**The Reduction of Coral Disease**

**Through Seagrass Meadows**

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# A picture containing outdoor Description automatically generatedLesson objectives:

The purpose of this lesson is to learn about the novel ecosystem service of seagrass meadows that potentially allows for the reduction of coral diseases. Students will explore this relationship by looking at the effects of seagrass meadows on White Syndrome and Skeletal Eroding Band Disease using a Poisson Generalized Linear Model. The use of the statistical software, R, will be used to analyze a global dataset to test this relationship.

1. Explore and understand the importance of Seagrass Meadows and the ecosystem services they provide
2. Learn about coral diseases that significantly impact the health of coral reefs

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| *“Seagrass meadows are one of the most threatened habitats globally and also one of the most overlooked.”* |
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1. Use a Poisson Generalized Linear Models to test the effects of Seagrass Meadow Status on coral diseases.

## Prerequisites:

* R and R studio downloaded on a working computer with basic skills in R.
* A basic understanding of a linear models
* Read the focal paper by Joleah B Lamb et al, 2017

## Seagrass Meadows

Seagrass meadows are soft-sediment marine habitats comprised of flowering plants adapted to the sea. There are approximately 72 types of species of seagrass that live in shallow intertidal and subtidal areas. These meadows are globally distributed and are estimated to cover up to 600,000 km2 of the ocean floors except Antarctica. Although seagrass meadows cover approximately 1% of the ocean, they provide many essential ecosystem services (Cullen-Unsworth & Unsworth, 2013). However, seagrass meadows are one of the most endangered ecosystems on Earth. About 15% of seagrass species are considered threatened and are reported to be declining worldwide. These declines are a result of a variety of causes including climate change, poor water quality, overexploitation, etc. (Hughes et al., 2008). Therefore, it is important to understand how we can protect seagrass meadows in order to protect the ecosystem services they provide.

## Ecosystem Services

Seagrass meadows provide ecosystem services that support the functioning of coastal zones and humans. It is important to note that seagrass meadow ecosystem services are not evenly distributed and may depend on the seagrass genera. Larger seagrass genera are said to provide a wider variety of ecosystem services compared to small species. However, small seagrass species are still known to provide important services (Nordlund et al., 2018).

Ecosystem services provided by seagrass meadows include the support of biodiversity, carbon sequestration, water purification, the potential to reduce bacterial pathogens, etc. Seagrass meadows support biodiversity through the act of shelter, feeding, and nursery grounds. They are known to protect threatened marine biodiversity that includes marine megafauna (dugongs, sea turtles, and sharks). As megafauna feeds on seagrass, it results in the process of the export of nutrients to nearby ecosystems such as coral reefs. In addition, the export of nutrients also promotes carbon storage in seagrass meadow substrates. Seagrass meadows are significant carbon sinks that allow for the storage of carbon in sediment. They are estimated to store as much as 19.9 Pg in organic carbon around the world (De Los Santos et al., 2020). In addition, seagrass meadows can improve water quality through the process of uptake by filtering, cycling, and storing nutrients and pollutants. Lastly, a new potential ecosystem service was recently discovered that seagrass meadows can reduce bacterial pathogens and coral diseases. Moreover, this reduces the exposure of bacterial pathogens to fish, humans, and invertebrates. Seagrasses produce natural biocides that inactivate or kill numerous bacterial pathogens. A study in Indonesia discovered that there was a 50% reduction in the relative abundance of potential bacterial pathogens. Moreover, they also found that coral located adjacent to seagrass meadows showed reductions in disease levels compared to sites without seagrass meadows (Lamb et al, 2017). This study will be the focus of the QUBES lesson as students will learn more about the different coral diseases and their relationship to seagrass meadows.

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| A picture containing outdoor, aquatic mammal  Description automatically generated  Dugong eating seagrass |

**Dugong Eating Seagrass**

Image Source: https://naturemind-ed.com/portfolio/seagrass-dugong-conservation/

**Extra Resource:**

Introduction to Seagrass Meadows from Hakai Institute

[Seagrass: Life in the Underwater Meadows](https://www.youtube.com/watch?v=uRnFLujT368)

## Coral Diseases

Coral disease frequency has increased significantly over the last 10 years leading to widespread mortality among coral reefs. They generally occur in response to biological and environmental factors such as bacteria, increased sea surface temperature, and pollution (NOAA, n.d.). The bacterial pathogens studied in the focal paper above include black and, white syndromes, growth anomalies, skeletal eroding band, and brown band. To get a better understanding on how seagrass meadows reduce these pathogens, it is important to understand what they are and how they affect coral reefs. A picture containing reef, nature, coelenterate, coral

Description automatically generatedFor this lesson, we will focus on White Syndromes and Skeletal Eroding Band.

Image Source: <https://www.usgs.gov/media/images/coral-reef-affected-white-syndrome-0>

## White Syndromes

A picture containing indoor, close, fish, spiny-finned fish

Description automatically generatedWhite Syndromes are known as coral tissue loss diseases that share similar macroscopic disease signs. It is characterized by tissue loss that exposes the white skeleton adjacent to asymptomatic coral. White syndromes can be identified based on lesion shape and progression rate. This group of diseases has wide geographic distributions, diverse host ranges, and irreversible damage that has the potential to significantly decrease coral cover (Polluck et al., 2017).

## Skeletal Eroding Band

Skeletal eroding band is a ciliate infection in corals associated with tissue loss. It can be identified macroscopically from a black band that surrounds healthy coral tissue. Ciliates become embedded in the skeleton that produces the eroding appearance. In addition, it can often be confused with black band disease since the band of ciliates may be so dense it appears similarly to black band. This infection is found globally and is known for its rapid colonization (Palmer & Gates, 2010).

Image Source:https://eorhawaii.org/photo-galleries/train\_your\_eye\_gallery/coral-disease-gallery/growth-anomalies-gallery/

## Statistical Analysis

The data students will use for this lesson comes from the following report *Seagrass ecosystems reduce exposure to bacterial pathogens of humans, fishes, and invertebrates* by Joleah B Lamb et al, 2017 from Science. Their study was focused on how seagrass meadows have a potential ecosystem service that could remove pathogens and improve water quality. For this lesson, students will focus on how seagrass meadows located adjacent to coral reefs can potentially reduce coral diseases.

## Understanding the Data

The dataset contains field surveys of more than 8,034 reef building corals located adjacent to seagrass meadows and pair sites not adjacent to seagrass meadows. Four islands were selected located in Indonesia that were surrounding by reef platforms and areas of mixed seagrass meadows. Since seagrass meadows and coral reefs are tightly linked habitats, they used this opportunity to assess the data in situ. Of the 8,034 reef-building corals they visually examined the sites to search for visual signs of tissue loss characteristic at all sites. Based on their observations they found 5 types of coral diseases: Black band, white syndromes, growth anomalies, skeletal eroding band, and brown band. In addition, the authors also looked at bleaching and sediment deposition associated with coral tissue mortality in the field. In addition, it is important to note that the dataset we will be using does not contain 8,034 data points and the sample size is 12 for “Seagrass” and 12 for “NoSeagrass”. The sample size significantly decreases because we are not considering the total number of corals they recorded. We will only focus on the corals that are diseased and further limit it to only coral that has White Syndrome and Skeletal Eroding Band disease.

Map

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**Map of the study islands located in Sulawesi, Indonesia.**

Image Source: https://www.science.org/doi/10.1126/science.aal1956

## Methods

For this Qubes Lesson, we will approach the analysis differentially compared to the authors analysis. The authors used a generalized linear mixed model, but we will simplify the analysis by using a Poisson GLM. A Poisson GLM will test for effects of the status of seagrass meadows on White syndromes and Skeletal Eroding Band as response variables since they are count data. The status of seagrass meadow is classified into two categories and is known as the explanatory variable and is categorical: No Seagrass and Seagrass.

## What is a Poisson GLM?

When doing a GLM analysis on count data, the Poisson distribution and log link function are used. The Poisson distribution can be defined having variance equal to its mean in most cases. In addition, the log link function is used to ensure that all counts are positive by taking the exponent of the linear predictor. Moreover, count data are often overdispersed and contain many low values that cause the distribution to skew to the left. When applying a Poisson GLM to this data, this allows for the distribution to become more bell shaped and have a normal distribution. For more information, click the following hyperlinks: [POISSON REGRESSION HELP](https://stats.oarc.ucla.edu/r/dae/poisson-regression/) and [Understanding intercepts and p-values](https://www.youtube.com/watch?v=9eD3HufGsfs)

## Seagrass Status and Coral Disease Analysis

The first step of the analysis is to open the .Rmd file into R and load in the CSV file. Students should run the code line by line to understand how to complete the Skeletal Eroding Ban analysis portion on their own.

The next step is to test the data to evaluate it for normality. To test the distribution of a dataset, students will use a histogram plot to test the normality of the WS or White Syndromes.

Chart, histogram

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**QUESTION 1: Is the data normally distributed?**

**No- the data is not normally distributed. It is skewed to the left.**

To create the Poisson Generalized Linear Model, we first need to understand what syntax to use. Since we are doing a Poisson analysis the family will equal “Poisson”, the linear predictor is our count data or WS, and the link function is equal to “log”.

Graphical user interface, application

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Based on the summary of model 1, we can see the intercepts and p-values that will also help us visualize the data:Text

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Now that we have set up the Poisson GLM, we can now model it to see if the status of seagrass meadows has an effect on White Syndrome Count.

Chart, box and whisker chart

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**QUESTION 2 – Based on the graph above, the intercept value, and the p-value shown in summary of model1, does Seagrass status have an effect on White Syndrome Count?**

**\*Yes - Seagrass meadow status has an effect on White Syndrome Count. This is observed in the graph above and the summary of the GLM model contains intercept values that are statistically significant from one another since P-values are equal to <2e-16 and 8.35e-07. The intercept values are 1.4469 and -1.9859 which are not similar to one another.**

Students will now complete the next portion on their own. To complete the next section students will have to:

* Plot a histogram of the SEB data to test for normality
* Determine if the data is normally distributed
* Create a GLM with a Poisson distribution
* Plot the GLM to test if seagrass status effects SEB count.

Once this analysis is completed answer the following questions:

**QUESTION 3: Is the data normally distributed for Skeletal Eroding Band Count?**

* **No it is not normally distributed, it is skewed to the left.**

**QUESTION 4: Based on the graph above, the intercept value, and the p-value shown in summary of model2, does Seagrass status have an effect on Skeletal Eroding Band Count?**

* **No - Seagrass Status does not have an effect on Skeletal Eroding Band count.This is observed in the graph above and the summary of the GLM model contains intercept values that are not statistically significant from one another since the P-values are equal to 0.0233 and 0.2011. The intercepts of No Seagrass and Seagrass are 0.5108 and 0.3716 which are similar to one another..**

**QUESTION 5: Do we reach the same conclusions as the authors in the focal paper? Refer to Figure 5 in the focal paper.**

* **Yes – based on our analyses we were able to reach similar conclusions to the authors that only White Syndromes is affected by the presence of seagrass.**

**Citations**

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