity and provide us with many resources.
- Because of anthropogenic effects, coral reef ecosystems are in danger of collapse.
- The resilience of a system here means the ability of a system to continue recover reasonably rapidly following disturbances.

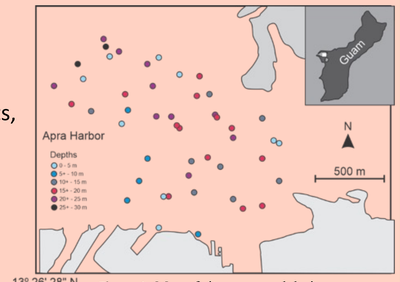


Figure 1. Map of sites surveyed during original analyses, colored by depth (m).

- Public-domain data was used from a study by a group of U.S. government agencies and consultants of selected sites in Apra Harbor in Guam prior to planned dredging for a potential aircraft carrier turning basin – a task which was later cancelled for financial reasons.
- **In this study, this data was analyzed using modified 'catch curve' approaches and CoralPatchSim** (McManus and McManus in prep.)**, to understand the potential resilience of the coral patches at each site.**
- **The resilience was be quantified by how fast the coral assemblage form each site reached 60% overall bottom coral cover in simulations, versus depth and species richness.**

Methods

- Data for the CoralPatchSim "Species Input" spreadsheet was collected and calculated.
  - The growth rate for each species was found online and ages estimated from coral radii in the data set.
  - For each species, the number of corals in each annual age bin was plotted against age bin midpoint.
  - As per standard practice, age bins determined to be under-sampled were omitted (young ages clearly not in the descending limb of the graph).
  - Mortality (slope) and recruitment (intercept) values were calculated three different ways:
    - Using a log-linear regression line in MS Excel.
    - Using GLM method in R with the NB2 extension.
    - Using the Chapman-Robson method in R.
  - The values were very similar for each method. Based on recent published recommendations, the results from the GLM method were used in the simulations.
- Run parameters were set up identically for each site.
- The data was input into CoralPatchSim and run in simulation from totally cleared patches for 50 to 100 years. The simulator works essentially by forward projecting recruitment and mortality for each species in recent years, accounting for space competition.

Results

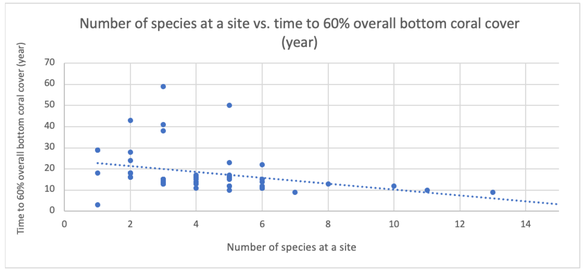
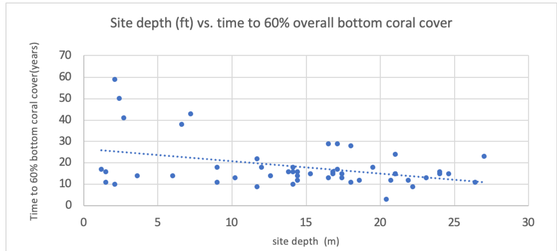


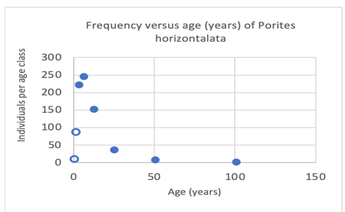
Figure 3. Graph of the total time it takes a site to get to 60% overall bottom coral cover in years versus the number of species originally present at a site. A linear trendline is included as a dotted line. Adjusted R squared value of 0.084 and p value of 0.022.

Figure 3. Graph of the total time it takes a site to get to 60% overall bottom coral cover in years versus the depth of each site in meters. A linear trendline is included as a dotted line. Adjusted R squared value of 0.133 and p value of 0.0049.



A negative correlation between the time it took a coral patch to reach 60% coral cover (resilience) and the depth of the coral patch was found AND a negative correlation was found between time to 60% coral cover and the number of species at a site. Depth was not significantly correlated with number of species.

Figure 2. Example graph of the number of individuals per age class (frequency) versus the age of the corresponding class in years for *Porities horizontalata*. The empty points were not used in the analyses of the data.



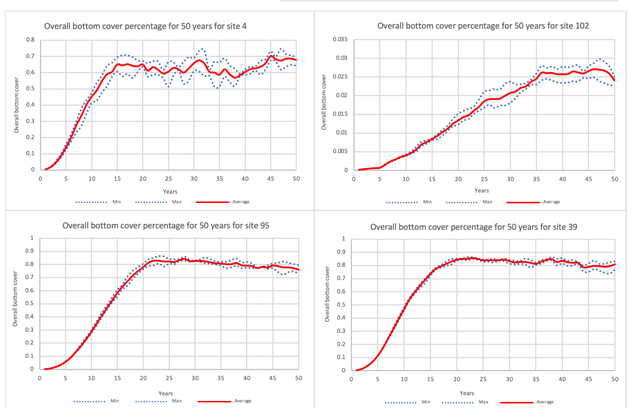


Figure 7. Example graphs of the overall bottom coral cover for each year after disturbance (out of 51 sites analyzed). Maximum and minimum of the 3 runs done for each site are in blue dotted lines. The average of all 3 runs is in red solid line. Site 4, 39 and 95 all made the 60% overall bottom coral cover goal but site 102 did not. The latter was true of 11 other sites.

Conclusion

- Depth and species diversity were seen to act independently in regard to resilience.
- **As depth decreased, resilience increased**, which is opposite to what was hypothesized.
- The adjusted R squared value was 0.142 and the P value was 0.0053 ($p < 0.01$), thus these results are significant
- This could be due to decreased disturbance in the deeper sites, which allowed the corals to grow with less stressors
- **As the coral species richness at a site increased, so did resilience.**
- All the sites which did not achieve 60% coral cover in 100 years had 3 or less coral species. Thus, species richness is an important factor when looking at coral resilience
- The R squared value is 0.084 with a p value of 0.027 ($p < 0.05$)
- Depth was found to be a more significant indicator for resilience than species richness.

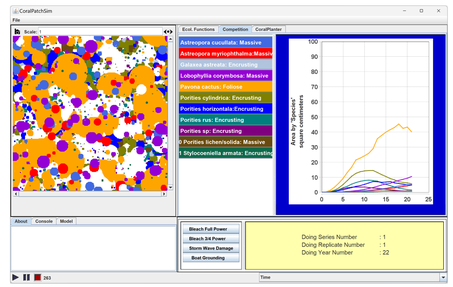


Figure 6. Screenshot of the desktop of CoralPatchSIm while running. The area of bottom covered by each species in described in the graph shown on the right, and the colors of the left represent the depiction of the coral cover by species.

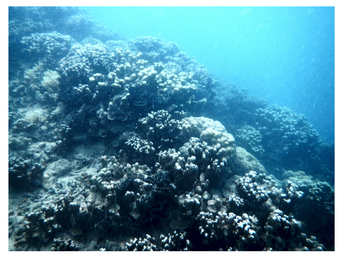


Figure 8. Mixed species coral patch from an Apra Harbor survey site (J. McManus).

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- Coral Reef Simulation Lab