MTFC Project Proposal 2025-26

Team Name	CAARAL Reefs
Team ID #	23914
Short Title for Proposal	A Risk Analysis of the Effects of Coral Reef Degradation in Tropical Climates
Topic Category	Climate Change/Environment

MTFC Project Proposal Template Use Notes:

- *Note that the topic for the Project Proposal is the **team's choice** (i.e., it is **NOT** intended that you use the 2025-26 Scenario Quest corn farming for your project proposal topic)*
- *Refer to the official MTFC Project Proposal Prompts 2025-26 for the 15 prompts and scoring instructions.*
- *The use of this template is OPTIONAL.*
    - *It is provided as an optional resource for teams to keep their Project Proposal response organized. Teams who wish to use this template should make a copy in order to edit.*
- *The final version of the team's MTFC Project Proposal should be downloaded as a PDF or Word document to submit on the ICS Dashboard. A single file will be submitted.*
- *Additional resources (including the Actuarial Process Guide) can be found on the Modeling the Future Challenge website: https://www.mtfchallenge.org/resources/*
- *Please direct any questions to challenge@mtfchallenge.org.*

Part 1: Project Definition *(Team's Topic)*

These prompts can be found on page 3 of the MTFC Project Proposal Prompts 2025-26. Additional information on Project Definition can be found in ***Step 1: Project Definition*** in the Actuarial Process Guide.

Team Responses:

#1: Identify the topic

- Response:
    - The topic for this project is modeling growing coral reef degradation and its predicted effects on global markets and ecosystems, and developing recommendations to combat this.
    - Coral reef degradation is currently at an alarmingly high rate, with nearly half of the hard coral cover lost over the past year. For certain reefs, overall degradation has approached nearly 70%, primarily due to increases in climate-driven heat stress and the number of tropical cyclones.
    - Minorities, low-income, and indigenous communities are disproportionately affected as they rely more heavily on coral reef inhabitants for local food supply, and the effects are mostly prevalent in coastal populations, though effects on tourism will also impact global markets. The impact of this can range from harming industries such as fishing and tourism to global climate and biodiversity risks.

#2: Identify potential risks

- Response:
    - Over half a billion people directly rely on reefs for their livelihoods and food. Specifically, the food supply will suffer as catches from fishermen will be smaller and lower quality, protection from ocean waves will decline, as coral reefs absorb 97% of wave energy from storms, and coastal markets will suffer due to a decline in fishing and tourism. Additionally, coral reef degradation can impact ecosystems on a larger level due to damage to the food chain and habitat loss.
    - Individual:

        Fishermen and indigenous peoples suffer greatly from coral reef degradation. Since many fish rely on coral reefs for protection, the loss of coral reefs leads to a decrease in the marine populations. Consequently, the number of catches for the fishermen is decreasing, leading to a loss of business, and the number of catches for the indigenous peoples is decreasing, leading to a loss of food and loss of life. The best-case scenario for this risk is that fishermen will be able to find other locations for fishing and will meet their quotas without overfishing, or that they are able to continue fishing in their original locations, either due to fish populations staying stable or coral reefs not degrading as much as expected.
    - Society:

        Changes in ecosystem composition in certain reefs can proliferate effects globally. Loss of biodiversity in reefs around the world results in lower food supply for society as a whole, along with a variety of other effects, such as increased disease vulnerability. The best-case scenario for this risk is that biodiversity will not decline, and effects from coral reef degradation will not proliferate globally either due to the role of man-made habitats compensating for degraded reefs or coral reefs not degrading as much as expected.
    - Organizations/Industry/Governmental:

        Impacts to coral reefs will negatively impact tourism as the destruction of these reefs reduces the aesthetic and economic value of the respective area. This affects local economies that rely on tourism, and can also lead to overfishing since economies that rely

on tourism now have to move to fishing in order to sustain themselves. While coral reef aesthetics are not directly recoverable if they are diminished, the best-case scenario for this risk is that the areas that rely on the aesthetic values of the coral reef can focus their tourism on other pleasing factors that their areas provide, such as weather, attractions, or landforms. Or, another best-case scenario is that coral reefs maintain their aesthetic value such that tourism stays constant.

#3: Identify a behavior change risk mitigation strategy

- Response:
    - A combination of rising ocean temperatures and pollution causes coral bleaching. A behavioral recommendation to reduce coral bleaching is to wear mineral sunscreen when swimming in the ocean to minimize contact between harmful chemicals and coral reefs.
        - Action against climate change, focusing on areas such as ocean acidification or things that affect storm patterns, etc.
        - The audience that is impacted by this mitigation strategy's implementation is everyday civilians and tourists. In tropical climates, wearing mineral sunscreen during activities on beaches or in the ocean is a policy intended to affect the general population.

#4: Identify a modifying outcomes risk mitigation strategy

- Response:
    - One recommendation could be building manmade housing units for fish to replace the habitat loss that comes with coral reef degradation. This solves most fishing industry issues, and fish populations won't decline as much since the habitat that they once lived in gets replaced by a similar alternative
    - Another recommendation could be to construct energy-absorbing structures to mitigate the impact of losing coral reefs, as coral reefs absorb 97% of wave energy, and substitutes must be implemented to prevent erosion, coastal flooding, and storm damage.
    - Planting more trees to offset the reduction in oxygen production by the ocean, as trees produce oxygen.
- The audience that is impacted by this mitigation strategy's implementation are fishermen and insurance companies. This is because fishermen's jobs will be protected by a safety net, in the form of artificial habitats, and insurance companies that would otherwise be required to mitigate the potential risks will not have to interfere. Another group that will be affected will be coastal populations, especially ones that rely on tourism as a major source of income. This is because protecting coral reefs will maintain their aesthetic appeal.

#5: Identify an insurance risk mitigation strategy

- Response:
    - One of the major groups directly affected by reef degradation is fishermen. Loss of habitats and decreased food availability for fish populations lead to a decrease in fish diversity. As a result, fishermen will have a difficult time sustaining business, as the availability of fish declines. An insurance mitigation strategy that can address this issue is providing fishermen with a "safety net" insurance policy that ensures that their businesses are not at risk due to these effects.
    - The people that would be impacted by this risk mitigation strategy would be fishermen. This is because fishermen will be able to have a buffer such that they can search for a new source of income or to be less affected by this loss of product as a result of this buffer.

#6: Identify driving research questions for your topic

- Response:
    - How do rising global temperatures correlate with coral reef area and population, and what effects do these have on surrounding economies?
    - Is there a difference between the income and catch rate of fishermen who are near reefs versus fishermen who are not near reefs? Has this changed over time as reefs become degraded?

Part 2: Data Identification & Assessment *(Team's Topic)*

These prompts can be found on page 4 of the MTFC Project Proposal Prompts 2025-26. Additional information on Data Identification and Assessment can be found in ***Step 2: Data Identification & Assessment*** in the Actuarial Process Guide.

Team Responses:

#7: Identifying the type of data you hope to find

- Response:
    - Area data on the size of coral reefs
    - We hope to find data on the area of coral reefs as well as environmental factors such as ocean acidity, ocean warming, and altered rainfall, which could contribute to reef degradation
    - An ideal dataset would include a list of coral reefs by name around the world, with categories being geographic location, area of reef, change in area of the reef over the past 5 years, average ocean temperature, change in ocean temperature over the past 5 years, average rainfall, and change in average rainfall over the past five years.

#8: Identify potential data sources for your topic

- Response:
    - Potential data sources include government data releases from coastal countries or tropical countries, releases from independent climate activist organizations, and qualitative data from the coastal population
    - https://www.coris.noaa.gov/
        - This source gives various data, such as coral reef mapping, monitoring, and assessment, as well as natural and socioeconomic research and modeling. It is very credible as it is a .gov
        - This source falls into the category of "Defining historical trends" and "Defining the severity of potential losses". This is government data.
        - We could make graphs, tables, and potentially even simulations for the future using the data/trends from this source.
    - https://icriforum.org/restoration/coral-restoration-database/
        - The International Coral Reef Initiative, or ICRI, protects coral reefs across the world that has been recognized by the United Nations for partnering with organizations to spread coral reef awareness and responsibility.
        - The Coral Restoration Database is managed by ICRI and contains information, along with relevant scientific literature, about various coral reefs and their current statuses, including any recent environmental or atmospheric changes
    - https://www.bco-dmo.org/dataset/773466
        - This is a dataset of coral reef bleaching, a process in which coral reefs 'die' and lose their color
        - It's a credible and comprehensive source curated by established marine scientists. It fits mainly into categories 1 (characterizing outcomes) and 2 (estimating frequency) from the Actuarial Process Guide.

Part 3: Mathematical Modeling *(Team's Topic)*

These prompts can be found on page 5 of the MTFC Project Proposal Prompts 2025-26. Additional information on Mathematical Modeling can be found in ***Step 3: Mathematical Modeling*** in the Actuarial Process Guide.

Team Responses:

#9: Modeling research on your topic

- Response:
    - General Results
        - They look at general health indicators on coral reefs, which means that we could find datasets other than the area that can still help us with our model
            - Fish populations can be used to determine coral reef area (if the fish live there, for example)
            - Fleshy algae
            - Sponges
        - Surveys were used
        - Bar graphs used
            - Error bars
        - Data was tested for accuracy
        - Familiar, more or less, with all the math done
            - Lots of statistics knowledge required
    - Links:
        - https://www.frontiersin.org/journals/marine-science/articles/10.3389/fmars.2025.1525438/full → very close to us (wave energy + coastal populations)
        - https://www.nature.org/content/dam/tnc/nature/en/documents/TNC_Comparative-Analysis-Risks-Worlds-Coral-Reefs.pdf
        - https://www-sciencedirect-com.ezpv7-web-p-u01.wpi.edu/science/article/pii/S0025326X99000028

#10: Goals of a mathematical model in the project phase

- Response:
    - We hope that a mathematical model will help us accurately predict the rate of coral reef degradation, accounting for multiple potential factors that could affect it. It would also help us pinpoint the most important factors to develop risk mitigation strategies. Through statistical analysis, mathematical modeling, and machine learning algorithms, we hope to model change over time through probabilities, integral calculus, and predictive machine learning. By doing so, we will analyze which risks are important to mitigate and offer appropriate solutions.

#11: Assumption development

- Response:
    - Environmental Assumptions:

        - We aim for our model to apply for at least 10-15 years in the future. Since human emissions aren't decreasing and global warming is getting exponentially more prominent, our model should be able to predict trends with this flow of global warming
        - Our data currently fit a Poisson Distribution, but as the data grow over time, the distribution could shift toward a more skewed, biased one as global warming intensifies and/or mitigation efforts are put in place.

Part 4: Risk Analysis *(Team's Topic)*

These prompts can be found on page 6 of the MTFC Project Proposal Prompts 2025-26. Additional information on conducting a Risk Analysis can be found in ***Step 4: Risk Analysis*** in the Actuarial Process Guide.

Team Responses:

#12: Goals for mitigation strategy

- Response:
    - Individual:
        - Fishermen and indigenous peoples suffer greatly from coral reef degradation. Since many fish rely on coral reefs for protection, the loss of coral reefs leads to a decrease in the marine populations. Consequently, the number of catches for the fishermen is decreasing, leading to a loss of business, and the number of catches for the indigenous peoples is decreasing, leading to a loss of food and loss of life.
        - Mitigation Strategy:
            - A mitigation strategy for declining fish populations is offering insurance as a safety net for fishermen. This will ensure that fishermen's livelihoods are not detrimentally affected by low fish populations.
            - Man-made fish habitats can help to replace the benefits that coral reefs provide, making sure that food sources are still available to be used for consumption and selling by coastal and indigenous populations.
    - Society:
        - Changes in ecosystem composition in certain reefs can proliferate effects globally. Loss of biodiversity in reefs around the world results in lower food supply for society as a whole, along with a variety of other effects, such as increased disease vulnerability.
        - Mitigation Strategy:
            - It's key to prevent the degradation of coral reefs. Coral reef implementation can make sure that reefs continue to persist even if they have died out previously. Mineral sunscreen can prevent coral reefs from getting damaged, rather than traditional sunscreens, which can harm reefs.
    - Organizations/Industry/Governmental:
        - Impacts to coral reefs will negatively impact tourism as the destruction of these reefs reduces the aesthetic and economic value of the respective area. This affects local economies that rely on tourism, and can also lead to overfishing since economies that rely on tourism now have to move to fishing in order to sustain themselves.
        - Mitigation Strategy:
            - Coastal economies that are built on tourism rely on the aesthetic value of coral reefs more than they rely on their environmental value (fish habitats). However, if

their reefs become bleached, they will suffer greatly. There are two possible strategies to mitigate this risk. First, we could supply these governments with money to build physical barriers to protect coral reefs. This is seen in the natural expansion of the Narrowneck Artificial Reef in Australia and the Rotterdam Reef in the Netherlands. Specifically, building limestone structures could rapidly increase their populations. Secondly, we could ramp up the coral reef implantation processes in these areas to help revive their coral reefs.

Part 5: Recommendations *(Team's Topic)*

These prompts can be found on page 7 of the MTFC Project Proposal Prompts 2025-26. Additional information on making Recommendations can be found in ***Step 5: Recommendations*** in the Actuarial Process Guide.

Team Responses:

#13: Recommendation differences between mitigation strategies

- Response:
    - Some important metrics to consider when selecting between our three risk mitigation strategies would be cost, time, and predicted coral reef restoration. Firstly, we would need to consider cost, as some of our options would require funding from the government or private donors. Secondly, we would need to consider time, as economies driven by tourism for their coral reefs need the rapid restoration of their reefs' aesthetic value. Finally, we would need to consider predicted coral reef restoration to evaluate whether or not the strategy is worth the time and money.

#14: Audience for recommendations

- Response:
    - One audience that can make decisions based on our recommendations is governments in the target region. One of the recommendations in this project is building man-made fish habitats, so a real-life application of this is government programs/incentives to fund the creation of these habitats.

#15: Goals for situation improvement

- Response:
    - Our recommendations would lead to improvements in a variety of markers. One includes coral reef size increasing, due to things like reduced ocean acidification and other climate change effects. Another marker is fish populations staying constant or rising, either due to coral reefs not dying out or due to them not losing their habitat and instead switching to man-made habitats. Ideally, tourism and global markets also stay stable, due to little change in coral reef size.