CORAL RESTORATION FOUNDATION™

COLUMBIA UNIVERSITY

Empowering Environmental Stewardship in Florida Title I Students Through Coral Restoration Education

Coral Restoration Foundation

Columbia University
Master of Science in Sustainability Management
Capstone Report

Fall 2022

Faculty Advisor

Chandler Precht

Authors

Anuschka Ried

Aaron Hampton

Nandin Natsagdorj

Devon Rufo

Grace Ling

Nora Apelgren

Aditi Desai

Eva James

Christopher Reid

Adriel Chang

Table of Contents

Table of Contents

Part 2

Findings and Recommendations

Acknowledgements

This report is the collective work of 10 Columbia University graduate students as part of the Fall 2022 Integrative Capstone Workshop for the Master of Science in Sustainability Management program. This project could not have been completed without the support of the following organizations and individuals who generously provided their knowledge and expertise.

The Coral Restoration Foundation

We extend our sincerest gratitude to the Coral Restoration Foundation for the opportunity to contribute to its environmental education efforts. We are immensely grateful to Chandler Wright, who gave so much of her time to provide guidance, endless encouragement, and outstanding feedback to our team.

Chandler Precht

A special thanks to Chandler Precht, our faculty advisor, for providing the opportunity to be a part of this project. We appreciate her for connecting us to industry and academic experts who provided a wealth of knowledge. Her unwavering support, invaluable advice, and motivation inspired us to dedicate our all to this project. Through her encouragement, we were challenged to perform at our highest level and have grown as academics. It has been an amazing experience working together!

William Precht

We extend our deepest gratitude to William Precht, a coral reef scientist and author of the Coral Reef Restoration Handbook. William Precht met with the Capstone Team numerous times to provide resources and insights that greatly contributed to the direction of this report. His passion for coral research is infectious, and it was a privilege to have him share his experience and knowledge. Not even Florida's hurricane season and inconsistent cell service prevented Mr. Precht from connecting with us.

Laurel Zaima-Sheehy

An immense thank you to Laurel Zaima-Sheehy, the Program Manager of Non-Degree Education and Outreach Programs at the Columbia Climate School. We greatly appreciated the valuable discussion, which substantially informed the methodology for the report's survey administration and outreach recommendations.

Lisa Garrido

Our pilot surveys would not have been possible without Mrs. Garrido's help and her students' passion. Mrs. Garrido is a high school teacher at Westminster Christian School who allowed CRF to debut our new recommended pre- and post-program surveys across three presentation sessions. Her responsiveness and willingness to engage allowed us to trial a key deliverable and we gained invaluable insights in the process.

Stakeholders in Monroe County

Last but not least, we wish to give a heartfelt thank you to all the stakeholders who took the time to speak to the Capstone Team. The findings gave us an invaluable and nuanced understanding of the Monroe County landscape. Their perspectives on the Coral Restoration Foundation, as well as coral restoration in the area, are essential for the continued collaborative work of preserving the Monroe County marine ecosystems

Lauren Toth

Special thanks to Dr. Lauren Toth, a coral reef scientist and author of numerous publications on the topic, without whom our coral coverage calculations would be incomplete. Her guidance and advice on understanding these complex calculations proved crucial to establishing our methodology and determining our final economic valuation.

Martha Monroe

A big thank you to Professor Monroe at Florida University for her industry expertise and research information on current educational evaluation metrics and effective environmental education. Our Gap Analysis would not have been the same without her help.

Executive Summary

Coral reefs are unequivocally vital for marine life's prosperity. The underwater rainforests are biodiversity hotspots that provide habitats, food, breeding sites, and shelter for thousands of species. These biological communities also provide immense benefits to humans, including local jobs, an influx of tourism spending, and opportunities for nature recreation. In many cases, thriving coral reefs can protect coastlines from wave energy and storms, but most of these fragile ecosystems are steeply declining. The Florida Reef Tract (FRT), the third largest barrier reef in the world, is no exception.

Headquartered out of Key Largo, Florida, the Coral Restoration Foundation (CRF) actively strives to revitalize coral coverage across the FRT. CRF is the world's largest non-profit ocean conservation organization dedicated to restoring coral reefs. Its mission is threefold: coral restoration, furthering coral research and monitoring practices, and environmental education. Community relationships and perception are prioritized across CRFs initiatives, which is evident in CRF's robust commitment to coral restoration education and outreach. Environmental education has proven benefits for school-aged children that range from increased civic and academic engagement to boosted self-esteem.

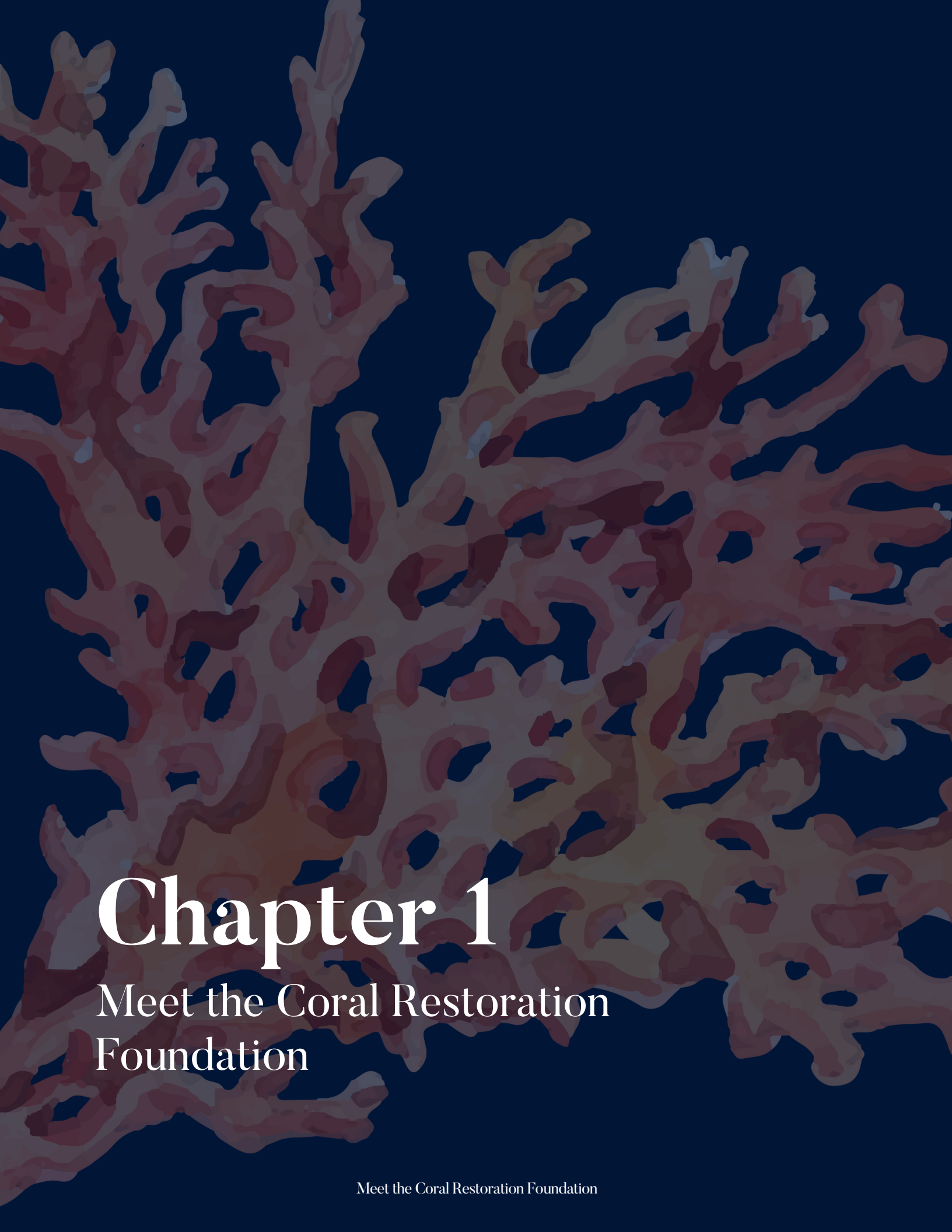
Most of CRF's restoration and education efforts take place in Monroe County, Florida– a municipality that covers the entirety of the Florida Keys. As environmental education practitioners, CRF wanted to understand its current outreach efforts and better expand upon them, specifically to Title I students and their families. To support CRF's efforts and educational programs, the Columbia University Capstone Team set out to establish the link between successful environmental education, low-income households, Title I students in Monroe County, and the various threats to the FRT. This report is a culmination of detailed research, interviews, program analyses, pilot surveys, and details potential next steps for CRF. The Capstone Team recommends that CRF move forward with targeted community engagement and education programs, short and long-term impact targets, and new program feedback collection techniques. If implemented, these recommendations could help CRF better monitor the impact of and corroborate the value of their educational programs. By following these recommendations, CRF will expand its educational reach and improve program efficacy across Monroe County and, ultimately, to global audiences.

Glossary

ALICE	Asset Limited, Income Constrained, Employed
CRF	Coral Restoration Foundation
FKRT	Florida Keys Reef Tract
FRT	Florida Reef Tract
FWC	Florida Fish and Wildlife Conservation Commission
GDP	Gross Domestic Product
IRB	Institutional Review Board
K-12	Kindergarten through Grade 12
NAAEE	North American Association for Environmental Education
NCRMP	National Coral Reef Monitoring Program
NEEAP	National Environmental Education Advancement Project
NGO	Non-governmental Organization
NOAA	National Oceanic and Atmospheric Administration
PPRA	Protection of Pupil Rights Amendment

Part 1
Background and Methodologies

The Capstone Team introduces the Coral Restoration Foundation and the scope of this project, as well as the methodologies behind the deliverables and recommendations.



Chapter 1

Meet the Coral Restoration Foundation

1 Meet the Coral Restoration Foundation

The Coral Restoration Foundation (CRF) is the world's largest marine conservation non-profit. Headquartered in Key Largo, Florida, CRF has been working to restore the Florida Reef Tract (FRT) since 2007 (CRF, 2022). The non-profit also aims to further coral research and monitoring techniques while educating others on the importance of oceans. CRF has restored over 17,500 square meters of reef coverage through propagation, coral outplanting, genetic diversity, and natural recovery (See Figure 1). CRF collaborates with universities, aquariums, non-governmental organizations (NGOs), and government agencies to guide its outreach efforts. CRF has a variety of active public education efforts, including dive programs, presentations, internships, K-12 activity packs, 'edutainment,' and numerous after-school programs. CRF's core mission is to restore coral reefs, educate others on the importance of our oceans, and use the best available science to further coral research and monitoring techniques.

> "Large-scale and massive action is required to save our reefs."
>
> CRF, 2020

Figure 1. Florida Keys Reef Tract (FKRT) and the eight reefs that CRF is currently working to protect through various restoration programs. (CRF, 2022)

1.1 Restoration Techniques and Support

Propagation, Outplanting, and Photomosaics

CRF runs extensive propagation and restoration programs in the waters surrounding the Florida Keys. Initially, the non-profit propagated (or farmed) new corals by fragmenting coral from wild colonies to start its restoration processes. CRF's nurseries are now large and robust enough to handle internal asexual propagation. CRF is credited with developing a revolutionary nursery structure with its "Coral Trees," shown in Figure 2. Fragments are hung along 740+ of these buoyed nursery trees, which mature horizontally toward the surface for six to nine months (Nedimyer et al., 2011).

CRF then outplants dozens of these genetically diverse young corals back onto one of its reef restoration sites. CRF is currently focused on recovering the eight sites mapped in Figure 1. CRF monitors the progress of these efforts by recording coral survival and resilience manually through dives (Ware et al., 2020) and, more recently, by stitching together thousands of digital images to create site photomosaics. Using photomosaics and the help of Artificial Intelligence allows CRF's team to record increases in coral coverage and spot changes to

Figure 2. Coral fragments hanging from a CRF Coral Tree nursery structure. (CRF, 2022)

the FKRT and surrounding habitats (CRF, 2022). Behind these restoration techniques are teams of biologists, ecologists, conservationists, and coral experts to maximize coral coverage. CRF also partners with local, national, and international coral experts from institutions, including the National Wildlife Foundation, the Coral Restoration Consortium, and National Oceanic and Atmospheric Administration (NOAA) (CRF, 2022).

1.2 Education and Outreach

To gain support for coral restoration efforts and convey the urgency of the coral collapse, CRF relies on dedicated education and outreach teams, programming, and funding. Their mission is two-fold: 1) inspire the next generation of ocean stewards, scientists, and environmental activists and 2) ensure local attitudes and regulations align with restoration efforts.

Their research focuses on outplanting techniques, genetic resilience, and monitoring technology improvements. CRF incorporates science-based curriculums in its hands-on workshops, day-long coral planting excursions, after-school programs, and internships to educate program participants on the impact and importance of coral restoration. CRF runs in-person and virtual events out of their "Exploration Center" in Monroe County. Their long-term goal is to be able to deliver their content to students and audiences around the world.

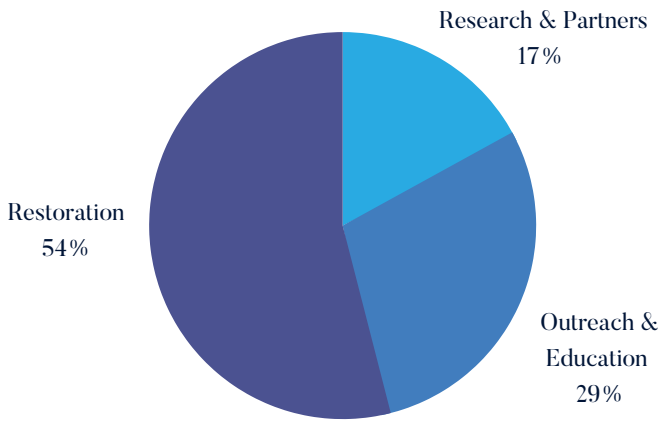


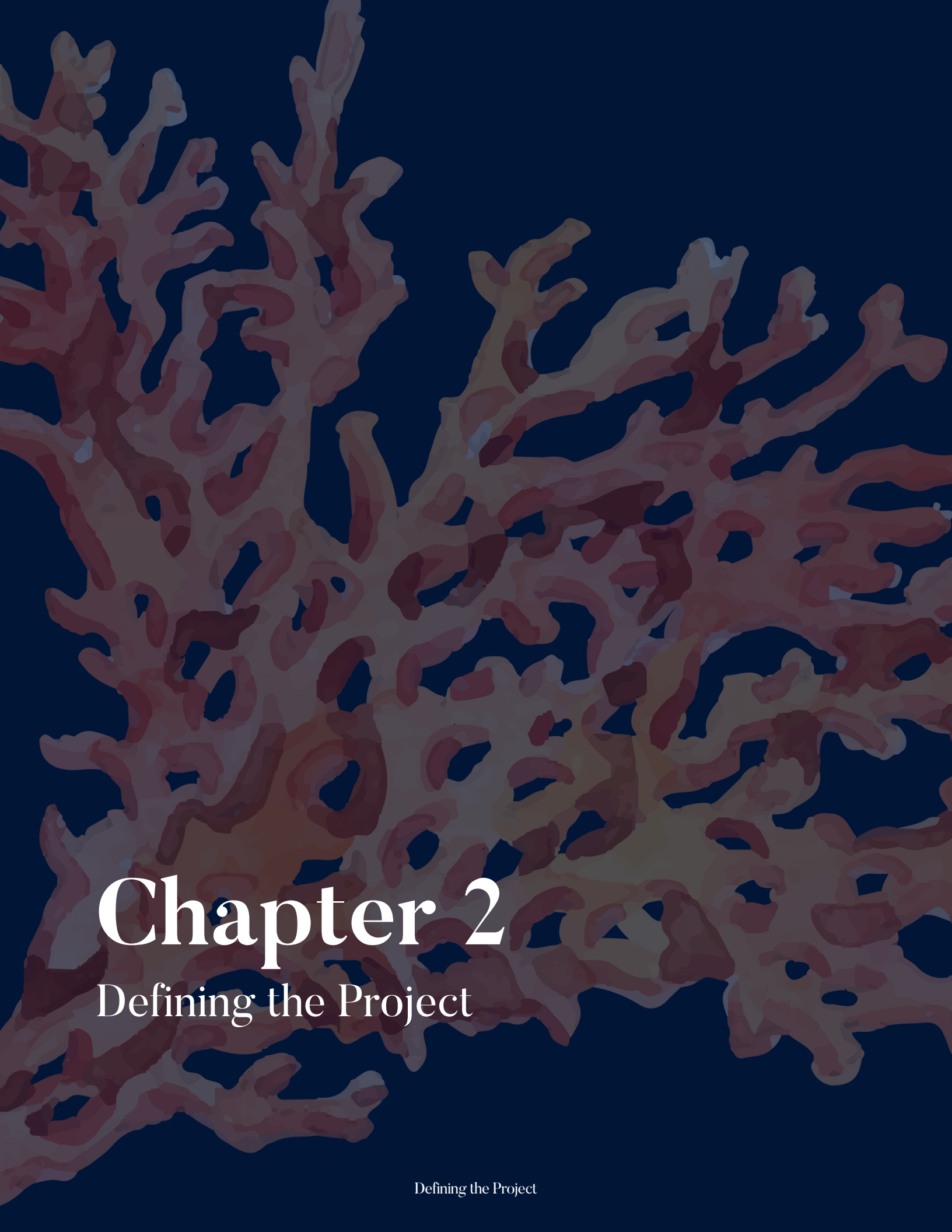
Figure 3. CRF's funding allocation by category. (CRF, 2022)

Funding for Education Programs

Restoration comprises 54% of CRF's budget, followed by outreach and education (29%), and research and partners (17%) (CRF, 2022). The allocation of CRF's expenses is depicted in Figure 3. In 2021, net program expenses amounted to $2.6 million, with $676,000 dedicated to education-related costs (CRF, 2022). This 2021 funding allocation is on par with CRF's average outreach and education expenditure of ~$634,000 in the last three fiscal years (CRF, 2022). This funding goes towards six types of educational programs:

- Educational Presentations
- Dive Programs
- Internships
- Edutainment
- K-12 Activities
- After-School Programs

These programs are a central focus of this project and are discussed in greater detail throughout the report.



Chapter 2

Defining the Project

2 Defining the Project

2.1 Project Structure and Ask

CRF is interested in understanding the relationship between climate change and coral restoration efforts. CRF is also interested in how these issues impact Title I students and their families. To ensure their educational programming is highly effective, meaningful, and targeting the right audiences, CRF requested a Capstone report from Columbia University Students (the Capstone Team) to research these topics.

CRF tasked the Capstone Team with researching how environmental education links climate change, coral restoration, and Title I students. CRF also tasked the Capstone Team with developing metrics to measure the efficacy of its environmental education programs. CRF's exact project asks were:

- How are Title I students of Southern Florida impacted by anthropogenic climate change?
- How are Title I students of Southern Florida impacted by coral restoration?
- We all want the students to become lifelong reef ambassadors, but how do you measure the impact of environmental education on students and their families in the short-term?

With the information and initial ask in mind, the Capstone Team worked with CRF to answer three key questions:

- How do climate change and coral restoration impact Monroe County?
- What is the impact of environmental education on Title I students and their families?
- How can CRF measure the impact and develop criteria to gauge the efficacy of its educational programs?

To answer these questions, the Capstone Team divided into three groups. The first group conducted background research on Monroe County, forming the foundation for the project with an understanding of the local economy, demographics, and sentiments toward CRF and coral restoration. The second group investigated the current state of CRFs educational programming, including their content, accessibility, impact, and efficacy, conducting a gap analysis to compare all these attributes to industry benchmarks. The final group sought to deliver new program metrics and accompanying feedback best practices to help CRF measure and analyze their educational programming efficacy in the short-term.

2.2 What are the Benefits of Environmental Education?

CRF is interested in scaling its existing education and outreach initiatives. CRF can achieve this by conveying why their work is valuable on local and global scales to stakeholders, donors, and program participants. CRF should articulate the benefits of environmental education, specifically in K-12 students.

In 2017, researchers at Stanford University analyzed 119 peer-reviewed studies performed over a 20-year period that assessed the benefits of environmental education for K-12 students to definitively understand the impact over the course of their academic careers. Upon completing the analysis of said studies, the researchers' findings showed that environmental education provides multiple life-building benefits to students and fosters environmental stewardship (Ardoin et al., 2017). Stanford University researchers found that 98% of K-12 students experienced knowledge gains from environmental education programs (NAAEE, 2013). Ardoin et al. (2017) indicated that environmental education:

- Improves academic performance and engagement, especially in science, mathematics, reading, and writing
- Enhances critical thinking, oral communication, analytical skills, and problem-solving skills
- Develops personal growth and life-building skills, including:
  - Confidence, self-esteem, and character development
  - Collaboration and leadership
  - Motivation and enthusiasm for learning
- Increases civic engagement, feelings of empowerment, and ability to act
- Increases positive environmental behaviors

(More research and information on the benefits of environmental education in Chapter 4, Section 1)

"Stanford University researchers found that 98% of K-12 students experienced knowledge gains from environmental education programs."

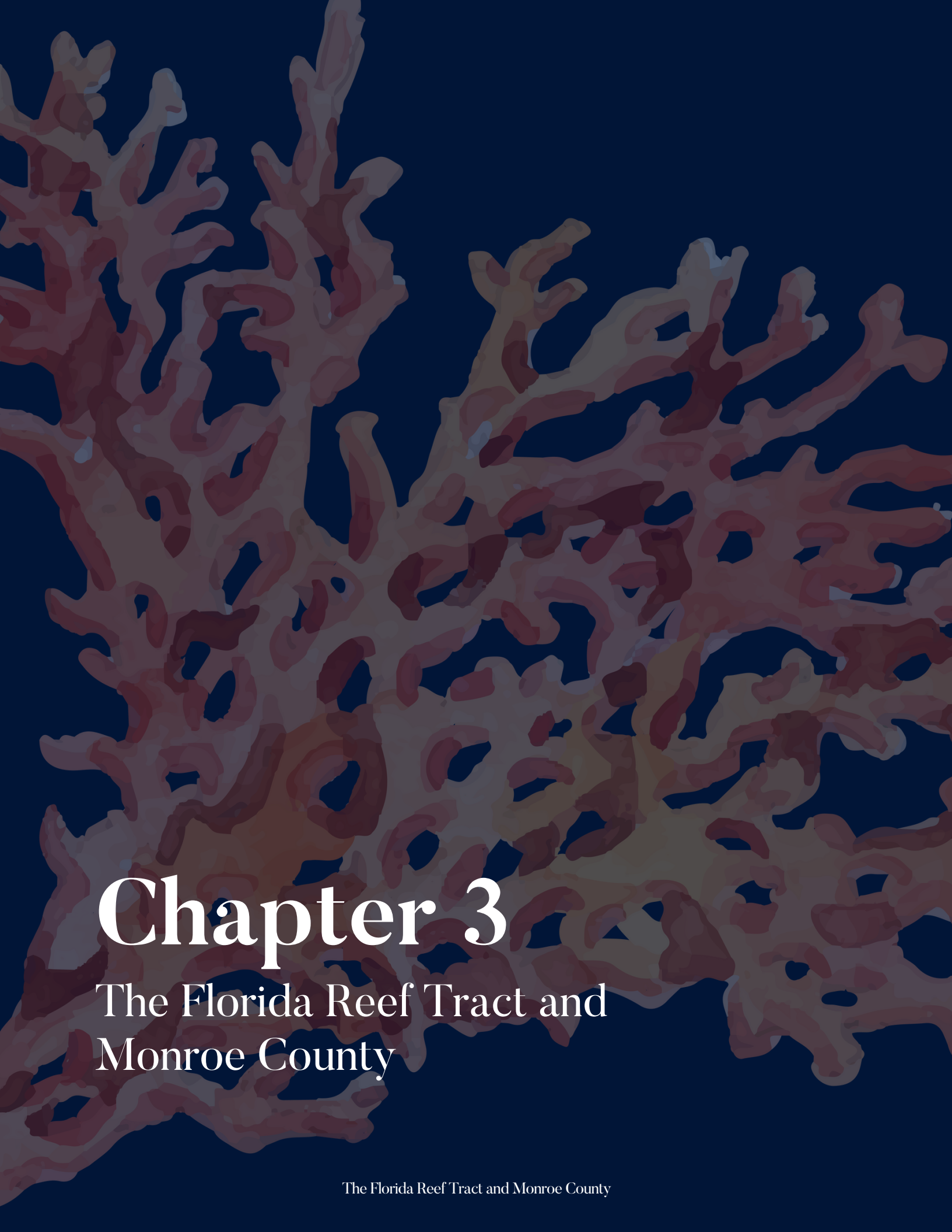
NAAEE, 2013

Focusing on Title I Students

CRF directed the Capstone Team to investigate how their organization could better narrow coral education efforts' impact on local Title I students and their families. Title I programs are designed to supplement existing state funding to boost low-achieving students to meet certain academic expectations. For example, Title I funds can "support extra instruction in reading and mathematics, as well as special preschool, after-school, and summer programs to extend and reinforce the regular school curriculum" (USDE, 2018). The United States Department of Education directs Title I funding to schools where 40% or more of the student body comes from low-income households (USDE, 2018).

In 2020, more than 25 million K-12 children in the United States benefited from Title I funding, making up 60% of public school enrollment (Ed Post, 2021). The United States Department of Education (US DOE) defines low-income students as students that qualify for Free or Reduced Lunch, meaning their families make no more than 130% or 185% of the Federal Poverty Level, respectively. Their household income determines this status compared to the Federal Poverty Level (Ed Post, 2021).

As of 2020, the Federal maximum annual household income for a family of four had to be $48,470 or less for a student to qualify for Free or Reduced Lunch and, in turn, be classified as low-income (ASPE, 2020).



Chapter 3

The Florida Reef Tract and Monroe County

3 The Florida Reef Tract and Monroe County

3.1 Florida's "Rainforests of the Sea"

Coral reefs provide diverse habitats, shelter, food, and countless other ecosystem services to nearly 25% of all marine species despite occupying less than 0.1% of the ocean (NOAA, n.d.; Smithsonian Ocean Portal, n.d.; Spalding & Grenfell, 1997). Thus, they have been appropriately nicknamed the "rainforests of the sea."

Corals are grouped into two main categories: stony corals and octocorals. Octocorals resemble stony corals but lack their rigid limestone skeletons. On the other hand, stony corals build reefs through the secretion of limestone skeletons. In tropical reef systems, there is a symbiotic relationship between coral polyps (animals) and the zooxanthellae (algae) that live in their endodermal tissues. The zooxanthellae photosynthesize incoming sunlight from the surface, aiding the coral in excreting waste products while simultaneously secreting a calcium carbonate skeleton.

The Florida Reef Tract

The Florida Reef Tract (FRT) is the third largest barrier reef in the world, and the The history of the FRT dates back to at least the late Pleistocene around ~125,000 years ago—during the last major interglacial (Marine Isotope Stage 5e)—when the reef was dominated by stony coral species, including massive boulder star coral (*Orbicella annularis)* (Budd & Johnson, 1999; Precht & Miller, 2007; Toth et al., 2019). However, alongside most tropical reef systems worldwide, the FRT has experienced significant reductions in coral coverage over the last 40 years (Aronson & Precht, 2006; Hughes et al., 2018). These reductions are found to be the combined result of an increased frequency of coral bleaching events caused by ocean warming, higher levels of pollution (e.g., eutrophication from industrial and agricultural runoff), as well as higher frequencies of disease outbreaks (Aronson & Precht, 2001; Kuffner et al., 2015; Williams & Miller, 2012).

The FRT is currently experiencing an extended and severe outbreak of stony coral tissue loss disease. Lesions were first identified on reefs around southeast Florida in the fall of 2014, and further sightings have been reported across the

rest of the FRT's reefs as of 2021 (NOAA, n.d.; Precht et al., 2016; Walton et al., 2018). Consequently, coral cover in the FRT portion that surrounds the Florida Keys has dropped from between 40 and 60% in the 1970s to less than 7% (Jackson et al., 2014). Elkhorn and staghorn coral, the FRT's primary reef-builders, were greatly affected, suffering an overall decline of over 97% in the FRT since the 1970s (ABRT, 2005; Precht et al., 2002, 2004; Precht & Miller, 2007; Southeast Regional Office, 2015). In 2006, the Endangered Species Act listed elkhorn and staghorn as threatened species (Hogarth, 2006), while boulder star coral and others, including mountainous star coral, lobed star coral, rough cactus coral, and pillar coral were added a few years later in 2014 (USFWS, 2014).

each with a municipality (See Figure 4). The largest municipality in Monroe County is Key West (Monroe County, FL, 2022).

"Coral cover in the FRT portion that surrounds the Florida Keys has dropped from between 40 and 60% in the 1970s to less than 7%."

Jackson et al., 2014

3.2 Monroe County

Monroe County is the southernmost county in Florida – approximately 150 miles south of Miami – extending from the southern tip of Florida to the Dry Tortugas. Its boundaries include portions of Everglades National Park, Big Cypress National Preserve, and the entirety of the Florida Keys, home to 99.9% of the County's population (United States Census Bureau, 2020). The County's total area is 3,737 square miles, which includes 73% that is water. The area is divided into five districts,

General Demographics and Population Distributions

A 2021 American Community Survey (ACS) estimated the population of Monroe County at 82,170 people (ACS, 2021). The ACS is the largest annual household survey in the United States. ACS survey data is utilized by local officials, community leaders, and businesses to understand economic and social changes in communities.

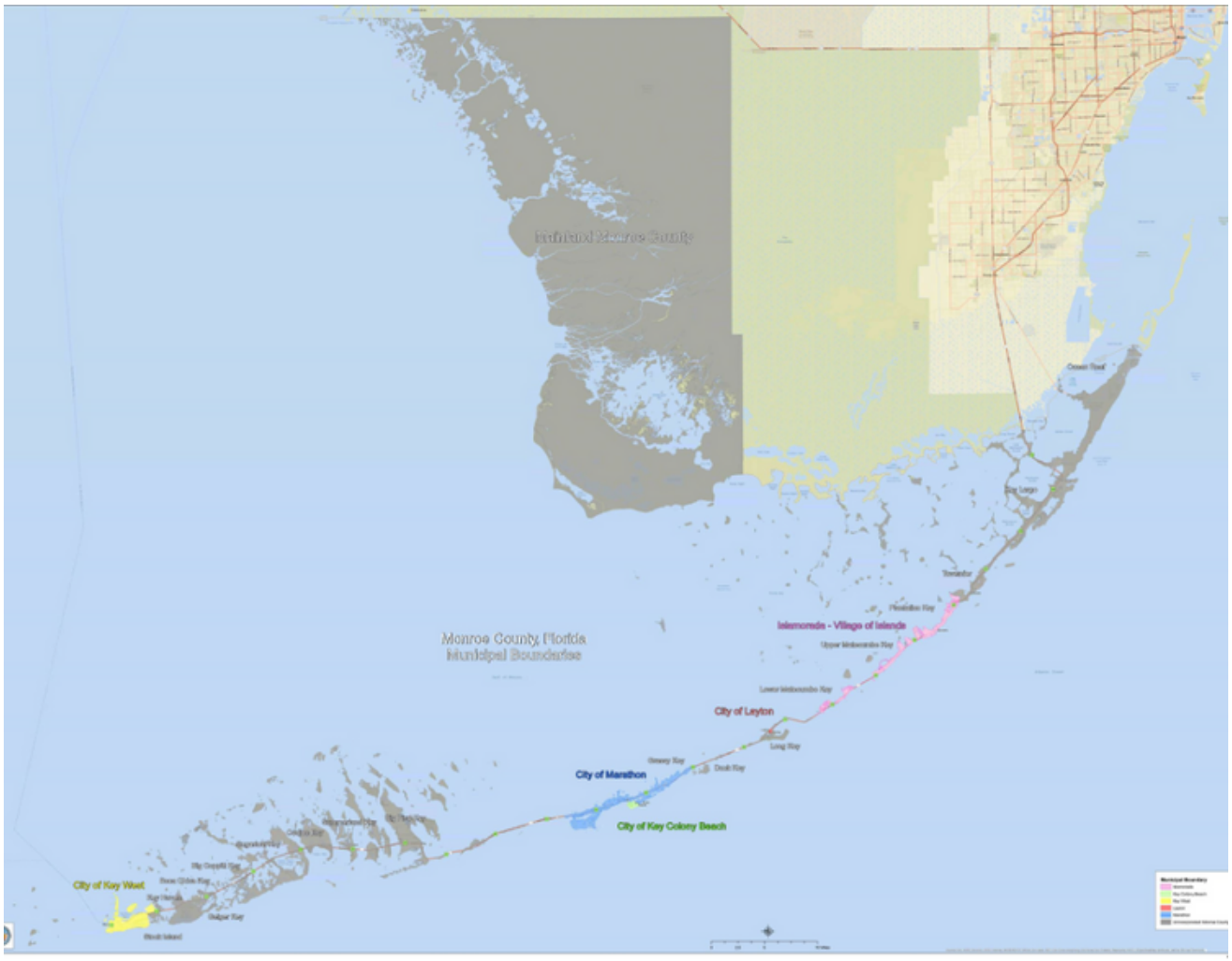


Figure 4. Monroe County Municipal Boundaries. (Monroe County - FL.Gov, 2022)

Other Monroe County statistics derived from the ACS 2021 survey include gender, age, race, and enrollment across different school levels. Of the County's population, 46.1% are female and 53.9% male. The majority of the population are between ages 25 and 84 (Figure 5). Individuals of retirement age (65+) make up over 23% of the overall population (ACS, 2021). Figure 6 shows the racial distribution in the County where White residents constitute 64% of the County's population. Hispanic (or Latino) residents make up the second largest racial group at 25.7%, and Black, Asian, Native American, Mixed Races and Other Races (which were not further categorized by ACS) make up the remaining 10.26% of the population (ACS, 2021). The total population enrolled in school (including nursery and preschool) is 13,595. This constitutes 16.54% of the population and Figure 7 shows that there is a relatively even distribution between students enrolled in elementary, secondary, and postsecondary schools (ACS, 2021).

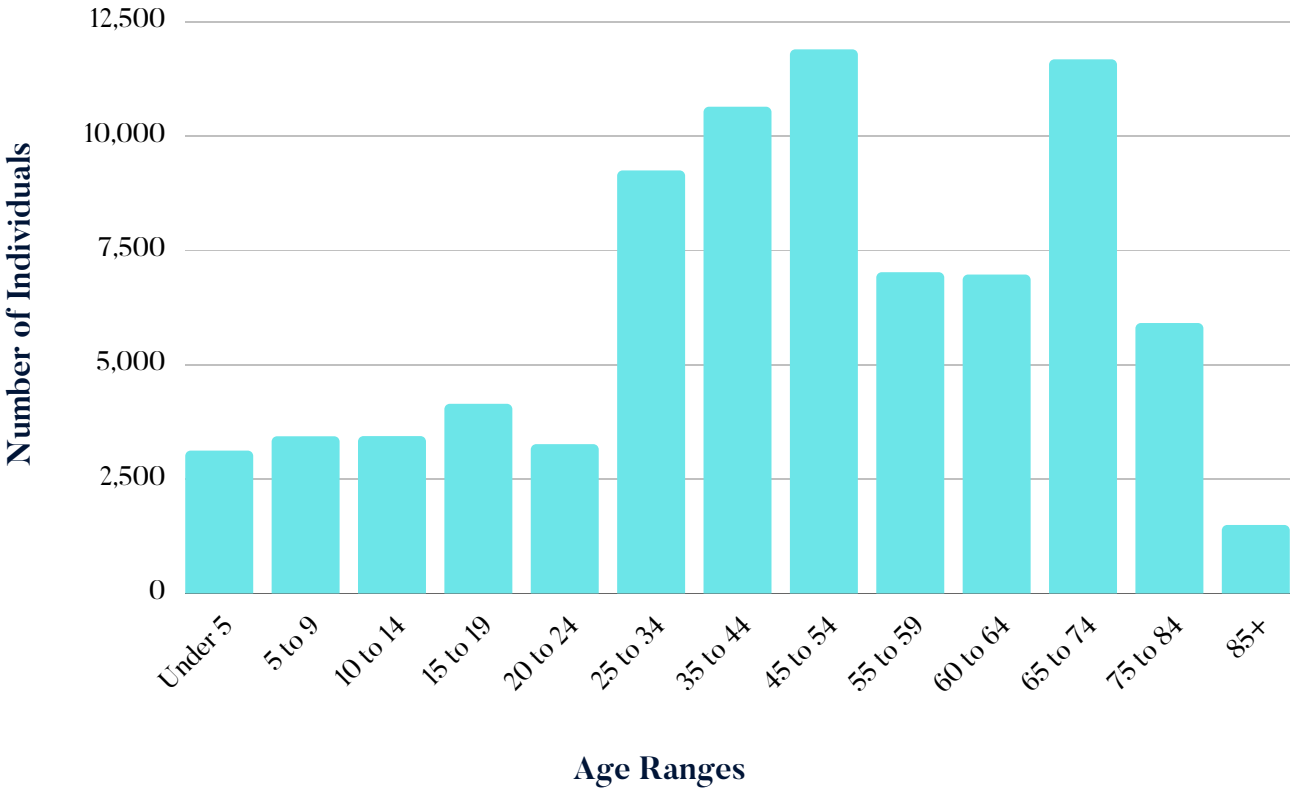


Figure 5. Age distribution of Monroe County in 2021. (ACS, 2021)

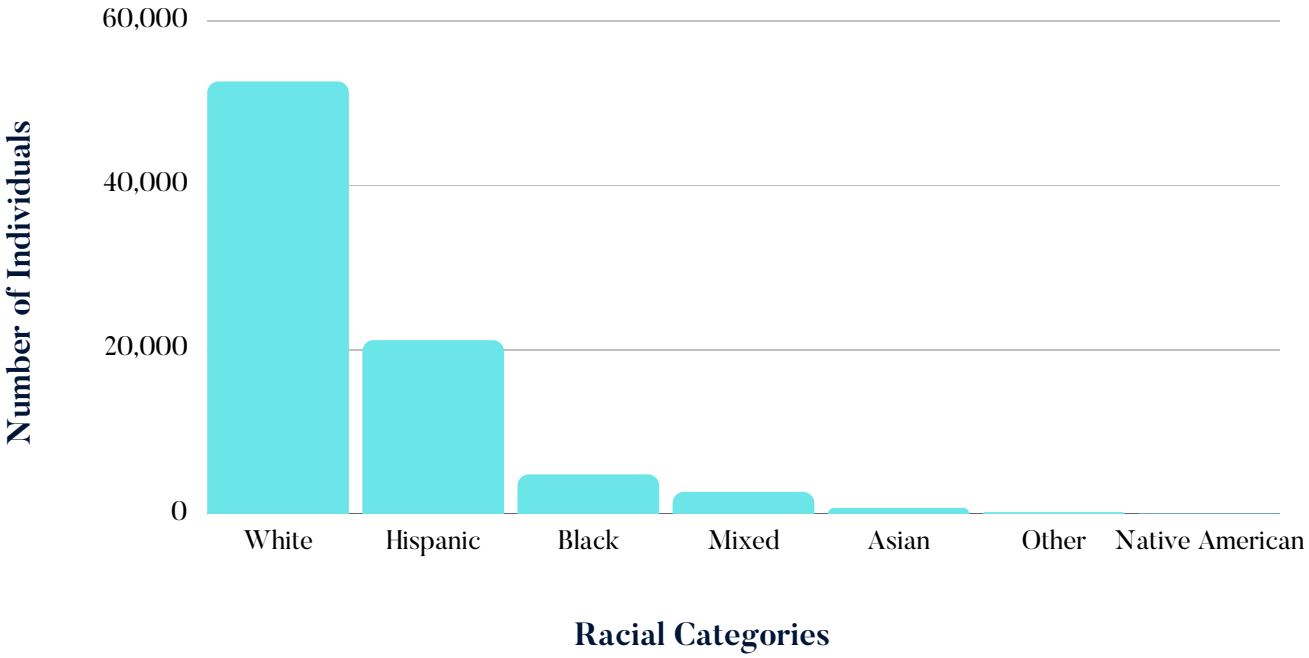


Figure 6. Race Distribution of Monroe County in 2021. (ACS, 2021)

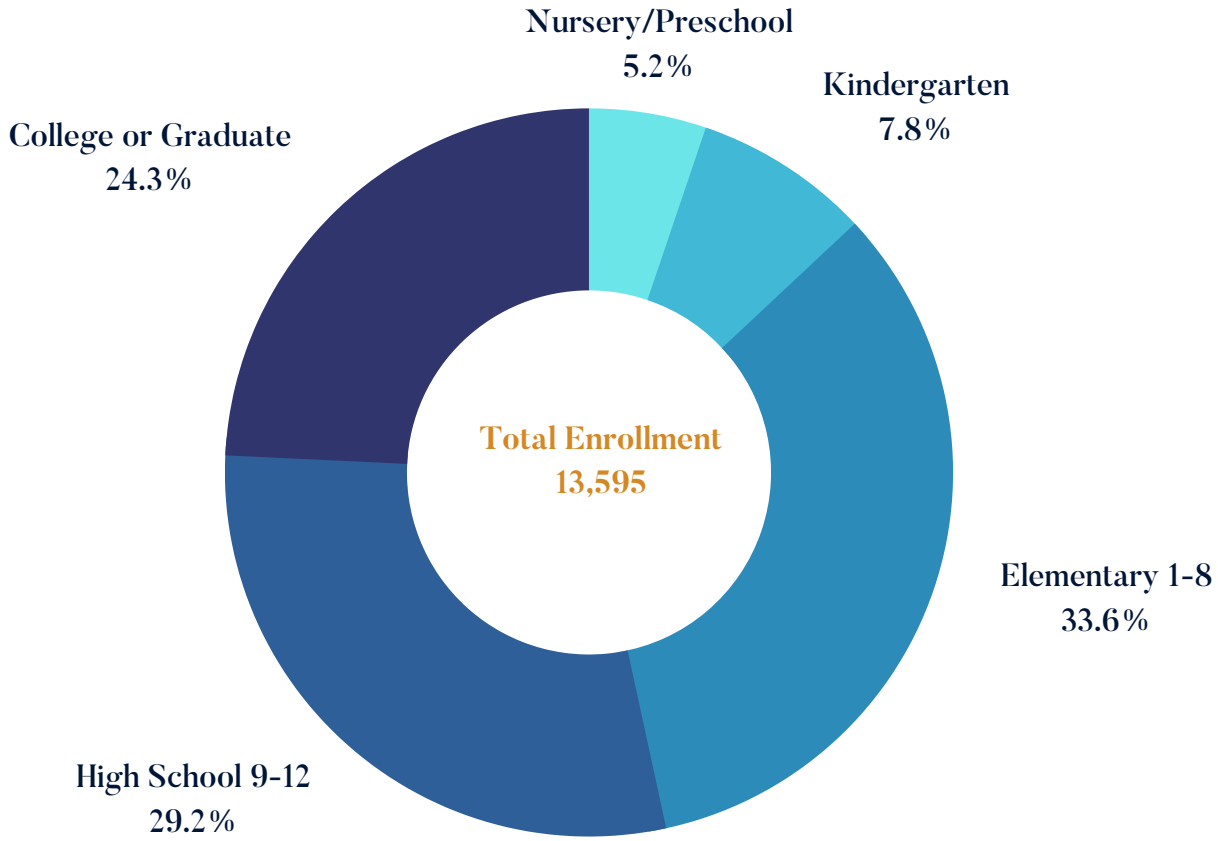


Figure 7. Educational Enrollment in Monroe Country for ages over three. (ACS, 2021)

Economic Income Characteristics

In 2021, the average income in Monroe County was $72,000. More than 63% of households earn less than $99,000 yearly (See Table 1) (ACS, 2021).

In 2021, an estimated 10.21% of the Monroe County population lived in poverty which is slightly lower than the 2021 Federal Poverty Level of 11.6% (Creamer et al., 2022; United States Census, 2021). However, when the Asset Limited, Income Constrained, Employed (ALICE) represents families and workers who cannot afford housing, child care, food, and healthcare based on their local costs of living. ALICE research is led by an organization called United For ALICE, which leads research across the United States aimed at identifying the number of households that are struggling financially.

Of the 31,362 households captured in the 2018 ALICE Report, 5,509 households contain families with children, and 42% of these households with children live under the

Table 1. Income data from 36,078 households in Monroe County, sorted by income bracket. (ACS, 2021)

Income Bracket	No. of Households	Percentage of Households	
< $10k	2,431	6.74%	22.02%
$10k - $14K	569	1.58%	
$15k - $24k	2,586	7.17%	
$25k - $34k	2,358	6.54%	
$35k - $49k	4,847	13.43%	41.30%
$50k - $74k	6,459	17.90%	
$75k - $99k	3,595	9.96%	
$100k - 149k	6,162	17.08%	36.68%
$150k to $199k	3,064	8.49%	
$200k or more	4,007	11.11%	

the ALICE threshold (UnitedForALICE, 2020). For reference, Table 1 compares the federal poverty levels versus the cost-of-living thresholds reported by ALICE for Monroe County.

The household Survival Budget is 236% higher than the Federal Poverty Level for families of four in Monroe County, as shown in Table 2 (ALICE Report, 2022). The difference is important to highlight because

Table 2. Federal Poverty Level Income vs. ALICE Survival Budget Income Numbers for 2018. (ALICE Report, 2020)

Household Size	Federal Poverty Level Income	ALICE Survival Budget Income in Monroe County
Single Adult	$12,140	$30,216
Family of Four	$25,100	$84,432

compared to the Federal Poverty Level, the ALICE Survival Budget reflects a more realistic threshold under which households are likely to be financially struggling.

Monroe County School District and Title I Students

In 2022, there were 16 K-12 schools within the Monroe County School District, with a total enrollment of 9,129 students. Student demographics are 44.6% White-Non-Hispanic, and 55.4% Hispanic, Black, Indigenous, or Multi-Racial (See Figure 9) (Keys Schools, 2022).

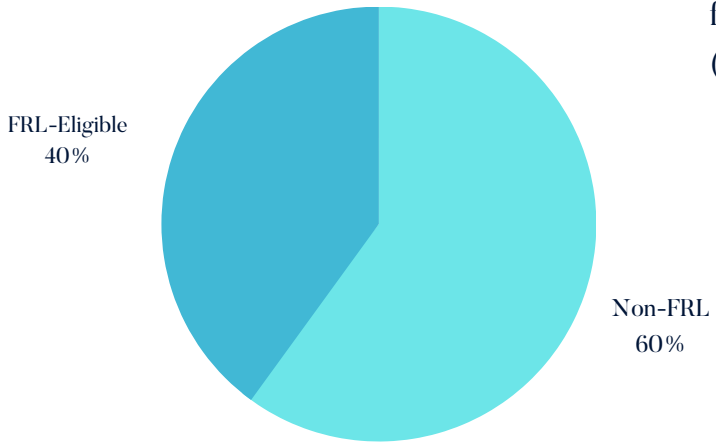


Figure 8. Socioeconomic Status of Monroe County K-12 Students. (Keys Schools, 2022)

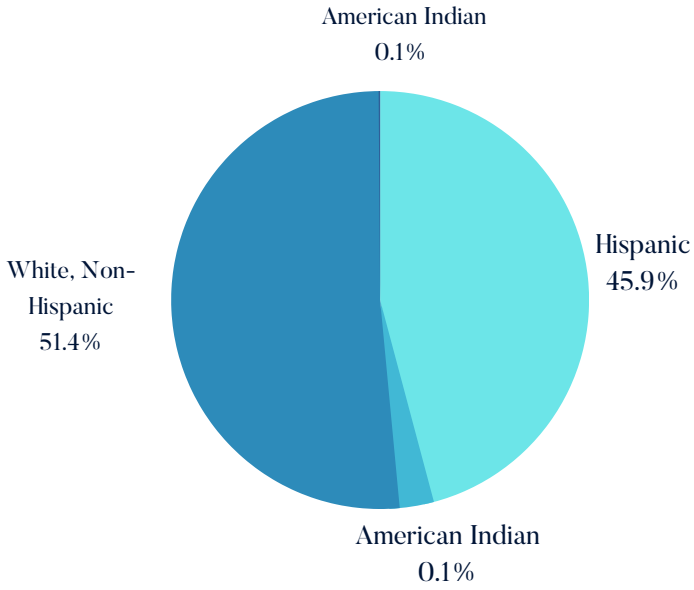


Figure 9. Ethnicity of Monroe County K-12 Students. (Keys Schools, 2022)

While 40% of the County's student body is considered low-income, the exact concentration of low-income students varies from school to school (See Figure 8). Of the 16 K-12 schools, 11 do not receive Title I funding, while five receive Title I funding (Keys Schools, 2022).

Non-Title I Schools

In Monroe County, 59% of the student population, or 5,426 students, attend a non-Title I school. Within this population, 26% of students are considered low-income (See Figure 10). Regarding ethnicity composition, 54.8% of students are White, Non-Hispanic and 45.2% are Hispanic, Black, Indigenous, or Multi-racial (See Figure 11) (Keys Schools, 2022).

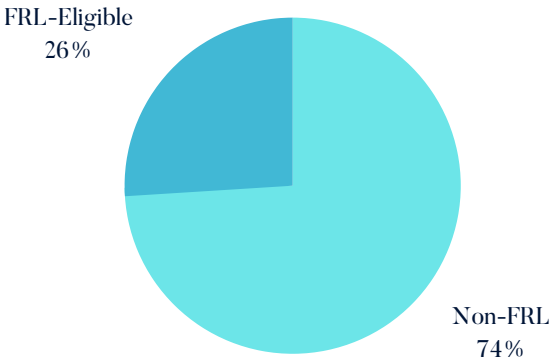


Figure 10. Socioeconomic Status of Non-Title I Monroe County K-12 Students. (Key Schools, 2022)

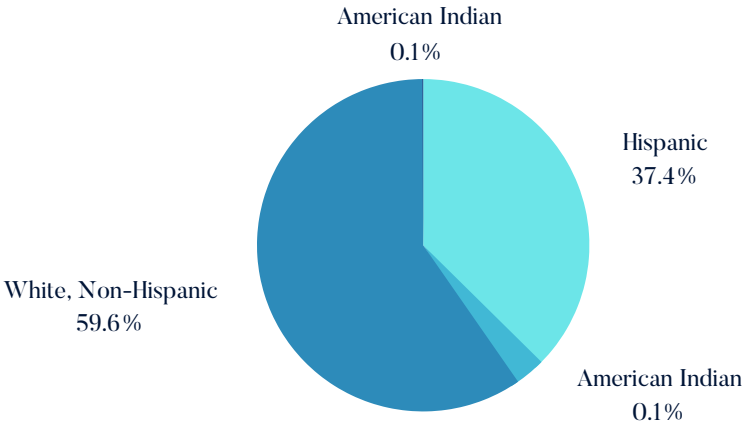


Figure 11. Ethnicity of Non-Title I Monroe County K-12 Students. (Key Schools, 2022)

Title I Schools

In Monroe County, 41% of the County's student population, or 3,703 students, attend a K-12 Title I school. Within the County's Title I schools, 62% of students are considered low-income, with uneven distribution (See Figure 12). In these Title I schools, 29.5% of students are White, Non-Hispanic and 70.5% are Hispanic, Black, Indigenous, or Multi-racial (See Figure 13) (Keys Schools, 2022).

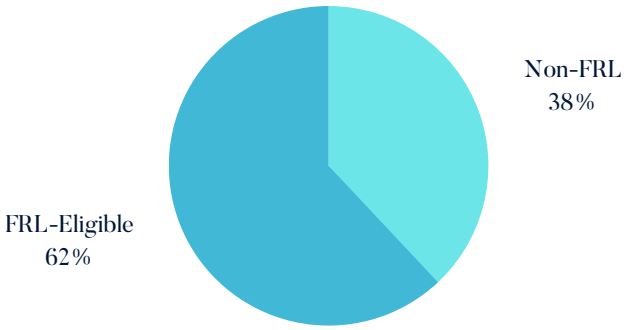


Figure 12. Socioeconomic Status of Monroe County Title I K-12 Students. (Key Schools, 2022)

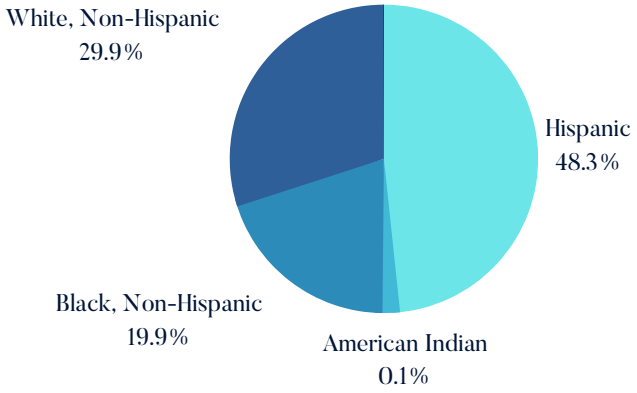


Figure 13. Ethnicity of Monroe County Title I K-12 Students. (Key Schools, 2022)

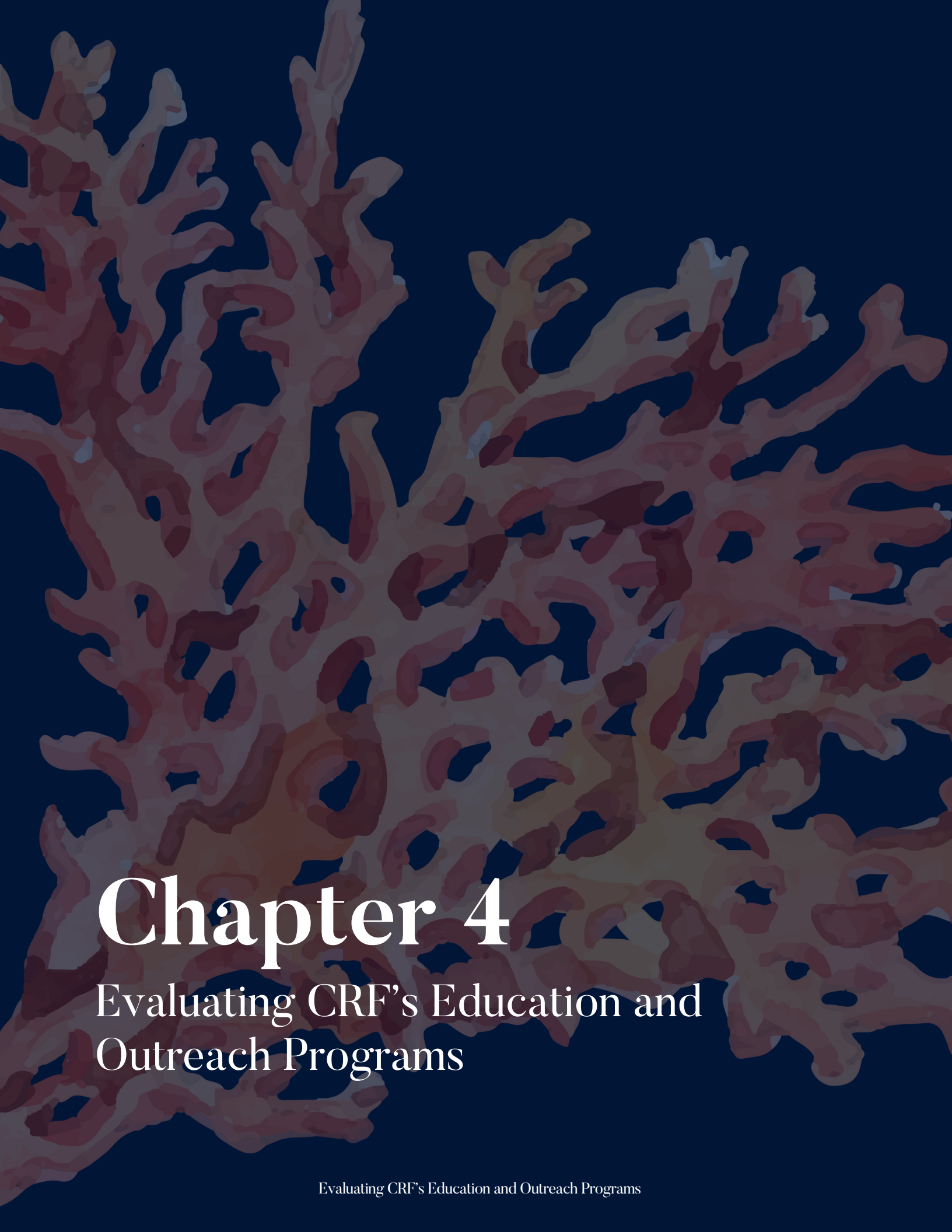
Monroe County Title I schools and their socioeconomic and ethnic composition are listed in Table 3 below.

Table 3. Monroe County Title I Schools and Enrollment Breakdown. (Key Schools, 2022)

School	Student Enrollment	% low-income	% non-white
Gerald Adams Elementary	661	72%	79%
Horace O'Bryant School	1099	60%	75%
Key Largo School	791	60%	65%
Poinciana Elementary	557	58%	68%
Stanley Switlik Elementary	595	63%	62%

At Monroe County's Title I schools, most students are both low-income and non-white (See Table 3). Of the 3,703 students enrolled in Title I schools, 2,300 low-income students, 25% of Monroe County's total student population, directly benefit from Title I funding. Title I schools have a higher proportion of low-income and non-white students when compared to the student-wide demographics of the Monroe County School District. Title I funding is, therefore, an invaluable tool to provide an equitable education to lower-income, primarily non-white students within Monroe County. (Keys Schools, 2022)

"25% of Monroe County's total student population, directly benefit from Title I funding."



Chapter 4

Evaluating CRF's Education and Outreach Programs

4 Evaluating CRF's Education and Outreach Programs

4.1 The Role of Environmental Education in Climate Change Mitigation

Environmental education has gained traction in raising awareness for climate change mitigation strategies. According to the United Nations Educational, Scientific and Cultural Organization (UNESCO, 2018) and the United Nations Framework Convention on Climate Change (UNFCCC, 2015), environmental education "brings a fundamental shift in the way we think, act, and discharge our responsibilities toward one another and the planet." Scientific climate education was recognized as a UN Sustainable Development Goal (Goal 13, Target 13.3) by 195 countries during the Paris Agreement at COP21 in 2015 (UN Org, 2022).

4.2 Methodology for Evaluating CRF's Educational Programs

The Capstone Team used The North American Association for Environmental Education (NAAEE) environmental education standards and the National Environmental Education Advancement Project (NEEAP) to analyze CRF's education programs and efficacy. According to NEEAP, "environmental education is a learning process that increases people's knowledge and awareness about the environment and associated challenges, develops the necessary skills and expertise to address the challenges, and fosters attitudes, motivations, and commitments to make informed decisions and take responsible action" (NEEAP, 2013).

To further evaluate the success of CRF's educational programs, the Capstone Team analyzed research on climate change education programs and coral restoration programs. The Capstone Team based their

recommendations on research from NAAEE and scientific reviews on environmental education that state:

- Conservation education evaluation requires an understanding and application of both natural and social sciences to maximize benefits for people, the planet and biodiversity through a process of data-based decision-making.
- Metrics should be guided by the program objectives that include cognitive, social, and ecological objectives.
- There should be indicators for cognitive, social, and ecological objectives.

Holistic measures of environmental education will include indicators that quantify "changes in knowledge, changes in behavior, changes in social group awareness and action together with the desired ecological measure or outcome" (NAEE, 2022; Thomas et al., 2019). Another scientific review by Professor Martha Monroe from the University of Florida aggregated over 900 scientific articles on climate change education. Monroe's review (2019) identified six key aspects of successful climate change education programs for students:

- Inclusion of relatable and meaningful information
- Actively learning and engagement
- Engaging in deliberate discussion
- Interacting with scientists
- Debunking misconceptions about climate change
- Engaging in environmental stewardship through school or community projects

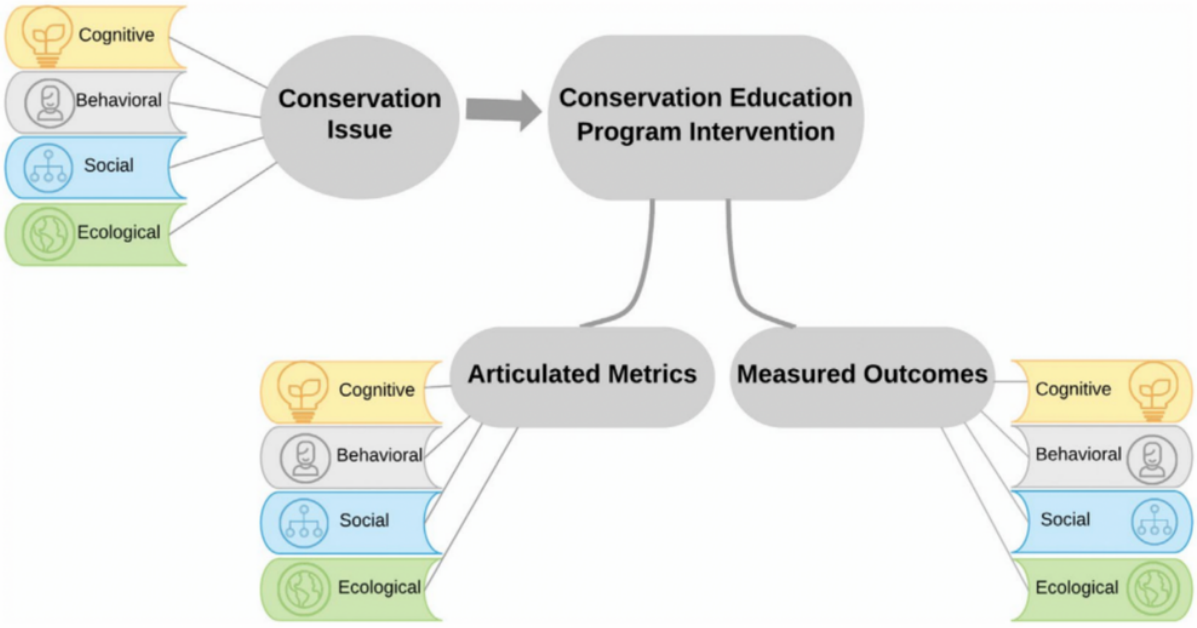


Figure 14. Heuristic model of relationships between the development of conservation educational program interventions and measured outcomes. (Thomas et al., 2019)

Another scientific review by Professor Martha Monroe from the University of Florida aggregated over 900 scientific articles on climate change education. Monroe's review (2019) identified six key aspects of successful climate change education programs for students:

- Inclusion of relatable and meaningful information
- Actively learning and engagement
- Engaging in deliberate discussion
- Interacting with scientists
- Debunking misconceptions about climate change
- Engaging in environmental stewardship through school or community projects

In summary, the research on effective environmental education evaluation highlights the importance of science and interactive learning, discussion, and behavioral change (Figure 14). They also portray the importance of connecting environmental education efforts with desired ecological conservation goals (Monroe, 2019; Thomas et al., 2019). Therefore, it is critical for the gap analysis to identify how CRF's educational and ecological goals connect and align with their practice to create a meaningful impact. The gap analysis, therefore, sought to highlight gaps between CRF's strategies and identified best practices for effective educational programs.

4.3 Evaluation Criteria

The Capstone Team organized CRF's educational and outreach efforts into six programs:

- Educational Presentations
- Dive Programs
- Internships
- Edutainment
- K-12 Activities
- After-School Programs

The Capstone Team conducted a gap analysis to provide a holistic, industry-based criteria to evaluate the efficacy of CRF's education programs based on three key metrics:

- Science and Misconceptions: Science participation and how programs address misconceptions
- Engagement: Engaging content that encourages action, behavioral change, and knowledge gains
- Community Impact: Measurement of the impacts on the community and environment

The Capstone Team developed these metrics using a research-backed blend of high-priority metrics and evaluation methods sourced from industry experts, including NAAE and NEEAP. Metrics were

also selected based on CRF's mission and expressed priorities. The Capstone Team also researched NOAA recommendations specific to coral restoration projects to incorporate measures of environmental and social impacts concerning CRF's educational programs (Goergen, 2020). CRF focuses on serving its community and making its programs accessible to Title I students. Therefore, CRF must include program-specific measurements to track the accessibility of programs and its demographic reach.

Based on best practices for the successful benchmarking of climate education, the Capstone Team split the evaluation metrics for CRF into 12 criteria (Figure 15).

4.4 Conducting the Gap Analysis

All six of CRF's educational and outreach programs were scored with a number from one (1) to five (5) on the Educational Program Efficiency Rubric that can be seen in Table 4 below. The scoring system was adopted from research and the scores given are described further in Chapter 8.

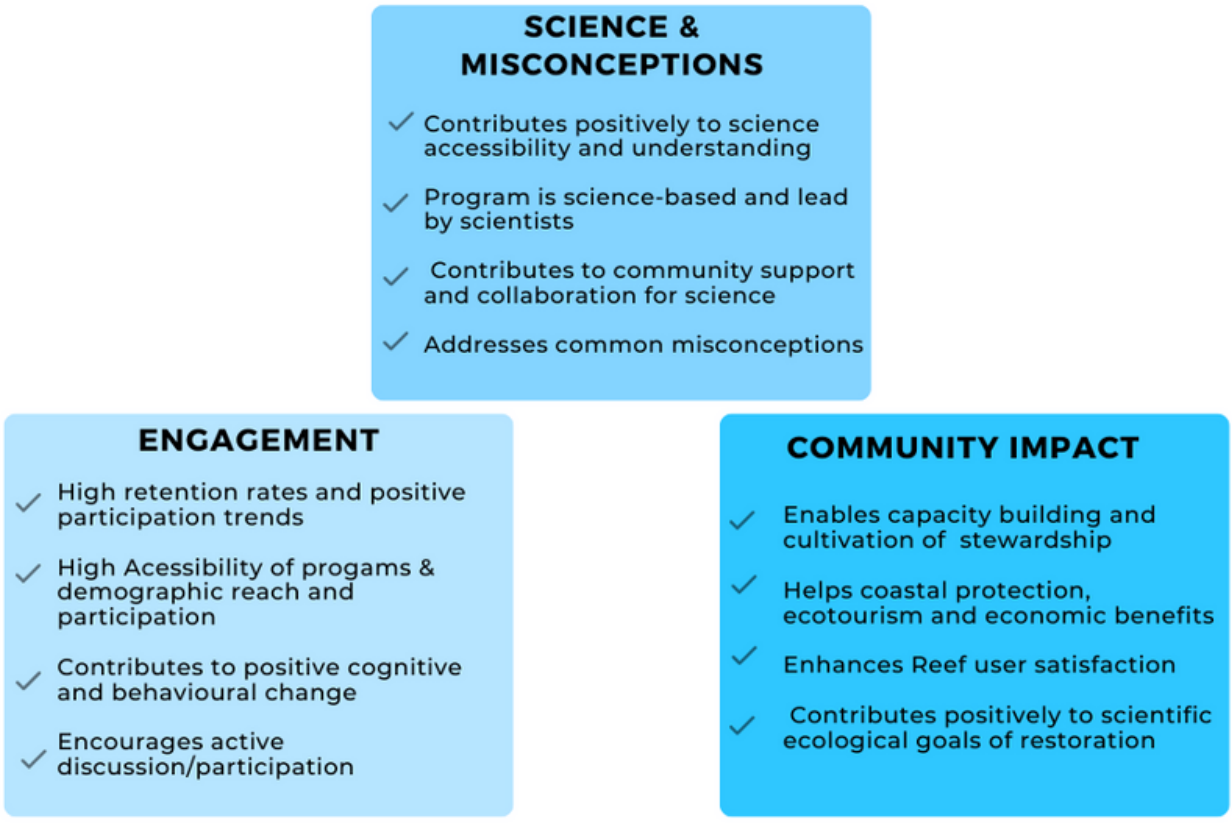
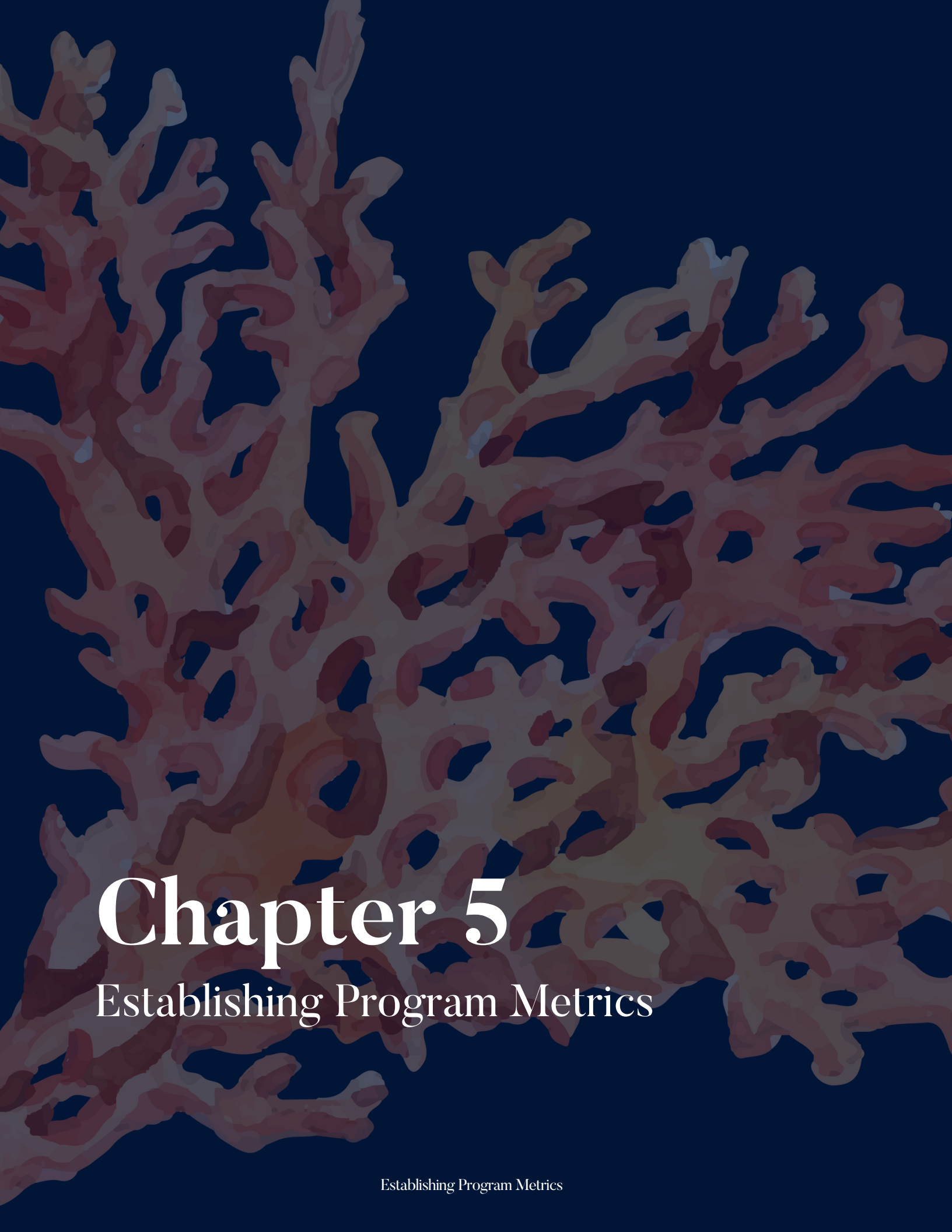


Figure 15. Criteria for evaluating the educational efficacy of CRFs educational programs developed from Blatt et al (2021), NEEAP (2013), NOAA (2020), Monroe (2017), and Thomas et al. (2019). (Created by the Capstone Team)

Table 4. The significance of each score, one (1) to five (5), on the Educational Program Efficiency Rubric.

Rubric Score	Score Significance
1	Not enough data to evaluate the criteria for the program
2	Not enough data to evaluate the criteria for the program
3	The program has several areas for improvement
4	The program criteria matched industry standards
5	The program exceeded industry standards



Chapter 5

Establishing Program Metrics

5 Establishing Program Metrics

5.1 Measuring Educational Program Success

An additional project goal was to develop metrics that track the efficacy of CRF's day-to-day educational programming. CRF expressed that its existing program feedback methodology lacked clear purpose, consistency, and quantifiable outputs. Developing and delivering tools to track new efficacy metrics will allow CRF to identify the areas in which it excels and where it needs to improve when engaging with educational program participants.

The program metrics developed by the Capstone Team should answer the following key questions that were identified through alignment with CRF:

- Do students understand the threats to coral reefs and how they can support stewardship and conservation?
- Are students excited about protecting and restoring reefs?
- Are students able and willing to share what they've learned?
- Are students interested in continued participation in CRF's programming and events?

Given the primary goals of CRF's educational programming, the presentations, dives, and in-person workshops aim to foster excitement for coral restoration and environmental stewardship in anyone. CRF's educational programming material is designed to captivate a wide range of age groups, from Girl Scouts to retirees. CRF's presentation tries to convey the implications of coral degradation and restoration. The focus of the new recommended metrics reflects this goal. CRF did not design its surveys to measure participants' ability to memorize vocabulary terms and statistics, but to evaluate their interest in becoming ocean stewards. As outlined in Chapter 4, Section 1, behavioral change is a more effective and sustainable approach to creating future ocean stewards and increasing climate change awareness.

5.2 Creating New Pre- and Post-Program Surveys

Original Approach

Before this project, CRF obtained its educational program feedback data from inconsistent post-program surveys. The data outputs from these original surveys did not aggregate in a central repository. CRF emailed surveys to participants after virtual or in-person engagements held in CRF's Exploration Center. Questions in the original surveys (Appendix B) are mostly qualitative or open-ended. The post-program survey was primarily composed of qualitative or open-ended questions–making data collection and interpretation lengthy or difficult.

CRF shared that the original feedback surveys had lower completion rates than what was desired, and the Capstone Team looked to identify why. Sending out surveys in a post-program email limited the accessibility of the survey. Some participants, such as younger students, do not have email addresses. Furthermore, survey administration and feedback analysis are not dedicated job functions for CRF staff. Conducting program surveys is a valuable and legitimate approach to gathering data and gaining insights (Ponto, 2015). For this reason, the Capstone Team did not want to discard CRF's original system entirely. Rather, the goal was to rework the material to eliminate coverage and measurement errors, and bolster CRF's ability to track changing attitudes towards coral restoration attitudes over time. CRF can measure education, enthusiasm, enrollment, and emergence of the General Presentation using the methodology of the pilot surveys developed by the Capstone Team.

Piloted Approach

The Capstone Team met with CRF to get feedback on the new surveys. The purpose of the first session was to dive into the content of each educational program, gaining insight into the logistics of each program type and the time allotted for any feedback engagement. CRF and the Capstone Team then agreed to collaboratively develop two new surveys: one pre-program survey given at the start of an educational session and one post-program survey administered at the end.

When designing the new surveys, the Capstone Team noted that CRF was initially experiencing two popular types of surveying error: measurement error and non-response error. Measurement error occurs when

pre- and post-program surveys addressed these error gaps in CRF's original feedback approach. A driver for the non-response errors was a lack of immediacy and inconsistent administration. Having program participants receive and complete surveys on their own time after leaving the program site contributed to non-response errors. This administration structure did not allow participants to complete the survey in the presence of CRF staff who could help them through questions or remind them to complete the task. The pre-survey formed a baseline to assess how participants' comprehension and interest levels shifted from program start to finish. This can help reduce measurement error, helping more directly measure CRF's effectiveness at getting its message across. Creating metrics to address this question was essential in remediating CRF's pre-existing measurement errors.

The Capstone Team piloted the surveys before and after CRF's General Presentation programs. CRF's General Presentations are the organization's most frequently delivered educational program. The General Presentation content is adjusted to target different audiences, from kindergarteners to college students. The pilot surveys are accessible via QR codes (See Figure 16 and Figure 17), and web links are displayed at the start and end of the program.

The Capstone Team reworked CRF's original survey to feature captivating, single-concept questions and ranked answer choices. Four of five questions repeat in the pre- and post-program surveys to capture the participant's change in **education**, **enthusiasm**, and **enrollment** . The pre- and post-program survey questions are presented in Appendix B. A top priority was to keep the pilot survey questions brief and targeted to encourage high completion rates, minimizing the chance of non-response errors.

- **Education** - Do students understand the problem CRF is trying to address? Can they identify how to help restore coral reefs?
- **Enthusiasm** - Are students excited to engage with coral restoration efforts?
- **Enrollment** - Are students interested in engaging further with CRF? Do they want to participate in a hands-on program? Will they recommend the General Presentation to others?
- **Emergence** - Are students likely to share what they've learned with others? Will they bring this information back to family and friends?

The last metric, **emergence**, is only tracked in the post-program survey, as the question would not apply until participants complete CRF's program.

Figure 16. Pre-program survey slide with a QR code and survey link displayed at the start of CRF's General Presentation (Created by the Capstone Team).

Figure 17. Post-program survey slide with a QR code and survey link to be displayed after CRF's General Presentation (Created by the Capstone Team).

The Capstone Team received feedback from CRF on the pre- and post-program survey content before it was finalized and loaded onto the organization's SurveyMonkey account. This discussion ensured that the design of the pilot surveys aligned with CRF's style and aesthetic. Dillman et al. (2014) survey research emphasizes the importance of visual appeal, font size, graphics, and logical item ordering, especially when administering electronic questionnaires. Addressing these topics collaboratively with CRF helped reduce measurement and non-response errors.

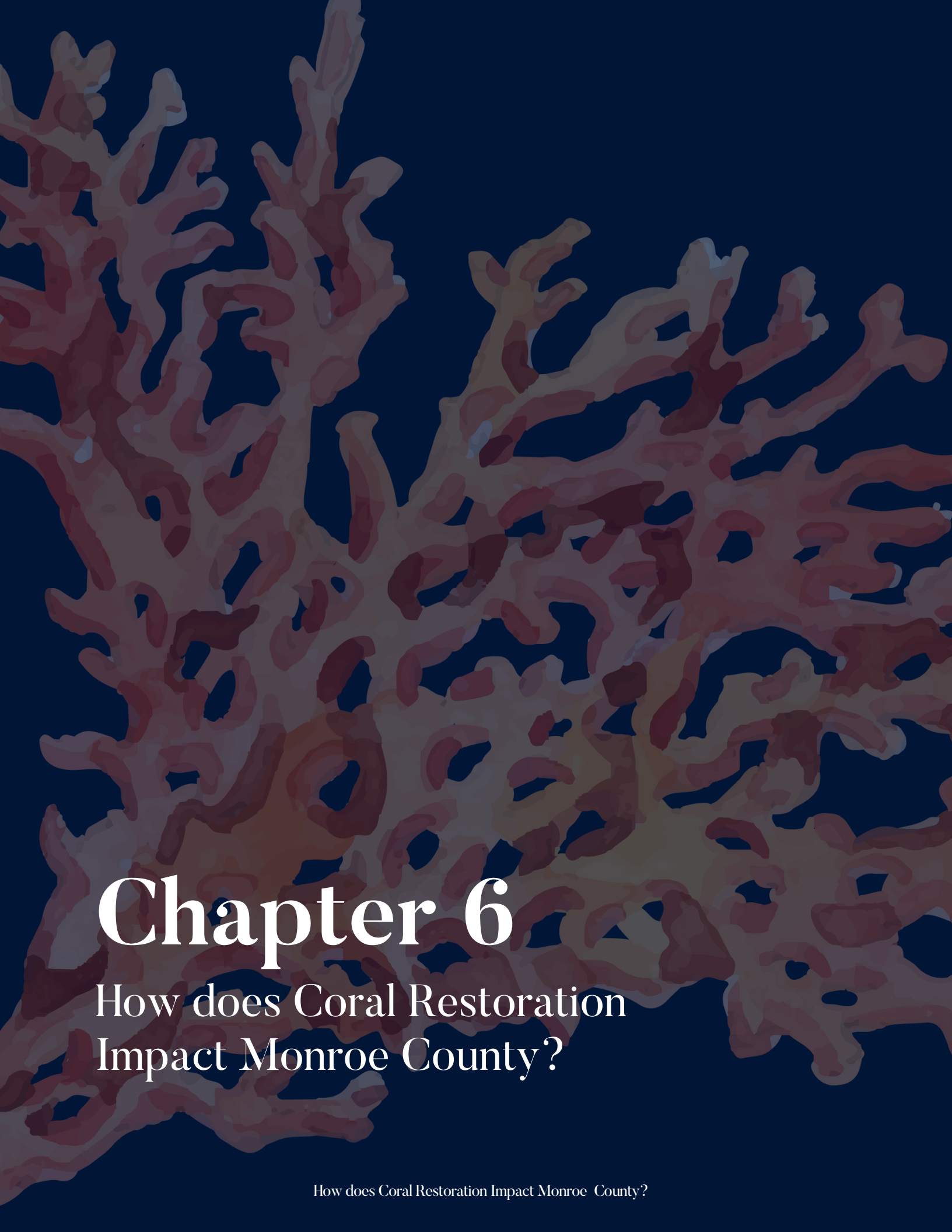
5.3 Administering the Pilot Survey

It was imperative to pilot the surveys before the conclusion of the Capstone project to analyze the new metrics, outputs, and data collection approach. The Capstone Team drafted a user-friendly Survey Implementation Guide to inform CRF why, how, and when to run the pre- and post-program surveys (See Appendix B).

The Capstone Team organized three General Presentations at a K-12 school in Miami, Florida, and CRF piloted the two new surveys. Details on the outcomes of the pilot surveys are in Chapter 9.

Part 2
Findings and Recommendations

The Capstone Team breaks down the key takeaways from the three project asks and provides recommendations and next steps for CRF.



Chapter 6

How does Coral Restoration Impact Monroe County?

6 How does Coral Restoration Impact Monroe County?

6.1 Stakeholder Engagement

The Capstone Team interviewed community stakeholders across Monroe County to ascertain current perceptions and opinions on reefs, restoration efforts, and CRF. To gather a variety of perspectives, the following key stakeholder groups were identified & interviewed:

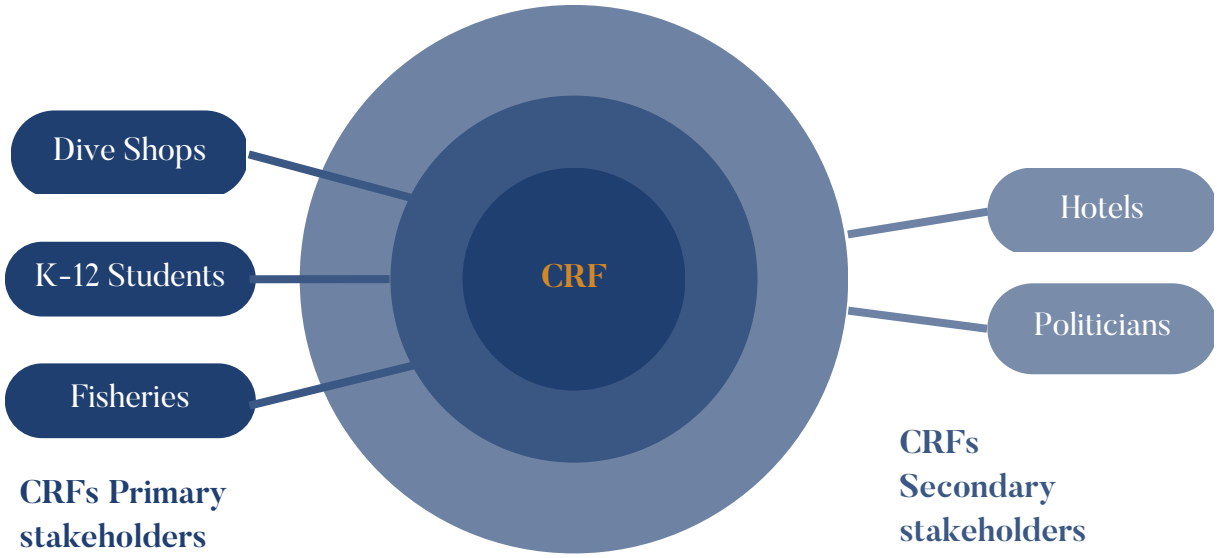
- Dive Shops
- Fisheries
- Hotels
- Politicians

The Capstone Team identified stakeholders using various methods, including, but not limited to, Google searches, blog lists, and verbal referrals. The interviewees were contacted via cold calls and emails and conducted in a semi-structured manner.

Stakeholders were allowed to elaborate on specific topics and bring the interview out of the scope of pre-selected questions.

The Capstone Team captured additional insights and information with this approach. The interviews capture qualitative data on the following:

- Knowledge of coral reefs
- Coral reefs' impact on the stakeholder
- Awareness of climate change
- Impacts on coral reefs
- Understanding of how coral reef health impacts the stakeholder
- Opinion on ideal coral reef situation
- Current involvement with coral reef restoration
- Knowledge/involvement with CRF
- Recommendations/suggestions for CRF



The Capstone Team used these interviews to reveal potential knowledge gaps and identify opportunities for CRF to step in and educate or collaborate with their coral stakeholders. Stakeholders that provided CRF-specific feedback were used to gauge public perception of CRF and potential opportunities for strategic outreach. As detailed in Appendix A, interview responses were recorded verbatim before being edited for conciseness.

6.2 Interview Findings

The Capstone Team's interviews with select coral reef, coral restoration, and CRF stakeholders yielded three major themes:

Greater investment is needed to enforce reef protection regulations.
The Florida Reef Tract covers a large area, making it challenging to always monitor protected areas. There is a perceived lack of enforcement for reef protection regulations, and the efficacy of deterrents, like violation fines, may not be sufficient. Underinvestment has also made it difficult to police violators.

Reef health directly impacts tourism and reliant industries, but some are more affected than others.
Interviewees generally agree that the healthier reefs are, the more beautiful and appealing the Florida Keys are for tourists. However, one interviewee raised the point that snorkelers would feel the negative impacts on corals more significantly than divers.Unlike diving, snorkeling is an activity limited to shallow waters, and it benefits from near-surface biodiversity and activity typically only offered by reef habitats. On the other hand, even in scenarios where no healthy corals remain in the area, divers would likely continue to be drawn by non-coral attractions like shipwrecks, caves, etc.

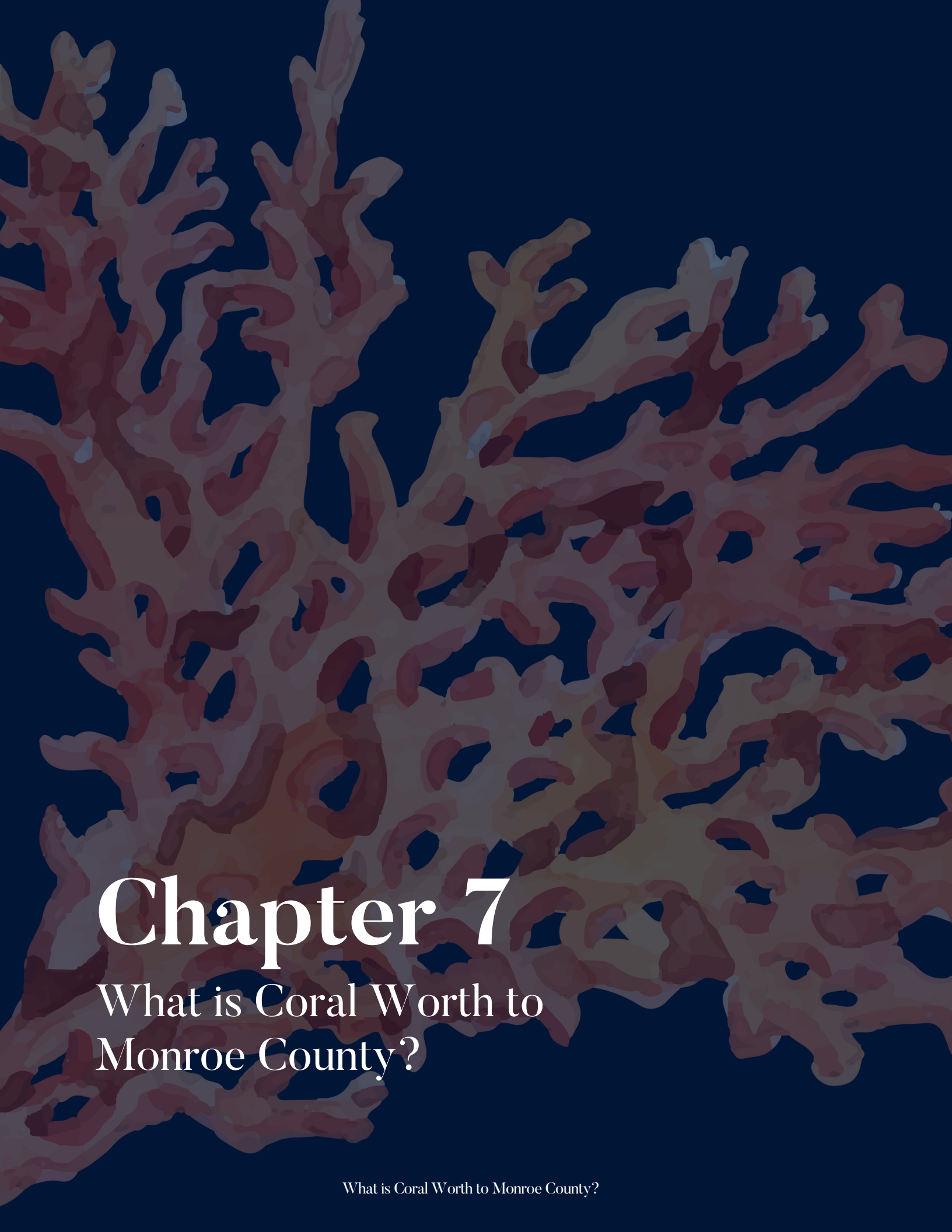
Water quality is a significant issue that requires more attention.
Dive shops are especially concerned as poor water quality is highly detrimental to reef ecosystems, and the problem is out of the control of the local community. Stakeholders are grateful for water quality-focused non-profits that alert when pollution levels in waters near popular dive spots reach dangerous levels. Interviewees commented that to alleviate this issue, municipalities should treat all wastewater, including water originating outside the Keys, before it reaches the ocean.

Recommendations for Future Community Engagement
From those three major themes, the most significant takeaway for CRF is the value of being strategic, targeted, and active with outreach efforts. A more direct approach applies to educational programs, community outreach and awareness building, and collaborative policymaking with legislators.

Understanding community stakeholders' internal dynamics and relationships are essential in crafting effective strategies. For example, recognizing that recreational fisheries are more likely than commercial fisheries to disregard reef regulations can inform policy decision-making and CRF outreach. Targeting recreational fisheries, as opposed to commercial fisheries, with reef awareness campaigns or stricter legislation would redirect CRF's efforts to a more productive avenue. CRF's name is well-established across Monroe County, and the organization has a positive reputation. Some stakeholders are unaware of CRF's current efforts and how its work is distinguished from other coral restoration organizations active across the FRT, such as the Mote Marine Laboratory and I.CARE.

The findings linked to reef regulation enforcement and Florida water quality issues may be outside of the scope of CRF's immediate focus. However, the Capstone Team still recommends that CRF become acquainted with the chief concerns and priorities of stakeholders in Monroe County. Maintaining this style of local stakeholder engagement in the future will further CRF's larger mission and help develop diverse and lasting community partnerships.

"Recreational fisheries are more likely than commercial fisheries to disregard reef regulations."



Chapter 7

What is Coral Worth to Monroe County?

7 What is Coral Worth to Monroe County?

After gaining insight from Monroe County stakeholders on their perceptions of coral reefs and restoration efforts, the Capstone Team took steps to put these topics into context. What benefits do the FRT and restoration provide to the local community? Are the benefits noteworthy? Can these benefits of coral coverage be quantified?

7.1 Coral in the Florida Reef Tract

The FRT provides numerous economic, environmental, and cultural benefits to its bordering communities, especially the residents of Monroe County. Depending on reef type and health (Precht et al., 2022), the FRT provides coastal protection from hurricanes and storm events via wave energy reduction (Ferrario et al., 2014). It also provides a "sense of place" to the humans that visit or reside near the submerged rainforest (Hausmann et al., 2016; Ryfield et al., 2019), and its extensive biodiversity catalog gives the FRT lots of pharmaceutical potential as well. One such example is AZT, an antiretroviral drug discovered in a Caribbean sponge that was revolutionary in treating HIV (Gibson et al., 2008). Marine organisms have high phylogenetic diversity, meaning the likelihood of finding medicinal compounds can be 400 times higher among coral reefs than in terrestrial ecosystems (Bruckner, 2002).

The reef's rapid decline threatens the benefits associated with the FRT. For example, recent global studies estimate that reductions in the structural complexity of reefs, as well as the loss of just 1 m of reef elevation, could result in storms having over twice their current impact on coasts by the end of the century (Beck et al., 2018; Reguero et al., 2021; Yates et al., 2017). A combination of natural and anthropogenic causes is driving this crisis. As a result of warming and acidifying conditions, many reefs have already experienced degradation —such as coral bleaching—and significant changes in species composition and diversity. Latest research projects, with a high degree of certainty, that these changes will continue even if global warming remains below 2°C (Bindoff et al., 2019). Natural stressors, like the ongoing stony coral tissue loss disease outbreak, are also exacerbated by human-driven activities (DCA, 2015; Precht et al., 2016). However, the most severe threats are human driven. Direct anthropogenic threats include bottom-trawling, overfishing, and vessel groundings, while indirect threats include pollution runoff from fertilizers and sewage and the

effects of human-induced climate change such as rising ocean temperatures and ocean acidification (NOAA Fisheries, 2022). These impacts are critical, particularly in the case of the FRT, as Caribbean reefs take longer to recover from environmental stressors than reefs in the Pacific and Indian Oceans (Gibson et al., 2008). Additionally, given its geographic location, the FRT is also vulnerable to hurricane and tropical storm damage, and projections show severe weather events will only increase in frequency and intensity as global temperatures rise (Bindoff et al., 2019).

7.2 Evaluating the Benefits of Coral Coverage

In addition to the environmental benefits the FRT provides, healthy coral reefs contribute to Florida's economy. The economic significance of this ecosystem is recognized so much that in 2018, the Monroe County Board of Commissioners passed a resolution to support H.R.53/S.232 in establishing the Southeast Florida Coral Reef Ecosystem Conservation/Protection Area (Monroe County Commissioners, 2018). In the resolution, the commissioners cite that "from tourism to marine recreation and sport fishing, coral reefs are an important part of the State of Florida's ocean economy and play a central role in the economies of Southeast Florida's communities" (Monroe County Commissioners, 2018). Given the locally recognized connection between Monroe County's economy and its coral reef ecosystem, the Capstone Team sought to understand the estimated financial value of the local coral coverage and its relation to critical industries for the County. This was done by (1) researching economic data on two industries linked to coral health, Tourism and Commercial Fishing, and (2) estimating the square footage of coral coverage within Monroe County (including the Dry Tortugas) boundaries.

Tourism is Essential in Monroe County

Recreational tourism supports between 33% - 75% of the Monroe County economy depending on the methodology used to categorize income. Methods can include income made by residents vs. income earned by workers who do not reside in the County, and the number of services linked to tourism (NOAA, n.d). A study by Rockport Analytics, a global market research and insights firm, analyzed the impacts of tourism on Monroe County across calendar-year 2019 (Rockport Analytics, 2022). The company estimated that of the $2.5 billion of tourism spending in the Florida Keys and Key West, $1.9 billion (76%) remained in Monroe County's local economy. Retainment came through supporting various businesses and jobs and producing state and local government revenue through taxes.

As summarized in the Rockport Analytics report on Monroe County Tourism in, 2019, tourism spending can also be related to employment and tax generation (See Figure 18).

Tax Revenue

Monroe County tourism generates a substantial amount of state and local tax revenue. Rockport Analytics reported that over $545 million in tax receipts were filed in 2019, of which $253 million

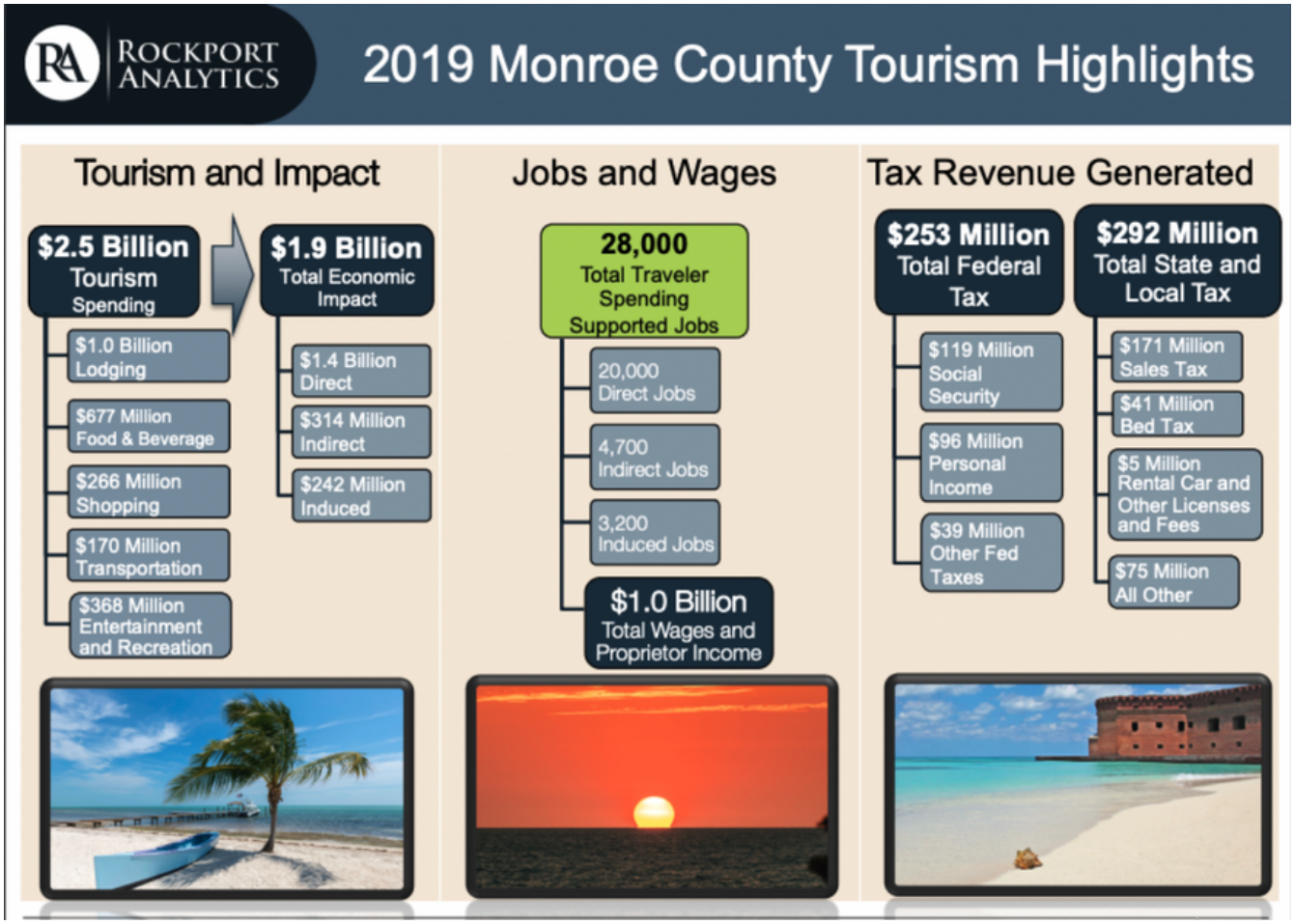


Figure 18. Monroe County Economic Impacts from Tourism in 2019. (Rockport Analytics, 2022)

Employment

Rockport Analytics states tourism in the Florida Keys supported over 28,000 Monroe County residents in 2019 when accounting for direct, indirect, and downstream employment. Tourism represents 43% of all Monroe County jobs, making it the largest employer in the County and a leading economic driver. (Rockport Analytics, 2022)

(46%) went to the federal government, $160 million (29%) went to the state of Florida, and $132 million (24%) went to Monroe County. In the absence of tourism, Monroe County's ~32,000 county households would need to generate $5,190 in additional local taxes to maintain tax revenues. Tourist-supported state and local tax revenues allow for funding of community benefits such as public schools, relieving household tax burdens, and other public services. (Rockport Analytics, 2022)

Fish Landings Depend on Reef Health

The fishing industry is another clear economic contributor to marine ecosystem health in and around Monroe County. One way to measure the economic value of fishing is based on the estimated value of fish landings. NOAA defines commercial landings as the "weight of, or revenue from, fish that are caught, brought to shore, processed, and sold for profit" (NOAA, 2022). Commercial landings do not include sport, recreation, or sustenance fishing (NOAA, 2022). Based on commercial fisheries landings data reported to the Florida Fish and Wildlife Conservation Commission (FWC), Florida generated an average of $230M/yr worth of commercial fish landings between 2012 and 2021. Monroe County's contribution to this total was about 28% at $63.89 million per year during that period (FWC, 2022).

Of Monroe County's estimated annual landings value, nearly 60% of the total landings value are from spiny lobsters averaging over $37M/yr in dockside value. The yellowtail snapper was the second most valued landing, averaging $6.22M/yr in dockside value. The substantial monetary value attributed to this species is important because once spiny lobsters mature into their juvenile stage, they congregate in protective habitats closer to the shore. Adult spiny lobsters in Florida find protection in crevices and spaces of coral reefs, sponge flats, and other hard-bottomed areas where they forage on snails, clams, and urchins (South Atlantic Fishery Management Council, 2022).To summarize the data evaluated from FWC, Table 5 lists the top nine species that were landed annually from 2012-2021. Even amongst the top 10 species during these 10 years, spiny lobsters led in value by a significant amount.

Table 5. The estimated annual average fish landings value of the top 9 most valuable species in Monroe County. (FWC, 2022)

Species	Average Annual Value (Millions)
LOBSTER, SPINY	$37.14
SNAPPER, YELLOWTAIL	$6.22
CRAB, STONE, LARGE	$4.79
CRAB, STONE, MEDIUM	$3.34
CRAB, STONE, JUMBO	$3.06
SHRIMP, PINK	$2.38
MACKEREL, KING	$0.94
CRAB, STONE, SMALL	$0.86
CRAB, STONE, UNGRD	$0.78

Table 6. The datasets referenced for the Capstone Team's economic research into Monroe County with the time period covered and sources. (Federal Reserve Economic Data, 2022; FWC, 2022; Monroe County Tourist Development Council (MCTDC), 2022; My Travel Intelligence, 2022)

Area	Specific Data Set	Time Period	Source
GDP	GDP for Monroe County	2010 - 2020	Federal Reserve Economic Data
Tourism	Total Leisure Spending Tax Revenue Remitted From Tourism	2015 - 2020 2014 - 2021	My Travel Intelligence MCDTC
Commercial fishing	Commercial fish landings	2012 - 2021	FWC

Data Used for Economic Indicators

For the economic valuation of coral coverage in Monroe County, the Capstone Team researched data in three areas: (1) local Gross Domestic Product (GDP), (2) Tourism, and (3) Commercial Fishing. Based on the datasets, the Capstone Team calculated the annual estimates for 2015-2020, shown in Table 6.

As part of the economic data selection process for the use of the economic valuation of coral coverage in Monroe County, data was chosen based on the following criteria:

- The data is made publicly available by an official source (such as Monroe County or the FWC).
- The data is recent and inclusive of the calendar year 2020.
- The data covers more than three calendar years which allows for adjustment form anomaly years such as 2020 during the COVID-19 pandemic.

Several considerations went into account while reviewing the economic datasets in this report. First, it was challenging to find official and consistent data for tourism. Monroe County's official website links The Rockport Analytics and My Travel Intelligence reports; however, the reported leisure travel spend for 2019 differs. The Capstone Team assumes that the two reporting agencies used different approaches to calculate leisure spending. Unfortunately, neither report included detailed methodologies for the Capstone Team to determine what drives the differences.

Second, the My Travel Intelligence report does not indicate if the annual values follow the calendar or fiscal years. The Capstone Team assumes that the values reported are per calendar year for valuation purposes. Third, the original data on Tax Revenue Remitted from Tourism is based on Monroe County's fiscal year, which runs from October to September.

The Capstone Team converted the values to line up with the January to December calendar year format. Finally, recreational fishing data was not included in the analysis because the available data from FWC is survey-based.

Economic Data Findings

Based on the datasets mentioned in Table 6, the Capstone Team chose a five-year period for the economic valuation. The time frame, 2015-2020, was chosen because data was available for each data set (data was not readily available for each category before 2015). The annual estimates for each economic category and the values used for the economic valuation of coral coverage to Monroe County are shown below in Table 7. From the economic data findings, the Capstone Team observed three insights. First, as expected, economic values were lower during the COVID-19 pandemic year of 2020. Secondly, leisure spending is significant to local GDP. Total leisure spending accounted for more than 62% of local GDP, except for 2020 at 45%. Finally, commercial fish landings make less than 2% of the local GDP; however, this is the dockside value of commercially caught fish. The additional value of fish from other economic activities, such as restaurant and store sales, or out-of-state exports, is not considered.

Table 7. Yearly Estimates for Economic Categories from 2015-2020

Economic Category	2015	2016	2017	2018	2019	2020
GDP for Monroe	$4.43B	$4.69B	$4.93B	$5.04B	$5.47B	$5.26B
Total Leisure Spending	$2.92B	$2.96B	$3.10B	$3.20B	$3.42B	$2.39B
Total tax revenue remitted from tourism	$35.09 M	$36.83 M	$35.66 M	$34.69M	$40.64 M	$31.73 M
Commercial fish landings	$71.26M	$67.68 M	$63.07 M	$70.79M	$58.92 M	$45.62 M

Note. Data sourced from sources listed in Table 6.

Calculating Coral Coverage in Monroe County

To attribute an economic value to coral coverage, the Capstone Team needed to determine the total coral coverage in Monroe County. Monroe County-specific coral coverage data was not readily available. Therefore, the Capstone Team calculated coverage values based on larger FRT data sets. These needed to be filtered down to fit within Monroe County's boundaries. Two main inputs to calculate the coral coverage surface area are (1) the percentage of coral coverage in the area as determined by 2016 and 2018 surveys conducted by the National Coral Reef Monitoring Program (NCRMP) under NOAA (NOAA, 2018), and (2) the Florida coral and hardbottom habitats supplied by the FWC.

Determining Coral Coverage Percentage

To calculate coral coverage within Monroe County, it is important to subset FRT areas within the Monroe County boundary. This area will be referred to as the "Florida Keys Reef Tract" (FKRT). The data source used to calculate the percent of coral coverage throughout the FKRT was based off the "Assessment of coral reef benthic communities in the Florida Reef Tract" dataset put together by the National Coral Reef, Monitoring Program (NCRMP) under NOAA (NOAA, 2018).

NCRMP's Benthic Coral Surveying Scope and Methodology

The NCRMP surveyed 723 sites within the FRT to quantify benthic (seafloor) coral coverage at each site (Morris et al., 2022). These sites were distributed throughout the entire FKRT and segmented into three regions: Dry Tortugas, Florida Keys, and Southeast Florida. The Florida Keys were split into four subregions: Lower Keys, Middle Keys, Upper Keys, and Biscayne (Morris et al., 2022). Surveys followed the standard line point-intercept sampling design. This approach drapes a 15 m weighted transect over the ocean floor, recording the benthic composition every 15 cm. Each 15 cm interval represents one point, so at one 15 m site, there are 100 points (Morris et al., 2022). The Capstone Team converted these points into relevant benthic composition percentages, including percentages for corals on hardbottom, soft bottom, and rubble.

Scoping Down the NCRMP Survey

Geographically, Monroe County boundaries include a majority of the FRT. The County also overlaps a large part of the Florida Keys National Marine Sanctuary, excluding Biscayne Bay to the east (Florida Department of Environmental Protection, n.d.). Given that the NCRMP data covered areas beyond Monroe County, the Capstone Team filtered the data to only include the Upper, Middle, Lower, and Marquesas Keys, and the Dry Tortugas subregions of the FKRT (GeoPlatform ArcGIS Online, 2016).

See Figure 19 for a view of the Monroe County borders. See Appendix D for subregion data filters utilized.

In terms of surface type that was used for the analysis, the Capstone Team focused on coral coverage on hardbottom surfaces because hardbottom coral coverage is the most prevalent throughout the FKRT. The two additional surface types that were part of the NCRMP survey of coral coverage were soft bottom and rubble, which constituted a small percentage of coral coverage. Another reason for the focus on hardbottom coral coverage is that there is higher data availability for hardbottom coverage within the Monroe County boundary (Morris et al., 2022). Therefore, in addition to filtering the NCRMP data for regions that are within Monroe County, an additional filter was set for hardbottom coral coverage. The filtered results showed an average hardbottom coral coverage of 6.51% between 2016 and 2018.

Determining Hardbottom Surface Area

Coral coverage is often expressed in percentage coverage, but the Capstone Team wanted to determine a specific coverage area value. To do so, the 6.51% hardbottom coral coverage value was multiplied against the total coral and hardbottom habitats that are part of Monroe County. The area of coral and hardbottom habitats for Monroe County was calculated based on the "Coral and Hard Bottom Habitats in Florida" GIS and mapping data sourced from the FWC (FWC GIS Librarian, 2015).

The dataset is an aggregate of the coral and hardbottom areas within the entire FRT. It is important to note that the data may not provide a complete picture of all the suitable habitats. The data set is a compilation of coral and hardbottom data made available to the FWC in 2013. The individual datasets that make up the "Coral and Hard Bottom Habitats in Florida" were collected over varying time frames using different methodologies. The maps do not represent a comprehensive survey of the area (FWC GIS Librarian, 2015) but are the most complete set the Capstone Team found.

The "Coral and Hard Bottom Habitats in Florida" dataset was filtered for areas within Monroe County, which is 2.14 billion square meters. The 2.14 billion square meters represent the total area where coral coverage is possible within Monroe County.

Determining Area Measurement for Coral Coverage

To determine the area measurement of coral coverage in Monroe County, the hardbottom coral cover percentage of 6.51% was applied against the 2.14 billion square meters of total coral and hardbottom habitats. The resulting hardbottom coral coverage within the Monroe County boundary is roughly 39 million square meters, or 53.71 square miles. This results in coral coverage being slightly larger than half of the Dry Tortugas National Park (United States National Park Service, n.d.). Figure 19 provides a visual of the coral coverage within Monroe County, which are represented by orange circles.

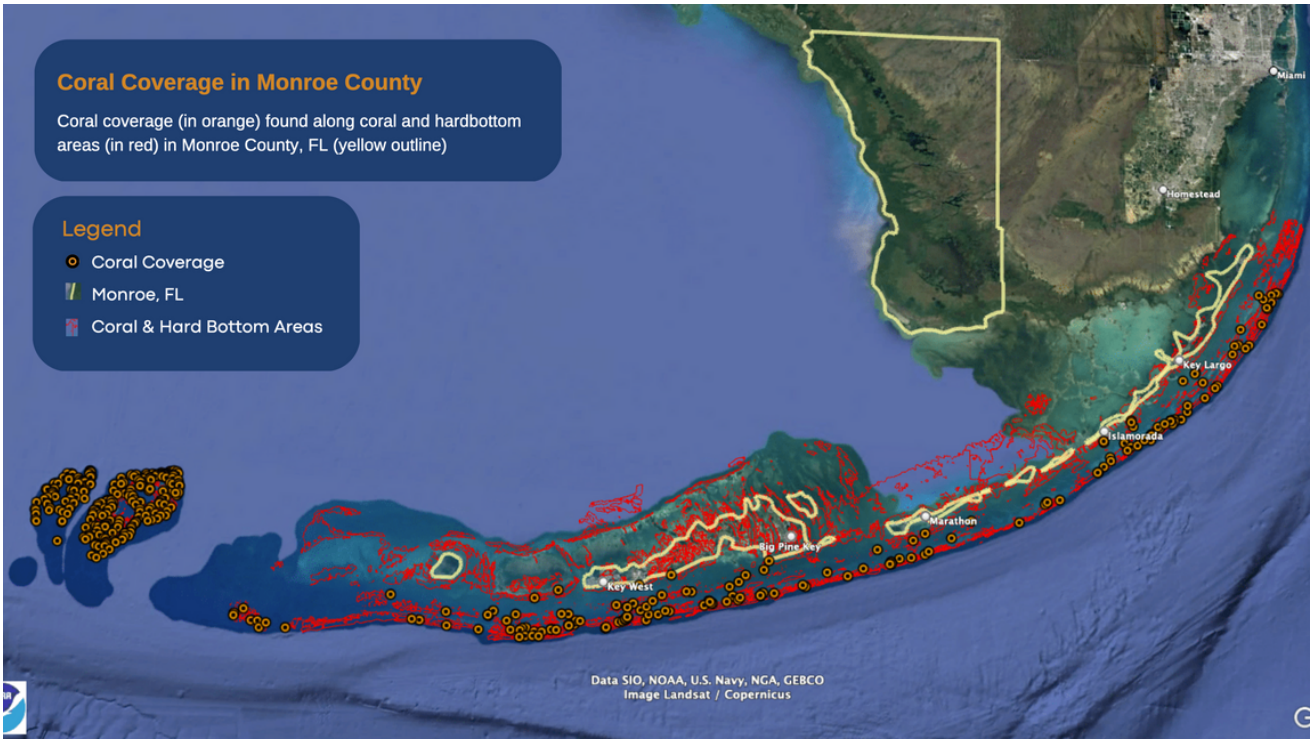


Figure 19. Coral Coverage in Monroe County. Created by overlaying (1) the dataset from NCRMP of coral coverage (NOAA, 2018) which are represented by orange circles and (2) the Coral and Hard Bottom Habitats in Florida (FWC GIS Librarian) which are the areas outlined in red. Both datasets were filtered to include areas within Monroe County as indicated by Google Earth to stay within the municipal boundaries.

7.3 Valuation Results

Relating Economic Activity to Coral Coverage
Leveraging the economic indicators and the coral coverage area within Monroe County, the Capstone Team determined the economic value of coral coverage for Monroe County for each of the researched economic categories.

Table 8 summarizes the economic value per square mile of coral coverage for the listed economic categories. The average value of Total Leisure Spending from 2015 to 2020, was roughly $3 billion a year. Distributing the $3 billion against the 53.71 square miles of coral coverage, leads to $56 million of Leisure Spending being associated with one square mile of coral coverage. Under this methodology (dividing the average annual economic value by 53.71 square miles), one square mile is associated with $664,165 in Tax Revenue Remitted from Tourism, and nearly $1.2 million in Commercial Fish Landings. Based on these figures and understanding how essential healthy coral habitats are to Monroe County's economy, one can imagine that there would be economic loss if there is coral coverage decline.

Total average coral coverage is based on latest available data (2016 & 2018); however, this does not include the effects of stony coral tissue loss disease throughout the FRT. Coral coverage presented in this report is likely an overestimate of present-day.

Table 8. Average of economic indicators from years 2015-2020 divided by average coral coverage in Monroe County. (Created by the Capstone Team)

Economic Category	2015-2020 Annual Average	Average per square Mile of Coral
GDP for Monroe County	$4.97B	$92.57M
Total Leisure Spending	$3.00B	$55.86M
Tax Revenue Remitted from Tourism	$35.67M	$664.17K
Commercial Fish Landings	$62.89M	$1.17M

Attribution Assumptions

Some attribution assumptions are necessary to get the economic activity associated with coral coverage when associating these economic values with coral coverage. It is clear that the health of coral reefs and the abundance of coral coverage directly impact the highlighted economic indicators. The first major assumption is the association of the specific economic activity being directly related to coral coverage. As noted from the stakeholder interviews, reef health directly impacts tourism and reliant industries. Additionally, coral reefs are recognized as biodiversity hotspots that support fishing industries and contribute to local economies through tourism (Toth et al., 2022).

Moreover, it was noted that coral communities with more sustained degradation are more likely to maintain lower tourism values, especially as decreases in specific species can be linked to declines in tourism (Woodhead et al., 2019). Finally, coral degradation creates areas that cannot support reef-associated species, leading to the inability of these areas to sustain necessary fish populations to support the fishing industry. This can lead to subsequent health implication and socioeconomic consequences, such as the loss of livelihoods for community members (Woodhead et al., 2019).

7.4 Impact of Coral Degradation on Title I Students

As derived from the Capstone Team's research and valuation results, coral ecosystems are economically significant to Monroe County. From a household perspective, the health of the coral ecosystems also impacts Title I students and their families. As outlined in Chapter 2.2, the maximum Federal annual household income for a family of four was $48,470 or less for a student to qualify for Free or Reduced Lunch and be considered "low-income" in 2020. Comparing the $48,470 threshold to Monroe County's major occupations and average annual income levels (Figure 20), occupations that pay $48,470 or under include food preparation and service, fishing, farming, and forestry. Given that Title I families are lower income, Title I families rely more on wages from these tourism-related industries.

Tourism and fishing industries are closely linked to the prosperity of Monroe County's natural habitats, as discussed earlier in Chapter 7. Threats to coral habitats and marine ecosystems, including human-driven climate change, water pollution, and overfishing, could threaten the ability of Title I households to meet daily expenses.

The Capstone Team makes this connection based on information that is currently available, but further research and surveys on the occupations held by Title I households are required to draw a direct correlation.

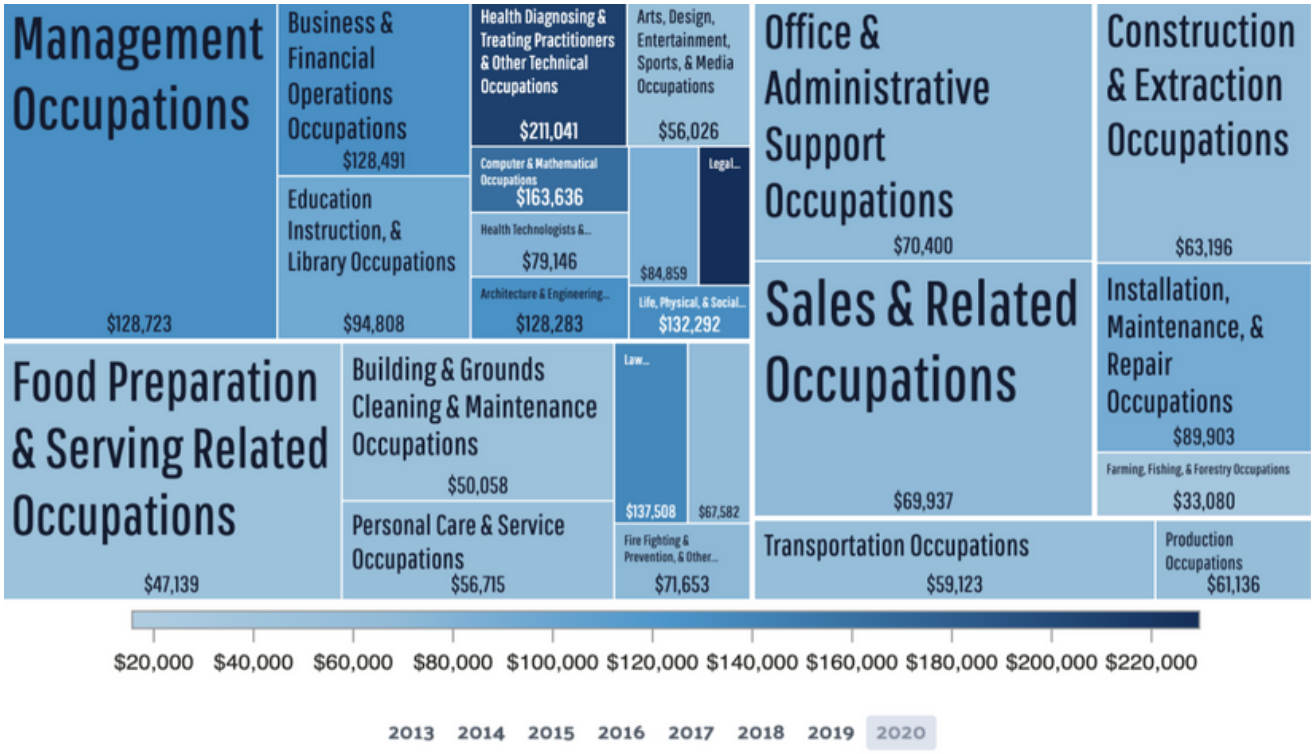


Figure 20. American Community Service Census Bureau data on occupation industry and annual average income for Monroe County. (Data USA, 2022)

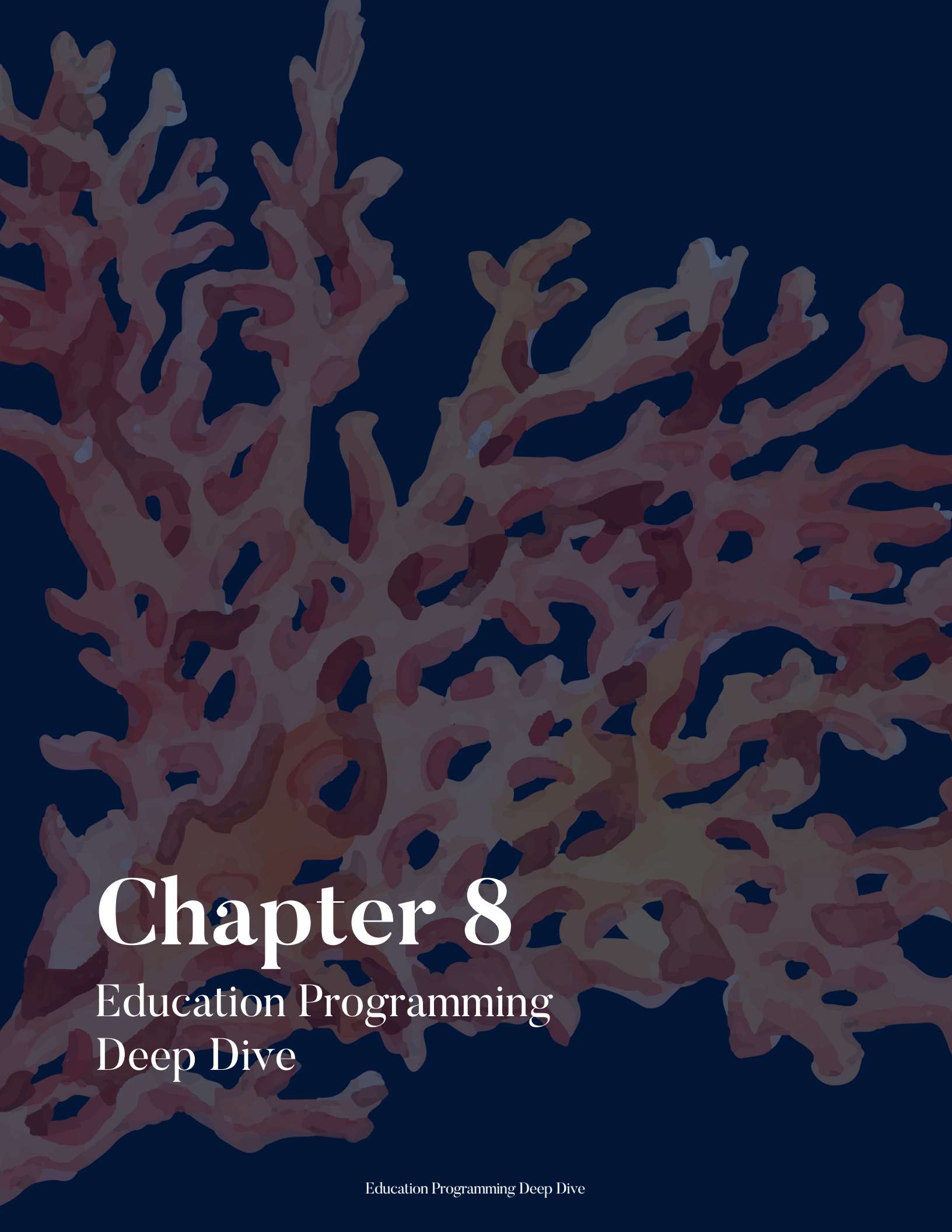
Warming is expected to continue increasing in both lower and higher CO2e- emission pathway scenarios. Atmospheric temperatures in Florida have risen more than 2°F since the beginning of the 20th century. By 2050, most of the state is projected to increase by more than 50 days with temperatures of 95°F or higher. Florida is also the most humid state in the United States. Prolonged periods of extreme heat and high humidity can result in heat-related illness among vulnerable populations and place excess stress on water supplies, agricultural production, and energy systems. (Runkle et al., 2022)

With the projected increase in atmospheric temperatures, there is also an expected increase in extreme precipitation, drought, and sea level rise in Florida (Runkle et al., 2022). Hurricanes are expected to strike more frequently along the Florida coast. Hurricanes are already frequent in Florida with an average of three to five events striking the state yearly (Runkle et al., 2022). High intensity hurricanes, like Hurricane Michael in 2015 and Hurricane Irma in 2017, caused major economic and social impacts in Florida, the Florida Keys and Monroe County. For example, Hurricane Irma was a category four Hurricane that caused around $4,846 of physical damage per capita in Monroe County and damaged 31% of Monroe County's houses (Lee, 2021).

Nuisance Floods are floods that surpass a local impact threshold that is set by NOAA's weather service. These Nuisance Floods are expected to cause challenges to South Florida's coastal water management system due to aging flood control facilities, flat topography, and permeable aquifers (Runkle et al., 2022). As sea levels rise, nuisance floods are also expected to occur regularly in Monroe County.

"With the projected increase in atmospheric temperatures there is also an expected increase in extreme precipitation, drought, and sea level rise in Florida."

Runkle et al., 2022



Chapter 8

Education Programming Deep Dive

8 Education Programming Deep Dive

8.1 Where are the Program Strengths and Gaps?

This chapter measures up the six CRF education programs against the three key metrics, as described in Chapter 4:

- (S) Science and Misconceptions
- (E) Engagement
- (CI) Community Impact

Each program was scored based on the criteria listed above as shown in Appendix C. These scores were summed to present a total score of 100%. In total, there were 12 criteria in the rubric, all weighed on a scale of one (1) to five (5). 1 indicates unknown or insufficient data, 2 indicates an apparent failure to meet the industry standard, 3 indicates the need for some improvement to reach the industry standard, 4 meets the industry standard, and 5 exceeds the industry standard. A visual summary of all the total scores can be seen in Figure 21. At the end of this chapter, there is a summarized list of improvements CRF can address to strengthen their educational programming. This chapter provides an in-depth assessment of each program's strengths and gaps that require improvement.

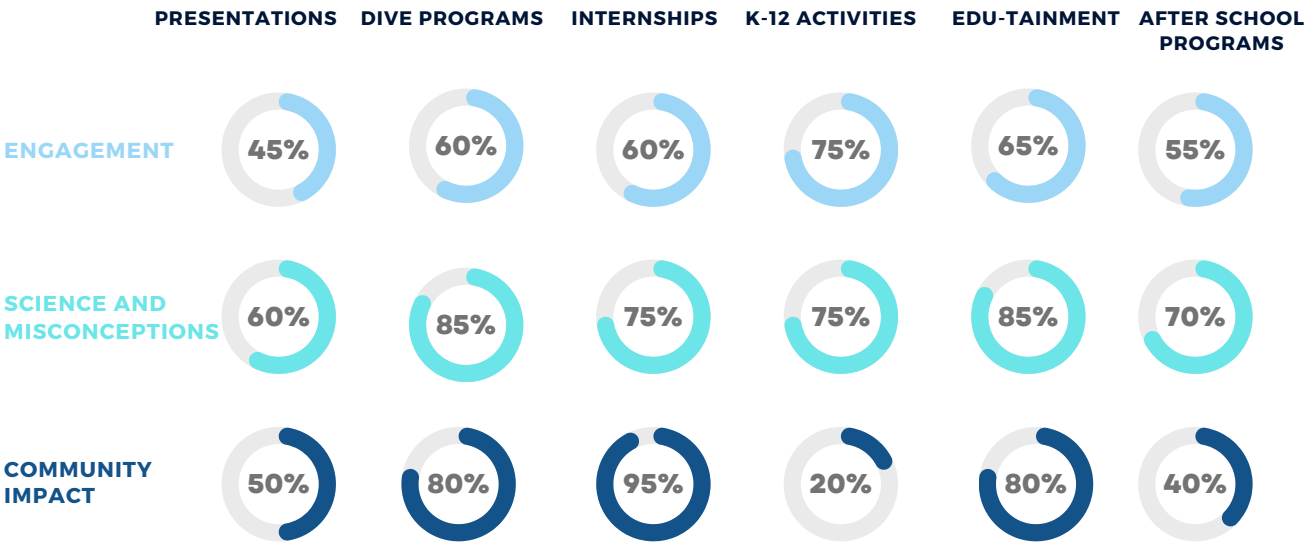


Figure 21. Total scores for CRF's education programs. (Created by the Capstone Team)

8.2 Presentations

Total: 52%. (S) 60% (E) 45% (CI) 50%

CRF holds in-person and virtual educational presentations for audiences in the local community and the United States. They engage the local and regional community members and spread CRF's message about the importance of coral restoration. CRF's presentations primarily focus on the anatomy of corals, climate change, and the organization's coral restoration work. Anyone can request a presentation from CRF and even though there is a standard slide deck, the content can be adjusted to best suit specific audiences. For example, younger children or elementary school students can receive a shorter, less science-intensive 25-minute delivery upon request. This is also important given CRF's goal to work with Title I students.

Strengths

Accessibility of programs: The presentations are accessible to anyone upon request. They can be held locally in-person and to audiences globally over zoom.

Audience Participation: The presentations encourage active participation and discussion from audiences.

Gaps

Call to action: To spur effective behavioral change in students, presentations must have a strong call to action. Providing examples of what students can do to contribute to coral restoration will expand CRF's impact on the environment and communities through its presentations.

Content: CRF can also improve how presentations address misconceptions of coral science and policies. For example, current presentations address misconceptions about coral anatomy. The presentations can also offer a broader scope of scientific opinions about coral restoration practices and research, while maintaining the stance that restoration is critical.

Knowledge-base disconnect: CRF interns come to the presentation with a robust coral knowledge-base. They are involved in the marine science community and have experience diving and coral outplanting. The audience does not have this extensive background, and the disconnect leads to complex scientific information being explained in a high-level manner. This inhibits audiences' ability to retain information.

Collecting and tracking participant data: If possible, CRF should start collecting presentation participant's demographic data. This data can be used to identify gaps in presentation audiences, and to target CRF's outreach efforts moving forward. This can also help CRF target their program efforts more towards Title I students and families in their community moving forward. Participants or their legal guardians must authorize permission to collect such data and an IRB (Institutional Review Board) would be required for this. The format for IRB forms used by Columbia University for social and behavioral science research are featured in Appendix E.

Short-term efficacy: Presentations have the potential to cultivate environmental stewardship for coral restoration, but more consistent data collection is necessary to track this. Conducting pre- and post-program surveys can fill this gap and measure short-term changes in attitude. (See Chapter 9 for more information)

Long-term efficacy: CRF could also conduct follow-up surveys within one, three, and six months following their presentations to gauge whether presentations led to real action by audience members in the longer term. Without consistent longer-term feedback mechanisms, it is difficult to determine whether the presentations contribute to community support for coral restoration or economic growth. CRF can begin to gauge the long-term efficacy of their presentations by keeping track of where their presentations are, seeing if these locations overlap with changing sentiments towards coral restoration. Positive indicators could be more conservative fishing practices or local coral protection policies. Additionally, CRF should track ongoing student engagement in CRF programs in the weeks and months after presentations are administered. Doing so will give a strong indicator on the long-term impacts that presentations have on students.

Collaborative relationships: CRF can establish long-term relationships with stakeholder groups and schools to measure whether forming these relationships will result in community benefits. CRF should track presentations' capacity to foster collaborative, community-based science. Columbia University recently implemented a similar project for its summer students. Students have access to a portal where they can engage and connect with other students in their program. Columbia University can track the students' educational progress to understand the impact of the summer programs in the longer-term career path of the student. CRF should establish a system like this for students who participate in the organization's educational programs. Overall, the impacts of presentations need to be measured and tracked with quantitative data. There is a greater capacity to cultivate long-term behavioral change in audiences.

8.3 Dive Program

Total: 75% (S) 85% (E) 60% (CI) 80%

The dive program scored well overall. This program is actively helping students become stewards for coral restoration and contributes positively to community impact. There are, however, areas for improvement in accessibility. The dive program is a one-day educational session that consists of two presentations and two dives. It is led by a dive instructor with a Master of Marine Sciences and 6+ years of experience in diving. The program includes one nursery dive where the participants get to clean CRF's coral trees and an outplanting dive where participants learn how to plant out new corals. The dives are done in collaboration with 12 dive shops. The cost is $200 for visitors to participate on this day of diving and the dive-participants also must rent gear, if they do not have their own. To evaluate behavioral change, retention rates, and the students interest in rejoining, CRF has implemented a post-participation survey for their dive programs.

Strengths

Encourages stewardship: The dive program offers participants an opportunity to participate in coral restoration actively. It contributes directly to the conservation of corals.

Content and science: Through incorporating hands-on experience with coral outplanting and coral nursery care, the dive program provides an understanding of marine science. This program is led by an expert that is experienced in the field. The leader of this program also expressed a goal and interest in addressing misconceptions and conveying the many different viewpoints in the marine science community for what can constitute successful coral restoration.

Community impact: The dive program cultivates stewardship and builds capacity for participants to make a real impact. The program also creates economic benefits for the community by collaborating with 12 local dive shops.

Gaps

Accessibility: Diving is an expensive activity, and the program has a high financial barrier of $200. Financial allowances should be made for disenfranchised groups wherever possible. To better target Title I students and families there is an opportunity to combine diving and snorkeling sessions to increase accessibility and the number of participants per session. Other accessibility improvements include creating more snorkeling events, land interactions with corals, and increasing student trips on glass-bottom boats to nurseries and outplanting sites.

Community collaboration: CRF should collaborate with other coral restoration or marine conservation organizations to expand its reach.

Community impact metrics: CRF should regularly conduct stakeholder interviews to evaluate the perception and success of the dive program.

Ecological impact metrics: The dive program contributes to the ecological goals of restoration by facilitating the outplanting of corals and nursery care. To more directly monitor this CRF could start tracking how many of their corals have been outplanted by the dive program participants. Right now, CRF tracks total outplanting done by the foundation but does not highlight just the volunteer contributions of the operation.

8.4 Internship Program

Total: 77% (S) 75% (E) 60% (CI) 95%

Internship programs score high for science and misconceptions, and community impact. The interns positively impact the community by drawing in students interested in coral restoration. CRF internships are organized in four-month terms that allow interns to participate in outplanting, presentations, and CRF's internal operations. This is a unique opportunity for early-career marine scientists to engage in conservation efforts. Interns can stay for up to one year, three internship periods, and may later be hired full-time by CRF upon completion of the program.

Strengths

Encourages and builds stewardship: The internship programs are CRF's best scored science-based programs. The inherent nature of internships provides experiences and opportunities to learn, apply, converse, and work in coral restoration. Long-term interest and impact: The number of interns has increased every year from 2017 to 2021 (except 2020), demonstrating positive growth and reception of the program.

Community impact: The internship program supports stewardship by cultivating leaders in coral restoration. The interns gain experience in outplanting, public speaking, and educating students about coral science. The interns are responsible for outplanting 46% of CRF's corals to date and are a vital part of the organization's progress toward its ecological restoration goals.

Gaps

Accessibility: In order to increase access to the internship program, CRF should consider helping disadvantaged communities by awarding fellowships to students interested in marine conservation who may not have the means to attain a diving license and equipment without financial assistance. Providing greater access to these internships can develop a space of inclusivity, innovation, and inspiration. According to CRF's current requirements and information on the program, interns and students must

have a scuba license, diving experience, and their own diving gear to participate in the program. Students must also pay an estimated $800-1200 per month to live in the area where CRF has its nurseries and coral outplanting (CRF, 2022). This can be a barrier that hinders students from lower-income families from participating in the program, primarily Title I students.

Long-term community metrics: The internship program has the potential to be the educational program with the most significant long-term impact on CRF's local community. CRF internships draw people to the FRT and create benefits for the economy of Monroe County. The internships are also positively impacting the community because the interns directly help restore the health of the ecosystem. CRF should track demographic data on its interns to understand how many interns are local versus not local. CRF could also track how long the interns stay after completing their program, and how the community perceives the interns and their work. Additionally, CRF could track the economic interaction or benefits to Monroe County by asking their interns about their spending habits.

8.5 K–12 Activity Packs

Total: 57% (S) 75% (E) 70% (CI) 20%

CRF offers six activity packs: Appetizing Acropora, Sibilating Scleractinia, Gamete and Greet, Creating $CaCO^3$, Maritime Slime, and Anthropogenic Aftermath. All these activity packs are interdisciplinary – encouraging students to think about what coral reefs are made of and how long coral reefs have been on the planet. Some are more hands-on than others, particularly Creating $CaCO^3$, which uses a chemistry demonstration to teach about the production of coral skeletons. The demonstration shows students that under certain conditions, solid materials can be extracted from a solution. Another hands-on engagement-based activity is the Maritime Slime, which is an activity that encourages students to think about the dependence and detriment in the relationship between the sun and coral reefs, and the purpose of coral mucus. The activity that highlights human impact on coral reefs is the Anthropogenic Aftermath activity pack. This interdisciplinary activity encourages students to think about the current conditions of the FRT, human impacts on the marine ecosystem, the long-term impacts of ocean stewardship and coral degradation. This was designed to be used in collaboration with the 2019 Coral to Action Competition for K-12 students.

Strengths

Creative and engaging content: The activity packs are meant for hands-on collaboration with students from a range of age groups. CRF excels at providing creative opportunities for students to engage in coral reef related activities.

Accessibility: CRF has created a range of easily accessible activity packs to provide marine science exploration for everyone.

Gaps

Age group specificity of content: The science and misconception criteria aim to evaluate whether the programs provide students with opportunities to interact with scientists and explore the scientific process. Doing so will allow students to discover misconceptions about climate change. CRF has created a range of easily accessible activity packs, to provide marine science exploration for everyone. However, many of these activity packs are targeted for younger students. For example, Anthropogenic Aftermath, is meant to show long-term human impacts on coral, whereas Creating $CaCO^3$ is an in-person chemistry demonstration that replicates the production of coral skeletons. Creating $CaCO^3$ shows students that under certain conditions, solid materials can be extracted from a solution. The chemical reaction demonstrated here is not the same in a coral polyp but is used to show that solids can be produced from dissolved substances. CRF can increase the technical difficulty of their activity packs and include more science-based content for higher grade students. It is recommended hat CRF identify learning milestones and benchmarks for each grade so that each activity pack has a target audience and measurable learning outcome.

Targeted engagement metrics: A significant component of engagement is positive behavioral change, including retention rates, active discussion, and participation. Although activity packs are hands-on and engaging, there is limited data to identify impacts on various demographic groups and shifts in perception or engagement. Also, there is a lack of learning objectives by education level (elementary versus middle versus high school). The purpose of these programs, as communicated by CRF, is to facilitate inspiration and engagement. Without identifying measurable target benchmarks, evaluating the impacts of engagement through the activity packs is limited to data accessibility and reliability.

Community impact metrics: Inspiration is a crucial goal for CRF through their education programs. The community impact criteria are based on the level of stewardship, coastal protection, economic benefits, reef user participation, and positive conservation contribution. There is limited data to assess community impact. Although the activity packs' potential for long-term cultivation of stewardship and positive conservation contribution is possible, it is not guaranteed. There should be long-term studies of students' participation and contribution to conservation through identifying benchmarks of success for each age group or year-to-year assessments. These long-term studies will require CRF to submit an application to the IRB.

8.6 Edutainment

Total: 75% (S) 85% (E) 65% (CI) 80%

Edutainment workshops introduce students to coral physiology, reef ecology, and ocean stewardship. According to CRF, 'edutainment' is a way to educate students about coral anatomy and coral restoration while making it fun and engaging. Edutainment workshops include a calcium carbonate experiment, a hands-on experiment where students learn how coral skeletons are produced and how they can break down over time in acidic ocean water. Maritime Slime is an experiment about how corals produce slime to protect themselves from ultraviolet radiation. CRF has expressed a desire to increase the frequency of these workshops. The goal for 2023 is to host two edutainment workshops per month, doubling the current frequency.

Strengths

Creative and engaging content: Edutainment workshops are one of CRF's most creative and unique educational programs. CRF is consistent in making coral reef restoration science engaging and creative.

Community collaboration: CRF conducts edutainment workshops in collaboration with other community stakeholders. CRF is consistent in its creative approach to education and efforts to collaborate with the community in which it operates and engages.

Gaps

Age group specificity of content: To make a significant impact in education, workshops should challenge students at any grade level to discuss their ideas about what coral restoration is. This would clear current misconceptions around the topic. Given that topics have different complexities depending on the grade level, CRF should tailor their workshops to each grade level and target specific concepts, thereby increasing science accessibility, dialogue, and contribution.

Targeted engagement metrics: Edutainment has a high engagement potential given its creative structure. However, there is insufficient data to evaluate the level of engagement and impact these workshops have. Engagement includes more than retention rate. A significant component of environmental education is accessibility and demographic reach. CRF does not have an established mechanism to evaluate its demographic reach--a finding that is consistent in each program. These workshops can facilitate better retention and dialogue long-term, but this cannot be measured if CRF does not establish internal time bound mechanisms to evaluate its demographic reach and diversity.

Community metrics: While edutainment workshops help capacity building and stewardship for reef restoration, more data is needed to thoroughly evaluate how edutainment workshops directly influence the ecosystem, ecotourism, reef knowledge and awareness, and contributions to reef restoration efforts.

8.7 After-School Program

Total: 55% (S) 70% (E) 60% (CI) 40%

The after-school program is tailored to all students in Grades K – 12. The program is adapted from CRF's edutainment programs which follow Florida State and Cpalm Curriculum Standards. CRF groups students by class and age range where possible. The CRF STEAM edutainment programs combine elements of project-based, team-based, and problem-based curriculum to deliver a message about taking personal responsibility to protect reefs. Topics include coral anatomy, restoration techniques, reef taxonomy, and conservation. After-School Clubs meet for one hour after school one day per week for four to ten weeks based on the needs and availability of the school.

Strengths

Creative and scientific content: The after-school program provides a good mix of science-based marine and conservation content. The curriculum is based on problem-based and project-based varieties. These programs are critical for highlighting technical and science-based content regarding coral anatomy, restoration, and conservation. This program excels in this particular criterion.

Gaps

Long-term impact: CRF should incorporate behavioral and policy practices to encourage actionable solutions and engagement.

Engagement metrics: There is insufficient data to evaluate the demographic reach, retention rates, or level of behavioral change in the students. The after-school program is an opportunity for CRF to highlight science-based conservation solutions to students.

Community metrics: There is insufficient data to conduct a thorough analysis of the impact of after-school programs on the community. Impacts on ecosystems, ecotourism, economic benefits, and restoration efforts are critical to measure community impacts. There is also an opportunity to directly target Title I students or students from underrepresented groups, as this is a direct interest to CRF.

8.8 Recommendations to Improve Education Programs

CRF excels at providing creative solutions for coral reef education, and its priority program takeaway is inspiration. To most effectively foster inspiration, CRF should define short and long-term inspiration. Immediate recommendations include the following:

Establish internal systems to distinguish and identify the demographic data of the participants in its programs

By collecting data on demographic diversity and accessibility, CRF can reach a larger audience and improve retention rates. To achieve this, CRF should prioritize diversity, equity, and inclusion training to improve demographic diversity and accessibility of their educational programs. With this data, CRF will be able to target disadvantaged students or Title I students more effectively and track how they make a meaningful difference.

Strategically organize the curriculum of its programs in accordance with short- and long-term milestones

To evaluate impact and inspiration in the long-term, CRF should monitor the behavioral changes of various age groups as the students advance in grade levels. There is also an opportunity to create a cohesive student journey that follows students through middle school, high school, and the internships they participate in by having an overarching strategy and tracking student progress and participation over time.

> "CRF should prioritize diversity, equity, and inclusion training to improve demographic diversity and accessibility of their educational programs."

Distribute content evenly across programs and grade levels

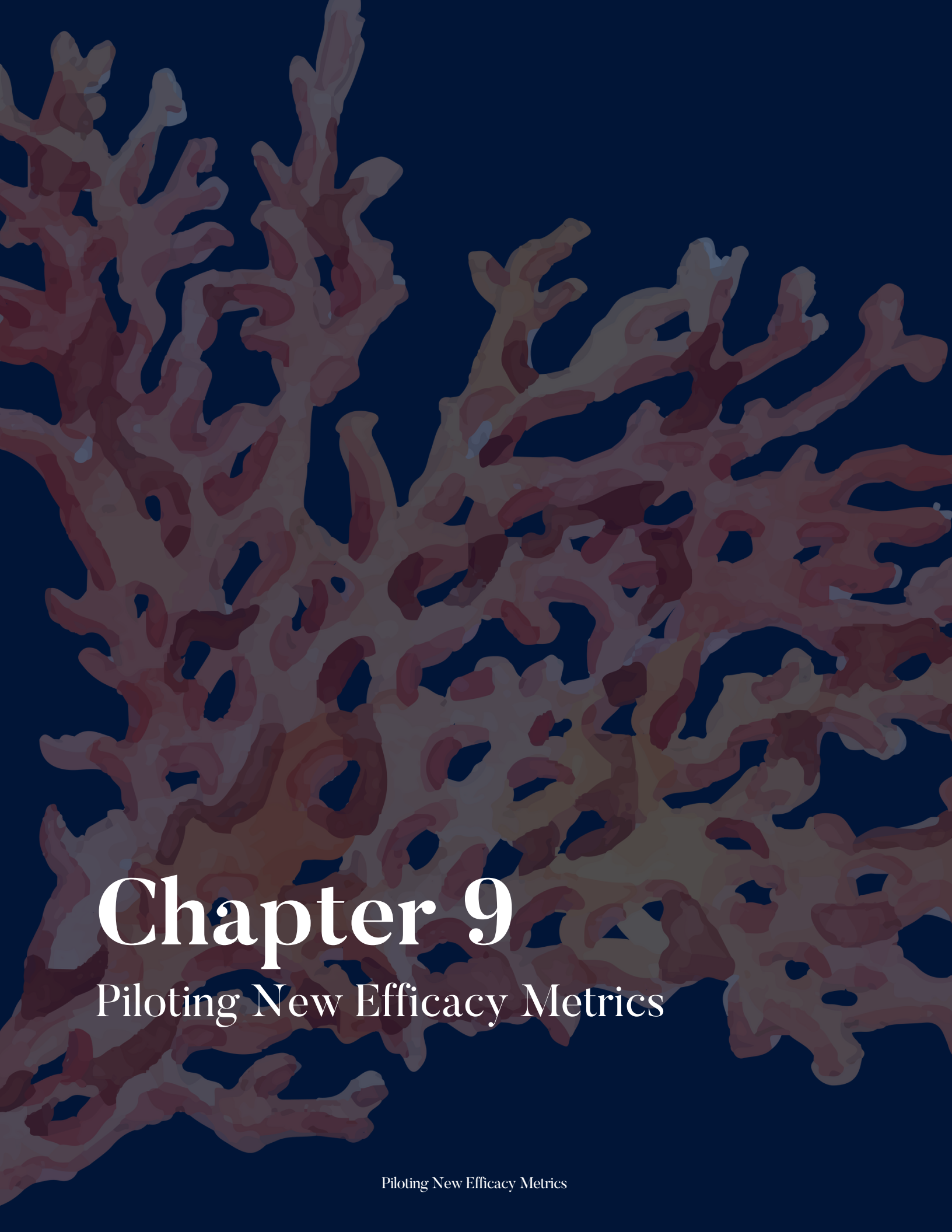
There is an abundance of workshops, slime-making activities, and experiments that cater to the academic level of primary students. An equal distribution of content and curriculum should be produced for students between middle and high school. This includes science-based content that facilitates discussions and dialogue regarding

policies, misconceptions, and solutions for coral restoration.

Consider opportunities for targeted resource use

If possible, CRF should consider allocating resources to provide fellowships and internship programs for Title I students in the community. This will help expand the demographic reach and accessibility of marine science programs. CRF's educational programs can directly benefit Title I students in Monroe County by providing opportunities for disenfranchised students to engage with interactive STEM content deeply, thereby enriching students' overall academic and civic performance.

The experiential learning provided through CRF's activities and workshops empower these students to become environmental stewards later in life. The benefits of environmental education carry across socioeconomic disparities. Environmental education programs can help support, empower, and uplift Title I students within Monroe County and beyond.



Chapter 9

Piloting New Efficacy Metrics

9 Piloting New Efficacy Metrics

9.1 Revamping the Feedback Survey

The Capstone Team piloted the pre- and post-program surveys with ninth-grade students from Westminster Christian School in southern Florida. These students attended three separate General Presentations where CRF debuted the Capstone Team's pre- and post-program surveys. As detailed further in Chapter 5, the survey questions measure participants' change in education, enthusiasm, enrollment, and emergence from program start to finish. Due to a misstep in securing parental consent for surveying minors, the Capstone Team cannot publish the results of the piloted surveys. The Protection of Pupil Rights Amendment (PPRA) requires parental approval for surveying any students under the age of 18. The Capstone Team drafted consent forms (See Appendix B) and strongly recommends that CRF use similar versions for all future surveys to ensure the data is usable. Our piloted surveys showed an increase across all measurement points and still provided valuable insights for CRF to review and learn from, internally. Most importantly, the survey outputs were positive indicators that CRF's General Presentations are effective and engaging. These results underscore the findings of the gap analysis (Chapter 8) that emphasize the importance of tracking program success with sophisticated data collection.

9.2 Recommendations for Future Surveys

The new surveys establish metrics CRF can use to assess their educational program efficacy. CRF can expand upon this initial overhaul to ensure high response rates, appropriate data analysis, and CRF re-engagement.

Increasing Response Rates
Transitioning from emailed links to surveys offered immediately before and after a program will positively impact CRF's feedback response rate. There are other ways by which CRF can increase the number of participants who complete their new program efficacy surveys.

Mimic the new feedback methodology across other CRF educational programs
The design of surveys in Appendix B captures data from CRF's General Presentations. The Capstone Team recommends that CRF administer questions before and after dives, edutainment events, after-school programs, and activity packs.

Try interactive survey formats CRF can work to develop a different style of program feedback collection. Any new developments should gear towards younger audiences unable to complete a survey or with CRF's more interactive outreach sessions. To capture data from younger audiences, techniques can include interactive questions with participants like "Raise your hand if you know..." or "Move to the left side of the room if you think...." These more dynamic questions and feedback responses will involve more difficult qualitative data collection. This different feedback style will help measure audiences' efficacy and engagement levels that are not currently compatible with the pre- and post-program surveys.

Offer small participation incentives

To enhance participation and ensure successful data collection, CRF can offer incentives for program participants. CRF can, for example, give raffle-style prizes to participants that complete the pre- and post-program surveys. Prizes can be simple, like local shop gift cards. CRF can incentivize participation while increasing program circularity by offering dive program discounts, Exploration Center tours, or branded merchandise.

Purchase technology that participants can use to complete the feedback surveys

CRF can widen its feedback pool by providing survey tablets at select educational outreach events. The Capstone Team recommends this over printing out the surveys because manually entering hard-copy responses into SurveyMonkey is time-consuming and not environmentally friendly.

Develop a feedback mechanism for CRF's internship program

Interns are vital to CRF's educational outreach success, and they are often conducting the day-to-day programs. CRF should collect quantitative and qualitative retrospective feedback from their educational program interns after their four-month tenures to field a different form of program feedback and opinions.

Data Analysis

To ensure CRF can gain insights from the new survey outputs, the Capstone Team recommends that CRF sets metric change thresholds and transitions away from their current survey database, SurveyMonkey.

Set metric thresholds

CRF can establish minimum improvement expectations when extracting and quantifying participant data from SurveyMonkey. A question CRF can ask to help set these thresholds is: What is an acceptable change rate for each efficacy metric before and after the program? Tracking how often these thresholds are met or missed can help gauge program effectiveness over a more extended period.

Transition survey database to Microsoft Teams

CRF should transition to a new survey software to alleviate the paywall, multi-access, data extraction, and formatting obstacles CRF currently faces with SurveyMonkey. Google and Teams survey platforms offer a more organized, user-friendly solution that integrates smoothly into CRF's existing Microsoft platform.

Mimic the new feedback methodology across other CRF educational programs

The survey design in Appendix B captures data from CRF's General Presentations.

Increasing CRF's Engagement Circularity

Lastly, CRF should track how participants interact with the organization upon program completion to further understand the recruitment impact of their presentations.

Follow-up with program participants:

The pilot surveys tracked an increase in enrollment (or interest in getting involved with CRF), and the pre-survey baseline was already high. CRF should take advantage of this excitement within one week of running a program to recruit new CRF volunteers, divers, or interns, and create forever ocean stewards! Re-engagement can be performed via email.

Tracking efficacy and circularity

The key priorities of CRF's educational outreach are bringing in interest, volunteers, and donation streams. There is value in tracking how the educational programs are contributing to these goals. The metrics could help answer questions: Are students who attend the General Presentations signing up for dive programs? Are teachers coming back to CRF for curriculum or after-school engagements year-over-year?

In compliance with IRB requirements, tracking participant names and affiliations can help establish links between educational outreach participants or program organizers and any monetary contributions to CRF's cause. Columbia University's IRB assent forms for research participants between the ages of seven to 11 and 12 to 17 are featured in Appendix E. The Capstone Team also recommends that CRF tracks when a school or individual schedules a presentation or program more than once, as recurring interest can be a positive indicator of program success.

References

References

20 u. S. Code § 1232h—Protection of Pupil Rights. (n.d.). LII / Legal Information Institute. Retrieved December 15, 2022, from https://www.law.cornell.edu/uscode/text/20/1232h

ABRT. (2005). Atlantic Acropora status review document. Acropora Biological Review Team. Report to National Marine Fisheries Service, p.152.

Alice Report. (2020). United Way of Collier and the Keys. United Way of the Florida Keys. Retrieved December 8, 2022, from https://www.keysunitedway.org/ALICE

Alice Report. (2022). ALICE in Monroe County. United Way of the Florida Keys. Retrieved December 8, 2022, from https://www.keysunitedway.org/sites/keysunitedway.org/files/20_ALICE_Monroe-County-FL-3-31-2020.pdf

Allen, M. E, Fleming, C. S., Zito, B. M., Gonyo, S. B., Regan, S. D., & Towle, E. K. (2021). National Coral Reef Monitoring Program Socioeconomic Monitoring Component: Summary Findings for South Florida, 2019 (NOAA Technical Memorandum CRCP). Coral Reef Conservation Program (United States)., from https://doi.org/10.25923/w6pa-hv50

American Community Survey. (2021). ACS Demographic and Housing Estimates. United States Census Bureau. Retrieved December 8, 2022, from https://data.census.gov/table?q=Monroe+County,+Florida&d=ACS+1-Year+Estimates+Data+Profiles&tid=ACSDP1Y2021.DP05

American Community Survey. (2021). Selected Social Characteristics in the United States. United States Census Bureau. Retrieved December 8, 2022, from https://data.census.gov/table?q=Monroe+County,+Florida&d=ACS+1-Year+Estimates+Data+Profiles&tid=ACSDP1Y2021.DP02

Ardoin, N. M., Roth, N. W., & Holthuis, N. (2017). Environmental Education and K-12 Student Outcomes: A Review and Analysis of Research. The Journal of Environmental Education, vol. 49, no. 1, pp. 1–17., from https://doi.org/10.1080/00958964.2017.1366155.

Aronson, R. B. & Precht, W. F. (2001). White-band disease and the changing face of Caribbean coral reefs. Hydrobiologia, 460(1/3), 25–38., from https://doi.org/10.1023/A:1013103928980

Aronson, R. B. & Precht, W. F. (2006). Conservation, precaution, and Caribbean reefs. Coral reefs, 25(3), 441-450.

ASPE. (2020). 2020 Poverty Guidelines, ASPE. United States Office of the Assistant Secretary for Planning and Evaluation., from https://aspe.hhs.gov/topics/poverty-economic-mobility/poverty-guidelines/prior-hhs-poverty-guidelines-federal-register-references/2020-poverty-guidelines.

Beck, M. W., Losada, I. J., Menéndez, P., Reguero, B. G., Díaz-Simal, P., & Fernández, F. (2018). The global flood protection savings provided by coral reefs. Nature Communications, 9(1), 2186. from https://doi.org/10.1038/s41467-018-04568-z

Bindoff, N. L., Cheung, W. W. L., Kairo, J. G., Arístegui, J., Guinder, V. A., Hallberg, R., et al. (2019). Changing ocean, marine ecosystems, and dependent communities, in IPCC Special Report on the Ocean and Cryosphere in a Changing Climate, eds H.-O. Pörtner, D. C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, et al. (Geneva: IPCC), 447–588., from doi: 10.1017/9781009157964.007

Blatt, E. N., et al. (2021). The Benefits of Environmental Education for K–12 Students. EePRO @ NAAEE, North American Association for Environmental Education., from https://eepro.naaee.org/eepro/research/eeworks/student-outcomes.

Bruckner, A. W., (2002). Life-saving products from coral reefs. Issues in Science and Technology, 18 no3:39–44 Spr 2002, from http://www.issues.org/18.3/p_bruckner.html

Budd, A. F. & K. G. Johnson. (1999). Origination preceding extinction during late Cenozoic turnover of Caribbean reefs. Paleobiology 25:188–200.

CRF. (2022). About Us. Coral Restoration Foundation, from https://www.coralrestoration.org/about

Creamer, J., Shrider, E. A., Burns, K., & Chen, F. (2022). Poverty in the United States: 2021. Census Bureau. Retrieved December 8, 2022, from https://www.census.gov/library/publications/2022/demo/p60-277.html

CU IRB. (n.d). IRB Protocol and Consent Form Resources. Columbia Research. Columbia University Institutional Review Board., from https://research.columbia.edu/irb-protocol-and-consent-form-resources

Data USA. (2022). Monroe County, Fl. Employment Occupation. Data United States of America. Retrieved December 15th, 2022, from https://datausa.io/profile/geo/monroe-county-fl?measureOccupations=wage

DCA. (2015). Quantitative post-construction analysis for hardbottom benthic communities. Dial Cordy and Associates, Inc. FDEP Final Order #0305721-001-BI. 2012, PortMiami Phase III Federal Channel Expansion Project. Florida Department of Environmental Protection, Tallahassee, FL., from http://www.saj.usace.army.mil/Portals/44/docs/Navigation/Ports/Miami%20Harbor/Near-ShoreHard-BottomReportNov2015.pdf

Dillman, D. A., Smyth, J. D., & Christian, L. M. (2014). Internet, phone, mail, and mixed-mode surveys: The tailored design method (4th edition). Wiley. ISBN: 978-1-118-45614-9

Ed Post. (2021). Explained: What Is Title I and How Is It Used to Fund Our Schools? Ed Post., from https://www.edpost.com/explainer/explained-what-is-title-i-and-how-is-it-used-to-fund-our-schools#:~:text=Right%20now%20more%20than%20half,are%20eligible%20for%20supplemental%20programming.

Enos, P. (1977). Quaternary sedimentation in South Florida, Part I, Holocene sediment accumulations of the South Florida shelf margin. Geol. Soc. Am. 147:198., from doi: 10.1130/MEM147-p1

Federal Reserve Economic Data. (2022). Gross Domestic Product: All Industries in Monroe County, FL. FRED. Retrieved November 10, 2022, from https://fred.stlouisfed.org/series/GDPALL12087

Ferrario, F., Beck, M., Storlazzi, C., Fiorenza, M., Shepard, C. C., & Airoldi, L. (2014). The effectiveness of coral reefs for coastal hazard risk reduction and adaptation. Nat Commun 5, 3794., from https://doi.org/10.1038/ncomms4794

Finkl, C. W. & Andrews, J. L. (2008). Shelf geomorphology along the southeast Florida atlantic continental platform: Barrier coral reefs, nearshore bedrock, and morphosedimentary features. J. Coast. Res. 244, 823–849., from doi: 10.2112/08A-0001.1

Florida DEP. (n.d.). Florida's Coral Reefs. Florida Department of Environmental Protection. Retrieved December 14, 2022, from https://floridadep.gov/rcp/rcp/content/floridas-coral-reefs

Florida DEP. (n.d.). Florida Keys National Marine Sanctuary. Florida Department of Environmental Protection. Retrieved December 16, 2022, from https://floridadep.gov/rcp/fknms

FWC. (2022). Public Fisheries-Dependent Monitoring: Commercial Fisheries Landings Summaries. Florida Fish and Wildlife Conservation Commission. Retrieved December 01, 2022, from https://app.myfwc.com/FWRI/PFDM/ReportCreator.aspx

FWC GIS Librarian. (2015). Coral and Hard Bottom Habitats in Florida. Florida Fish and Wildlife Conservation Commission. Retrieved December 16, 2022, from https://geodata.myfwc.com/datasets/myfwc::coral-and-hard-bottom-habitats-in-florida/about

GeoPlatform ArcGIS Online. (2016). United States County Boundaries. Retrieved December 16, 2022, from https://hub.arcgis.com/datasets/geoplatform::us-county-boundaries/explore?location=34.312761,-111.623190,3.36

Gibson, T., Wanless, H., Klaus, J., Foster-Turley, P., Florini, K., & Olson, T. (2008). Corals and Climate Change, Florida's Natural Treasures at Risk. Environmental Defense Fund., from http://www.edf.org/floridacorals

Goergen, E. A., Schopmeyer, S., Moulding, A. L., Moura, A., Kramer, P., & Viehmann, T. S. (2020). United States. National Ocean Service. National Centers for Coastal Ocean Science. NOAA Technical Memorandum NOS NCCOS ; 279., from https://doi.org/10.25923/xndz-h538

Hausmann, A., Slotow, R., Burns, J., & Di Minin, E. (2016). The ecosystem service of sense of place: Benefits for human well-being and biodiversity conservation. Environmental Conservation, 43(2), 117-127., from doi:10.1017/S0376892915000314

Hogarth, W. T. (2006). Endangered and threatened species: final listing determinations for elkhorn coral and staghorn coral. Federal Register 71:26852–26872

Hughes, T. P., Anderson, K. D., Connolly, S. R., Heron, S. F., Kerry, J. T., Lough, J. M., et al. (2018). Spatial and temporal patterns of mass bleaching of corals in the anthropocene. Science, 359, 80–83., from doi: 10.1126/science.aan8048

Jackson, J., Donovan, M., Cramer, K., & Lam, V. (2014). Status and Trends of Caribbean Coral Reefs. Gland: Global Coral Reef Monitoring Network; IUCN. https://portals.iucn.org/library/efiles/documents/2014-019.pdf

Keys Schools. (2022). Monroe County School District / Welcome to Our District, Monroe County School District. Retrieved December 15th 2022, from https://www.keysschools.com/domain/10#:~:text=The%20Monroe%20County%20School%20District%20is%20home%20to%208%2C700%20students,%2C%20middle%2C%20and%20lower%20keys.

Knowlton, N. (2001). The future of coral reefs. Proc. Natl. Acad. Sci. United States. 98, 5419–5425., from doi: 10.1073/pnas.091092998

Kuffner, I. B., Lidz, B. H., Hudson, J. H., & Anderson, J. S. (2015). A century of ocean warming on Florida Keys coral reefs: historic in situ observations. Estuar. Coasts 38, 1085–1096., from doi: 10.1007/s12237-014-9875-5

Lee, J. (2021). The Economic Aftermath of Hurricanes Harvey and Irma: The role of federal aid. International Journal of Disaster Risk Reduction 61. https://www.sciencedirect.com/science/article/pii/S2212420921002673#tbl1

Monroe County Commissioners. (2018). Resolution No. 021-2018. Retrieved December 09, 2022, from https://www.monroecounty-fl.gov/DocumentCenter/View/13543/Resolution-021-2018---Northern-Coral-Reef-Tract-protection?bidId=

Monroe County, FL. (n.d.). About Monroe County. Monroe County. https://www.monroecounty-fl.gov/27/About-Monroe-County

Monroe County Tourist Development Council. (2022). Four Penny Revenue Report Fiscal Year 2021 - 2022. Monroe County. Retrieved December 10, 2022, from https://www.monroecounty-fl.gov/DocumentCenter/View/31673/August-2022-4-Penny-Report

Monroe, M. C., Plate, R. R., Oxarart, A., Bowers, A., & Chaves, W. A. (2019). Identifying effective climate change education strategies: a systematic review of the research. Environmental Education Research, 25:6, 791-812., from doi: 10.1080/13504622.2017.1360842

Morris, J. T., Enochs, I. C., Besemer, N., Viehman, T. S., Groves, S. H., Blondeau, J., Ames, C., Towle, E. K., Grove, L. J. W., & Manzello, D. P. (2022). Low net carbonate accretion characterizes Florida's coral reef. Scientific Reports, 12(1)., from https://doi.org/10.1038/s41598-022-23394-4

My Travel Intelligence. (2022). 2020 Monroe County Visitor Volume and Spending. Retrieved November 10, 2022, from https://www.monroecounty-fl.gov/DocumentCenter/View/30094/2020-Monroe-County-Domestic-Visitor-Volume?bidId=

NAAEE. (2013). North American Association for Environmental Education. About EE and Why It Matters. December 08 2013, from https://naaee.org/about/ee.

Nedimyer, K., Gaines, K., & Roach, S. (2011). Coral Tree Nursery©: An innovative approach to growing corals in an ocean-based field nursery. Aquaculture, Aquarium, Conservation and Legislation, 4(4), pp.442-446.

NOAA. (2019). Coral reef ecosystems. National Oceanic and Atmospheric Administration.Retrieved November 19, 2022, from https://www.noaa.gov/education/resource-collections/marine-life/coral-reef-ecosy stems

NOAA. (2021). Florida's Coral Reef Disease Outbreak. Florida Keys National Marine Sanctuary. National Oceanic and Atmospheric Administration. Retrieved November 20, 2022, from https://floridakeys.noaa.gov/coral-disease/

NOAA. (n.d.). Socioeconomics - Florida Keys. National Marine Sanctuaries. National Oceanic and Atmospheric Administration. Retrieved December 9, 2022, from https://sanctuaries.noaa.gov/science/socioeconomic/floridakeys/

NOAA CRCP. (2020). Coral reef condition: A status report for Florida's Coral Reef 2020. CoRIS. National Oceanic and Atmospheric Administration. Retrieved December 9, 2022, from https://www.coris.noaa.gov/monitoring/status_report/docs/FL_508_compliant.pdf

NOAA Fisheries. (2022). How are Fisheries and Coral Reefs Connected? NOAA Fisheries. National Oceanic and Atmospheric Administration. Retrieved December 9, 2022, from https://www.fisheries.noaa.gov/feature-story/how-are-fisheries-and-coral-reefs-connected

Paris Agreement. (2015). Paris Agreement to the United Nations Framework Convention on Climate Change. Dec. 12, 2015, T.I.A.S. No. 16-1104.

Ponto, J. (2015). Understanding and evaluating survey research. Journal of the Advanced Practitioner in Oncology, 6(2), 168–171. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4601897/

Precht, W. F., Bruckner, A. W., Aronson, R. B., & Bruckner, R. J. (2002).
Endangered acroporid corals of the Caribbean. Coral Reefs 21:41–42.

Precht, W. F., Robbart, M. L., & Aronson, R. B. (2004). The potential listing of Acropora species under the US Endangered Species Act. Marine Pollution Bulletin, 49(7-8),pp.534-536.

Precht, W. F. & Miller, S. L. (2007). Ecological shifts along the Florida reef tract: the past as a key to the future. Pages 237–312 in R. B. Aronson, editor. Geological approaches to coral reef ecology. Springer, New York, New York, USA.

Precht, W. F., Gintert B. E., Robbart, M. L., Fura, R., & Woesik, R. (2016). Unprecedented disease-related coral mortality in southeastern Florida. Scientific Reports 6: e31374. https://doi.org/10.1038/srep31374

Precht, W. F., Modys, A., & Patterson, M. (2022). Bio-Engineered Reef Restoration Programs are Vital in Southeast Florida Under Increasing Impacts and Threats of Global Climate Change.

Reguero, B. G., Storlazzi, C. D., Gibbs, A. E., Shope, J. B., Cole, A. D., Cumming, K. A., & Beck, M. W. (2021). The value of United States coral reefs for flood risk reduction. Nature Sustainability, 4, 688–698., from https://doi.org/10.1038/s41893-021-00706-6

Rockyport Analytics. (2018). 2018 Tourism in the Florida Keys and Key West: Stable Growth Despite Challenging Times. Retrieved November 19, 2022, from MonroeCounty.gov

Rockport Analytics. (2022). 2019 Tourism in the Florida Keys and Key West: A Record Year for Visitor Impact. Retrieved December 10, 2022, from https://www.monroecounty-fl.gov/DocumentCenter/View/31535/2019-Economic-Impact-of-Tourism-in-The-Florida-Keys-

Runkle, J., Kunkel, K. E. S. M., Champion, R., Frankson, B. C., Sweet, S. W., & S. Rayne. (2022). Florida State Climate Summary 2022. NOAA Technical Report NESDIS 150-FL. NOAA/NESDIS, Silver Spring, MD, 5 pp.

Ryfield, F., Cabana, D., Brannigan, J., & Crowe, T. (2019). Conceptualizing 'sense of place' in cultural ecosystem services: A framework for interdisciplinary research. Ecosystem Services, 36, 100907., from https://doi.org/10.1016/j.ecoser.2019.100907

Schwarzmann, D., Freitag, A., Dorfman, D., Records, D., & Walz, M. (2022). Updating the florida keys national marine sanctuary management plan: Estimating the impact to commercial fishing in Monroe County, Florida. Water, 14(3), 290., from https://doi.org/10.3390/w14030290

Shinn, E. A., Steinen, R. P., Lidz, B. H., & Swart, P. K. (1989). Whitings, a sedimentologic dilemma: perspectives. J. Sediment. Res. 59., from doi: 10.1306/212F8F3A-2B24-11D7-8648000102C1865D

Smithsonian Ocean Portal. (n.d.). Coral and Coral Reefs. Ocean. Smithsonian. Retrieved November 19, 2022, from https://ocean.si.edu/ocean-life/invertebrates/corals-and-coral-reefs

South Atlantic Fishery Management Council. (2022). Lobster, Spiny. South Atlantic Fishery Management Council. Retrieved December 10, 2022, from https://safmc.net/species/lobster-spiny/

Southeast Regional Office, P. R. D. (2015). Recovery Plan for Elkhorn (Acropora palmata) and Staghorn (A. cervicornis) Corals. Retrieved December 10, 2022, from http://data.nodc.noaa.gov/coris/library/NOAA/CRCP/project/2160/final_acropora_recovery_plan.pdf (accessed December 10, 2022)

Spalding, M. D. & Grenfell, A. M. (1997). New estimates of global and regional coral reef areas. Coral Reefs, 16(4), 225–230., from https://doi.org/10.1007/s003380050078

Sustainable Development Goals. (2015). No. 1-17.

Thomas, R., Teel, T., Bruyere, B., & Laurence, S. (2019). Metrics and outcomes of conservation education: a quarter century of lessons learned, Environmental Education Research, 25:2, 172-192., from doi: 10.1080/13504622.2018.1450849

Toth, L. T., Stathakopoulos, A., Kuffner, I. B., Ruzicka, R. R., Colella, M. A., & Shinn, E. A. (2019). The unprecedented loss of Florida's reef-building corals and the emergence of a novel coral-reef assemblage. Ecology, 100(9)., from https://doi.org/10.1002/ecy.2781

Toth, L. T., Courtney, T. A., Colella, M. A., Kupfner Johnson, S. A., & Ruzicka, R. R. (2022). The past, present, and future of coral reef growth in the Florida Keys. Global Change Biology, 28(17), 5294–5309., from https://doi.org/10.1111/gcb.16295

UNESCO. (2018). Changing Minds, Not the Climate: The Role of Education. The United Nations Educational, Scientific and Cultural Organization. Retrieved December 5th, 2022, from https://www.gcedclearinghouse.org/sites/default/files/resources/190248eng.pdf

UnitedForALICE. (2020). Florida | UnitedForALICE. United For ALICE. Retrieved December 8, 2022, from https://www.unitedforalice.org/Florida

US Census. (2021). Monroe County, Florida - QuickFacts. United States Census Bureau. Retrieved December 8, 2022, from https://www.census.gov/quickfacts/fact/table/monroecountyflorida/IPE120221

USDE. (2018). Improving Basic Programs Operated by Local Educational Agencies (Title I, Part A). United States Department of Education (ED), 7 Nov. 2018, from https://www2.ed.gov/programs/titleiparta/index.html.

USCB. (2020). United States. United States Census Bureau QuickFacts: United States. Retrieved December 8, 2022, from https://www.census.gov/quickfacts/fact/table/US#

USDE. (2022). Fiscal Year 2021 Budget Summary. United States Department of Education, from https://www2.ed.gov/about/overview/budget/budget21/summary/21summary.pdf.

USFWS. (2014). Endangered and Threatened Wildlife and Plants; Adding 20 Coral Species to the List of Endangered and Threatened Wildlife. United States Fish and Wildlife Service. Federal Register., from https://www.federalregister.gov/documents/2014/11/13/2014-26893/endangered-and-threatened-wildlife-and-plants-adding-20-coral-species-to-the-list-of-endangered-and

USNPS. (n.d.). Dry Tortugas National Park. United States National Park Service. Retrieved December 16, 2022, from https://www.nps.gov/drto/index.htm

Walton, C., Hayes, N. K., & Gilliam, D. S. (2018). Impacts of a regional, multi-year, multi-species coral disease outbreak in southeast Florida. Front. Mar. Sci. 5:323. doi: 10.3389/fmars.2018.00323

Ware, M., Garfield, E. N., Nedimyer, K., Levy, J., Kaufman, L., Precht, W. F., Winters, R. S., & Miller, S. L. (2020). Survivorship and growth in staghorn coral (Acropora cervicornis) outplanting projects in the Florida Keys National Marine Sanctuary. PLoS One, 15(5), p.e0231817.

Williams, D. & Miller, M. (2012). Attributing mortality among drivers of population decline in acropora palmata in the Florida Keys (United States). Coral Reefs 31, 369–382. from doi: 10.1007/s00338-011-0847-y

Woodhead, A. J., Hicks, C. C., Norström, A. V., Williams, G. J., & Graham, N. A. J. (2019). Coral reef ecosystem services in the Anthropocene. Functional Ecology. from https://doi.org/10.1111/1365-2435.13331

Yates, K. K., Zawada, D. G., Smiley, N. A., & Tiling-Range, G. (2017). Divergence of seafloor elevation and sea level rise in coral reef ecosystems. Biogeosciences, 14, 1739–1772.

Appendices

Appendix A-E

Appendix A: Stakeholder Interview Transcripts

Interview A: Fishery Stakeholder	
Questions	**Responses**
Impact on stakeholder	Little change to quantity or variety of catch over recent years, though both fishing boat demand and wholesale fish demand is up. I've had to go further out to fish. The process to prepare for catching fish takes a lot of preparation: loading the ice, fuel, putting a crew together, harvesting a catch, processing it. Some boats are out in the morning, others in the afternoon/evening, and others are out from sunrise to sunset. The catch is for wholesale and retail. There are only a few boats that are owned directly, and many outsource fishing to other independent fishermen.
Are there any local regulations/laws that either enable you or hinder your fishing operations?	The lack of law enforcement has been hindering their fishing operations. Noticing that recreational fishing has a lot less accountability. People take multi-million-dollar boats out and catch whatever they want even if it's out of season. At worst they get fined but there isn't much enforcement around their catch. On the commercial side, this is their livelihood, and they don't want to risk losing their licenses so they must abide by

Are there any local regulations/laws that either enable you or hinder your fishing operations?	the regulations around fishing and only take what is in season. The commercial boats have to report what they catch, where they have been etc. There are federal observers watching them and some boats have monitoring systems on them as well. I've also noticed that apex predators are more abundant so there is naturally more competition for the fish. This is due to laws that are protecting predators which have increased their population. Ie: sharks, groupers
Knowledge of coral reefs	Know of it but don't think of it too often.
Knowledge/involvement with Coral Restoration Foundation (CRF)	Heard of the name but don't really follow them. A lot of other countries have artificial reef habitats which might be helpful in leading to less people throwing anchors onto reefs. The artificial reef will create somewhere else where the fish can congregate,congregate, and boats can go there to fish instead.

Interview B: Fishery Stakeholder	
Questions	**Responses**
Impact on stakeholder	Coral Reefs are vital. It's a main habitat that attracts different fish species. Catch is cyclical and moves up and down. There are some good years, and some are less than desirable. Cyclical over time.
Knowledge of coral reefs	Very well - I sit on the Sanctuary Advisory Council. Water in the Keys flows south leading to the reefs on the south side of the islands getting hammered.
Knowledge/involvement with Coral Restoration Foundation (CRF)	Yes, I know people at CRF, familiar with them through my work with the Sanctuary Advisory Council.
Recommendations/suggestions for CRF	There was a lot of education work in the Key Largo area, middle Keys and lower Keys back in the day. Don't know where things are now. Need to get educational messages out. Knows that it is hard to balance the various stakeholder interests. Seems like people don't want to look at the major overarching factors and go for smaller bites instead. Things like improving water quality would help e.g., have the counties in the North clean up their waters and put in [better] sewage systems. Some parts don't have sewage systems or crumbling infrastructure and directly impact the waters around the reefs.

Interview C: Hotel Stakeholder	
Questions	**Responses**
Impact on stakeholder	I own the resort and have been running it for over 3 decades. Coral reefs don't directly impact us, and we don't have dive shops, but people who come to dive and see the reefs stay with us and can see that the reefs have changed over the years. Don't partner with dive shops, but have a few we recommend and list on our website
Knowledge of coral reefs	Not much
Awareness of climate change impacts on coral reefs	Haven't thought about it too much, but logistical things like flood risk impacting 2 of my cottages. Thankfully they are on a high point in Key Largo and the rest of my units are not at risk. Recent storms have impacted the area, 2 storms back-to-back hitting the same spots. We've taken in people that were affected, housing them in 5-6 of our units.
Opinion on ideal coral reef situation	It's crazy that the government does not believe in climate change and is not doing anything to help.

Current involvement with coral reef restoration	No nonprofits have partnered with us directly, but I do donate to some. Haven't had the time to think about partnering/getting more involved.
Interest in increasing involvement in coral reef restoration	Open to it but have not had the bandwidth to think about it much so far. Clients seem to have more awareness of climate change and its impacts nowadays though. Remember a guest family that was very interested in coral restoration, and I recommended a few dive shops that were involved with that.
Knowledge/involvement with Coral Restoration Foundation (CRF)	Have heard of CRF, but not involved with them at all. However, I would be open to exploring how I can help in my own capacity. My resort is very small however and doesn't have meeting rooms etc. just hotel units.

Interview D: Dive Shop Stakeholder	
Questions	**Responses**
Impact on stakeholder	Bring tourists on to dives. The healthier the reef, the more fun the experience is. Generally, the folks who are out on these trips appreciate and are open to learning more about the reefs.
Knowledge of coral reefs	Most of Florida is nothing like the Keys - it's like the Caribbean. The Keys is the only place like it where you can drive from the mainland. Having the barrier reef is what drives all the tourism. People come from all over the US to visit.
Awareness of climate change impacts on coral reefs	I've noticed a lot more coral bleaching and algae covered rubble.
Opinion on ideal coral reef situation	Recreational fishing is under-regulated and a bigger threat than commercial fishing. No reporting is required on catches. Nothing currently enforcing what is being caught by recreational fishing - the Florida Wildlife Fishing Commission is understaffed. No way to check the boats that are out fishing. Out of towners/people who don't know the area well are renting boats and might not know the terrain and drive boats into shallow areas. There is a 2-day mini-season for lobster that is 100% recreational. This is probably the most detrimental thing to the Keys. Also, no boating education is required - just need a credit card.

Opinion on ideal coral reef situation	On the other hand, commercial fishing is strict, and licenses are hard to come by. Everything caught is reported to the State and NOAA, and once a license is lost, it cannot be regained. They are not giving out any more commercial licenses.
Current involvement with coral reef restoration	Not involved.
Knowledge/involvement with Coral Restoration Foundation (CRF)	Yes, heard of CRF and seen them in some areas. [They are] pretty cool. Any amount of education is good, but sensationalized things are "cringe". Definitely a good and bad way to do it.
Recommendations/suggestions for CRF	Current notices/education to recreational fisherman are not working: Notices of what can be fished are posted where licenses are sold, bait shops, phone apps. People don't care to review. Need better methods.

Interview E: Dive Shop Stakeholder	
Questions	**Responses**
Impact on stakeholder	Main thing is visibility and sea conditions that determine where they go - not so much what they're going to see. Often only 2-3 spots are visible, and sometimes if the weather isn't good there is only 1 spot, and every shop goes there, so damage can be concentrated. Feel that even if corals all die out, business can still be viable due to other structures that can harbor fish life e.g., caves, wrecks - people will dive anyway. But snorkeling may be much more severely impacted. Haven't affected the clientele yet, a lot of them are new divers, just certified. Wouldn't know the difference between a dead coral and live coral. That said, they also have regular customers that come every week (locals) that comment on coral growth. Some of them have gotten involved with CRF as well.
Knowledge of coral reefs	Decent amount
Awareness of climate change impacts on coral reefs	Hard corals are very few and far between, now mostly soft corals. But I haven't seen too much difference in fish quantity - there are so many dive sites that people spread out across, but most shops choose locations based on protection for divers (from winds etc.)

Awareness of climate change impacts on coral reefs	There's some coral disease - have seen hard coral on the reef die off but have to know what it looks like before or in a healthier place to see the difference.
Opinion on ideal coral reef situation	Would like the water quality to be improved - a lot of waste ends up in water. Keys has a sewage treatment plant that treats before it goes into the sea, but most of the rest of Florida doesn't do that. Ships have to go 15 miles offshore, can't get closer, boats pumping sewage is a problem - if they get caught, there would be serious consequences, but there are so many boats and the coast guard is limited, hence the lack of enforcement. People who use the reefs are not just divers/snorkelers but also recreational fishers and boaters - amount of private traffic - anchors where they shouldn't be rudders etc. they are a clear and present menace to the health of the reef and enjoyment of people. There's a protected area - marine sanctuary just updating their regulations - meetings they've been going to; main issues are law enforcement - strategy seems to block off more areas but not adding anyone to enforce (no enforcement whatsoever).
Current involvement with coral reef restoration	I know of Water Keeper and Surf Rider (water quality work), but those are more active in Miami, though there has been some recent work in the Keys - they will notify them sometimes when fecal/bacterial matter is too high in certain areas.

Knowledge/involvement with Coral Restoration Foundation (CRF)	Little at the moment, but open to discussing options.
Recommendations/suggestions for CRF	Know that CRF is out there talking to schools and doing stuff, but there could be a lot more outreach happening - not sure how though, but don't see much on social media from them. Used to get 5 email newsletters from them a week, but unsubscribed because it was too much. In Marathon, FL there is a turtle hospital - they do an amazing job. Would be great to have a tourist attraction like that that doesn't involve getting onto a boat. That said, turtles are charismatic creatures - eyes, smiles etc. while corals aren't. Part of it could be a visitor's experience (though CRF might already have something, but they haven't personally been to it if so). Would be nice if CRF, Mote, I.CARE etc. could work together more, as it is a little confusing to the general public with them being all in the same category. Ideal situation would probably be more ongoing engagement - not just plant once and never hear/see of them again.

Appendix B: Survey Materials

Coral Restoration Foundation (CRF) Survey Implementation Guide

Instructions

Please use the following survey links and slides for the CRF General Presentation program on 11/10/22:

1) Insert "Start of Program Survey" slide at the beginning of your slide show
2) Insert "End of Program Survey" slide at the end of your slide show

Once students are seated for the program, explain that CRF is conducting a study to gauge students' interest in and understanding of coral reef restoration. Please ask students to take 2 minutes at the presentation's start to complete the Start of Program Survey and do the same for the End of Program Survey.

Script for Start of Program Survey:

> "We'd like to kick off today's session with a survey. Please scan the QR code or enter the URL listed on this slide. It should only take 3-4 minutes to complete!"
>
> ***After a few minutes have passed*** "We'd love to get started as soon as possible. Does anyone need a bit more time to complete the survey?" If yes, give them another minute or two before proceeding. If not, "Great, thanks so much for completing this survey. Your feedback is important in helping us understand how to improve our program." ***Proceed with the presentation.***

Script for End of Program Survey:

> "We'd like to end this presentation with another short survey. Please scan the QR code or enter the URL listed on this slide. This one should only take 3-4 minutes to complete as well!"
>
> ***After a few minutes have passed*** "Does anyone need a bit more time to complete the survey?" If yes, give them another minute or two before proceeding. If not, "Great, thanks so much for completing this second survey, we hope you've had a great time and look forward to seeing some of you again." ***End***

Completed Slides (To insert at Start and Finish of presentation)

Start of Program Survey Slide:

- Start of Program Survey Slide

End of Program Survey Slide:

- End of Program Survey Slide

Survey Links (for internal reference)

Start of Program Survey (~3 minutes):

- TBD SURVEYMONKEY/GOOGLE LINK 1
- TBD SURVEYMONKEY/GOOGLE BITLY LINK 1
- TBD QR CODE 1

End of Program Survey (~4 minutes):

- TBD SURVEYMONKEY/GOOGLE LINK 2
- TBD SURVEYMONKEY/GOOGLE BITLY LINK 2
- TBD QR CODE 2

Pre- and Post- Survey Questions

Start of Program Survey

1. What is the current state of the Florida Keys Reef Tract? *(Education)*
    - 1- The reef is thriving.
    - 2 - The reef is naturally declining.
    - 3 - The reef is threatened but I don't know why.
    - 4 - The reef is threatened, and I know why.
    - 5 - The reef is collapsing.
2. I understand how I can help support coral restoration. *(Education)*
    - 1-5 (Strongly Agree to Strongly Disagree)
3. I feel excited to engage with coral restoration efforts. *(Enthusiasm)*
    - 1-5 (Strongly Agree to Strongly Disagree)
4. I'm interested in volunteering with the Coral Restoration Foundation. *(Enrollment)*
    - 1-5 (Strongly Agree to Strongly Disagree)

End of Program Survey

1. What is the current state of the Florida Keys Reef Tract? *(Education)*
    - 1- The reef is thriving.
    - 2 - The reef is naturally declining.
    - 3 - The reef is threatened but I don't know why.

    - 4 - The reef is threatened, and I know why.
    - 5 - The reef is collapsing.
2. I understand how I can help support coral restoration. *(Education)*
    - 1-5 (Strongly Agree to Strongly Disagree)
3. I feel excited to engage with coral restoration efforts. *(Enthusiasm)*
    - 1-5 (Strongly Agree to Strongly Disagree)
4. I'm interested in volunteering with the Coral Restoration Foundation. *(Enrollment)*
    - 1-5 (Strongly Agree to Strongly Disagree)
5. Do you want to share what you learned today with your friends and family? *(Emergence)*
    - 1 - No - I do not want to share what I learned today.
    - 2 - Maybe - I think I need more information first.
    - 3 - Yes - My friends and family would love to learn more about saving the coral reefs!

Survey Consent Form for Non-Adult Participants

COLUMBIA CLIMATE SCHOOL
THE EARTH INSTITUTE

Columbia Climate School x Coral Restoration Foundation (2022)
Survey Participation - Permission Form

Your son/daughter will be participating in a virtual presentation conducted by the Coral Restoration Foundation. There will be a short survey before and after the presentation to gather student feedback. Please note there will be no personal information or personal identifiers throughout the surveys. The surveys being conducted are anonymous and students non-identified ensuring confidentiality. These surveys will be used to evaluate the efficacy of the presentation.

In order to use the anonymous survey results, we need parent or legal guardian permission, or if the participant is a legal adult (18 or over), they can sign the consent form themselves.

Below is a permission form. Please sign and return it to _____ as soon as possible. If you have questions, please email _____

- -

Survey Participation Consent

I CONSENT to participating in a pre and post presentation survey issued by Coral Restoration Foundation and the Columbia Climate School. I understand and agree that I will not be compensated in any way for the use of my survey responses.

If the person who is being surveyed is under age 18, his/her parent or guardian must sign below instead.

Son/Daughter/Participant Name. . . . . .

Signed. . . . . Date. . . . . .
(Parent/Legal Guardian/Participant if 18 years or older)

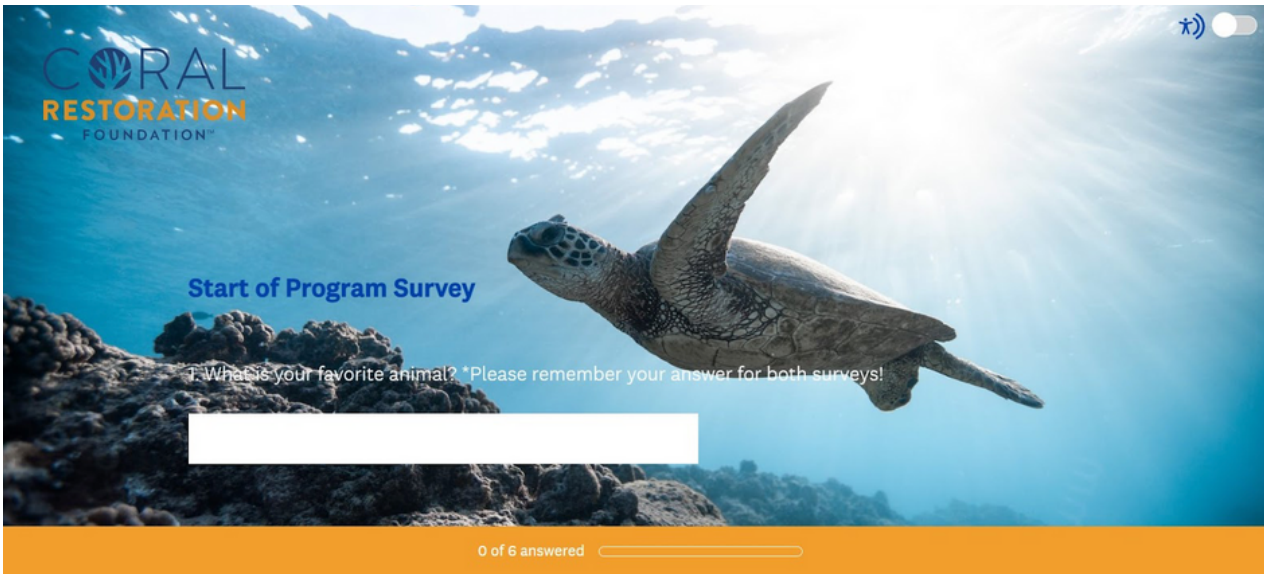
Site Location for the Event: _____

Description: 2022 Columbia Climate School x Coral Restoration Foundation Presentation Survey

Pilot CRF Edutainment Workshop Surveys

Start of Program Survey

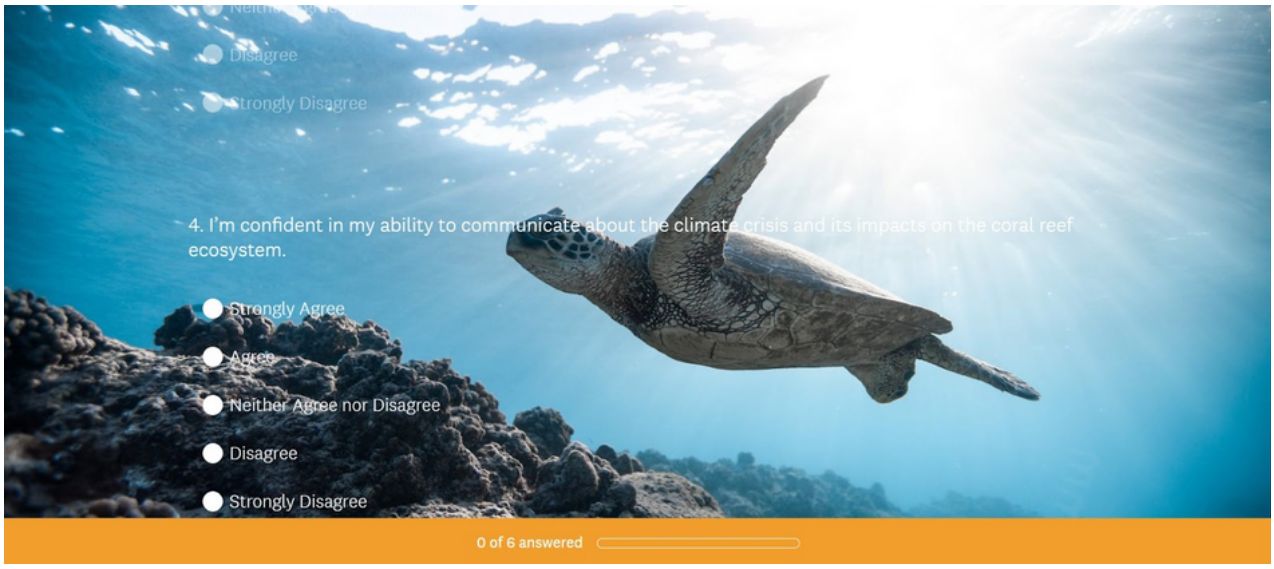
Question 1. What is your favorite animal? *remember your answer for both surveys!



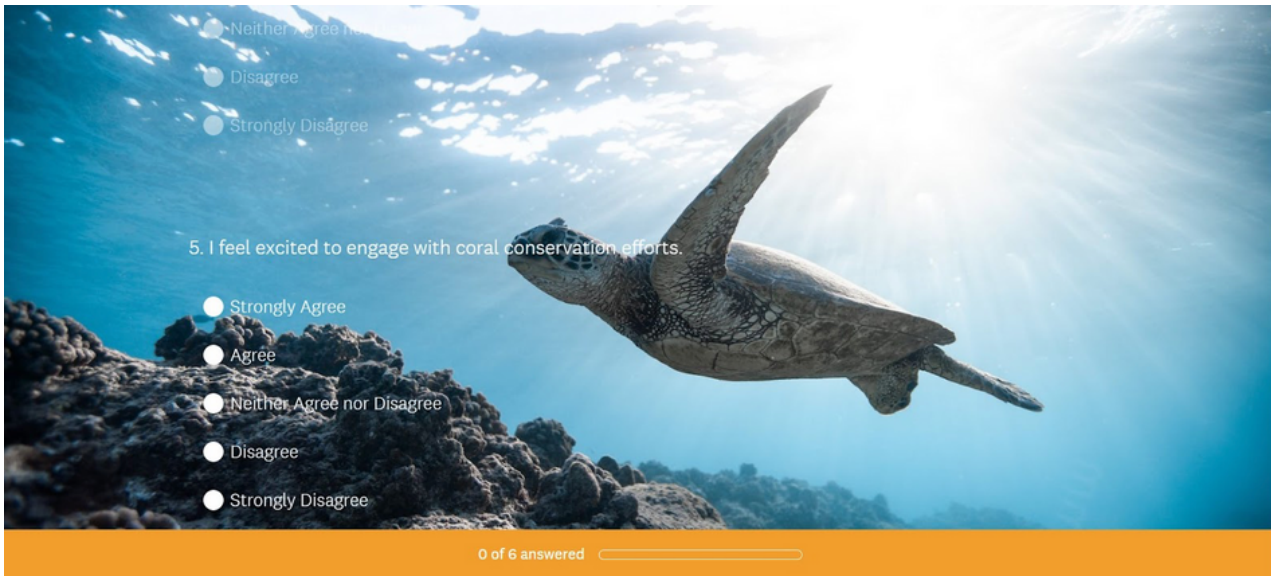
Question 2. What is the current state of the Florida Keys Reef Tract?

Question 3. I understand the impact of climate change on coral reefs.

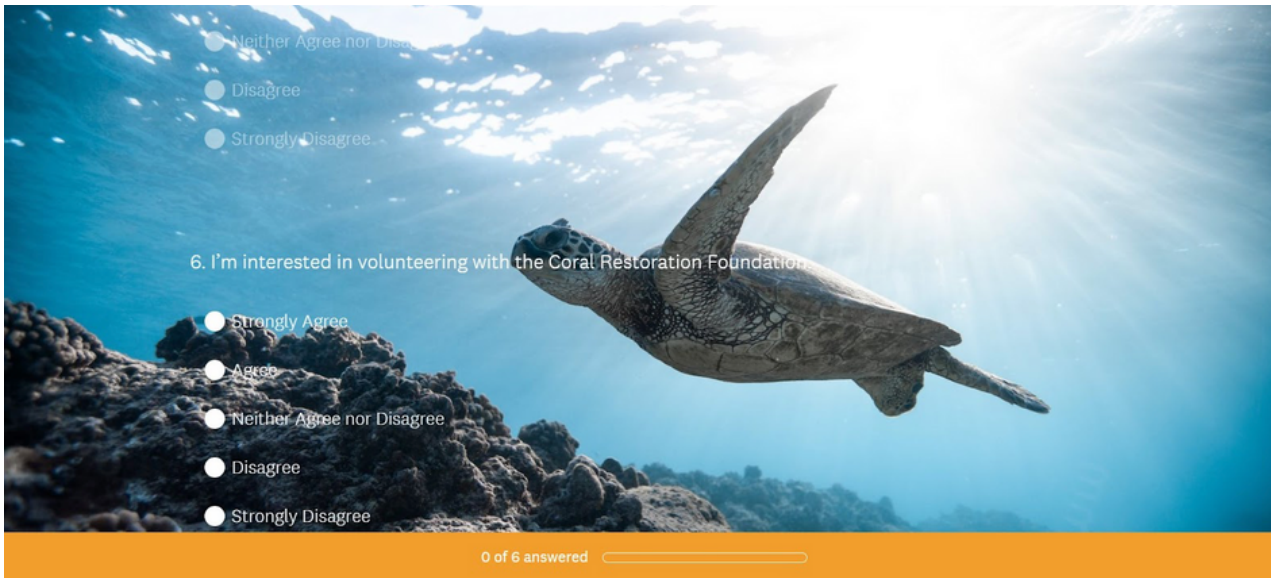
Question 4. I'm confident in my ability to communicate about the climate crisis and its impacts on the coral reef ecosystem.



Question 5. I feel inspired to engage with coral conservation efforts.



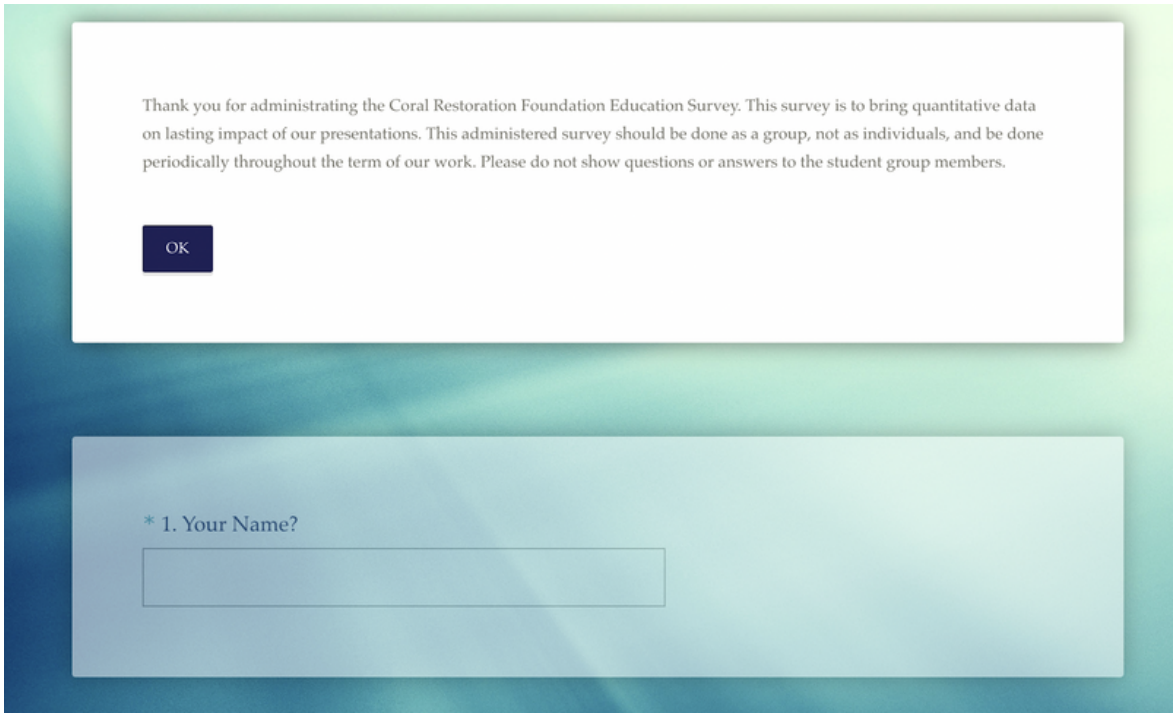
Question 6. I'm interested in volunteering with the Coral Restoration Foundation.

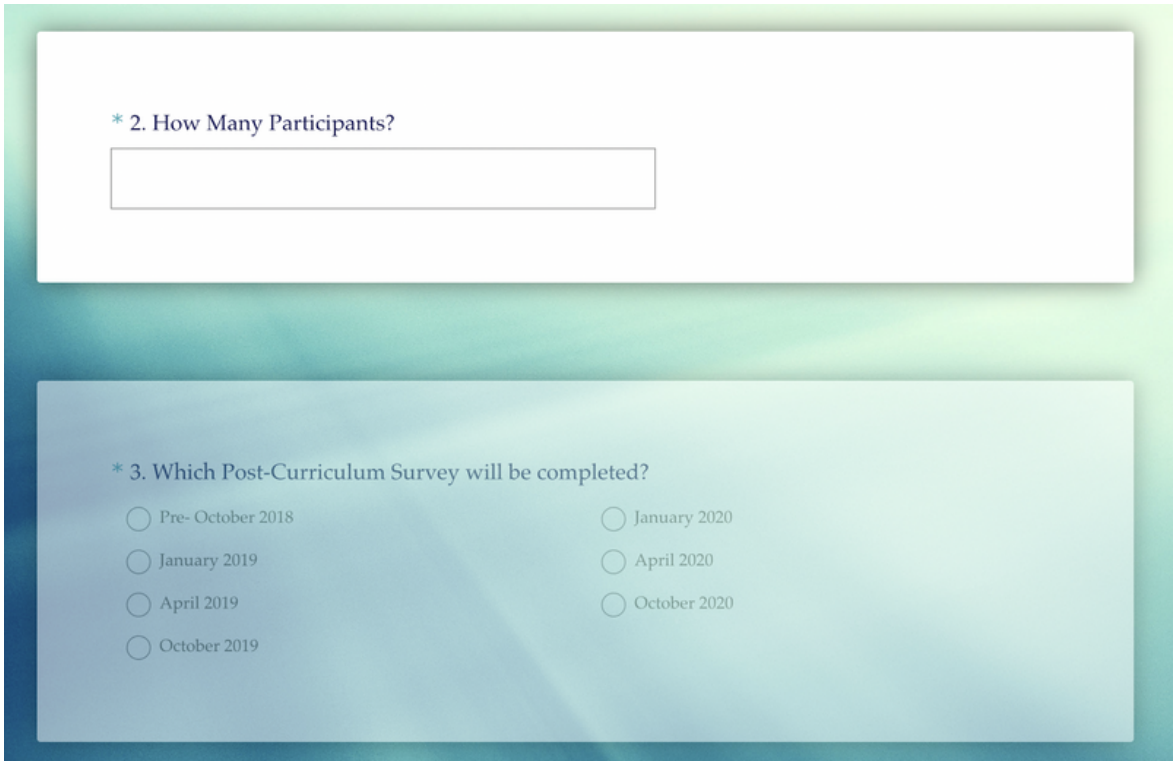


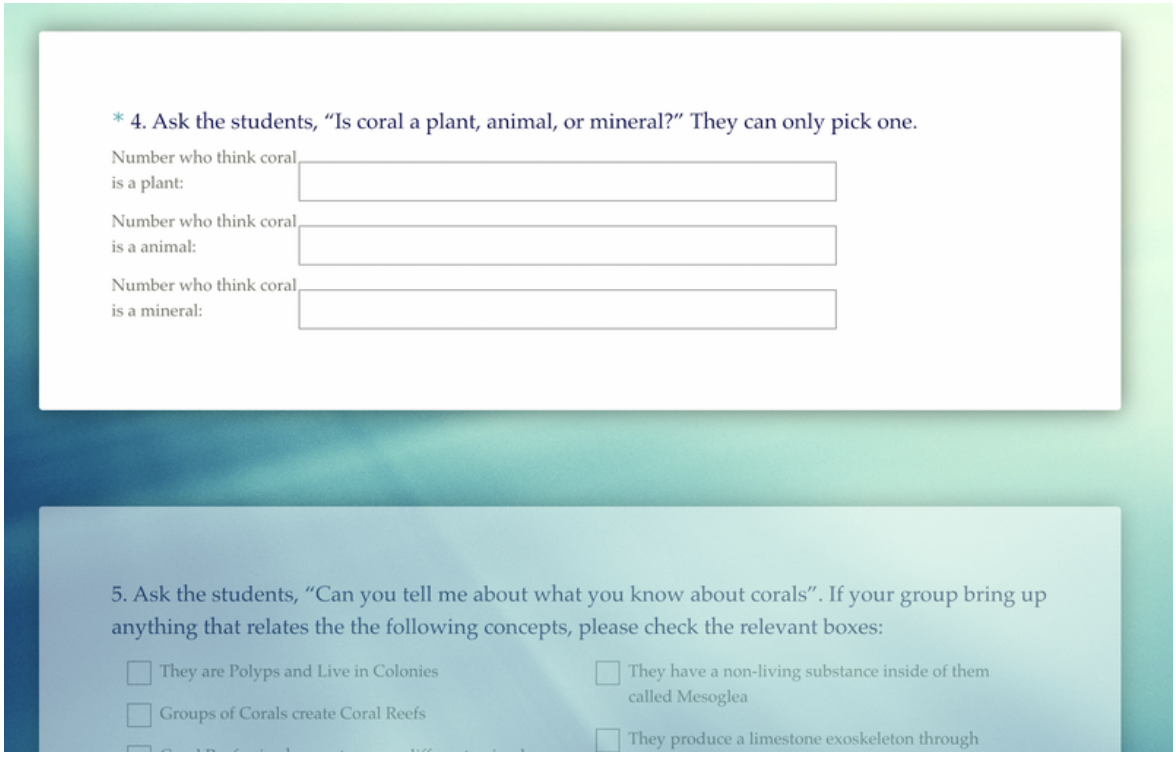
End of Program Survey

Question 7. I'm excited to share what I've learned today with my friends and family!

Previous CRF Edutainment Workshop Survey







* 4. Ask the students, "Is coral a plant, animal, or mineral?" They can only pick one.

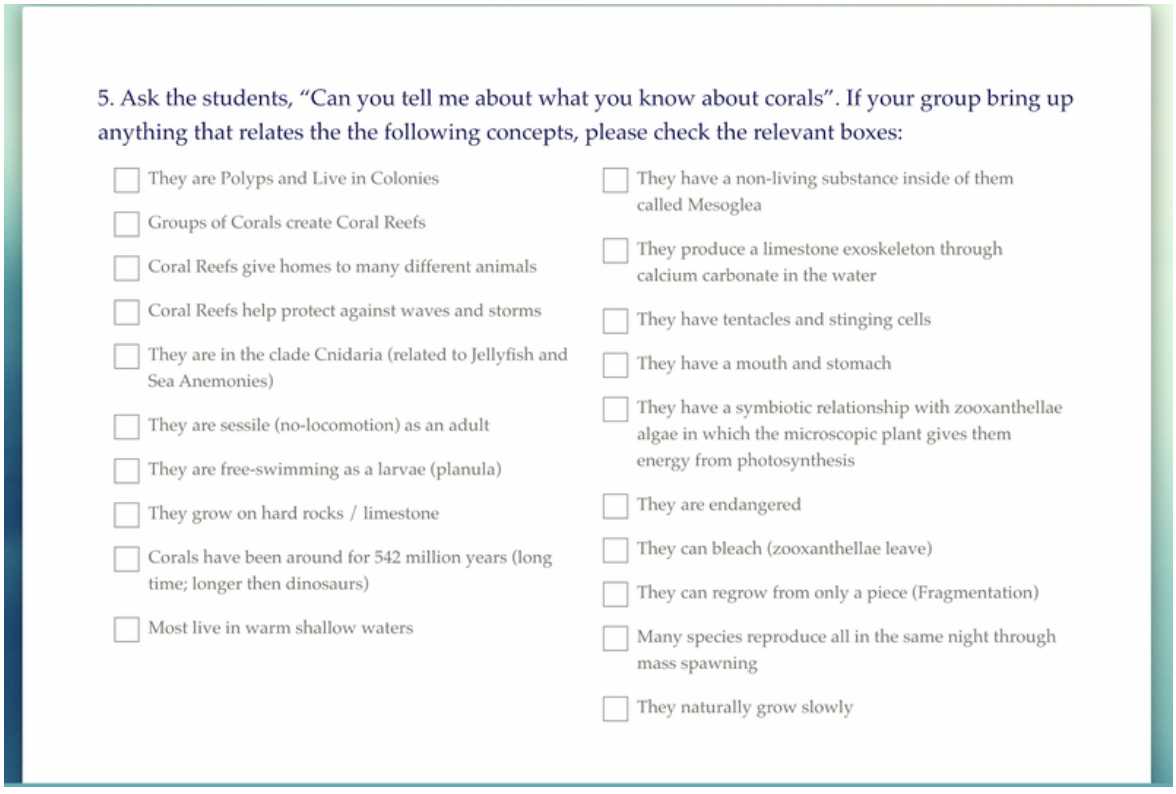
Number who think coral is a plant:

Number who think coral is a animal:

Number who think coral is a mineral:

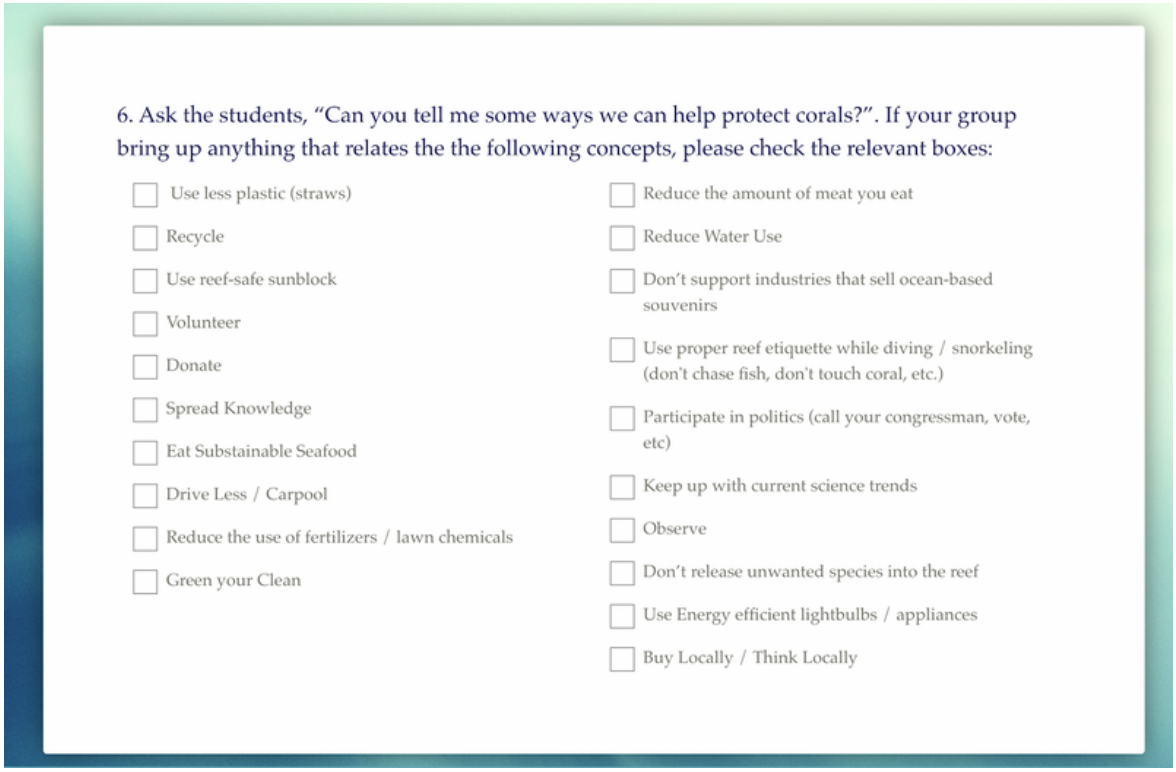
5. Ask the students, "Can you tell me about what you know about corals". If your group bring up anything that relates the the following concepts, please check the relevant boxes:

- They are Polyps and Live in Colonies
- Groups of Corals create Coral Reefs
- They have a non-living substance inside of them called Mesoglea
- They produce a limestone exoskeleton through



5. Ask the students, "Can you tell me about what you know about corals". If your group bring up anything that relates the the following concepts, please check the relevant boxes:

- They are Polyps and Live in Colonies
- Groups of Corals create Coral Reefs
- Coral Reefs give homes to many different animals
- Coral Reefs help protect against waves and storms
- They are in the clade Cnidaria (related to Jellyfish and Sea Anemonies)
- They are sessile (no-locomotion) as an adult
- They are free-swimming as a larvae (planula)
- They grow on hard rocks / limestone
- Corals have been around for 542 million years (long time; longer then dinosaurs)
- Most live in warm shallow waters
- They have a non-living substance inside of them called Mesoglea
- They produce a limestone exoskeleton through calcium carbonate in the water
- They have tentacles and stinging cells
- They have a mouth and stomach
- They have a symbiotic relationship with zooxanthellae algae in which the microscopic plant gives them energy from photosynthesis
- They are endangered
- They can bleach (zooxanthellae leave)
- They can regrow from only a piece (Fragmentation)
- Many species reproduce all in the same night through mass spawning
- They naturally grow slowly



6. Ask the students, "Can you tell me some ways we can help protect corals?". If your group bring up anything that relates the the following concepts, please check the relevant boxes:

- ☐ Use less plastic (straws)
- ☐ Recycle
- ☐ Use reef-safe sunblock
- ☐ Volunteer
- ☐ Donate
- ☐ Spread Knowledge
- ☐ Eat Substainable Seafood
- ☐ Drive Less / Carpool
- ☐ Reduce the use of fertilizers / lawn chemicals
- ☐ Green your Clean
- ☐ Reduce the amount of meat you eat
- ☐ Reduce Water Use
- ☐ Don't support industries that sell ocean-based souvenirs
- ☐ Use proper reef etiquette while diving / snorkeling (don't chase fish, don't touch coral, etc.)
- ☐ Participate in politics (call your congressman, vote, etc)
- ☐ Keep up with current science trends
- ☐ Observe
- ☐ Don't release unwanted species into the reef
- ☐ Use Energy efficient lightbulbs / appliances
- ☐ Buy Locally / Think Locally

Appendix C: Gap Analysis Rubric

Table 9. Rubric for Evaluating the Efficacy of the Educational Programs for CRF

Criteria	Exceeds Industry Recommended Standard	Meets Industry Recommended Standard	Needs Marginal Improvement	Fails to Meet Recommended Standard	Unknown/ Insufficient Data
Science and Misconceptions	5	4	3	2	1
Contributes to science accessibility					
Science-based curriculum and scientist-led					
Addresses common misconceptions					
Contributes to community support and collaboration for science					
Content/ Engagement					
High retention and Accessibility rates					
Positive cognitive and behavioral change					
Active classroom discussions					

High accessibility to demographic reach					
Community Impact					
Capacity building and stewardship					
Ecosystem, ecotourism, and economic benefits					
Enhances reef user satisfaction					
Contributes to ecological reef restoration					

Appendix D: Subregion Data Filters

This chart represents the specific data filters used to subset the NCRMP data to focus on coral coverage specific to Monroe County (Morris et al., 2022).

Monroe County Subregion	**NCRMP Subregion Data Filters**
Lower Keys	“Lower Keys”
Middle Keys	“Middle Keys” “Mid-Upper Keys Transition”
Upper Keys	“Upper Keys”
Marquesas Keys	“Marquesas”“Marquesas–Tortugas Trans”
Dry Tortugas	“Tortugas–Dry Tortugas NP”“Tortugas–Tortugas Bank”“Tortugas–Unmapped”

It is important to note that for the subregion titled, “Tortugas—Unmapped” there was no 2016 data and for subregions titled, “Marquesas—Tortugas Trans” and “Marquesas,” there was no 2018 data.

Appendix E: Columbia University IRB Forms

Standard Social/Behavior Science Format

Columbia University Informed Consent Document

[Title of Study]

Investigator: , Department

Telephone:

Investigators' statement

We are asking you to be in a research study [Sponsored by…]. The purpose of this consent form is to give you the information you will need to help you decide whether or not to be in the study. Please read the form carefully. You may ask questions about the purpose of the research, what we would ask you to do, the possible risks and benefits, your rights as a volunteer, and anything else about the research or this form that is not clear. When all your questions have been answered, you can decide if you want to be in the study or not. This process is called 'informed consent.'

PURPOSE

[State that this is a research activity. Describe the purpose of the activity.]

BENEFITS

[Describe the expected benefits to individual subjects and/or society. If there are no personal benefits, so state.]

PROCEDURES

[Describe the procedures involved. Include the commitment of time for each, the total amount of time involved, and how long the study will last. As appropriate, specify size of samples to be taken and names and doses of substances to be given. Describe questionnaires and interviews and describe or provide examples of the most personal and sensitive questions. State that subjects may refuse to answer any question or item in any test, inventory, questionnaire, or

interview. Include the use of medical, academic, or other records, photographs, audio or visual recordings.]

RISKS, STRESS, OR DISCOMFORT

[Include information on the risks, including side effects, stress, discomforts, or the invasion of privacy which might result from each procedure.]

OTHER INFORMATION

[State whether data will be confidential (linked to identifiers) or anonymous (no links). If data will be linked to identifiers, please state who will have access to identifiable data. Describe how the data will be used and how long they will be retained. State that subjects may refuse to participate or may withdraw from the study at any time without penalty or loss of benefits to which they are otherwise entitled. Include a description of inducements (money, service, course credit) subjects may receive for participation.]

PARTICIPATION

Participation in research is entirely voluntary. You may refuse to participate or withdraw from participation at any time without jeopardizing your employment, student status or any other entitlements. The investigator may withdraw you at his/her professional discretion.

ALTERNATIVES TO PARTICIPATION

Generally there are no alternatives to participation in social and behavioral sciences research other than choosing not to participate, as most of the research is non-therapeutic in nature. If, however, the study involves an experimental treatment or therapy or program for which there are standard therapies, treatments or programs, these should be noted here with contact information so that participants are aware of these options. If no alternatives other than non participation are available to participants, this should be stated here.

PRIVATE INFORMATION

Any information derived from this research project that personally identifies you will not be voluntarily released or disclosed without your separate consent, except as specifically required by law.

CONTACT INFORMATION

If at any time you have questions regarding the research or your participation, you should contact the investigator, name, who will answer all questions. His/Her telephone number is (xxx)

xxx-xxxx. You should also contact the investigator or a member of the research staff if you have any concerns or complaints about the research.

If at any time you have comments regarding the conduct of this research or questions about your rights as a research participant, you should contact the Institutional Review Board (IRB) Administrator at (212) 851-7040.

PARTICIPANT'S STATEMENT

I have read the above purpose of the study, and understand my role in participating in the research. I volunteer to take part in this research. I have had a chance to ask questions. If I have questions later, about the research, I can ask the investigator listed above. I understand that I may refuse to participate or withdraw from participation at any time without jeopardizing my employment, student status or other rights to which I am entitled. The investigator may withdraw me at his/her professional discretion. If I have questions about my rights as a research participant, I can call the Institutional Review Board office at (212) 851-7040. I certify that I am 18 years of age or older and freely give my consent to participate in this study. I will receive a copy of this document for my records.

Subject's signature/consent: _____Date: _____

Name: _____

INVESTIGATOR'S STATEMENT

I have discussed the proposed research with this participant, and in my opinion, the participant understands the benefits, risks and alternatives (including non-participation) and is capable of freely consenting to participate in the research.

Signature _____ Date: _____

Member of the Research Team

Print Name: _____

Standard Social/Behavior Science Format

Sample Children's Assent Form

We are doing a study to try to learn about people who tell the truth and people who lie. We are asking you to help because we don't know very much about whether kids your age expect people

to lie or tell the truth. If you agree to be in our study, we are going to ask you some questions about people. We will want to know if you think they usually tell the truth or if they usually lie. For example, you will be asked if a politician, teacher, parent, or other people usually lie or tell the truth.

You can ask questions at any time that you might have about this study. Also, if you decide at any time not to finish, you may stop whenever you want. Remember that these questions are only about what you think. There are no right or wrong answers because this is not a test.

Signing this paper means that you have read this or had it read to you and that you want to be in the study. If you don't want to be in the study, don't sign the paper. Remember, being in the study is up to you, and no one will be mad if you don't sign this paper or even if you change your mind later.

Signature of Participant _____ Date _____

Signature of Investigator _____ Date _____

LEAVE SPACE (minimum 1") FOR IRB STAMP

Columbia University Medical Center Assent Form to Participate in a Research Study, Minor (Ages 7-11)

Instructions for Consent Form Preparer:Fill in the information requested in italics or delete as applicable. Include a version date in the footer. If your study has more than one assent form, clearly identify the individual forms in the footer, e.g.,"screening consent form" or "assent form".

[All yellow high-light areas should be deleted when you are done.]

When developing your assent form, you may want to use certain fonts, such as Arial and Times New Roman, and font size 12 or 14, that are more appropriate for younger aged children.

If possible, the form should be limited to a few pages. If appropriate, illustrations may be used in addition to words to assist in the child's comprehension.

If assent is not waived by the IRB, children in this age group should be fully informed of the research using language suitable for their age, maturity and psychological state and assent should be obtained from those deemed capable of making a meaningful decision. Assent should be solicited in the presence of parent or guardian. When assent will be verbal only, the parental permission should include an acknowledgment by the person obtaining consent/assent/permission and parent or guardian. The assent script could also include an acknowledgment by the person obtaining assent that verbal assent was obtained (see acknowledgment of verbal assent in section 7 of this form). If assent is not solicited, the reason for not soliciting assent should be noted in the research record for the participant.

While it is important for all consent/assent processes that information be presented verbally, it is particularly important that the information in this form is presented verbally because the children to be enrolled are very young. Do not rely on the child's ability to read this form.

For this age group, assent may be obtained verbally. Unless required by the IRB, signature of the child is optional (see section 7).

1. Title of research study and general information

Study title: [This is the only section where medical/scientific terminology may be used. The title should conform to the title of any grant application/protocol.]

Study number: IRB-[insert IRB protocol number]

2. Researchers' contact information

Principal Investigator: [name and degree(s) of the Researcher conducting the study]

Phone Number(s):

Co-Investigator(s): [name(s) and degree(s) if applicable]

Phone Number(s):

LEAVE SPACE (minimum 1") FOR IRB STAMP

Study Coordinator: [name(s) and degree(s) if applicable]

Phone Number(s):

3. Why are we interested in talking with you?

We want to tell you about a research study we are doing. Research is a way to learn more about something. [Add the following as appropriate:] This is the way we find out if medicine or other treatments are safe and if they work.

We are asking you and other children to be in this research study because [insert simple/layperson name of medical condition or other reasons for inclusion. Use very simple language].

We are working to [find out/learn more about—i.e. provide a simplified explanation of the how or why you are doing the research. Use very simple language].

It is okay to ask questions about what we are telling you. If you do not understand something, just ask us. We want you to ask anytime you think of a question.

4. What will happen to you if you are in the study?

[Description of what will take place from the child's point of view.

Choose as appropriate:]

If you want to be in this study, this is what will happen:

- We will ask you to [insert specifics, e.g., answer some questions].
- We will have you do [insert specifics].
- We will look at your [insert specifics, e.g., doctor's records].

[Indicate the approximate total length of the participant's expected participation by the number of days, months or years (from screening to final completion). If the study has different stages, explain how long each will last.]

This research will take [insert how long total].

It will take [insert number of visits] visits that each last about [insert amount of time of visit(s)].

[Choose as appropriate:]

You may not benefit directly from this study. We hope to learn something that could help other children in the future [add, if applicable:] who have [Insert medical condition].

[OR]

LEAVE SPACE (minimum 1") FOR IRB STAMP

We don't know if being in this study will help you. Some of the ways you could be helped are:

- You could [insert specifics, e.g., get better].
- Some kids feel [insert specifics, e.g., less pain].
- Feel good about helping other kids.

5. Will it hurt?

Choose as appropriate:

There is a chance that during the study you could feel uncomfortable, afraid, lonely, or hurt. We will help you with these feelings and you can stop at any time if you want. If you are in the study you could experience any of the following:

- You could [insert specifics, e.g., get a bruise].
- You may feel [insert specifics].
- You may feel [embarrassed/sad/uncomfortable] by the questions we ask.
- Someone might be able to see the things you tell us but we will try our best to keep this a secret.
- The [insert specifics, e.g., blood sample] may hurt.
- The study [drug/device/treatment] could make you feel [insert specifics, e.g., dizzy, have an upset stomach].

6. What if you have questions?

You may ask questions at any time. You can ask now or later. You may talk to the researcher or someone else. Your parents/guardians have the information on who to call if you have questions after you go home.

7. Do you have to be in this study?

No, you do not have to be in this study. No one will be mad at you if you say no. You can also say yes now and change your mind later. Just tell the doctor or your parent/guardian that you want to stop.

If you say yes, you can ask as many questions as you want, at any time. No one else will know what you tell us [insert as relevant:] besides your parents/guardian.

Please talk this over with your parents before you decide if you want to be in the research study. Your parents have said that it is ok with them if you are in the research study. You can still say no even if your parents said that it is ok with them if you are in this research study.

LEAVE SPACE (minimum 1") FOR IRB STAMP

[This text box only applies if you will obtain the assent verbally, in which case the signature lines that appear later in the form should be deleted.

If you will obtain the child's signature, the "Acknowledgment of verbal assent" text box should be deleted and the signature lines should be retained.]

Acknowledgment of verbal assent

Print name of Child: _____

Print name of parent(s)/guardian(s) present: _____

Do you want to be in this study?

Child's response: Yes No

_____

Signature of Person conducting the assent process Date

Print name of Person conducting the assent process

If you sign this paper, it means that you want to be in this study. **If you do not want to be in the study, do not sign this paper.**

Signatures

[Omit signature lines that do not apply to your study. If the signature line remains, the expectation is that it will be used at the time of each enrollment.]

_____

Signature of Child Date

_____

Print name of Child

_____

Signature of Person Obtaining Assent Date

_____

Print name of person obtaining Assent

LEAVE SPACE (minimum 1") FOR IRB STAMP

_____

Signature of Witness Date

_____

Print name of witness

The signature of a witness is only required when obtaining assent from:

- a Non-English Speaking Research participant using the short form process, or
- a person who is physically not able to read, talk or write.

LEAVE SPACE (minimum 1") FOR IRB STAMP

Columbia University Medical Center Assent Form to Participate in a Research Study, Minor (Ages 12-17)

Instructions for Consent Form Preparer:
Fill in the information requested in italics or delete as applicable. Include a version date in the footer. If your study has more than one consent or assent form, clearly identify the individual forms in the footer, for example "screening consent form" or "assent form".

[All yellow high-lighted areas should be deleted when you are done.]

When developing your assent form, you may want to use certain fonts, such as Arial and Times New Roman, and font size 12 or 14, that are more appropriate for children.
If possible, the form should be limited to a few pages. If appropriate, illustrations may be used in addition to words to assist in the child's comprehension. Stand-alone charts or other visuals aids may be helpful for the child to have.

If assent is not waived by the IRB, children in this age group should be fully informed of the research using language suitable for their age, maturity and psychological state and assent should be documented. You can choose between developing an assent form or having the adolescents co-sign the parental permission form, so long as in either case, the form is written in age-appropriate language and has appropriate signature lines.

While it is important for all consent/assent processes to include verbal presentation of information, it is particularly important when the participants are minors. Do not rely on the minor's ability to read this form.

1. Title of research study and general information

Study title: [this is the only section where medical/scientific terminology may be used. The title should conform to the title of any grant application/protocol.]
Study number: IRB-[insert IRB protocol number]

Sponsor/Supporter: [insert names of funding agencies if any]

2. Researchers' contact information

Principal Investigator: [name and degree(s) of the Researcher conducting the study]

Phone Number(s):
Co-Investigators: [name(s) and degree(s) if applicable]
Phone Number(s):
Study Coordinator: [name(s) and degree(s) if applicable]
Phone Number(s):

LEAVE SPACE (minimum 1") FOR IRB STAMP

3. Why are we interested in talking with you?

We are asking you to participate in this research because [insert simple/layperson name of medical condition or other reasons for inclusion. Use simple language].

Before agreeing to participate in this study, it is important that you read this form and talk with the research staff. You should only take part in this study if you want to. This form will explain why we are doing the research and what will happen to you if you are in this research study. We would like to discuss the study and review this form with you. You can ask questions at any time before, during or after our discussion. You will also have time to read this form and ask any questions about the research study. At the end, we will ask you to sign this form if you agree to participate. It is okay to ask questions about what we are telling you. If you do not understand something, just ask us. We want you to ask any time you think of a question.

4. What is this research study about?

In this research study, we want to [find out/learn more about—i.e. provide a simplified explanation of the how or why you are doing the research. Use simple language].

There will be about [insert number] participants in this study.

5. What will happen if you agree to be in the study?

[Description of what will take place from the minor's point of view.]

The following will be asked of you, if you decide to be in this research study: [List the procedures that are required in this research. Use a bullet or numbering format].

[Choose as appropriate:]

- We will ask you to [insert specifics, e.g., answer some questions].
- We will have you do [insert specifics].

- We will look at your [insert specifics, e.g., doctor's records].
- This research will take [insert how long total].

[Indicate the approximate total length of the participant's expected participation by the number of days, months or years (from screening to final completion). If the study has different stages, explain how long each will last.]

This will take [insert number of visits] visits that each last about [insert duration of visit(s)]. You will have to come back to the office [insert total number of times or visits or revise accordingly to briefly indicate what is required of the child in terms of time].

6. Are there any consequences if you participate in this study?

[Choose as appropriate to describe the risks [physical, social, financial, psychological, privacy, or other] and possible discomforts.]

LEAVE SPACE (minimum 1") FOR IRB STAMP

There is a chance that during the study you could feel uncomfortable, afraid, lonely, or hurt. We will help you with these feelings and you can stop at any time if you want. If you participate in the study you could experience any of the following:

- You could [insert specifics, e.g., get a bruise].
- You may feel [insert specifics].
- You may feel [embarrassed/sad/uncomfortable] by the questions we ask.
- The [insert specifics, e.g., blood sample] may hurt.
- The study [drug/device/treatment] could make you feel [insert specifics, e.g., dizzy, have an upset stomach].

7. Will you benefit from being in this study?

[Choose as appropriate to describe the benefits:]

You will not benefit directly from this study. We hope to learn something that could help other children in the future [add, if applicable:] who have [Insert medical condition]

[Or]

Taking part in this study may help you feel better or may make your [Insert medical condition] go away, but we do not know this for sure.

8. What if you have questions?

You may ask questions at any time. You can ask now or later. You may talk to the researcher or someone else. If you have any questions about this study you can call [insert PI name] at telephone # [insert phone number].

If you have any questions about your rights when you are in a research study, you may contact the Institutional Review Board by mail, telephone, or email at:

Institutional Review Board
Columbia University
154 Haven Avenue, 1st Floor
New York, NY 10032
Telephone: (212) 305-5883
Email: irboffice@columbia.edu

An Institutional Review Board is a committee organized to protect the rights and welfare of human subjects involved in research.

9. What about your privacy?

To protect you, the information collected in this study will not be shared with anyone unless required by law. [Be sure this is accurate, e.g., if parents will have access, it should be so noted.]

LEAVE SPACE (minimum 1") FOR IRB STAMP

The researchers in this study will need to talk about you and the study [Insert as relevant: with your parent/guardian and with other researchers] but will not talk about you with anyone else except the people working on the study. If the researcher(s) need(s) to talk to anyone else about you he/she/they will ask you and your parent/guardian if it is okay to do so.

10. What will it cost you to be in this study?

There is [choose one: some/no cost] to you or your parents for being in this research study.
Add one of the following statements:

You will not get paid to participate in this study.
[or]

You will receive [add amount of gift cards] for your participation in this study.

11. Do you have to be in this study?

No, you do not have to be in this study. We are asking you if you would like to be in the study but if you say no, no one will be upset with you. You can also say yes now and if you change your mind later, you can quit the study at any time.

[Add, if this is an intervention study:] If you choose not to be in this study, you can:[List alternatives to participation, e.g., alternative treatments, if any].

Please talk this over with your parents/guardians before you decide whether or not to participate. Even though your parents/guardians have said it is all right with them if you want to be in the study, you can still say no. If you do agree to be in the study but later decide you would rather not be in the study, you may stop your participation at any time. Your decision will not affect your care or that of your parents or family members in any way.

If you sign this paper, it means that you want to be in this study. If you do not want to be in the study, do not sign this paper.

Signatures
[Omit signature lines that do not apply to your study. If the signature line remains, the expectation is that it will be used at the time of each enrollment.]

_____

Signature of Minor Date

_____

Print name of minor

LEAVE SPACE (minimum 1") FOR IRB STAMP

_____

Signature of Person Obtaining Assent Date

_____

Print name of person obtaining assent

_____

Witness Date

_____

Print name of witness

The signature of a witness is only required when obtaining assent from:

- a Non-English Speaking Research participant using the short form process, or
- a person who is physically not able to read, talk or write.