Model of Guam's Coral Reef Change

Coral Reefsearchers

Aaron Bumagat, Michelle Luces, Henry Song

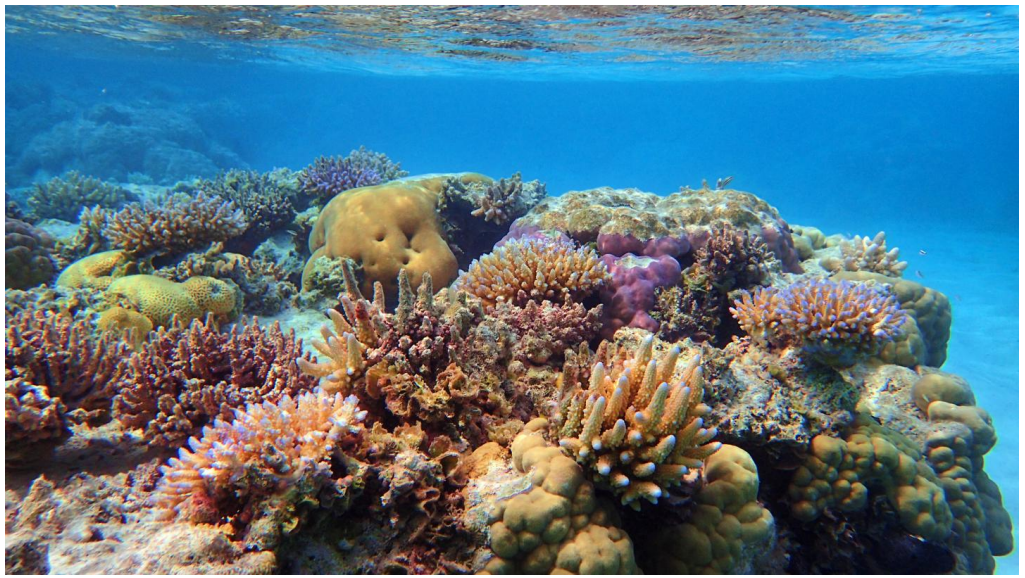
University of Guam

June 25, 2021

Table of Contents

Introduction

- General Question: How will Guam's reef ecosystem change over the coming decades?



Background

- Coral Reefs are large underwater structures composed of the skeletons of colonial marine invertebrates known as coral[6].

Background

- Coral Reefs are large underwater structures composed of the skeletons of colonial marine invertebrates known as coral[6].
- Climate change is a leading factor for the cause of coral bleaching/death.

Background

- Coral Reefs are large underwater structures composed of the skeletons of colonial marine invertebrates known as coral[6].
- Climate change is a leading factor for the cause of coral bleaching/death.
- Other factors that contribute to changes in a reef ecosystem are overfishing, temperature changes, and coral reef resilience.

Background

- Coral Reefs are large underwater structures composed of the skeletons of colonial marine invertebrates known as coral[6].
- Climate change is a leading factor for the cause of coral bleaching/death.
- Other factors that contribute to changes in a reef ecosystem are overfishing, temperature changes, and coral reef resilience.
- According to the 2008 State of the Coral Reef Ecosystems of Guam report, Guam's coral reef resources are both economically and culturally important, providing numerous goods and services for the residents of Guam, including cultural/traditional use, tourism, recreation, fisheries, and shoreline/infrastructure protection[1].

Literature Review

Articles covered:

- Assessing relative resilience potential of coral reefs to inform management[3]
- Prioritizing Key Resilience Indicators to Support Coral Reef Management in a Changing Climate[4]
- Model of coral population response to accelerated bleaching and mass mortality in a changing climate[5]
- Mathematical Analysis of Coral Reef Models[2]

Assessing relative resilience potential of coral reefs to inform management

Summary

This research discusses ecological resilience as a essential part of resilience-based management (RBM) and the use of such assessments to explain resilience potentials of coral reefs in the Northern Mariana Islands (CNMI).

Why is this article important?

- Explores and elaborates on factors affecting coral resilience.
- Acts as a guide to implement ecological resilience assessments.
- Analyzes inter-island and intra-island connectivity.

Prioritizing Key Resilience Indicators to Support Coral Reef Management in a Changing Climate

Summary

Empirical selection criteria was created in order to prioritize coral reef management.

Why is this article important?

- Provides data from certified scientists when it comes to resilience of coral reef.
  - Can be used to see which will be focused on when creating our parameters.

Model of coral population response to accelerated bleaching and mass mortality in a changing climate

Summary

Researchers studied coral populations located within the Arabian Peninsula. The study primarily focused on the Porites and *Acropora* species of coral. The researchers found that coral populations can survive more extreme conditions.

Model of coral population response to accelerated bleaching and mass mortality in a changing climate (Cont.)

Why is this article important?

- Methods used include a system of differential equations.
- It implements a compartment model to illustrate the relationships.
- It uses the Lotka-Volterra model to simulate a predator prey relationship between *Acropora* as the dominant species and others as the recessive species.
    - Incorporates ideas of Game Theory into methods.

Mathematical Analysis of Coral Reef Models

Summary

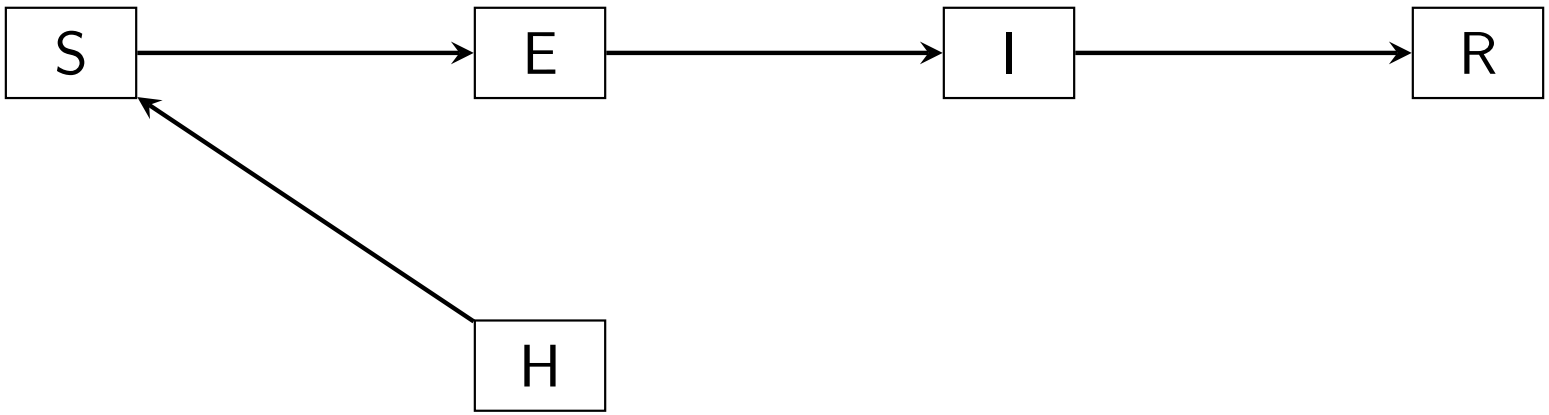
This research analyzes grazing in response to threatened coral reef systems. Specifically, this model is focused on the impact of different grazing intensities and their influences on coral-algae interactions. Results provided from this research can provide insight on how to revitalize unhealthy reefs.

Mathematical Analysis of Coral Reef Models (Cont.)

Why is this article important?

- The authors used ordinary differential equations (ODE) and delay differential equations (DDE) to model coral reefs.
- Discusses about the stability of three different states: extinction state, macroalgae-only state, and coral-only state.
- The mathematical results can help answer how to reverse the unhealthy reefs to a healthy status by knowing how overfishing affects our reefs.

Compartment Model



Compartments

- S: all susceptible corals
- E: our exposed corals
- I: our infected corals
- R: our recovered corals
- H: human factors potentially affecting coral reefs

Plans

- Specific ideas:
  - How will a specific coral species change throughout the upcoming decades on Guam?
  - Select a representative species of average resiliency (specifically on Guam) and examine how it will change over time through climate changes.
- Establish our methodology and mathematical model in order finalize our compartment model and to answer our question.
- Application of Game Theory (specifically education game theory).

Questions?

Acknowledgements

Support for the Young Scholars Research Experience in Mathematics (YSREM) is through the MAA Tensor SUMMA Program. Support for the MAA National Research Experience for Undergraduates Program (NREUP) is provided by the National Science Foundation (Grant Number DMS-1950644). Support for the NSF EPSCoR project, Guam Ecosystems Collaboratorium for Corals and Oceans (GECCO) is provided by the National Science Foundation (Grant Number DMS-1946352).

Special thanks to Dr. Bastian Bentlage, our faculty mentors (Dr. JaeYong Choi, Dr. HyunJu Oh, & Dr. Leslie Aquino), and our Research Assistants (Jaron Bautista & Regina-Mae Dominguez).

MAA MATHEMATICAL ASSOCIATION OF AMERICA

NSF

GUAM EPSCOR GECCO

UNIVERSITY OF GUAM UNIBETSEDÅT GUÅHAN

Bibliography I

[1] *Importance of Guam's Reefs*. DOI: http://www.guamreeflife.com/reef-conservation/importance-of-guams-reefs/.

[2] Xiong Li et al. "Mathematical analysis of coral reef models". In: *Journal of Mathematical Analysis and Applications* 416.1 (2014), pp. 352–373. ISSN: 0022-247X. DOI: https://doi.org/10.1016/j.jmaa.2014.02.053. URL: https://www.sciencedirect.com/science/article/pii/S0022247X14001917.

[3] Jeffrey A. Maynard et al. "Assessing relative resilience potential of coral reefs to inform management". In: *Biological Conservation* 192 (2015), pp. 109–119. DOI: 10.1016/j.biocon.2015.09.001.

Bibliography II

[4] Tim R. Mcclanahan et al. "Prioritizing Key Resilience Indicators to Support Coral Reef Management in a Changing Climate". In: *PLoS ONE* 7.8 (2012). DOI: 10.1371/journal.pone.0042884.

[5] Bernhard M. Riegl and Samuel J. Purkis. "Model of coral population response to accelerated bleaching and mass mortality in a changing climate". In: *Ecological Modelling* 220.2 (Jan. 2009), pp. 192–208. DOI: 10.1016/j.ecolmodel.2008.09.022.

[6] Rachel Ross. *What Are Coral Reefs?* Sept. 2018. URL: https://www.livescience.com/40276-coral-reefs.html.

Thank you!