2019-05-05

Biodiversity Counts! An Environmental Education Program Engaging Stakeholders with Biscayne National Park, FL

Krystle Anne Young
University of Miami, krystleyoung10.ky@gmail.com

UNIVERSITY OF MIAMI

BIODIVERSITY COUNTS! AN ENVIRONMENTAL EDUCATION PROGRAM ENGAGING STAKEHOLDERS WITH BISCAYNE NATIONAL PARK, FL

By

Krystle Anne Young

A THESIS

Submitted to the Faculty
of the University of Miami
in partial fulfillment of the requirements for
the degree of Master of Science

Coral Gables, Florida
May 2019

UNIVERSITY OF MIAMI

A thesis submitted in partial fulfillment of

the requirements for the degree of

Master of Science

BIODIVERSITY COUNTS! AN ENVIRONMENTAL EDUCATION PROGRAM ENGAGING STAKEHOLDERS WITH BISCAYNE NATIONAL PARK, FL

Krystle Anne Young

Approved:

_____ Kathleen Sealey, Ph.D. Associate Professor of Biology	_____ Don DeAngelis, Ph.D. Research Professor of Biology
_____ Keene Haywood, Ph.D. Sr. Lecturer Department of Marine Ecosystems and Society	_____ Guillermo Prado, Ph.D. Dean of the Graduate School

YOUNG, KRYSTLE ANNE (M.S., Biology)
Biodiversity Counts! A Program Environmental Education Program Engaging Stakeholders with Biscayne National Park, FL (May 2019)

Abstract of a thesis at the University of Miami.

Thesis supervised by Dr. Kathleen Sealey
No. of pages in text. (123)

Biological diversity is an important measurement for restoration success in Biscayne National Park, Florida. Projects guided by the Comprehensive Everglades Restoration Plan, CERP, changed the hydrology of South Florida to more historic conditions ultimately costing over $10 billion dollars and more than 60 years to complete. Therefore, the timing and cost creates an incentive to measure the success of these restoration projects and one way to measure restoration success is to evaluate the number of species in an ecosystem. Continued support of CERP throughout South Florida is vital for future projects to progress. An environmental education approach to engage the local stakeholders with scientific research in Biscayne National Park is a tool to increase long-term support for CERP. Environmental education increases knowledge and stewardship for participants involved in programs and connects participants to research projects. Biodiversity Counts! measures students change in attitudes toward the environment throughout the 5-week program. Finally, the program will be turned over to the National Park Service for implementation to a broader community where it will be used for creating reports with the biological diversity data collected to use for better resource management decisions.

TABLE OF CONTENTS

Page

List of Figures

Page

List of Tables

Page

Chapter 1: Understanding Biological Diversity to support Ecosystem Restoration

1.1 Thesis Goals

Environmental education programs that highlight the value of biological diversity are an important link in supporting the conservation and restoration of critical ecosystems around the world (Dickinson, Shirk et al. 2012, Magurran 2013, Kimble 2014). The thesis incorporates three main themes into the chapters:

1. Analysis of the research history of Biscayne Bay and the Comprehensive Everglades Restoration Plan to understand how to best communicate key concepts to a younger audience;
2. Development of an environmental education program (called *Biodiversity Counts!*) that teaches key concepts about the value of biological diversity and the importance of restoration, while also recording the participants' changing attitudes and beliefs concerning restoration projects in South Florida; and
3. Analysis of data on submerged aquatic vegetation (SAV) from three study sites in Biscayne Bay (inside and outside of Biscayne National Park, Florida) to better understand changes in biological diversity.

1.2 Introduction to Study Area: Biscayne Bay, Florida

Biscayne Bay is an estuarine lagoon located on the southeast coast of Miami-Dade County, Florida. The bay is a coastal marine environment which has freshwater inflow from rivers, creating fluctuating salinities across the bay, and provides protection and a nursery ground for many juvenile species of fish (Cantillo, Pikula et al. 2000). Biscayne Bay extends 35 miles in length from northern Miami to just north of Key Largo. Several rivers and canals supply freshwater discharge into Biscayne Bay. Dredging of the

bay started in the early 1900s, causing detrimental consequences to the benthic community making many parts of Biscayne Bay too deep to support the local life, thus altering the ecosystem (Cantillo, Pikula et al. 2000). The Comprehensive Everglades Restoration Plan, CERP, strives to reverse the damage caused by anthropogenic changes and partially restore historic water flow throughout the South Florida ecosystem. Retention ponds and lakes store large amounts of water to moderate storm runoff, but infiltration of inorganic pollutants at these sites is enhanced by the porous limestone geology of the Biscayne Aquifer (Cantillo, Pikula et al. 2000).

Estuarine communities promote the life cycles of many juvenile fish communities that humans consume and support organisms that balance shoreline ecologies (Hume, Snelder et al. 2007). Biscayne Bay is an important ecosystem, composed of fluctuating salinity levels that relies on freshwater flow from interior wetlands. The shallow, brackish water serves as protection for seagrass beds and fish which rely on ecosystem balance including high water quality, adequate salinity levels and the timing of water flow, in addition to other organisms living in the environment to support these higher levels of aquatic life.

Most major changes to Biscayne Bay occurred before 1930 (except for the Port of Miami. Dredging in northern Biscayne Bay). Dredging occurred in the early 1900s to produce causeways and canals for bigger ships to travel throughout the Bay (Cantillo, Pikula et al. 2000, Browder, Alleman et al. 2005). The biggest problem to the overall ecology of Biscayne Bay was the construction of the canal water diversion system, which was begun in earnest after 1945 to control flooding. The canals allowed water to move quickly from inland to the bay and removed coastal wetlands as a natural filtration of run-

off. Canals also disrupt the timing of freshwater coming into the Bay (Browder, Alleman et al. 2005, Lirman, Thyberg et al. 2014). Historically, water flowed slowly into Biscayne Bay with large amounts of water draining into the Bay during the rainy season (May-September) and less water entering the Bay during the dry season (October-April). When the flood-control canals were built, most of the water from Lake Okeechobee was diverted to the east and west coasts through the C-44 canal and Caloosahatchee River instead of through the Everglades wetlands and sloughs (See Figure 1.1). Timing of the discharge of freshwater proved to be detrimental and wasteful in estuarine communities throughout Florida (Browder, Alleman et al. 2005, Lewis 2005). An unhealthy, elevated amount of freshwater could potentially kill many marine fish and invertebrates trapped by the rapid influx of freshwater. At the other extreme, not enough freshwater in Biscayne Bay elevates salinities, changing a seasonal estuary into a marine lagoon; changes in salinity regimes impacts juvenile fish development and alters submerged aquatic vegetation communities (Lirman and Cropper 2003).

Shoreline development near central and northern Biscayne Bay has caused considerable damage to water quality and natural shoreline communities (Brooks, Mittermeier et al. 2006, Worm, Barbier et al. 2006, Lirman, Thyberg et al. 2014), while the southern portion of Biscayne Bay is more directly affected by water inflow and fluctuations through flood control measures. Disruption of hydrocycles due to anthropomorphic changes throughout the Everglades has caused detrimental effects to the greater South Florida ecosystem. In addition to the elevated freshwater inputs, pollutants entering the ecosystem through agricultural runoff and coastal landfills can cause

additional ecological stresses to the Bay. Land-based sources of pollution are exacerbated with heavy rainfall or storm events (Zhang, Kelble et al. 2009).

The Biscayne Bay ecosystem includes the marginal freshwater, saltwater wetlands, intertidal communities, and marine communities. Human alteration of the hydrocycles of South Florida has led to changes in many factors including:

- Quality and timing of freshwater entering Biscayne Bay.
- Increased storm runoff and pollutants entering Biscayne Bay as a result of the urbanization of Miami-Dade County.
- Natural and artificial changes to vegetation.
- Effects from natural disasters including hurricanes, and prolonged wet and dry seasons.
- Disturbance of animal distribution and abundance.

A balance between the interaction of plants, water, and animals is required to maintain the health of Biscayne Bay. Affecting one part of the ecosystem will affect its other parts. Mangrove communities are a key element to the shoreline ecology that creates shoreline buffers and provides food and shelter for many species of fish (Blaber 2007). Coastal mangrove habitats also protect inshore communities from storms, by absorbing wave action and preventing erosion. Studying Biscayne Bay provides valuable information on the role of restoration in maintaining the health of the ecosystem. Knowing how water quality affects the coastal plants, submerged aquatic vegetation, and fish communities in the area allows ecosystem managers to make informed decisions on how to improve or maintain the balance of water quantity and quality in Biscayne Bay (Wilcove, Rothstein et al. 1998, Wortley, Hero et al. 2013). A way to measure success of

restoration is to evaluate the changes in biological diversity with increases in diversity, equaling a healthy ecosystem.

The Comprehensive Everglades Restoration Plan (CERP)[1] seeks to restore, preserve, and protect the South Florida water resources, which include the Everglades and Biscayne Bay. CERP is one of the biggest restoration projects undertaken in the United States, reaching a budget of $10.5 billion, with a timeline encompassing over 50 years. Biscayne Bay and its coastal wetlands are the important components to CERP that *Biodiversity Counts!* focuses upon. The historic water flow originally exited into Biscayne Bay, but urban and agricultural development has filled wetlands, which diverts the amount of freshwater entering Biscayne Bay, causing abnormal salinity levels and high levels of pollution (McNulty 1961, Lirman, Thyberg et al. 2014). CERP seeks to partially restore the historic hydrology and limit nutrient run-off. Restored wetlands will not be the same as natural wetlands, but restored wetlands can provide ecosystem services for South Florida (Midgley 2012). *Biodiversity Counts!* will collect data on species occurrence, focusing on species from different trophic levels (e.g. coastal and marine plants to rays) to determine the success of CERP adjacent to Biscayne Bay.

[1] A complete description of CERP can be found at https://www.nps.gov/ever/learn/nature/cerp.htm

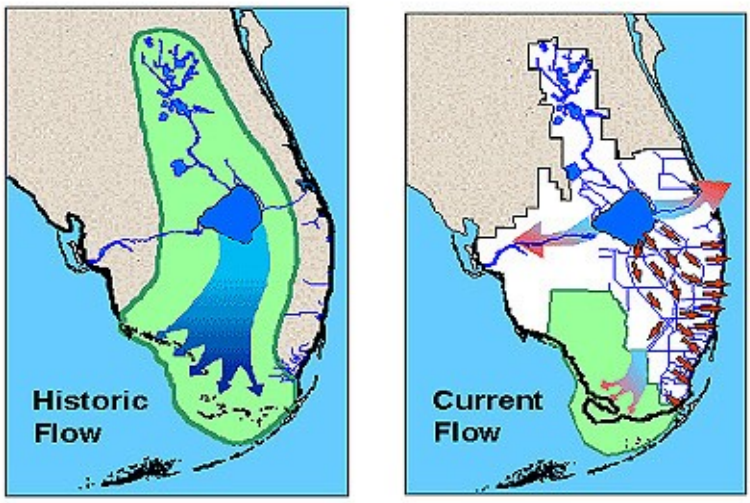


Figure 1.1: Historic flow and current flow of water in South Florida. CERP seeks to partially restore the water flow, timing, quality, and quantity throughout the Everglades. See overview at https://www.evergladesrestoration.gov/

1.3 Introduction to Biological Diversity Indices

Biological diversity, also called biodiversity, serves as a health indicator for ecosystems because there is a relationship between ecosystem health and the number of species present (Van der Heijden, Klironomos et al. 1998, Midgley 2012). Biological diversity is an important measurement for restoration success in Biscayne National Park, Florida. Evaluation and education of restoration projects are important to local stakeholders for continued support in future projects. Environmental education programs are shown to influence public opinion in resource protection; therefore, targeting a group that will have a continued influence in wetland restoration is key for continued restoration support. One of the simplest and most common ways of measuring biological diversity is species richness, which is simply, the number of species present in an area. When there is an increased number of species present in a habitat then ecosystem services tend to increase (Myers, Mittermeier et al. 2000). Ecosystem services include fisheries, water quality, tourism, and storm resilience. These ecosystem services have dollar values

associated with their loss, therefore humans living near estuaries can see the value of these delicate ecosystems (Myers, Mittermeier et al. 2000). Thus, humans have financial motivations to protect ecosystem services in Biscayne Bay with the intent to conserve biodiversity. Having a high number of species in an environment has the benefit of one species substituting the function of another species should the second species diminish in number. Biodiversity can also help when environmental pressures increase, as similar species may react differently, therefore enabling the survival of the function in that environment.

Loss of biodiversity and ecosystem function has been linked to human activity, such as overfishing, agriculture, and urbanization (Kappel 2005). Increased fishing pressure causes significant loss of organisms resulting in major changes to the environment. When there are decreased amounts of herbivorous reef fish and algae consumers in the habitat, algae growth increases on coral reducing coral numbers by inhibiting their growth. Not only does overfishing affect the environment negatively, but overfishing decreases fish numbers to the point that the fish community cannot repopulate adequately in the next season (Palumbi, Sandifer et al. 2009). If fish communities cannot repopulate to a healthy population size, then the fishery industry suffers from economic loss due to decreased catch yields. In addition to overfishing, agriculture introduces inorganic pollutants into the canals and rivers that exit into Biscayne Bay causing harmful algae blooms. Urbanization alters shoreline vegetation and weakens the health of the shoreline ecosystem by introducing freshwater runoff through storm drains contaminated with vehicle and other urban waste.

Restored wetlands cannot replace natural wetlands, but restored wetlands increase ecosystem function compared to non-restored wetlands. Humans have changed their views on ecosystem alteration from acceptance of short-term loss of species for development projects to the opinion that restoration and conservation of critical habitats are important for human survival (Stern 2000). There has been increased research on the value of restored wetlands and the results support how restoration positively affects the recovery of an area. When comparing restored wetlands to natural wetlands, they are similar, but restored wetlands still have less species richness after only three years of recovery (Galatowitsch and van der Valk 1996). The Coastal Wetlands Project (a component of CERP) is aimed at improving the ecology of Biscayne Bay by restoring wetlands along the margin of Biscayne National Park (Figure 1.2).

Assessment of biodiversity can be measured in many ways such as abundance, α, β, and γ diversity measurements (Gotelli and Colwell 2001, Anderson, Crist et al. 2011). Abundance of species is measured by the number of species relative to other species in the area (Edgar, Alexander et al. 2017). Tracking trophic diversity looks at species in different trophic levels, healthy ecosystems have typically have a robust trophic system of producers and consumers. Indicator species are another important component of biodiversity where the presence of certain species indicates a healthy ecosystem (*i.e.* seagrass beds, oysters, *etc.*) (Lirman, Thyberg et al. 2014).

Monitoring biological diversity will help managers of Biscayne Bay, Biscayne National Park, decide on the best practices for ecosystem management (Gentile, Harwell et al. 2001). Biscayne National Park's focus is on tourism and recreational use of the resources in Biscayne Bay; higher levels of biodiversity lead to increased tourism and

recreation. In 2016, Biscayne National Park had 514,709 visitors, many enjoying snorkeling, visiting islands, and canoe trips[2]. Protecting the ecosystems in the park is crucial for the BNP to maintain visitor numbers as many people come to the park for the beauty and outdoor recreation the park offers. Therefore evaluating the success of restoration in Biscayne Bay is an important component of resource management that measures the value of the projects since CERP costs billions of dollars and will take decades to complete (Wortley, Hero et al. 2013). Biscayne National Park will use the data collected from this project to supplement their ongoing efforts of water quality data collection.

[2] See website to learn about Biscayne National Park visitor statistics https://www.nps.gov/bisc/learn/management/statistics.htm

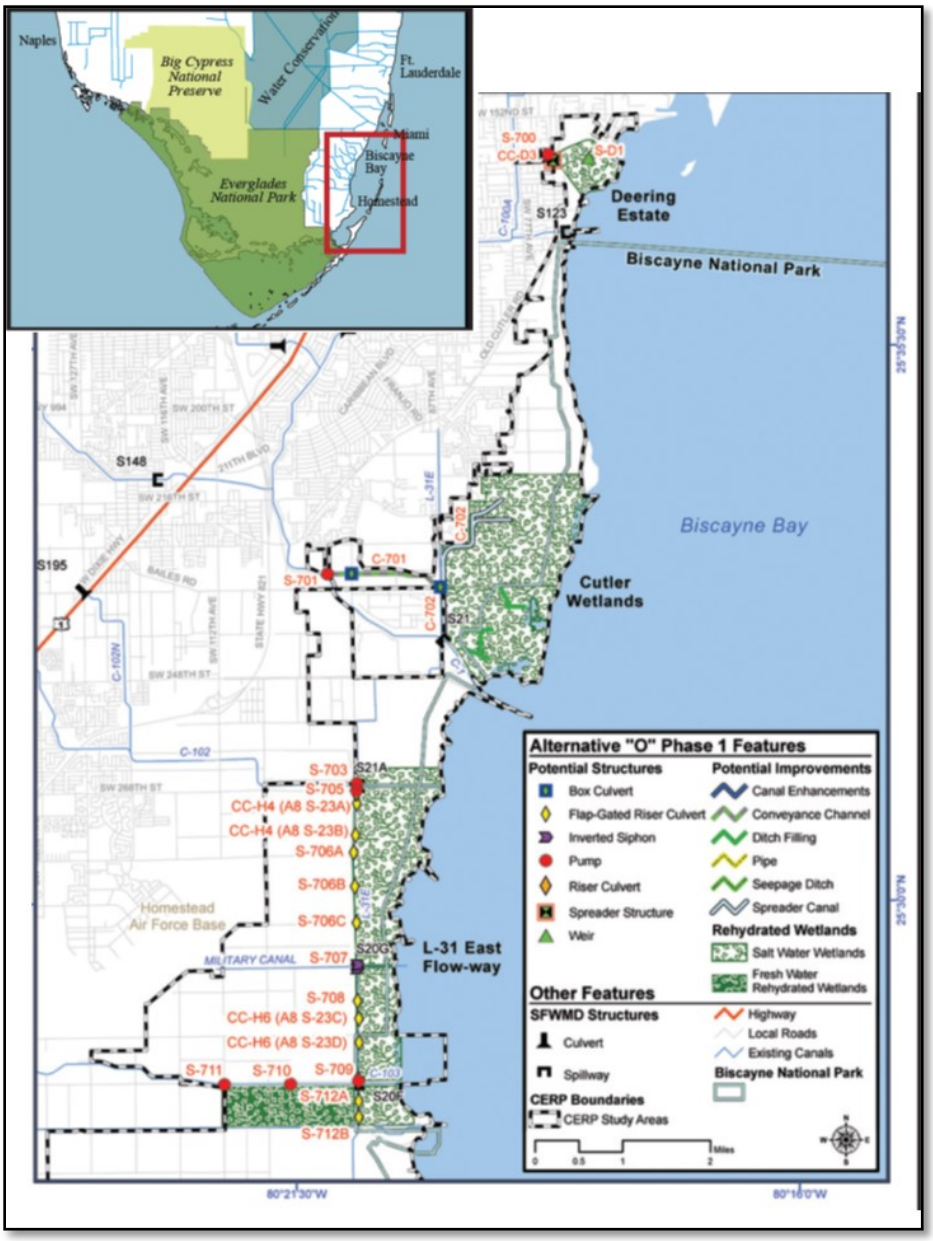


Figure 1.2 Map indicating the spatial extend of the Biscayne Bay Coastal Wetlands restoration component of CERP, see summary at http://141.232.10.32/pm/projects/proj_28_biscayne_bay.aspx

1.4 Youth Engagement in Environmental Stewardship: *Biodiversity Counts!*

Biodiversity Counts! is an environmental education program that targets middle and high school aged students for introduction to issues in the South Florida environment developed in my thesis research. Environmental education programs are shown to influence public opinion in resource protection; therefore, targeting a group that will have a continued influence in wetland restoration is key for continued restoration support. Many environmental education programs failed to determine knowledge, motivations, and belief throughout their programs (Pooley and O'Connor 2000). *Biodiversity Counts!* addresses all three concerns in surveys administered throughout the program. In the past, knowledge of a topic was thought to change the people's behavior therefore many environmental education programs focused on informing participants rather than appealing to their emotions. During the sessions, I sought to connect with the student's emotions by showing pictures of how the Everglades looked before development and after and how the degradation affects them on a personal level.

Many citizen science programs have assessment tools in place to gauge how well their students have learned or changed their attitudes toward an issue. *Biodiversity Counts!* implemented pre- and post-assessments to understand the changes that the participants experience during the program (Wiliam 2011). The program goal is to assess students' attitudes, behavior, and knowledge at the beginning of the program, intermittently throughout the program, and finally issue an exit survey. Knowledge is an important first step for people to change their opinions on a topic, but many programs do not assess attitudes toward issues. Studies show that one's attitude and beliefs toward an issue is important, regarding changing their opinions on environmental issues. Therefore

more environmental education programs need to target attitudes as well (Pooley and O'Connor 2000).

Biodiversity Counts! targets attitudes about environmental issues and identifies what influences their behavior in favor of the environment. We strive to create not only young scientists from this program but, also, young conservationists who will engage family and friends in the ideas gained. The pre-assessments are be used as a baseline for attitudes and knowledge toward their environment and CERP. Questions are designed to gauge their level of association with the outdoors, the value they have for the ecosystem, and knowledge of ecology.

The post-assessments capture changes in knowledge and attitudes of participants. Three measures of success for *Biodiversity Counts!* include:

1. Did the participants understand and retain information presented to them, including CERP, ecosystem services, and Biscayne Bay ecology?
2. Do participants value ecosystem services of Biscayne Bay?
3. Do participants feel they can contribute to conservation?

Early models of environmental education assumed that if people gained knowledge, education would lead to behavior changes. But new research shows that knowledge gained is not necessarily correlated with changes in behavior, and that emotions and belief tend to influence people to change behaviors (Pooley and O'Connor 2000, Kollmuss and Agyeman 2002). Attitudes need to be targeted during these programs so that citizens feel that they can contribute to research and conservation efforts, can think unbiasedly, and can change their behaviors toward environmentally friendly actions.

Assessments for *Biodiversity Counts!* measure the baseline behavior, attitudes, and knowledge of participants and then measures the success of the program through post-assessments. We issued the assessments through Survey Monkey using questions designed to assess progress throughout the program. The main goal for the program is to create better informed students who could continue to support restoration goals throughout South Florida. An additional goal is for students to feel they can contribute to science and have a greater appreciation for scientific work.

Chapter 2: *Biodiversity Counts!* Curriculum Development and Implementation

2.1 Overview of Curriculum Need and Rationale

The Comprehensive Everglades Restoration Plan (CERP) is a 60+ year and $10+ billion to complete restoration plan which seeks to partially restore South Florida hydrology to historic flow, quality, and distribution. Levees and canals were created in the 1920s to divert water for agriculture and homes, but now Floridians value the Everglades for the ecosystem services it provides. The Everglades cleans the water as it flows from the Kissimmee River to Florida Bay, but in order to do it properly, the flow needs to be partially restored. CERP encompasses all South Florida. Therefore, residents, stakeholders, and beneficiaries need continual support of the efforts for the duration of the plan. The time and cost of the plan, which will affect taxpayers throughout much of their lives, and the added benefit of clean drinking water in the aquifer are reasons to create education programs that promote CERP initiatives.

As a Native American living in South Florida, I am often engaged in conversations within the Seminole Tribe and Miccosukee tribe communities about CERP. Both of these South Florida tribes have communities that are located in the middle of CERP projects. The tribes have programs that work with the State of Florida to uphold nutrient standards on their lands[1], but many individual tribal members do not trust the research behind the restoration decisions being made by the State. For example, many tribal members do not trust that the State of Florida's scientists really understand how the Everglades ecosystem functions or know how to best correct past alterations to the

[1] To learn more about the Seminole Tribe of Florida's environmental resource department visit their page at https://www.semtribe.com/STOF/services/environmental-resource-management-department

system. There is a need for a comprehensive education program to bring all members of the tribal communities to a common understanding of what is known and what are hypotheses in the overall CERP efforts. Environmental outreach programs target participants' knowledge of the environment and offer solutions on how to make decisions that are better for the planet.

The development of *Biodiversity Counts!* stemmed from other environmental education models such as Young Marine Explorers and BioBlitz. Young Marine Explorers[2] is a program developed for Bahamian students that engages students to work inside a classroom setting and outside in the field. BioBlitz[3] is a program developed by National Geographic to partner globally with parks and protected areas. In Miami-County, the first Bioblitz was conducted in partnership with the National Geographic Society in Biscayne National Park in 2010. Now, locally, University of Miami and Florida International University partner with Vizcaya Museum and Gardens to educate local Miami high schools on the importance of biological diversity by holding annual Bioblitz events. These programs engage students to connect with their environment, learn the value of diversity and connect their actions to impacts on the environment.

Implementing environmental education programs that educate and encourage continued support for restoration in South Florida is important for public morale. Without the public support, projects around South Florida will not be supported politically. Recently, Florida had a huge problem with red tide blooms that cost many businesses revenue and caused health hazards along the coasts. The health and revenue issues

[2] See https://ymebahamas.org/index.html
[3] See https://www.nationalgeographic.org/projects/bioblitz/

spurred both of the political parties to run on the platform of cleaning the water from Lake Okeechobee, when usually the problem is addressed by a single party. Floridians are changing the way they think about environmental issues and support for restoration is now on both sides of the political parties. When you include a broader range of people in environmental education, then discussion can generate different ways to implement conservation plans (Bennett, Roth et al. 2017).

2.2 Curriculum Development

Educational assessments are ways to evaluate the outcomes of an education program. Assessments were designed to be used to determine participants' knowledge and motivations throughout the program. Questions included definitions of certain terms, feelings toward certain aspects of the environment (such as how important is Biscayne Bay to you?), and motivations toward pro-environmental behavior (including talking to other people about environmental issues). The aim of environmental education is to change learner behavior and, through assessments, test participants on their change in knowledge and motivations over the course of the program (Hungerford and Volk 1990). Learning objectives are measured through testing. If students answer more positively about the environment or define terms correctly over the course of the curriculum then that suggests that the program changes knowledge and attitudes. Curriculum development includes three components:

1. Facilitators or Teachers' Guides
2. Student Activities and lesson plan, and
3. Assessments of the lesson effectiveness.

FACILITATOR'S NOTES
First Lesson: What is Biscayne Bay?
Before the lesson: To start this lesson, the instructor needs to familiar herself to Biscayne Bay and the Everglades. This lesson will give history on Biscayne Bay and introduce the students to key words related to biology. Instructor may want to familiar herself with the important questions and how to answer to them. Bring notebooks so they can begin taking notes.

Important Questions
How are the Everglades and Biscayne Bay connected?
Why is Biscayne Bay important?
What pollutants can be found in Biscayne Bay?
What is an estuarine, CERP, restoration, conservation, and ecosystem services?

Students will understand: After this lesson, students will understand the history of Biscayne Bay and its connection to the Everglades. They will learn about restoration efforts conducted on the Bay and the park and community involvement in the decisions. This lesson will begin to plant the idea that normal citizens can make meaningful changes in the environment.

Background information: Biscayne Bay is an estuarine lagoon to the southeast of Miami-Dade County. An estuarine is a coastal marine environment that has freshwater flow from rivers creating changing salinities across the area. There are a wide variety of species that live in these types of environments and many have tolerances where they cannot survive pass a certain salinity, temperature, or etc. Biscayne Bay extends from northern Miami to just north of Key Largo, about 35 miles in length. Dredging of the bay caused detrimental consequences to the bottom (benthic) life as it made the Biscayne Bay too deep to support benthic life.
Where we are focusing for this project is Biscayne National Park which was established into a national monument in October 1968 and into a national park in June 1980.

Box 1: Example of a Facilitator's Guide outline for a lesson plan

Box 1 illustrates the general content of a Facilitator's Guide. This is crucial material to build a curriculum that can be effectively delivered by any educator.

Assessments can be designed as formative or summative. Formative questions are usually open-ended questions that give the participant freedom to answer, usually with a concept map which is a conceptual diagram that connects and shows relationships between concepts. Summative questions are questions that have a definitive answer, usually multiple-choice questions. Formative questions are more difficult to evaluate than summative questions. *Biodiversity Counts!* assessments consisted of mainly summative questions with one question that asked students to create a concept map on climate change or the Everglades.

The prevailing sentiment with environmental education was that if people had knowledge about the environment then their behaviors will change, but now there is research suggesting that behavior changes through many factors, such as knowledge, attitudes, gender and cultural beliefs (Hungerford and Volk 1990, Gadgil, Berkes et al. 1993, Czech, Devers et al. 2001, Lapinski, Rimal et al. 2007). Awareness and knowledge of an issue is the first step to changing behavior, but that alone will not be the motivating factor. Things such as time, motivation, and habits are important in creating pro-environmental behaviors (Jordan, Gray et al. 2011). Another barrier to changing behavior toward environmentally friendly actions is that these actions offer a limited reward to the individual even though it gives a greater reward for the collective society (Lapinski, Rimal et al. 2007).

Beginning the curriculum development on *Biodiversity Counts!* started by researching the Everglades and changes made throughout the 1900s. Source material such

as Biscayne National Park management plans from the 1970s helped me expand my knowledge on the history of Biscayne Bay. Also, I read through many peer reviewed papers on Biscayne Bay and the Everglades to understand the connections between Lake Okeechobee and Biscayne Bay.

Next thing that helped me create the curriculum was online curriculum templates that are available for educators[4]. There were two websites[5] used to create activities for the *Biodiversity Counts!* curriculum, which provided fun, educational activities to teach participants about a certain aspect of ecology. I choose three activities from the websites to implement in the curriculum. These activities focused on three aspects of ecology including identifying species, carrying capacity, and sieving sediment. The activities gave suggested topics to talk about with participants and print out to write out measurements or rules for the activity.

Finally, I worked with a professional educator to create and implement the curriculum. The professional educator, Dr. Suzanne Banas, has worked in education for over 30 years. Dr. Banas met with me and discussed curriculum development and made suggestions of how to deliver the program. She also provided a classroom to test the curriculum on at South Miami Middle School (SMMS).

2.3 Curriculum Delivery

Two groups of students participated in the testing of the curriculum that I created. One group of 15 students from Chicago were in the Schuler Scholar Program, which is a

[4] http://www.cpalms.org/Public/search/Standard
[5] https://www.nextgenscience.org/ and http://www.cpalms.org/Public/search/Standard

program that helps high school students from the Chicago area to enhance their academic and leadership skills. Another group that participated was an 8th grade class from South Miami Middle School that consisted of 22 students. The high school group flew down to Florida to learn about the ecological history and reached out to Dr. Sealey about doing a tour of the lab and an activity related to coastal ecology. Testing out the curriculum on this first group happened over the summer at the University of Miami.

A more complete curriculum was tested on middle school students in a middle school group was a partnership between the UM and Miami-Dade County Public Schools (MDCPS) to test out the curriculum (See **Table 1**). The teacher, Dr. Suzanne Banas, has taught for over 30 years and allowed me to come into her classroom on Fridays for 5 weeks to take over one 50-minute section. At the beginning and end of each session, students filled out surveys created on an online survey platform.

Table 2.1: A summary of age range and assessments conducted in the curriculum implementation at South Miami Middle School (SMMS), part of the Miami Dade County Public School system.

Students Aged 14-18	Students Aged 9-13	Total Number of Students	Total number of assessments
18	8	26	151

Summer Student Test, June 2018

On June 18, 2018, 15 students from Chicago in the Schuler Scholar Program came to Florida to participate in *Biodiversity Counts!* We tested one lesson plan on them, "Finding Our Way to Biscayne Bay," by giving a 45-minute overview of the ecology and

history of Biscayne Bay. A PowerPoint presentation was given and then students were asked to create concept maps about some aspect of South Florida and climate change.

Classroom Student Test, September 2018

The second implementation of *Biodiversity Counts!* provided an opportunity to work with a group of students over 5 weeks in a middle school classroom. This allowed for multiple assessments before and after the lessons (**Table 2**). On September 7, 2018, I went to South Miami Middle School to deliver the "Finding Our Way to Biscayne Bay" lesson. Like the first test, I began with an overview of the ecology and history of Biscayne Bay and how it connected to the entire Everglades. Next, students created concept maps about some aspect of Biscayne Bay for 20 minutes. Students began their concept maps with questions like "What services or benefits can humans get from having healthy estuaries?" and "What services do wetlands provide for humans and the environment?"

On September 14, 2018, the next lesson delivered to the South Miami Middle School students was "Wish We Had More Fish." First, I delivered a PowerPoint presentation on the importance of protecting estuaries for juvenile fish and that having a clean home is necessary for survival. Then I had the students play the ocean creatures card game to learn how to identify different fish they could possibly see in Biscayne Bay.

On September 21, 2018, the next lesson delivered to the students was "Grab a Handful of Crab – Mobile Invertebrates." I introduced the students to the importance of having crabs in Biscayne Bay and touched on how the fishing industry affects the Bay.

The students played a game that helped them understand carrying capacity and limiting nutrients.

On September 28, 2018, “Dredge and Fill Up a Sieve” was delivered to the students. This lesson focused on the history of hydrology changes in South Florida and how it affects humans and coastal zones. The students then sieved sediment collected from Biscayne Bay to understand the different substrate types.

On October 5, 2018, “One, Two, Trees and Other Coastal Plants” taught students the importance of coastal plants to our coastlines. I showed them different plants that they could encounter in Biscayne Bay and coastal Florida and some invasive plants as well. For the activity, students created a flyer with a slogan related to restoring the wetlands.

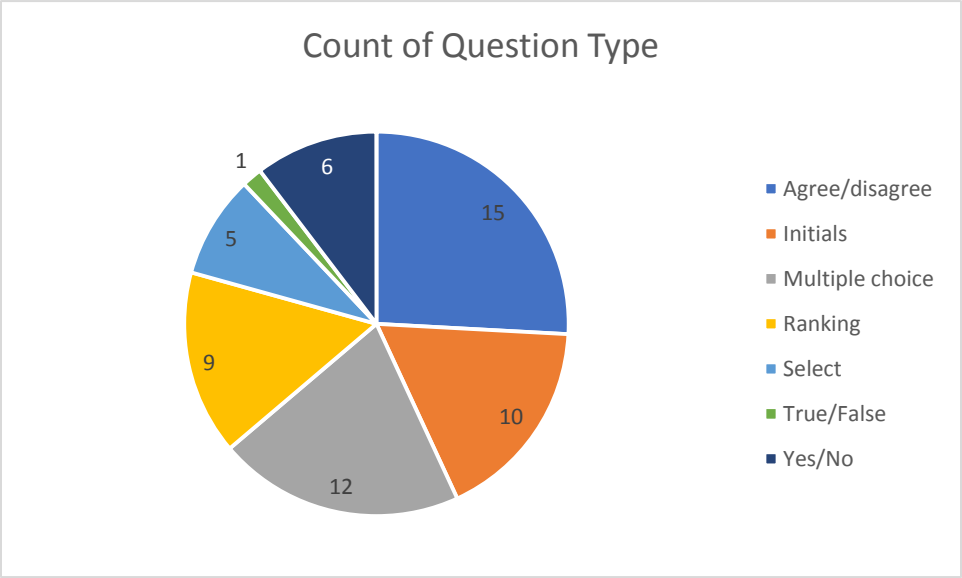
2. 4 Results

For the assessments, the questions were asked either as agree/disagree, multiple choice, ranking, true/false, yes/no, or select an image. Participants were also asked for their initials at the end of each survey. Below is a pie chart of all types of questions asked in the surveys. Agree/disagree questions comprised a total of 15 questions. Initials included 9 of the questions along with a question on the age of the respondent. Multiple choice questions were a total of 12 questions. There were nine ranking questions, five selection questions, one true or false question, and six yes or no questions (**Figure 2.1**). In total there were 58 questions that were asked of the students.

Table 2.2: Summary of the assessments, number of questions and number of responses recorded at SMMS implementation of *Biodiversity Counts!*

Survey	Number of Questions	Number of Responses
1 Finding Our Way to Biscayne Bay Pre-Test	6	26
2 Finding Our Way to Biscayne Bay Post-Test	5	14
3 Wish We Had More Fish Pre-Test	9	20
4 Wish We Had More Fish Post-Test	6	9
5 Grab a Handful of Crabs Pre-Test	7	17
6 Grab a Handful of Crabs Post-Test	6	8
7 Dredge and Fill Up a Sieve Pre-Test	7	22
8 Dredge and Fill Up a Sieve Post- Test	6	19
9 One, Two, Trees and Other Coastal Plants	6	16

Figure 2.1: Breakdown of question types used in the *Biodiversity Counts!* assessments for five lessons implemented in September 2018.

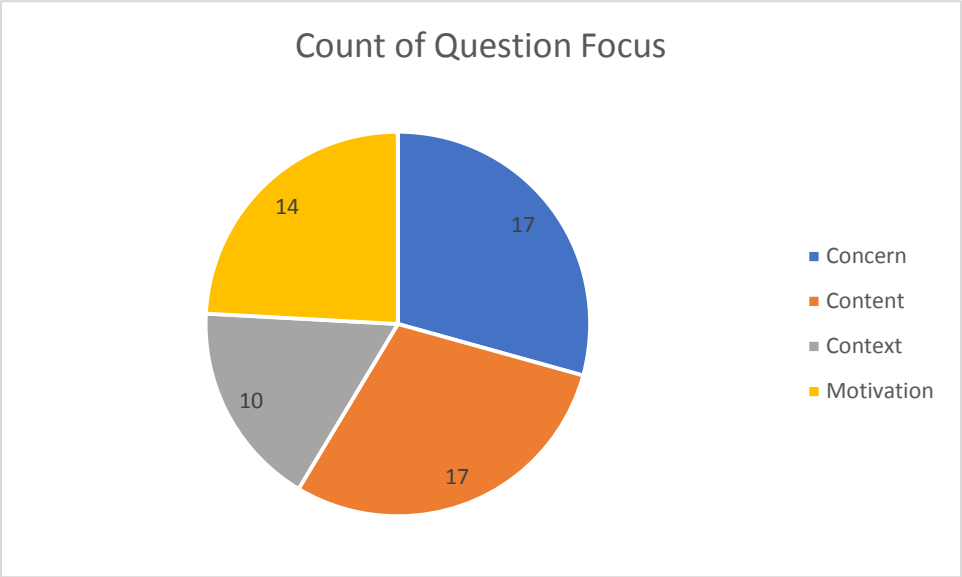


There are four types of focus questions including concern, content, context, and motivation. Concern questions included questions pertaining to students' feelings toward the natural environment and resources. Content questions gauged students' understanding of Biscayne Bay, biological diversity, and definitions pertaining to ecology. Context questions asked participants for their initials and age. Questions asking about motivation asked about students' motivations to do things involving the natural environment, such as talking about Biscayne Bay or visiting a National Park.

Table 2.3: Definitions of Assessment question foci used in the *Biodiversity Counts!* Curriculum implementation in September 2018.

FOCUS	Definition and purpose	Example
Concern	Questions to understand the overall concern or anxiety that the respondent may have about environmental issues.	*How much do you worry about sea level rise impacting your life in the next 10 years?*
Content	Questions that test the student's knowledge. Educational content questions review key concepts, information and ideas related to the curriculum goals	*What is the source of our drinking water in Miami-Dade County?*
Context	Questions to capture the respondent's context (i.e. middle school, high school or adults) and information on their background or previous exposure to curriculum content.	*What year were you born? How long have you lived in Miami-Dade County?*
Motivation	Questions to address the enthusiasm or interest of the respondent to act or participate in solutions.	*How likely are you to participate in a beach clean-up this summer?*

Figure 2.2: Distribution on Assessment question by focus area in Biodiversity Counts! Curriculum implementation in September 2018.



The questions were designed to test different aspects of participants knowledge, concerns, and motivations and how they changed over the course of the program. Students were expected to gain knowledge from participating in the program and expected to feel more concerned with environmental issues in South Florida.

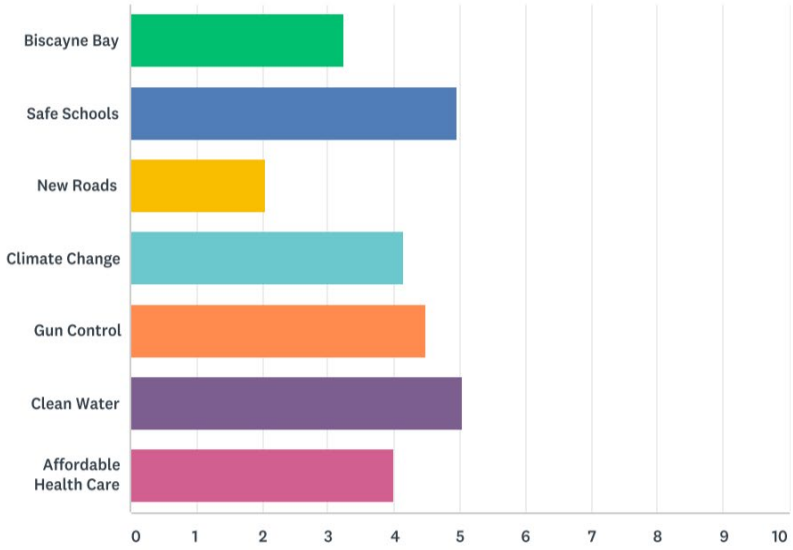
A survey was administered at the beginning of the program to determine base knowledge and level of concern about the Everglades. By the beginning of the second session (September 14), environmental or ecology knowledge-based questions were administered to the students with all but one questions being answered with 85% correct or more. Participants did not know the meaning of the benthic zone, with only 47.06% of students answering correctly by the beginning of the third session. The 8th grade class at South Miami Middle School had a 2.85 out of 5 average that climate change would have major affects in their lifetimes. All participants agree or strongly agree that marine

animals are important for the entire planet and all agree or strongly agree that humans can negatively affect marine animals. Therefore, the participants understand that humans can affect the environment, but did not think climate change can seriously alter the planet in their lifetimes. There was even less agreement that marine animal loss can affect the participants, two participants answered “strongly agree”, six answered “agree”, and one answered “neither agree nor disagree.” The previous two questions had most participants answering “strongly agree” with only two students answering “agree.” There does seem to be a disconnect with how the environment and loss of animals can affect them personally.

By the fourth session, participants were asked to rank seven major issues that could affect them in their lives. They were asked to prioritize the options based on the importance in their opinions with 1 being the most important and 7 being the least important. Three choices were environment related while the remaining four were other political issues. Clean water ranked as the top order of importance for the participants suggesting that the middle school students understand the value of having clean water. Figure 2 below shows the results for the ranking question, clean water and safe schools were high on the ranking for the middle school participants.

Figure 2.3 Pre Test 2 Question 7: “Rank these 7 issues in order from most important to least important, with one being most important and 7 being least”. Ranking questions on SurveyMonkey calculate the average rank on a question for each choice. The largest average is the answer that’s most preferred. W = weight of ranked position and X = response count for each choice. Since there are seven choices, the number one choice has a rank of 7, the number two choice has a rank of 6, and the number three choice has a rank of 5, and so forth.

$\frac{X_1W_1 + X_2W_2 + X_3W_3 \ldots X_nW_n}{\text{Total response count}}$



	1	2	3	4	5	6	7	TOTAL	SCORE
Biscayne Bay	9.52% 2	4.76% 1	9.52% 2	14.29% 3	9.52% 2	42.86% 9	9.52% 2	21	3.24
Safe Schools	14.29% 3	23.81% 5	28.57% 6	19.05% 4	9.52% 2	0.00% 0	4.76% 1	21	4.95
New Roads	4.55% 1	4.55% 1	0.00% 0	9.09% 2	9.09% 2	9.09% 2	63.64% 14	22	2.05
Climate Change	23.81% 5	4.76% 1	4.76% 1	23.81% 5	19.05% 4	19.05% 4	4.76% 1	21	4.14
Gun Control	9.52% 2	23.81% 5	28.57% 6	4.76% 1	19.05% 4	4.76% 1	9.52% 2	21	4.48
Clean Water	31.82% 7	9.09% 2	18.18% 4	13.64% 3	27.27% 6	0.00% 0	0.00% 0	22	5.05
Affordable Health Care	4.55% 1	27.27% 6	9.09% 2	18.18% 4	9.09% 2	27.27% 6	4.55% 1	22	4.00

Chapter 3 Understanding changes in Biological Diversity with Restoration: a study of submerged aquatic vegetation (SAV) diversity in Biscayne Bay, Florida.

3.1 Introduction

Often the most important mode of learning is by doing. Students at both the undergraduate and graduate level learn ecological methods by going into the field with more experienced scientists. The process of "learning by doing" can offer students a new perspective on concepts first presented in a classroom setting. This chapter examines the methods and tools used to evaluate changes in biological diversity in coastal ecosystems of Biscayne Bay that are included in the CERP through the Biscayne Wetlands Restoration Project. If restoration efforts are designed to improve ecological function of the Greater Everglades Ecosystem, then there should be measures of success in documenting biological diversity ("biodiversity") of some group of organisms. Learning to quantify changes in biological diversity serves to teach students at all levels the importance of scientific information to making management and policy. The focus of the research was documenting changes in the submerged aquatic vegetation (SAV) and coastal plants of restored sites within Biscayne National Park.

The purpose of the research was to explore methods of biological diversity assessment that could be accomplished by middle to high school students as a learning exercise as well as build a long-term dataset on biological diversity of organisms responsive to restoration efforts. The SAV includes seagrasses and benthic macroalgae, collectively referred to as marine plants. Biscayne Bay benthic communities are diverse assemblages of infauna (animals living in the sediment), epifauna (animals living on or over the sediment) and marine plants. Biological diversity is a key indicator of ecosystem

health and function. Improvements in biological diversity could be critical measures of success for coastal restoration projects (Lirman et al., 2014). The project goal was to test the hypothesis: "Increasing biodiversity enhances ecosystem function" (Midgley, 2012) for marine plants in nearshore environments.

Biscayne Bay Coastal Wetlands Restoration Project is designed to improve the ecological health of Biscayne Bay (including freshwater wetlands, tidal creeks and near-shore habitat) by adjusting the quantity, quality, timing, and distribution of freshwater entering Biscayne Bay and Biscayne National Park. Reestablishing more natural flows will restore estuarine salinity conditions, resulting in improved habitat for fish and wildlife resources. Biodiversity is a key aspect for the evaluation of restoration success. Ecological restoration is likely to increase the biodiversity (Wortley et al., 2013). Thus, regular assessments of marine plant diversity could be used to calculate diversity indexes as useful tools for quantifying restoration success.

High or low levels of disturbance could lead to low species richness, whereas an intermediate level disturbance could possibly maximize species diversity (Connell, 1978). Some natural coastal areas have undergone a succession of algae species (both green and red algae species) after hurricane events (Fenner, 1991; Woodley et al., 1981). However, when combined with factors such as overfished areas and absence of predation, algae may undergo long-duration "blooms" or dominance of one species, which may have deleterious effects on the ecosystem (Hughes, 1989). Environmental factors that are affected by hurricanes and may in turn affect algae diversity and occurrence are (amongst others) nutrients, suspended sediment, and light availability. These may be affected by the level of anthropogenic disturbance of each area.

Thus, by "learning by doing," the survey of marine plants off two stations in Biscayne Bay (Convoy Point and Black Point) might be both a learning system for teaching about biological diversity as well as a means for building a long-term dataset to understand the impacts of coastal restoration.

3.2 Methods

Study Sites

Three sites were selected based on proximity to CERP restoration projects, canals, and the convenience of public access for outreach activities. These sites include two popular access points to Biscayne National Park:

- Convoy Point is the location of the Ranger Station and Dante Fascell Visitor Center, which is located at 9700 SW 328th St, Homestead, FL 33033. Convoy Point has a marina as well. Snorkelers entered the water near the parking lot and typically swam west-north-west along the mangrove shoreline (**Figure 3.1)** . A county landfill site is located adjacent to Convoy Point, along with large agricultural fields to the west. Many of the canals near Convoy Point have gates and flood control that manage freshwater flow into the area.
- Black Point is home to the Black Point Park and Marina, located at 24775 SW 87th Ave, Homestead, FL 33032. There were several entry sites used by snorkelers to the north along the jetty. The first entry site used is near the parking lot north-east of Black Creek, and the other entry sites used are along the jetty (See **Figure 3.2**). Black Point is the northern-most survey site and is approximately 9 km away from Convoy Point. The site is at the tip of Biscayne National Park and is a popular location for many fishermen and exercise

enthusiasts (bicycling and running) along with boaters. Restoration projects along the causeway at Black Point include plant management and culverts for better water flow. Large amounts of freshwater enter Biscayne Bay at Black Point through the C-1 canal, can degrade water quality in the area. The largest of the Miami-Dade County landfills (aka "Mount Trashmore") is located to the west of Black Point.

The third site was Card Sound Road mangroves. This site is at the southern end of Biscayne National Park, just outside the park but is still in a wildlife refuge. Card Sound includes not only restored wetlands, but also the removal of marinas and human development in the vicinity of the Card Sound bridge.

The selection of sites represents a range of mangrove communities that can easily be accessed by snorkelers to visit for non-destructive inventory surveys. These surveys build on both formal research projects and citizen science projects (2010 National Geographic BioBlitz in Biscayne National Park). These surveys were conducted by groups of undergraduate students learning field identification of marine fauna and field survey techniques led by graduate students and faculty. The results were used to compare historical to current coastal diversity in South Florida protected areas

Due to the shallow nature of these areas, sites were surveyed at **high tide**. NOAA's tide predictions for Turkey Point [1] are used to schedule surveys for all three sites.

[1] See NOAA Tides here

https://tidesandcurrents.noaa.gov/noaatidepredictions/NOAATidesFacade.jsp?Stationid=8723423

Table 3.1: Locations in Biscayne Bay surveyed in 2015-2018 with restoration actions

SITE	Survey Area and Restoration Actions
BLACK POINT (BP)	*About 5500 square meters of soft bottm Coral patches north off the culverts installed along the 1-km breakwater along boat canal*
CONVOY POINT (CP)	*About 6000 square meters of soft bottom estuarine habitat off the Coral patches north of jetty and away from canal discharges*
CARD SOUND (CS)	*About 5300 square meters surveyed along restored mangrove channel. Restoration along Card Sound Road has reduced land-based sources of pollution, surveys will be conducted north of the Card Sound Bridge*

Figure 3.1: Map of the CONVOY POINT, the shoreline is highlighted in red, showing the canals that drain into Biscayne Bay in this area. Intact mangroves are shown in green, and the survey areas is indicated by the hatched polygon.

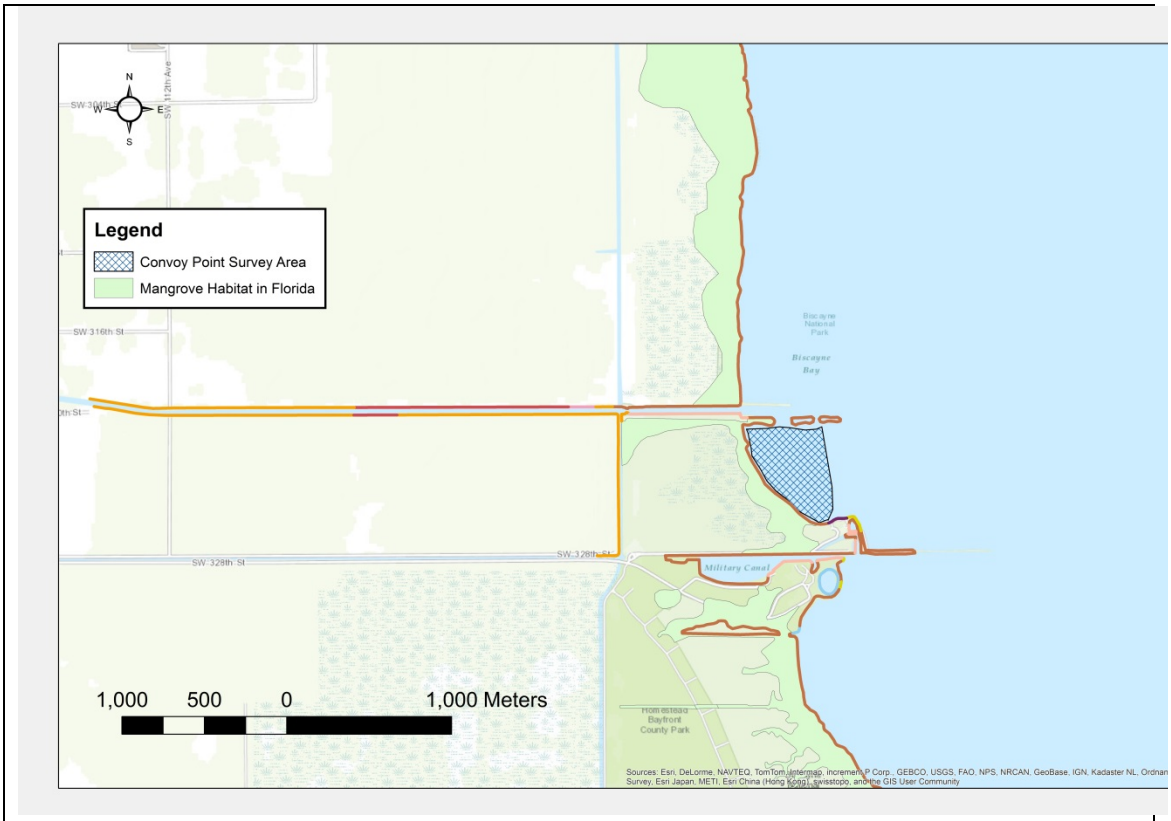
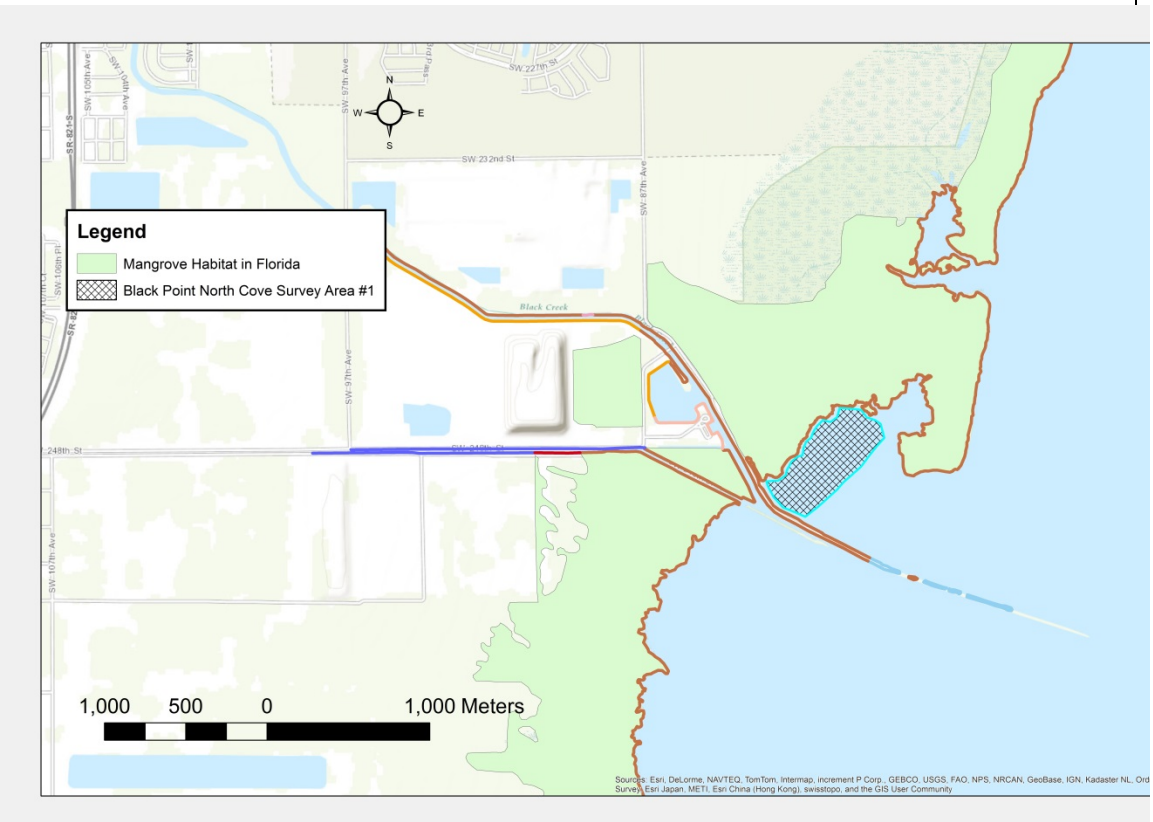


Figure 3.2 Map of the Black Point Survey area. The intact mangroves are shown in green, with the hatched polygon representing the survey area.

BLACK POINT SURVEY SITE



Marine Plant Assessments

SAV communities were surveyed by snorkelers using the roving diver technique survey (brief explanation of method) method. Surveyors snorkeled around the site and recorded the presence and abundance of every species of algae they observed.

Statistical analysis

The presence-absence data was used in non-parametric statistics to calculate a biodiversity index, Margalef's Species Richness (d) for fishes, submerged aquatic vegetation (SAV) and invertebrate epifauna. Margalef's Species Richness (d) is a biodiversity index that entails the number of organisms in the survey data set (N), and the total species count (S) in an effort to control sample bias (Pielou, 1984). Moreover, this biodiversity index takes into account both species richness and species evenness; species richness is the number of different organisms or species present, while species evenness is a comparison between species of relative abundance (Speight and Henderson, 2010). Historically, species richness is the standard metric for measuring biological diversity (Huang and Roy, 2015). The equation for Margalef's Species Richness is:

$$\mathbf{D_{MG} = (S\text{-}1) / \ln (N)}$$

For the project, the roving diver technique will be used along established transects, recording submerged aquatic vegetation, fish, and coastal plant species occurrence and abundance encountered. Roving diver survey is a method of free roaming for a certain number of minutes to record any fish that's seen during the survey (Schmitt and Sullivan, 1996). During our survey, we swam or walked 50 minute transects at all sites recording species that were seen.

3.3 Results

Table 2 illustrates the survey effort over years, including the pre/ post Hurricane Irma surveys (after10 September 2017). The least number of marine plants (N = 8) was recorded off Black Point; this area is adjacent to canals with extensive freshwater drainage from southern Miami-Dade County. The most marine plant species (N= 26) was recorded at the Card Sound site, this area is the furthest from direct canal inflow of all of the sites.

Table 3 illustrates the changes in marine plant diversity indices over time for the three sites. The largest changes in diversity indices over time occurred at Black Point. Two diversity indices were used, Pielou's evenness (J') and Magelaf's index (d). Black Point (BP) and Convoy Point (CP) are within 10 km of each other, both in south Dade, and both sites adjacent to coastal wetland restoration efforts. Both sites (BP and CP) are adjacent to large canals, and subject to large salinity fluctuations with storms and rain events. Both BP and CP are in Biscayne National Park and have the lowest plant diversity. However, both BP and CP increased in marine plant diversity after Hurricane Irma. These sites were visibly improved by the removal of sediment and increased marine plant diversity after the storm. Additional monitoring is needed to know if this trend persists. The marine plant assemblages changed primarily is the addition or loss of red fleshy algal species after the storm event.

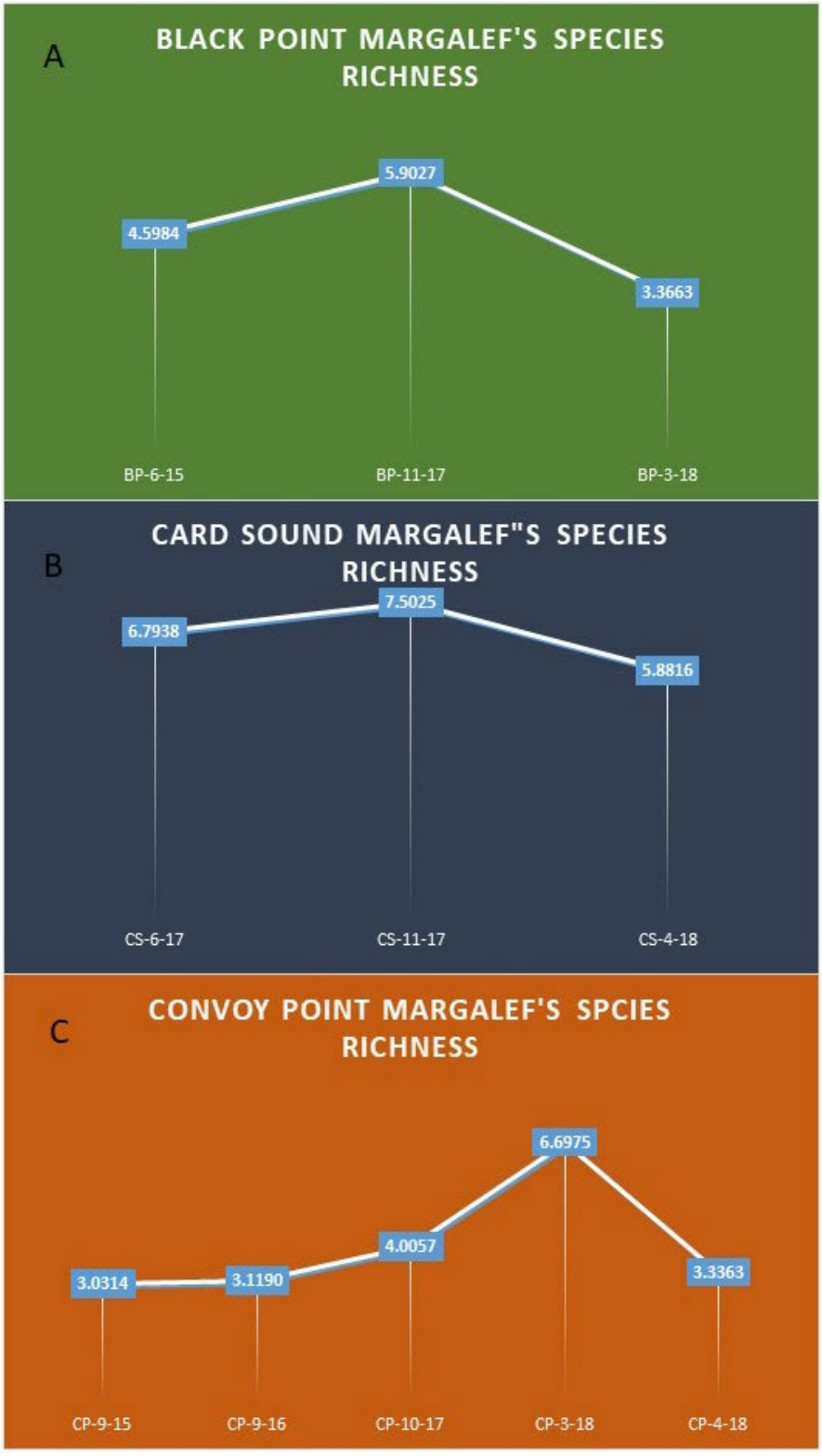
Table 3.2: Site survey history from 2015 to 2018. Survey time, season and the total number of marine plants recorded in the roving diver survey are shown for Black Point, Card Sound and Convoy Point.

SITE	DATE	SURVEY TIME	SEASON	# MARINE PLANTS RECORDED
Black Point	18-Jun-15	60	Wet	15
Black Point	3-Nov-17	60	Wet	20
Black Point	7-Apr-18	45	Dry	8
Card Sound	27-Jun-17	64	Wet	22
Card Sound	4-Nov-17	60	Wet	26
Card Sound	7-Apr-18	45	Dry	18
Convoy Point	7-Sep-15	60	Wet	9
Convoy Point	4-Sep-16	30	Wet	9
Convoy Point	14-Oct-17	60	Wet	13
Convoy Point	17-Mar-18	60	Dry	22
Convoy Point	7-Apr-18	45	Dry	9

Table 3.3: Biodiversity of Marine Plants at the three survey sites over time. The two indices presented are Margalef's (d) and Pielou's evenness (J').

SITE	DATE	SPECIES (N)	d	J'
Black Point	18-Jun-15	15	4.5984	0.9504
Black Point	3-Nov-17	20	5.9027	0.9680
Black Point	7-Apr-18	8	3.3663	1.0000
Card Sound	27-Jun-17	22	6.7938	1.0000
Card Sound	4-Nov-17	26	7.5025	0.9924
Card Sound	7-Apr-18	18	5.8816	1.0000
Convoy Point	7-Sep-15	9	3.0314	0.9417
Convoy Point	4-Sep-16	9	3.1190	0.9366
Convoy Point	14-Oct-17	13	4.0057	0.9686
Convoy Point	17-Mar-18	22	6.6975	0.9949
Convoy Point	7-Apr-18	9	3.3363	0.9766

FIGURE 3.3: Changes in Margalef's Species Evenness over time for three survey sites.



3.4 Discussion

Marine Plant species, particularly benthic algae, respond rapidly with changes in water quality or storm events. Long-term stability in the diversity, with seasonal changes in species composition, are expected for healthy species assemblages that could occur off restoration sites.

Our education goals need adaptive management practices in order to progress with environmental changes. Adaptive management assesses a program, receives feedback, and changes based on the feedback (McLain and Lee, 1996). For restoration goals to continue and increase around the world, people need to have environmental programs that support these restoration projects. By implementing assessments throughout the environmental education program, changes can be made to create an up-to-date curriculum that reflects the environmental changes. Restoration can make changes on the biota in an ecosystem therefore environmental education programs should adapt content in response.

Marine plants were a good thing to measure because there are 500 species to learn in Biscayne Bay. It is important in an environmental education program that students can continually learn throughout the process. Studying benthic algae diversity in Biscayne Bay shows the participants the vast amount of species that can be found therefore increasing the chances of a student showing interest in some aspect of the environment.

Plants are a little different with looking at restoration, they are more immediate and local in response to the restoration project. There are measures of success that use birds or other animals in ecological systems but since they can move, animal responses to

restoration success are different than plants. Measuring plant diversity gives a more direct measure of success to adjacent projects.

Conclusion

Biological diversity changes spatially and temporally, therefore its valuable to record data over long periods of time. Major rainfall events can dramatically alter the species composition in an area. The biological diversity data in Biscayne Bay adjacent to restoration and human altered areas suggest there are difference between the two types of sites over time. And Card Sound, which has the fewest human development adjacent to the location, has the highest level of diversity suggesting that Card Sound is a healthier site. The collection of the biological diversity led me to the idea that since sites can be dynamic then our education programs need to be adaptive as well. Education takes many years to achieve set goals and having a dynamic and adaptive program will keep up with changing information.

Implementing the curriculum in the classroom came with unexpected challenges that caused confusion among the students. Participants need detailed instructions on all activities or they may get confused and misinterpret the rules for the game or directions in the task. Also, students are reluctant to try things that they determine is repulsive, such as handling mud from the mangrove creeks for sieving.

ACKNOWLEDGEMENTS

Surveys in Biscayne National Park were carried out under Study # BISC-00055 and Permit BISC-2015-SCI-0010, renewed for 2016, 2017 and 2018 to Kathleen Sullivan Sealey.

LITERATURE CITED

Anderson, M. J., T. O. Crist, J. M. Chase, M. Vellend, B. D. Inouye, A. L. Freestone, N. J. Sanders, H. V. Cornell, L. S. Comita and K. F. Davies (2011). "Navigating the multiple meanings of β diversity: a roadmap for the practicing ecologist." EcologyLletters 14(1): 19-28.

Bennett, N. J., R. Roth, S. C. Klain, K. Chan, P. Christie, D. A. Clark, G. Cullman, D. Curran, T. J. Durbin and G. J. B. C. Epstein (2017). "Conservation social science: Understanding and integrating human dimensions to improve conservation." Biological Conservation 205: 93-108.

Blaber, S. J. (2007). "Mangroves and fishes: issues of diversity, dependence, and dogma." Bulletin of Marine Science 80(3): 457-472.

Brooks, T. M., R. A. Mittermeier, G. A. da Fonseca, J. Gerlach, M. Hoffmann, J. F. Lamoreux, C. G. Mittermeier, J. D. Pilgrim and A. S. Rodrigues (2006). "Global biodiversity conservation priorities." Science 313(5783): 58-61.

Browder, J. A., R. Alleman, S. Markley, P. Ortner and P. A. Pitts (2005). "Biscayne Bay conceptual ecological model." Wetlands 25(4): 854-869.

Cantillo, A. Y., L. Pikula, K. K. Hale, E. V. Collins and R. Caballero (2000). "Biscayne Bay environmental history and annotated bibliography."

Connell, J.H. (1978) Diversity in Tropical Rain Forests and Coral Reefs. Science 199, 1302-1310.

Czech, B., P. K. Devers and P. R. Krausman (2001). "The relationship of gender to species conservation attitudes." Wildlife Society Bulletin: 187-194.

Dickinson, J. L., J. Shirk, D. Bonter, R. Bonney, R. L. Crain, J. Martin, T. Phillips and K. Purcell (2012). "The current state of citizen science as a tool for ecological research and public engagement." Frontiers in Ecology and the Environment 10(6): 291-297.

Edgar, G. J., T. J. Alexander, J. S. Lefcheck, A. E. Bates, S. J. Kininmonth, R. J. Thomson, J. E. Duffy, M. J. Costello and R. D. Stuart-Smith (2017). "Abundance and local-scale processes contribute to multi-phyla gradients in global marine diversity." Science Advances 3(10): e1700419.

Fenner, D.P. (1991) Effects of Hurricane Gilbert on Coral Reefs, Fishes and Sponges at Cozumel, Mexico. Bulletin of Marine Science 48, 719-730.

Gadgil, M., F. Berkes and C. Folke (1993). "Indigenous knowledge for biodiversity conservation." Ambio: 151-156.

Galatowitsch, S. M. and A. G. van der Valk (1996). "The vegetation of restored and natural prairie wetlands." Ecological Applications 6(1): 102-112.

Gentile, J., M. Harwell, W. Cropper Jr, C. Harwell, D. DeAngelis, S. Davis, J. Ogden and D. Lirman (2001). "Ecological conceptual models: a framework and case study on ecosystem management for South Florida sustainability." Science of the Total Environment 274(1): 231-253.

Gotelli, N. J. and R. K. Colwell (2001). "Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness." Ecology Letters 4(4): 379-391.

Hughes, T.P. (1989) Community Structure and Diversity of Coral Reefs: The Role of History. Ecology 70, 275-279.

Hume, T. M., T. Snelder, M. Weatherhead and R. Liefting (2007). "A controlling factor approach to estuary classification." Ocean & Coastal Management 50(11): 905-929.

Hungerford, H. R. and T. L. Volk (1990). "Changing learner behavior through environmental education." The Journal of Environmental Education 21(3): 8-21.

Jordan, R. C., S. A. Gray, D. V. Howe, W. R. Brooks and J. G. Ehrenfeld (2011). "Knowledge gain and behavioral change in citizen-science programs." Conservation Biology 25(6): 1148-1154.

Kappel, C. V. (2005). "Losing pieces of the puzzle: threats to marine, estuarine, and diadromous species." Frontiers in Ecology and the Environment 3(5): 275-282.

Kimble, G. (2014). "Children learning about biodiversity at an environment centre, a museum and at live animal shows." Studies in Educational Evaluation 41: 48-57.

Kollmuss, A. and J. Agyeman (2002). "Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior?" Environmental Education Research 8(3): 239-260.

Lapinski, M. K., R. N. Rimal, R. DeVries and E. L. Lee (2007). "The role of group orientation and descriptive norms on water conservation attitudes and behaviors." Health Communication 22(2): 133-142.

Lewis, R. R. (2005). "Ecological engineering for successful management and restoration of mangrove forests." Ecological Engineering 24(4): 403-418.

Lirman, D. and W. P. Cropper (2003). "The influence of salinity on seagrass growth, survivorship, and distribution within Biscayne Bay, Florida: field, experimental, and modeling studies." Estuaries 26(1): 131-141.

Lirman, D., T. Thyberg, R. Santos, S. Schopmeyer, C. Drury, L. Collado-Vides, S. Bellmund and J. Serafy (2014). "SAV Communities of western Biscayne Bay, Miami, Florida, USA: Human and natural drivers of seagrass and macroalgae abundance and distribution along a continuous shoreline." Estuaries and coasts 37(5): 1243-1255.

Magurran, A. E. (2013). Measuring biological diversity, John Wiley & Sons.

McLain, R.J., Lee, R.G. (1996) Adaptive management: promises and pitfalls. Environmental management 20, 437-448.

McNulty, J. K. (1961). "Ecological effects of sewage pollution in Biscayne Bay, Florida: Sediments and the distribution of benthic and fouling macro-organisms." Bulletin of Marine Science 11(3): 394-447.

Midgley, G. F. (2012). "Biodiversity and ecosystem function." Science 335(6065): 174-175.

Midgley, G.F. (2012) Biodiversity and Ecosystem Function. Science 335, 174-175.

Myers, N., R. A. Mittermeier, C. G. Mittermeier, G. A. Da Fonseca and J. Kent (2000). "Biodiversity hotspots for conservation priorities." Nature 403(6772): 853.

Palumbi, S. R., P. A. Sandifer, J. D. Allan, M. W. Beck, D. G. Fautin, M. J. Fogarty, B. S. Halpern, L. S. Incze, J.-A. Leong and E. Norse (2009). "Managing for ocean biodiversity to sustain marine ecosystem services." Frontiers in Ecology and the Environment 7(4): 204-211.

Pooley, J. A. and M. O'Connor (2000). "Environmental education and attitudes: Emotions and beliefs are what is needed." Environment and behavior 32(5): 711-723.

Schmitt, E., Sullivan, K. (1996) Analysis of a volunteer method for collecting fish presence and abundance data in the Florida Keys. Bulletin of Marine Science 59, 404-416.

Stern, P. C. (2000). "New environmental theories: toward a coherent theory of environmentally significant behavior." Journal of social issues 56(3): 407-424.

Van der Heijden, M. G., J. N. Klironomos, M. Ursic, P. Moutoglis, R. Streitwolf-Engel, T. Boller, A. Wiemken and I. R. Sanders (1998). "Mycorrhizal fungal diversity determines plant biodiversity, ecosystem variability and productivity." Nature 396(6706): 69.

Wilcove, D. S., D. Rothstein, J. Dubow, A. Phillips and E. Losos (1998). "Quantifying threats to imperiled species in the United States." BioScience 48(8): 607-615.

Wiliam, D. (2011). "What is assessment for learning?" Studies in educational evaluation 37(1): 3-14.

Woodley, J.D., Chornesky, E.A., Clifford, P.A., Jackson, J.B.C., Kaufman, L.S., Knowlton, N., Lang, J.C., Pearson, M.P., Porter, J.W., Rooney, M.C., Rylaarsdam, K.W., Tunnicliffe, V.J., Wahle, C.M., Wulff, J.L., Curtis, A.S.G., Dallmeyer, M.D., Jupp, B.P., Koehl, M.A.R., Neigel, J., Sides, E.M. (1981) Hurricane Allen's Impact on Jamaican Coral Reefs. Science 214, 749-755.

Worm, B., E. B. Barbier, N. Beaumont, J. E. Duffy, C. Folke, B. S. Halpern, J. B. Jackson, H. K. Lotze, F. Micheli and S. R. Palumbi (2006). "Impacts of biodiversity loss on ocean ecosystem services." science 314(5800): 787-790.

Wortley, L., J. M. Hero and M. Howes (2013). "Evaluating ecological restoration success: a review of the literature." Restoration Ecology 21(5): 537-543.

Zhang, J.-Z., C. R. Kelble, C. J. Fischer and L. Moore (2009). "Hurricane Katrina induced nutrient runoff from an agricultural area to coastal waters in Biscayne Bay, Florida." Estuarine, Coastal and Shelf Science 84(2): 209-218.

Appendix

Finding Our Way to Biscayne Bay

Vocabulary	Estuarine, Restoration, Biodiversity, Climate Change, Wetlands
Objectives	Introduction to Biscayne Bay and its connection to the Everglades. Students will understand that Biscayne Bay provides Miami residents with ecosystem services such as fish, ecotourism, and storm protection. For ecosystem services to increase, Miami needs data for resource management to best understand restoration effects.
Teacher Instruction	Give an overview of Biscayne Bay, Everglades, and urban development (15 mins). Have students draw a Cmap of the Biscayne Bay ecosystem, including humans and the sun (15 mins). Next, talk about the cost of restoration in South Florida and the worth of the fishing and tourism industry. Students can then work out a 5% or 10% increase in fish production and discuss whether that increase in worth restoration (10 mins). Create an advertisement involving Biscayne Bay and a way to make it better, either through reduced pollution, loving animals, controlled fishing, etc (10 mins).
Florida Education Requirements	SC.912.L.15 SC.912.L.17

Wish We Had More Fish- Importance of Biodiversity in Marine Fish

Vocabulary	Habitat, Sustainable, Ecosystem Services, Conservation
Objectives	Participants will learn the interconnectedness of biotic and abiotic aspects in Biscayne Bay. This lesson will introduce students on the basics of identifying fish in the water.
Teacher Instruction	Give an overview of fish that could be found in Biscayne Bay and that juvenile fish need the shelter of mangroves and the estuary to survive into adulthood (10 mins). Have students play the ocean creatures game. The game is played by giving students cards with a description of a marine animal and the students must decide which creature the cards describes. Play the game individually and then play the game in groups (20 mins). Next, have students write down as many fish species as they can in 3 minutes (5mins).
Florida Education Requirements	SC.912.L.17

Grab a Handful of Crab- Mobile Invertebrates

Vocabulary	Population, Carrying Capacity, Exoskeleton, Benthic, Predator, Prey
Objectives	Marine invertebrates in Biscayne Bay rely on salinity gradients to survive, just like fish. Crustaceans feed on plants

	and other fish. Oysters filter pollutants in the water to feed and breathe. Participants will learn about carrying capacity and that some species are limited in population growth due to food or predators.
Teacher Instruction	Talk about carrying capacity and that there are limiting nutrients or resources for species to survive. Introduce the word benthic when talking about crabs and lobsters and their role in the fishing industry (10 mins). Have students play the population dynamics game, which teaches students that populations have a carrying capacity limited by death and birth. The rules are groups are split into groups of four, a builder, destroyer, accountant, and time keeper that they must keep secret from their other group members. Builder connects two Lego pieces together, represents one organism. Destroyer pulls apart the Lego pieces once it reaches a certain number. Accountant keeps track of the number of connected pieces every 20 seconds in a chart. Time keeper tracks the time for 5 minutes and announces the time every 30 seconds. After, the team makes a graph of their data (20min).
Florida Requirements	SC.912.L.15.7 SC.912.L.17

Dredge and Fill Up a Sieve

Vocabulary	Eutrophication, Abiotic, Biotic, Sieve, Limiting Nutrient
Objectives	Students will understand the hydrology changes in South Florida and affects it had on humans and coastal zones. Sediment size can correlate with the type of organic material that's trapped underground. Trapped sediment can be released during disturbances causing a release of carbon into the environment.
Teacher Instruction	Begin by going over the history of dredging in South Florida and why dredging is bad for ecosystems (10 mins). Next introduce the sieves and sediment samples (collected previously) to the students and show them how to use it. Allow a few students to do it at one time, while others record the data or weigh the results (30 mins).
Florida Requirements	SC.912.L.17.19

One, Two, Trees and Other Coastal Plants

Vocabulary	Erosion, Mangroves, Sequestration, Primary Producer

Objectives	Students will learn the importance of coastal plants to our coastlines and that they offer protection from natural disturbances. Mangroves are critical for a healthy coast as they provide protection to both juvenile fish and humans during major hurricanes.
Teacher Instruction	Talk about the importance of mangroves for our coastline, how they help with storm protection, sequestering excess nutrients, and protect juvenile fish (10 mins). Have students make a slogan or design a bumper sticker that encourages people to restore the wetlands. (20 mins)
Florida Requirements	SC.912.L.17

Assessments

A total of 50 different questions were administered to the South Miami Middle School students spread over 9 different surveys. Students were asked to answer questions from the pretest at the beginning of each sessions and questions from the posttest at the end of each session. The only session that did not have a pretest was the last session, the posttest was still administered.

Finding Our Way to Biscayne Bay

1 - Pretest

1. Does climate change affect you now? On a scale of one to five.
2. I can make a difference to the environment around me

3. When was the last time you visited a state or national park?
4. Do you know what a concept/spider web map looks like?
5. How do you feel about the natural environment (forest, ocean, wetlands)?

2 - Posttest:

6. Biscayne Bay is part of the Greater Everglades Ecosystem
    a. True
    b. False
7. I can make a difference to the environment around me
    a. Agree
    b. Disagree
    c. I don't know
8. Do you know what a concept/spider web map looks like?
9. How much did you enjoy this lesson?

<u>Wish We Had More Fish- Importance of Biodiversity in Marine Fish</u>

3 - Pretest

10. What is biological diversity?
    a. Variety of life in an area
    b. Variety of people
    c. A group of organisms that can breed with each other
    d. I don't know
11. What is a habitat?
12. Select the Barracuda.

a. Shown picture of 5 different fish species

b. I don't know

13. Select the Angelfish.

a. Shown picture of 5 different fish species

b. I don't know

14. Agree or disagree? Marine animals are important for the entire planet
15. Agree or disagree? Humans can negatively affect animals in the marine environment
16. Agree or disagree? The loss of marine animals affects me personally
17. Agree or disagree? The ocean is an important part of my life

4 - Posttest:

18. Select the yellowtail snapper.

a. Shown pictures of 5 different fish species

b. I don't know

19. Select the angelfish.

a. Shown pictures of 5 different fish species

b. I don't know

20. Agree or disagree? Marine animals are important for the entire planet
21. Agree or disagree? Humans can negatively affect animals in the marine environment
22. Agree or disagree? The loss of marine animals affects me personally

<u>Grab a Handful of Crab- Mobile Invertebrates</u>

5 - Pretest

23. What is the benthic zone?

    a. Bottom of a body of water
    b. Middle of a body of water
    c. Top of a body of water
    d. All the above
    e. I don't know

24. Fishing too many marine animals affects the ecosystem they are collected from.

25. Harmful algal blooms affect me personally.

26. We should limit the amount of fish/invertebrates removed from the ocean.

27. What does it mean to have a limiting nutrient in an environment?

    a. Nutrient that limits growth
    b. Nutrient that allows growth
    c. Nutrient that stops light from entering the water
    d. I don't know

28. What does carrying capacity mean for a population?

    a. Number of individuals in an area that can be supported due to food, shelter, and competition
    b. The amount of water in a certain area
    c. The amount of food available for an animal
    d. I don't know

6 - Posttest

29. What is the benthic zone?

a. Bottom of a body of water

b. Middle of a body of water

c. Top of a body of water

d. All of the above

e. I don't know

30. What does carrying capacity mean for a population?

a. Number of individuals in an area that can be supported due to food, shelter, and competition

b. The amount of water in a certain area

c. The amount of food available for an animal

d. I don't know

31. Did you enjoy the session today?

a. Yes

b. No

32. Did you learn anything from the sessions so far?

a. Yes

b. No

33. Agree or disagree? Restoration is important for South Florida

<u>Dredge and Fill Up a Sieve</u>

7 - Pretest

34. How valuable is Biscayne Bay to you?

a. Extremely valuable

b. Very valuable

c. Somewhat valuable

d. Not so valuable

e. Not at all valuable

35. In your opinion prioritize these choices in the order of importance.

a. Biscayne bay

b. Safe schools

c. New roads

d. Climate Change

e. Gun Control

f. Clean water

g. Affordable health care

36. How often do you make sustainable (reduce, reuse, recycle) choices?

a. Every day

b. More than once a week

c. More than twice a month

d. Once a month or less

e. Never

37. What is eutrophication?

a. Excess nutrients in a body of water

b. Excess water in a system

c. Too many fish in an area

d. I don’t know

38. Have you talked to anyone outside the classroom about the importance of Biscayne Bay?
    a. Yes
    b. No
39. Do you feel these sessions changed your opinion on Biscayne Bay?
    a. Yes
    b. No

8 - Posttest

40. What is eutrophication?
    a. Excess nutrients in a body of water
    b. Excess water in a system
    c. Too many fish in an area
    d. I don't know
41. Agree or disagree? I enjoyed working with the sediment and sieves.
42. Do you think hotels close to the beach are beneficial for everyone living in Miami?
    a. Yes
    b. No
    c. I don't know
43. Agree or disagree? Restoration is important for South Florida
44. Agree or disagree? Restoration is important to me

<u>One, Two, Trees and Other Coastal Plants</u>

9 – Final Test

45. How likely do you feel you will talk to someone else about Biscayne Bay? 0 being not all likely and 5 being very likely
46. How likely will you talk about restoration of the Everglades with someone else? 0 being not at all likely and 5 being very likely.
47. Rank your favorite sessions in order with 1 being your favorite and 5 being least favorite.
48. Rank how valuable you think Everglades restoration is, 5 being very valuable and 0 being not at all valuable.
49. Would you try to visit Biscayne Bay in the next two months?
    - Yes
    - No

Student Handbook

Hello learner,

This book guides you through learning about the importance of clean water in Florida, which can be applied to many places around the world. South Florida offers residents warm weather all year long, making it an attractive city to live. In a growing city, people need new places to live, water, energy, and time efficient transportation. These activities are designed to inform you on water related issues in South Florida, and I encourage you to think about the connection of water to housing, energy, and transportation as well.

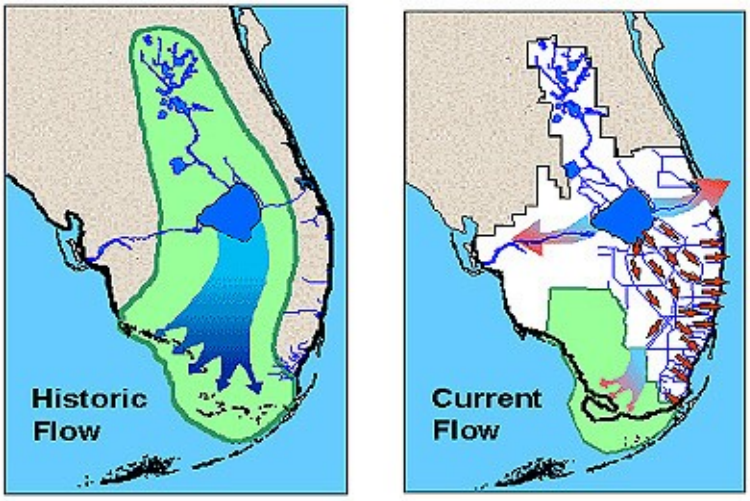
Water is a necessity for all organisms to survive, therefore we must protect fresh drinking water. Much of Florida residents get their freshwater from the Biscayne Aquifer, which is a storage of freshwater just below the ground. But that is only part of the story of our water's journey. Freshwater begins moving south from the Kissimmee River, runs through Lake Okeechobee, and exiting in many estuaries along the coast of Florida. In between Kissimmee River, humans live and work allowing disturbances and pollution to seep into the water.

The Comprehensive Everglades Restoration Plan, CERP, will take 50 years to complete, therefore as you grow up the plan will still be making changes in Florida. Restoration brings back some of the natural water flow that existed before humans lived in Florida, but we will never get back to pre-human conditions. Below are two maps of Florida, the historic flow shows how water moved throughout South Florida starting from Orlando going through the Keys and how water moves now.

The water we drink is a resource that we all need to work to protect. Its important to understand that healthy ecosystems clean our water and that restoration can return some of those healthy ecosystems that were lost. I hope this book helps you understand restoration and the water (and species that live in it) in South Florida.

Sincerely,

Krystle Young



Finding Our Way to Biscayne Bay

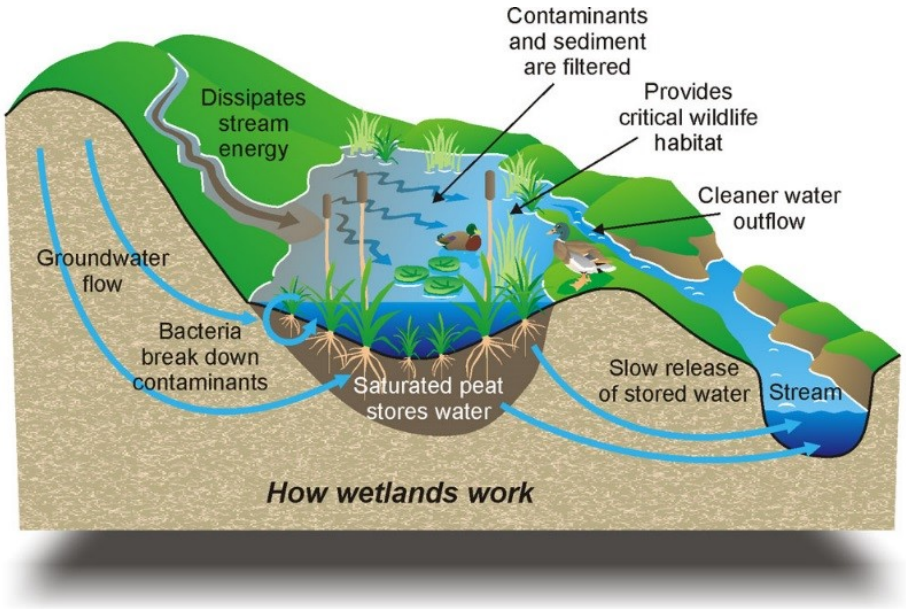
Biscayne Bay is an estuary located to the East of Miami-Dade County. An **estuary** is a coastal marine environment that has freshwater flow from rivers creating changing salinities across the area. Florida has many estuaries along its coastline, each one provides valuable services for humans.

What services or benefits can humans get from having healthy estuaries? Biological diversity, or **biodiversity** is all the species in a certain area and increases the health of our ecosystem. Having a variety of biological species increases the services we get from these areas. Estuaries provide homes for juvenile fish and many species depend of estuaries at some part of their life cycle. People consume many of the species that live in Biscayne Bay such as grouper, mojarra, and snapper. Another benefit that South Florida residents get from estuaries is protection from major storms. Mangroves and healthy coastlines protect homes, properties, and beaches from damage due to heavy rains, winds, and waves.

Clean water is another service that Biscayne Bay provides South Florida residents. Our beaches attract many tourists from all over the world, but if have water that is polluted or too dangerous to swim then that means there is less money coming into Florida. Clean water is a major reason why **restoration** should be supported. The huge issue is that water in South Florida is all connected from Kissimmee River in Orlando, the **wetlands** in the Everglades, and estuaries along the coast. Wetlands clean pollutants from water, making them a valuable ecosystem.

Climate change is the altering of global weather patterns, causing extreme weather. Humans affect the climate by releasing greenhouse gases into the atmosphere, gasoline is an example of a greenhouse gas. Extreme weather in Biscayne Bay can cause disturbances to the biodiversity on the coastline degrading the services we get from our estuary.

The health of Biscayne Bay effects all residents in Miami-Dade, not just ones living close to the shoreline. You deserve to have clean water, free from pollutants delivered from other people's choices. Water is the source of your life, it's a basic human need to have clean, accessible drinking water.



Draw a concept map that asks a question about Biscayne Bay.
Please draw your concept map below:

Wish We Had More Fish

Have you ever eaten fish or been fishing? Most people eat marine animals or at least enjoy looking at them. Humans must abide by fishery management recommendations for taking fish out of the ocean. The reason its important to follow recommendations for marine animals is that without guidelines then people will grab as many fish as they can which is not a sustainable practice. **Sustainable** practices are actions that allow for a resource to be used now and for future generations. By restoring polluted water to clean water is an example of a sustainable practice or taking a certain number of lobsters during lobster season is another example.

Fish can be cute, gross, slimy, yummy, smelly, beautiful, or scary but we rely on our marine animals to keep the balance in our ocean systems. Many fish use Biscayne Bay as a **habitat**, which is the area that an animal use for shelter and finding food, their home. Whether or not you love fish, they are an important part of our lives and needed for our survival, therefore we must care to protect their habitat from pollution or destruction. In their habitat, fish need food, clean water, and shelter. All three can be affected by human activities. Fish eat algae, mangroves leaves, and other marine animals, therefore humans shouldn't collect large amounts of fish. Many fish use the mangroves and seagrass for protection from larger fish, therefore conserving both is important for young fish. Human interactions affect the ocean and it begins at our coastlines.

Sustainable practices preserve our **ecosystem services**. Ecosystem services are benefits that humans gain from the environment, such as clean water, storm protection, and food. These services can be used by all citizens in an area therefore its important that we all conserve the environments that house them. **Conservation** of our environments means that we keep our natural environments safe from trash, pollution, and urban development. For South Florida, building new homes for new residents is increasingly important because many people want to live in Miami and have a home with a yard. There is a limit to how many homes that can be built while keeping our everglades and coasts in good conditions.

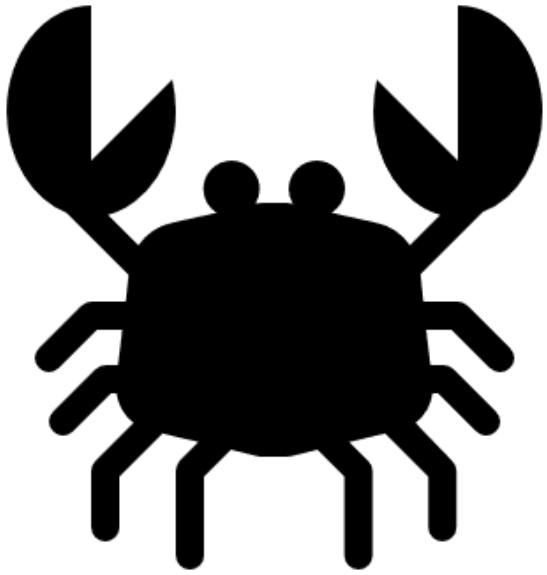
Grab a Handful of Crabs

Imagine grabbing a handful crabs, how scary it would be to stick your hand into the bundle, receiving multiple pinches would be the most likely outcome from that interaction with these marine invertebrates. Crabs and many other invertebrates are called **benthic** animals because they live on the bottom of the ocean floor. Benthic animals include crabs, lobsters, some worms, sea stars, and corals.

Crabs are like the bugs of the ocean floor since like bugs on land, they both have **exoskeletons**, an outer, rigid support for invertebrate animals similar to skeleton but on the outside instead of the inside. They have joints that allow their appendages or legs to move. Unlike bugs, many humans eat blue crabs (although some cultures will eat crickets and cockroaches), which is a huge industry in Florida. Crabs need to molt their exoskeleton to grow and can only molt 25 times in their lifetime. Female blue crabs can produce up to 2 million eggs, but not all the eggs survive to adulthood.

Animals produce more eggs than will live to adulthood, not only crabs experience that but many land and marine species as well. Many of those eggs, larvae, and adult crabs will be eaten by **predators**, animals that eat other animals. When crabs are smaller or younger they are easier **prey**, animals that get eaten by other animals. The **carrying capacity** of an animal is the amount of individuals that an area can support. That number can change from species to species, some areas can support a large number of one species such as beetles but a small number of wasps.

Oysters are another type of invertebrate that's important for marine ecosystems as they serve as the foundation for many areas because they provide habitats for other animals. A group of oysters is called a bed, and a **population** would be all individuals of the same species that live in the same area. Female oysters can produce up 100 million eggs annually and once they mature, they settle onto a hard surface. Oysters eat by filtering water and by doing that they are cleaning the water of nutrients, providing humans with an ecosystem service.



We will play a game that will demonstrate carrying capacity.

1. Split into groups of 4
2. Grab supplies from instructor
3. Do not share your instructions for your role to anyone
4. Read the instructions for your role
5. Planter, Predator, Time keeper, and Accountant
6. You will be given 5 minutes to complete this exercise.

30 Seconds	
60 Seconds	
One minute 30 Seconds	
Two Minutes	
Two Minutes 30 Seconds	
Three Minutes	
Three Minutes 30 Seconds	
Four Minutes	
Four Minutes 30 Seconds	
Five Minutes	

Create a graph with the data you just collected from the game. Label both axes and connect the points with a line.

Dredge and Fill Up a Sieve

Dredging is the process of scooping out sand, mud, and soil from water to deepen the water near the shoreline or in creeks and rivers. In the early 1900s, South Florida went through dramatic change as many businesses wanted to create more buildings, homes, and canals. The canals were built to control the time and direction of water flow throughout South Florida. But dredging new canals created new issues including harmful algal blooms or HABs, which are large amounts of algae that can kill marine animals and release toxins harmful to humans. HABs are caused by **eutrophication**, which means a large amount of nutrients in a system.

Eutrophication can happen when nutrients are introduced into an area from agriculture, fertilizers, or septic tanks. Septic tanks are used in many homes to clean the water from our toilets, but not all septic tanks do a good job at cleaning the water before releasing it into the environment. Normally, ecosystems have a **limiting nutrient** that keeps a plant or algae from growing without limits. When a nutrient that usually keeps the plants from growing uncontrollable releases into an area, then plants can grow much faster and bigger. Nutrients and other non-living things in an environment are called **abiotic** factors.

Abiotic and biotic factors must be balanced in an ecosystem for the area to be healthy. **Biotic** factors are all things that are living, so plants, fungi, and animals. Sediments, nutrients, and living things coexist in an area to create a healthy ecosystem that provides humans with a healthy place to live. We rely on this balance for living space, water, and food.

A **sieve** is a device used to separate grains of sand based on the size. Sand is passed through a sieve using water and those grains that are left in the sieve are bigger than openings on the surface, and those grains that pass through are smaller than the opening on the surface. We use a sieve to determine the sizes of sand we collect in the ocean.

Things you need:

1. Sieve
2. Bottle of water
3. Tub to collect sand
4. Graduated cylinder
5. Sand

Directions:

1. Place sand on your sieve with collection tub underneath.
2. Shake the sieve over an empty bowl.
3. Sand that passed through must go through smaller sieve.
4. Sand on top of sieve must be measured.
5. To measure the sand, fill up graduated cylinder with known amount of water (write this down, can be 50 or 100 mL) and then add sand.
6. The water level will rise, giving you the amount of sand placed in the graduated cylinder. Write down this number.
7. Repeat until sand has passed through all sieves.

Water (A)	Water + Sand (B)	Sand (B-A)

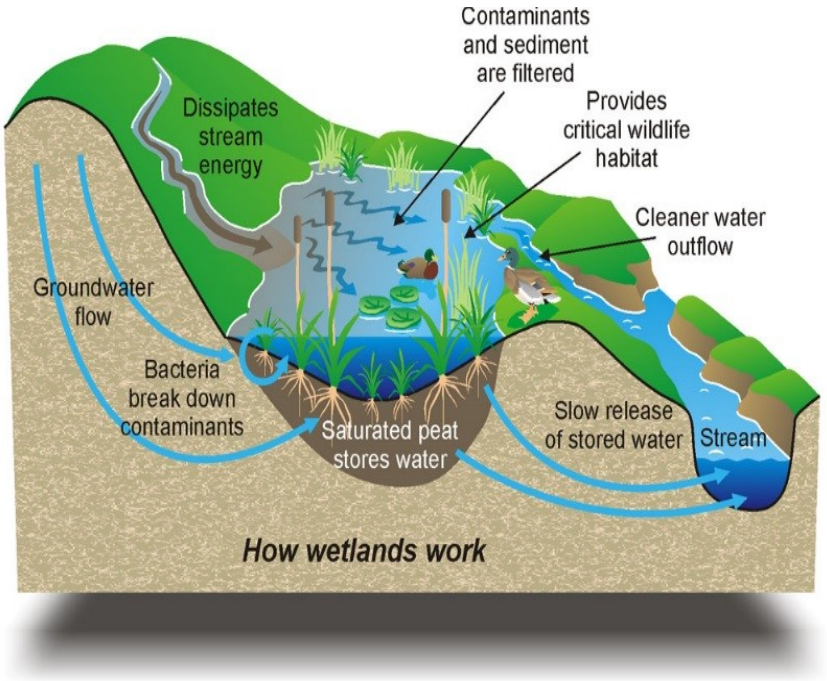
One, Two, Trees and Other Coastal Plants

Coastal plants are vital for our beaches as they provide the benefits of storm protection and carbon storage. **Mangroves** are trees that can withstand a certain amount of flooding and saltwater. There are three types of mangroves in South Florida, they are white mangroves, black mangroves, and red mangroves. Red mangroves have roots that look like they are reaching into the water. Black mangroves are distinguished by their dark black trunk and small roots that surround the tree sticking out from the ground, looking as if the ground is peppered with tiny pieces of wood. White mangroves have smooth broad leaves and usually occur at higher elevation.

Mangroves are important for humans because they protect the beach from erosion and protect our homes from storm damage. Coastal **erosion** is the process of losing coastline and sediment through waves and wind. Many people live along the along coast around the world therefore losing the coastline means that they are losing their living space. Mangroves and other coastal plants hold sediment in place with their roots, which holds our coastlines in place.

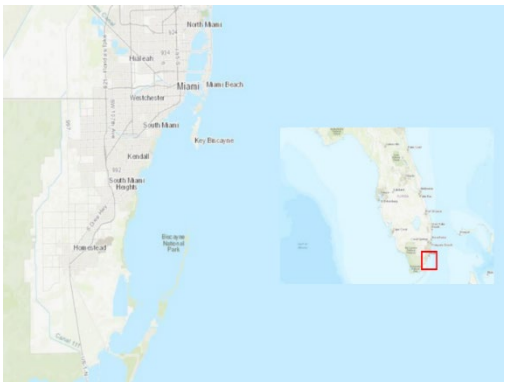
Another service that mangroves provide is that they **sequester** carbon, meaning they store carbon so that its not in the atmosphere. Carbon is a greenhouse gas which traps heat from the sun and warms the planet. Excess carbon in the atmosphere contributes to climate change. Since mangroves and all plants are **primary producers**, that convert sunlight into stored energy, they can convert sunlight and the carbon in the atmosphere into leaves, which is a storage place for carbon (sequestration).

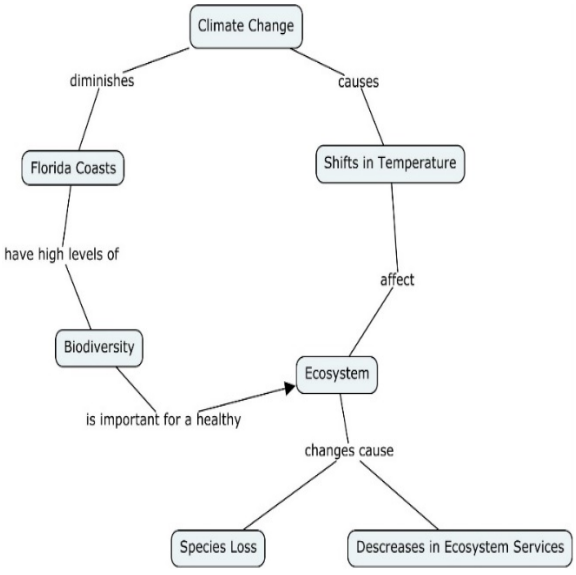
Teacher Reference



Biscayne Bay is an estuarine lagoon to the southeast of Miami-Dade County. An estuarine is a coastal marine environment that has freshwater flow from rivers creating changing salinities across the area, called brackish water, that is crucial for many organisms to survive. There are a wide variety of species that live in these types of environments and many have tolerances where they cannot survive pass certain salinity or temperature. Biscayne Bay extends from northern Miami to just north of Key Largo, about 35 miles in length. The Bay is surrounded by the Florida Keys on the East side and the mainland of Florida on the West. Most of Biscayne Bay is protected waters, and a part of it is in the boundary of Biscayne National Park. Biscayne National Park was established into a national monument in October 1968 and into a national park in June 1980. The park was created because of a growing demand for the state to protect the waters from pollution and restore function to the Bay.

Climate change is the altering of weather patterns that can be caused by many things, with human activity being the biggest effect. For South Florida, climate change will cause extreme hurricanes and extreme wet and dry seasons. Global warming and climate change are used interchangeably in political debates, but many people misinterpret the meaning of the global

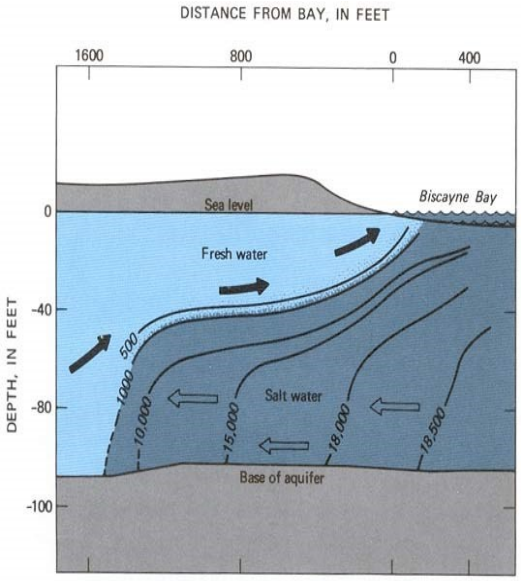




warming or don't believe humans can cause either. Humans affect climate by releasing greenhouse gasses from burning fossil fuels. Fossil fuels include gasoline which we use for most of our vehicles. The reason they are called greenhouse gases is that they allow heat from the sun to enter Earth's atmosphere, but then prevent the heat from dissipating into space. Another contributor to climate change is land degradation. Land degradation releases carbon trapped in the plants that would inhabit the area. Carbon releases into the atmosphere and into the oceans contributing to climate change and increasing acidity, respectively. A changing climate affects the ecosystems throughout the world, and those that can survive in that ecosystem. Many species have thermal limits or water needs that weather patterns affect in ecosystems. When weathers pattern shift in an ecosystem, some species of plants or animals may not survive the change causing a decrease in biodiversity.

Biological diversity, or biodiversity, in our local environments increases the health of ecosystem and the services that can be provided. Such ecosystem services include clean water, storm protection, and game and fish sustainability. A biological diverse area has a variety of species, including plants and animals that interact with each other and the inorganic elements. Biodiversity is used as an indication of health, so when we see higher levels of species diversity that means the area is healthier. Think about a habitat as a car, you need many parts for the car to be successful and useful. Some parts of the car are vital to move from one area to another, just as some species are vital for the ecosystem to function and move. We want our local ecosystem to function and provide us with ecosystem services, therefore having a biologically diverse community is necessary.

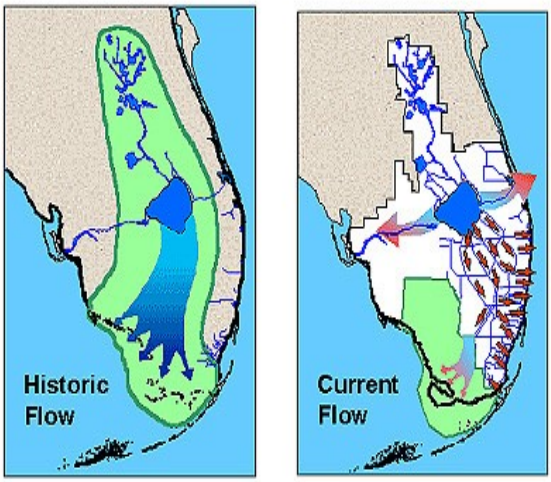
Ecosystem services are services that the environment provides naturally that's beneficial for humans. These services include cleaning our water for consumption, without the proper combination of plants to sequester harmful pollutants from water, our waters would be harmful to drink. If we relied on human technology alone to clean our drinking water then water would be expensive to drink, even from our faucets. Most Floridians rely on the Biscayne Aquifer for drinking water and the aquifer gathers freshwater from the Everglades. As rain falls from onto the land or water flows from northern areas, it seeps through the rock and soil to enter the Biscayne Aquifer. Altering water flow in South Florida (talked about in more detail below) diminishes freshwater from the aquifer and sea level rise from climate change causes saltwater intrusion into the aquifer. To protect our local ecosystems is to protect our drinking water, our basic human right to survival we must continue to support restoration efforts in South Florida and politicians who will help push these projects through.



In South Florida all the water is connected to the inland and the coast. Historically, Lake Okeechobee emptied throughout southern Florida's marshland and slowly exited along the coast of Florida. Now, most of the water exits east and west of

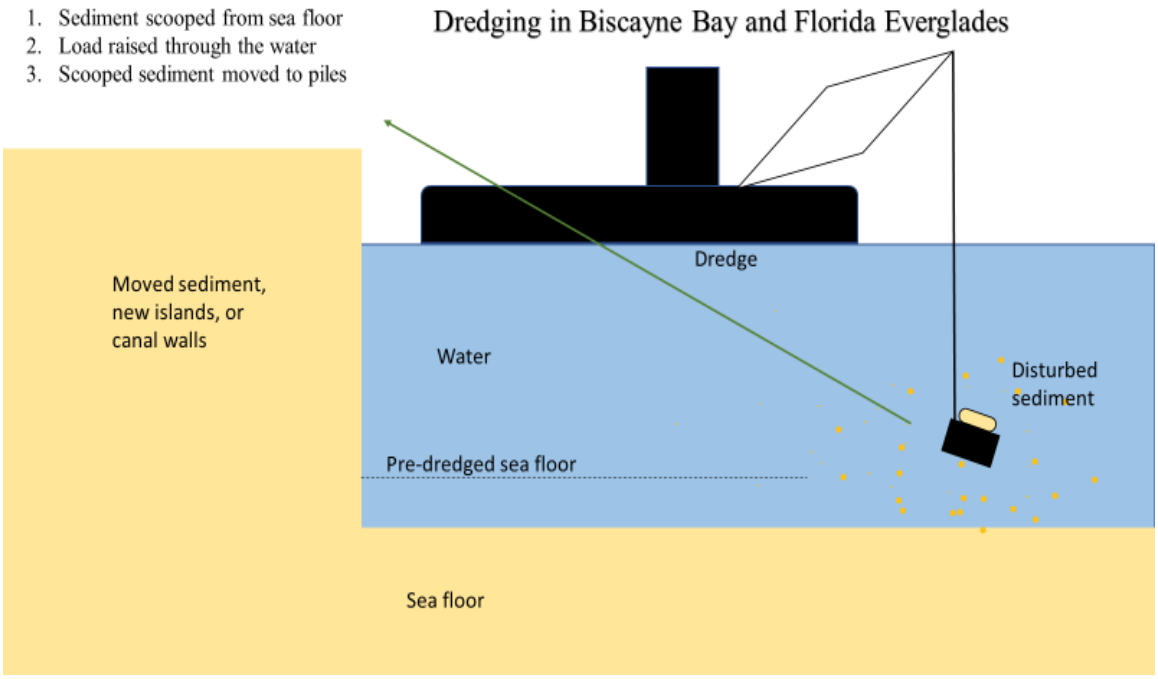
Lake Okeechobee through the C-43 and C-44 canals. This is damaging to the estuaries along the shores where the canals exit because they require a certain timing and amount of freshwater to sustain life.

Dredging of the Florida everglades began in 1906 and was backed by landowners to create more farmland, and Biscayne Bay dredging began in 1912 with the construction of the Collins Bridge to connect Miami to Miami Beach. To create farmland, developers needed to create canals to control and alter hydrology so that humans managed the timing and path of water discharge. As with all the other bridges built in Biscayne Bay, much of the sediment had to be dredged to build the bridge, which disturbs benthic communities. The sediment moved from Biscayne Bay was used to create islands such as Fisher Island, Venetian Island, Star Island, and much more. In the Florida Everglades, sediment was used to build canal walls to prepare for high volumes of water. Development projects cause high ecological damage and when research isn't conducted for risk and reward many projects will go unchecked. Dredging in Florida is more highly regulated now compared to the beginning of the 1900s, thanks to many normal citizens recognizing the risks associated with development in both the everglades and Biscayne Bay. Citizens collected together to fight big developers from ruining natural ecosystems that provide a huge service to the residents.



Agriculture became a major cause of pollution for water in South Florida after the canals were completed. Excess nutrients or eutrophication from fertilizers used to grow crops runoff into canals and seep into our drinking water. Without the slow movement through grasses, water in the Everglades cannot be filtered and since all the water in South Florida is connected that unfiltered water makes it way into our coasts. The reason fertilizers from agriculture runoff is damaging to our waters, is that it causes harmful algal blooms. These harmful algal blooms are caused because algae receive excess nutrients that allows them to grow quickly and deplete the oxygen in the water. All animals need oxygen to survive, so when these algal blooms occur, they cause enormous amounts of fish to die. Not all algae are harmful to the environment, algae are part of the ecosystem that helps filter the water and serves as fish food. A healthy environment has certain amount of algae, just as the estuary needs a certain freshwater flow to be productive.

Another problem that occurred in many oceans was that raw sewage was dumped straight into the ocean because many people believed that the ocean is huge that no amount of sewage could affect the quality of the water. Of course, now, we know that



raw sewage in any amount is not tolerated in the ocean. The reason untreated sewage cannot be tolerated by coastal ecosystems is that it causes an increased amount of phosphate in the system. Eutrophication from sewage also causes the same problems as agricultural runoff. Algal blooms block light from penetrating the ground and consumes all the oxygen in the area, together preventing seagrass and fauna survival. Once researchers confirmed that untreated sewage and septic tank leaks were causing our coastal waters to deteriorate, our government installed water treatment facilities.

South Florida residents need to realize that climate change affects them closely. When temperatures increase, not only does ice melt and enter our ocean, but also water expands when it is warmer. Our oceans are expanding and those living near the coast are going to be affected the most. There are some rising concerns in Miami since residents see the effects of some high tides flooding their streets, like on Miami Beach. But many homes built on islands

Florida Manatees are gentle mammals that are mainly herbivorous but may feed on small fish and invertebrates. Manatees have no natural predators, but a high percentage of their deaths are caused by collisions with water vehicles.

will be flooded within 30 years because of rising waters. Since Florida is low and flat, it only takes a few feet of rising sea levels to put much of South Florida underwater. Rising water is also a huge problem during hurricanes as the storm brings in huge surges of water, streets into rivers. During Hurricane Irma, Brickell Avenue, where many condo and shopping complexes are located, looked like a raging river. Floridians need to make changes in how they think about land use and understand climate change then strive to make changes toward progress and restoration.

Biodiversity in an estuarine environment is important because all species interact with one another to create a great productive ecosystem. If you take out one species of fish that is the main food for another species of fish, then you are putting their population at risk. The second species of fish will have a population limit that is based on their food source. Another scenario is that one species is a keystone species, controlling the population of many other species in the area. Keystone species can be starfish in a marine environment because they control the mussel population. When starfish are removed from an area, mussels take over the area so exclusively that no other species can establish themselves there. Having many species in a habitat ensures that the ecosystem is healthy and can maintain life. We especially want to protect our estuaries as they serve as sanctuaries for young fish, which gives them time to grow before continuing into adulthood. Many of these young fish utilizing estuaries are the fish that humans consume. Groupers, lobsters, snappers, crabs, and mojarras use estuaries during a vulnerable time in their development.

In Biscayne Bay, there are many interesting species of fish, birds, invertebrates, and plants to see. The most common type of fish is a mojarra, which are small, oval silver fish, that many people consume. Many seabirds rely on the fish from estuaries to sustain their diets. Blue crabs and lobsters are two crustaceans critical to many fishermen and people who consume them.

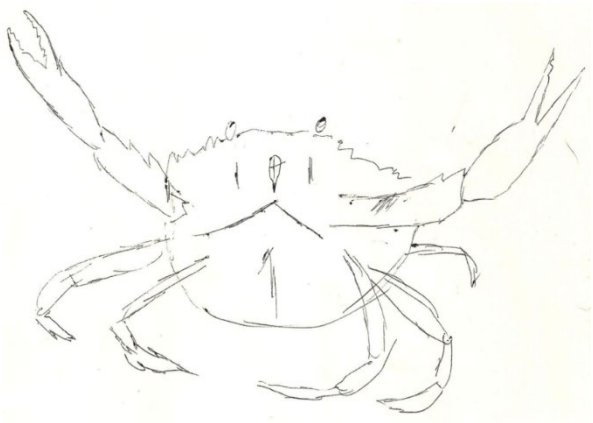
Terrestrial plants help reduce erosion and just like terrestrial plants, coastal and submerged aquatic plants reduce erosion of sediment. Algae, seagrass, and mangroves play a big role in how sediment moves in coastal areas, keeping sediment in place and reducing turbidity in the water. Mangroves protect our coasts from hurricanes by lessening the
impact of storm damage. They also act as shelters for small fish and crustaceans from predators.

There are four types of mangroves, red mangroves, white mangroves, black mangroves, and buttonwood. Red mangroves have distinct roots, called prop roots, that make them easy to spot on the coast. Prop roots have arching shapes, like they are carefully reaching into the ocean. Red mangroves are the most abundant trees in Biscayne Bay and have a wide range including many Caribbean countries and western tropical Africa.

Florida also have Black mangroves, which have roots called pneumophores. These roots pop up through the soil like little spikes surrounding the tree. The reason black mangroves have these roots is for gas exchange so that when the area floods the tree still has access to air. The trunks of black mangroves are also dark in color, almost black.

White mangroves are not as easily distinguishable as black or red mangroves as they don't have prop roots or pneumophores. But white mangroves can be identified by their rounded leaves that a notched apex, meaning instead of the leaf pointing out there is a small triangle facing toward the stem.

Seagrasses grow in meadows in shallow marine environments, making estuaries a great place for seagrass growth. Like terrestrial plants seagrasses produce oxygen, which adds oxygen to the surrounding water. Aquatic vegetation serves as a primary producer for marine environments, meaning they are the organisms converting sunlight into energy. Secondary producers includes organisms that consume primary producers and tertiary producers includes organisms that eat secondary producers.



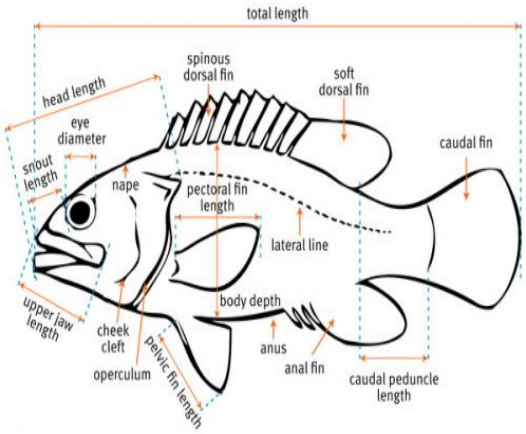
A Blue Crab above. As juveniles, blue crabs live in estuaries in lower salinity areas and are omnivorous (eat plants and animals). Adult blue crabs move to higher salinity areas in estuaries and fed on fish, crustaceans, worms, and mollusks. To mate, female blue crabs must molt so that males can deposit sperm.

What can you do to help the ocean?

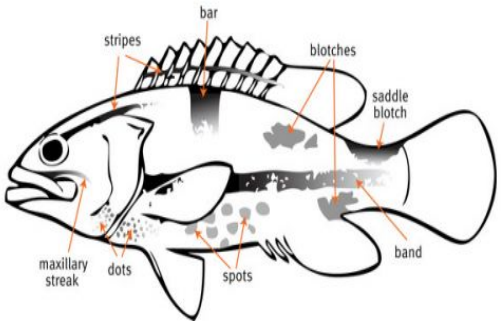
First off, as young adults, you can volunteer to clean up a local beach or get involved in political groups with clean coast agendas. Many organizations rely on volunteers to help keep their program running, just like many research groups. Another thing you can do is waste less food and materials by buying only what you need or try composting. Composting is a great way to dispose of food and paper waste while also creating rich soil for growing plants. Many cities around our country have banned the use of plastic bags because they are wasteful and much of it ends up in our ocean. Plastic bags could get accidently eaten by animals and cause harmful side effects or death. Another way to help is to use public transportation whenever possible as it reduces the amount of gasoline used or walk or bike to wherever you need to go. Lastly, you can spread the word to other people. Educating people on what they are doing causes harm to others could likely change their behavior.

Most animals that we will encounter in Biscayne Bay are boney fish. Fish breathe with gills and have scales for protection from the environment and other animals. They use their fins to propel themselves through the water and maintain position. The dorsal and anal fins help stabilize the fish so that it doesn't roll over. And the pectoral and pelvic fins are used in steering and mobility.

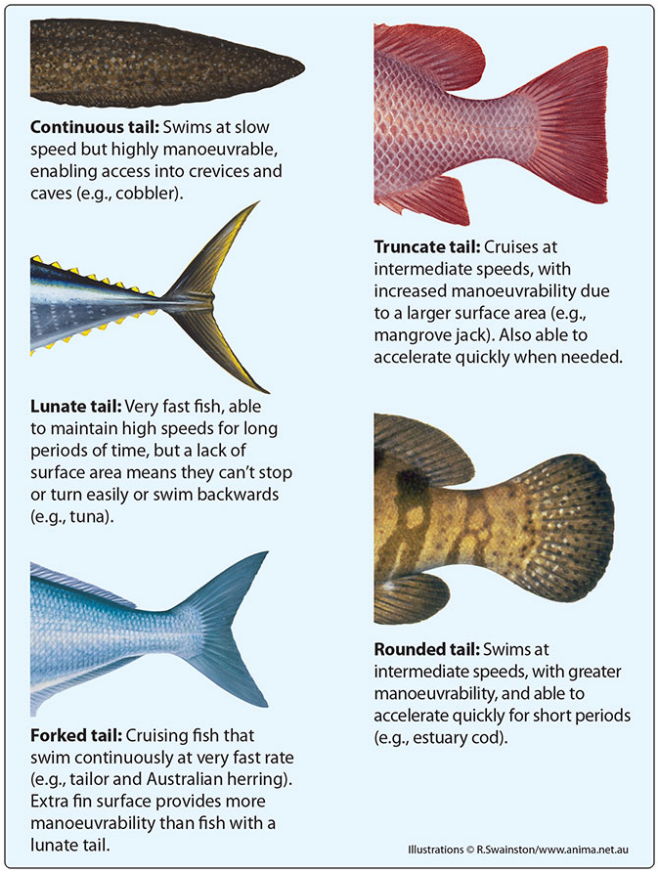
Knowing the parts of the fish and if it has spots or stripes will help you to identify what type of fish it is. Also, knowing the behavior of the fish can help you or others to identify the fish. Such behaviors as was the fish isolated, with others, or in a school, at the bottom or middle of the water, or hiding in the mangroves. When identifying fish, be cognizant of their behavior and any distinguishing features it may have.



Below are the types of caudal fins that fish can have and what each tail is adapted for doing. It can be important to note the shape of the tail in identifying the species of fish you encounter. When swimming, many species of fish will be afraid of you, therefore noticing distinguishing features can be key to knowing what type of fish you saw (if you can't get a picture quick enough).



When researching a problem, we must write down all the evidence we gather. Just like a paper for class, we want to be ethical and truthful when presenting our data, ideas, and argument. We never create or falsify data to make our hypothesis work, if the data doesn't match the hypothesis we formed then we change our hypothesis. Also, much of the preliminary research you conducted was thanks to many others who answered questions before you, make sure to give credit to those who helped you form those ideas. Finally, contribute to the scientific community by publishing your results. Science is all about sharing your work and the best way to do that is to publish your findings or to present it at a conference.



Links to Resources

https://www.nps.gov/bisc/index.htm

https://www.inaturalist.org/

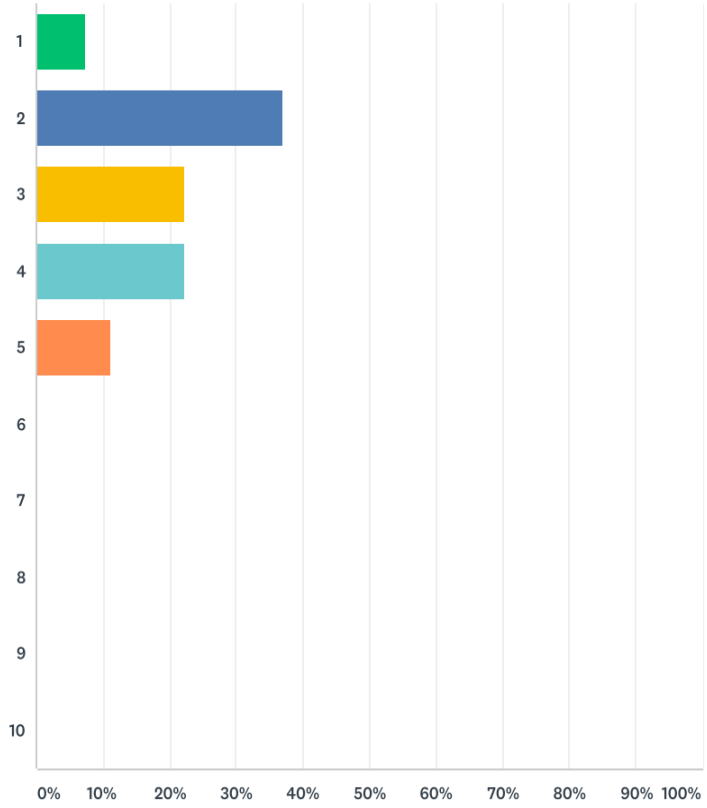
https://www.sfwmd.gov/our-work/cerp-project-planning

https://floridadep.gov/fco/aquatic-preserve/locations/biscayne-bay-aquatic-preserve

Pre Test 1

Q1 How much does climate change affect you now? On a scale of 1 to 5, 1 being “Not at all”, and 5 being “Major changes in my life".

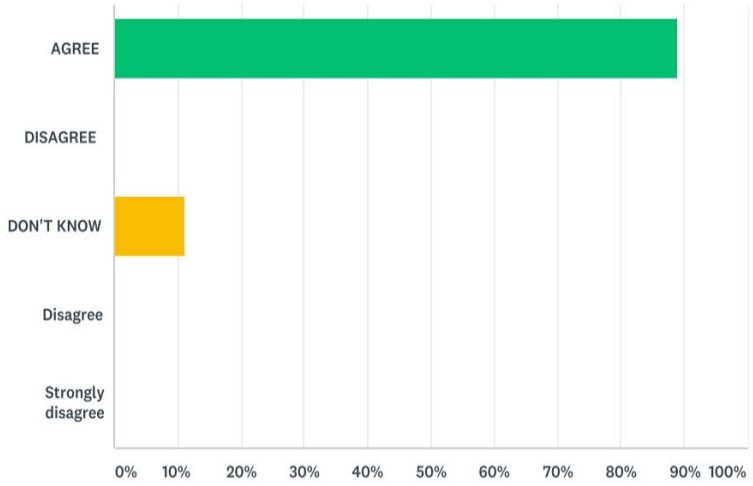
Answered: 27 Skipped: 0



ANSWER CHOICES	RESPONSES	
1	7.41%	2
2	37.04%	10
3	22.22%	6
4	22.22%	6
5	11.11%	3
6	0.00%	0
7	0.00%	0
8	0.00%	0
9	0.00%	0
10	0.00%	0
TOTAL		27

Q2 I can make a difference to the environment around me.

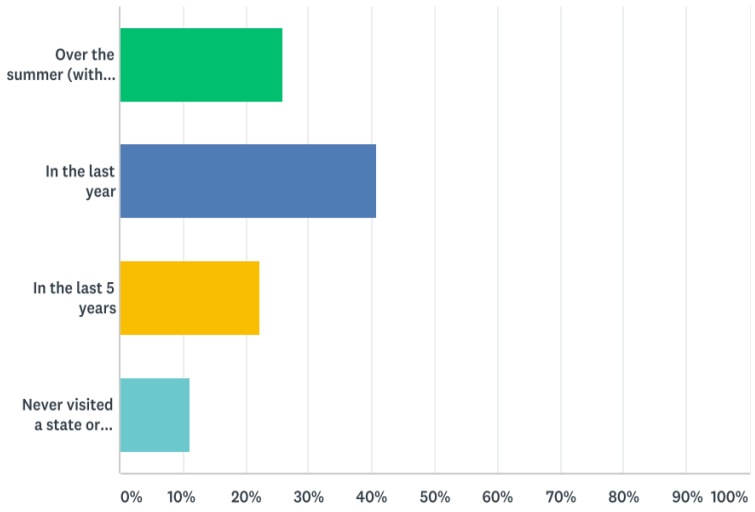
Answered: 27 Skipped: 0



ANSWER CHOICES	RESPONSES	
AGREE	88.89%	24
DISAGREE	0.00%	0
DON'T KNOW	11.11%	3
Disagree	0.00%	0
Strongly disagree	0.00%	0
TOTAL		27

Q3 When was the last time you visited a state or national park?

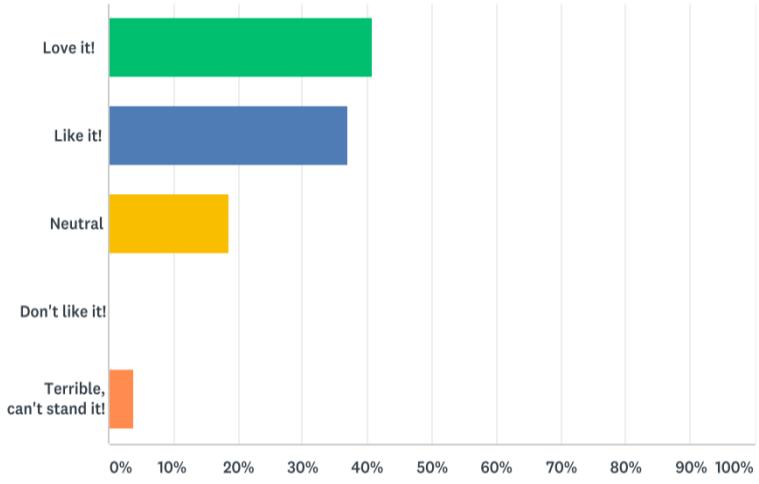
Answered: 27 Skipped: 0



ANSWER CHOICES	RESPONSES	
Over the summer (within the last three months)	25.93%	7
In the last year	40.74%	11
In the last 5 years	22.22%	6
Never visited a state or national park	11.11%	3
TOTAL		27

Q4 How do you feel about the natural environment (forest, ocean, wetlands)?

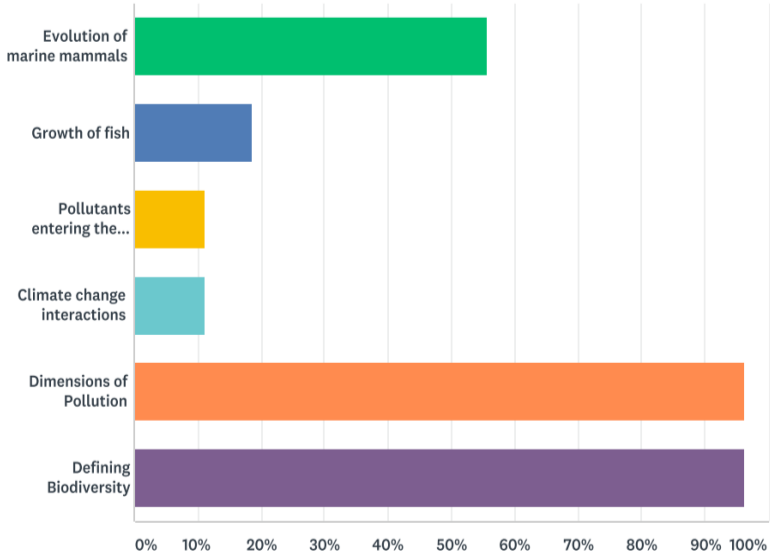
Answered: 27 Skipped: 0



ANSWER CHOICES	RESPONSES	
Love it!	40.74%	11
Like it!	37.04%	10
Neutral	18.52%	5
Don't like it!	0.00%	0
Terrible, can't stand it!	3.70%	1
TOTAL		27

Q5 Select all the images that you think are spiderweb diagrams or concept maps:

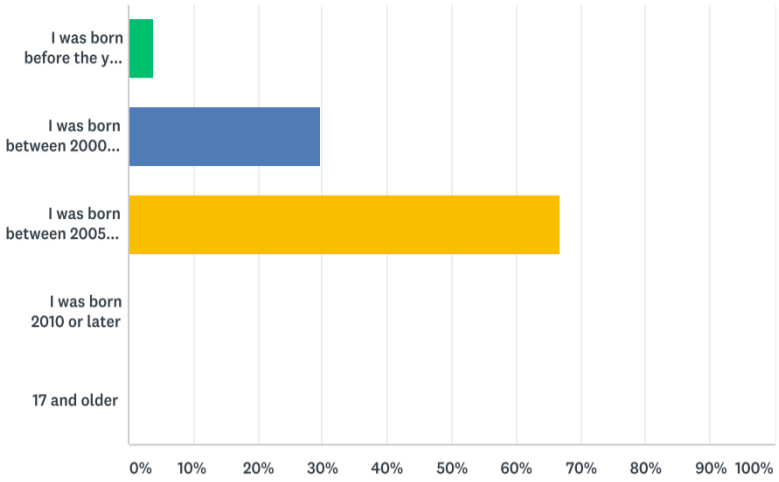
Answered: 27 Skipped: 0



ANSWER CHOICES	RESPONSES	
Evolution of marine mammals	55.56%	15
Growth of fish	18.52%	5
Pollutants entering the ocean	11.11%	3
Climate change interactions	11.11%	3
Dimensions of Pollution	96.30%	26
Defining Biodiversity	96.30%	26
Total Respondents: 27		

Q6 What year were you born?

Answered: 27 Skipped: 0

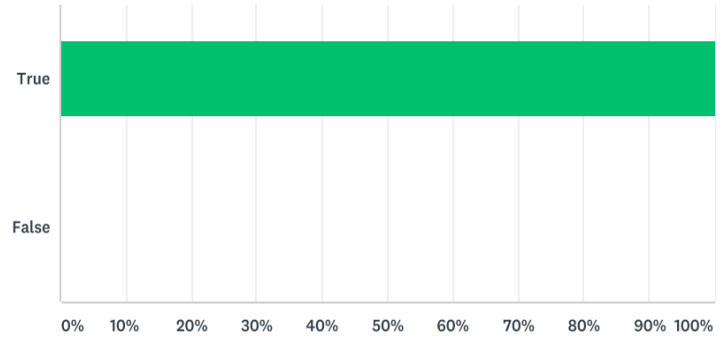


ANSWER CHOICES	RESPONSES	
I was born before the year 2000	3.70%	1
I was born between 2000 to 2004	29.63%	8
I was born between 2005 to 2009	66.67%	18
I was born 2010 or later	0.00%	0
17 and older	0.00%	0
TOTAL		27

Post Test 1

Q1 Biscayne Bay is part of the Greater Everglades Ecosystem

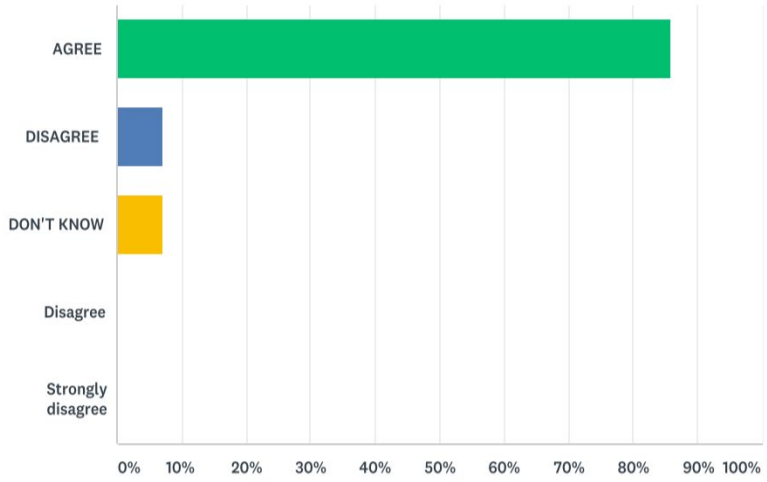
Answered: 14 Skipped: 0



ANSWER CHOICES	RESPONSES	
True	100.00%	14
False	0.00%	0
TOTAL		14

Q2 I can make a difference to the environment around me.

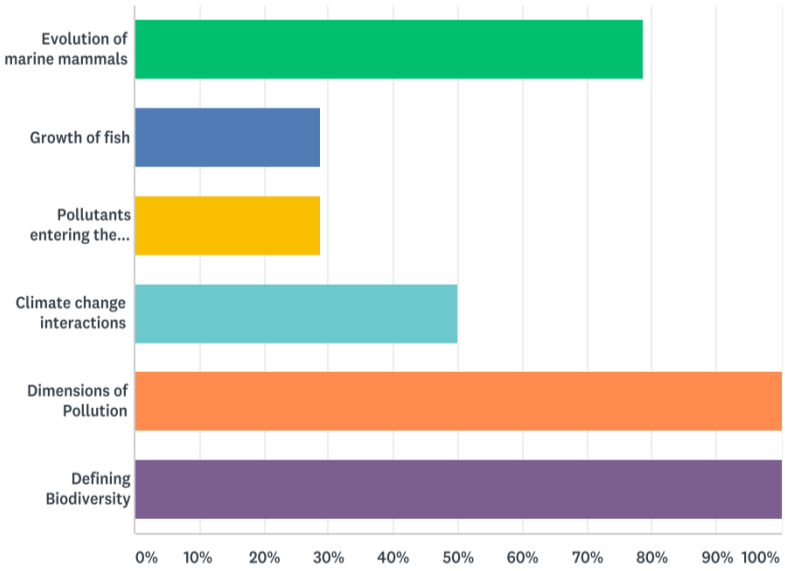
Answered: 14 Skipped: 0



ANSWER CHOICES	RESPONSES	
AGREE	85.71%	12
DISAGREE	7.14%	1
DON'T KNOW	7.14%	1
Disagree	0.00%	0
Strongly disagree	0.00%	0
TOTAL		14

Q3 Select all the images that you think are spiderweb diagrams or concept maps:

Answered: 14 Skipped: 0

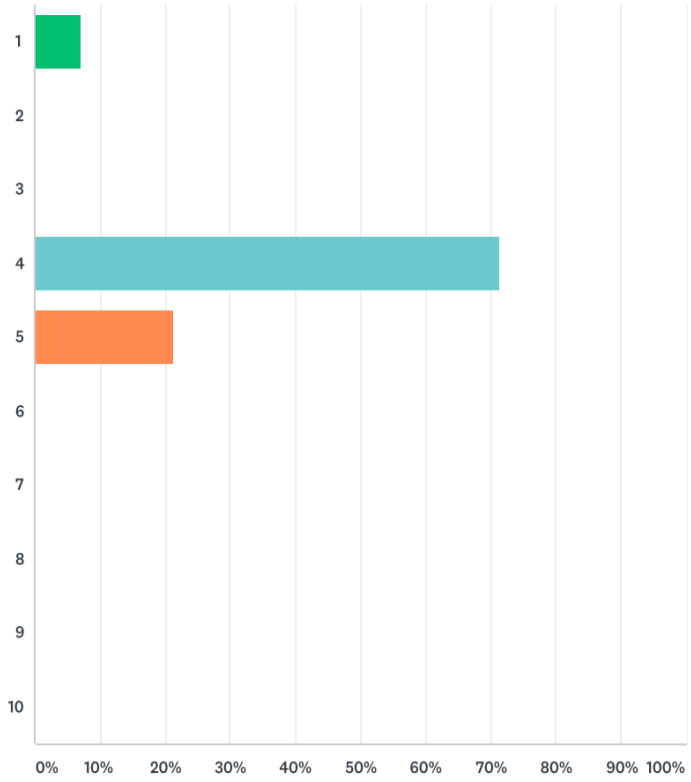


ANSWER CHOICES	RESPONSES	
Evolution of marine mammals	78.57%	11
Growth of fish	28.57%	4
Pollutants entering the ocean	28.57%	4
Climate change interactions	50.00%	7
Dimensions of Pollution	100.00%	14
Defining Biodiversity	100.00%	14
Total Respondents: 14		

TOTAL	14

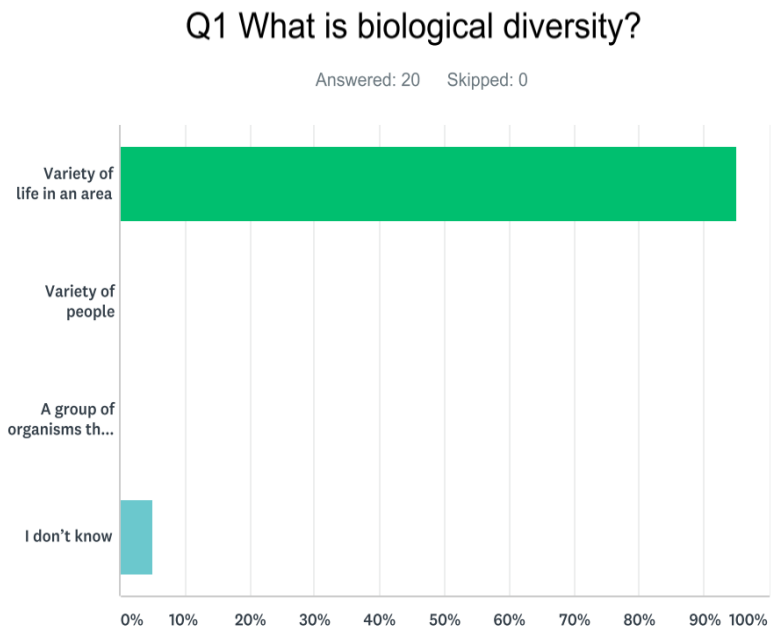
Q4 How much did you enjoy this lesson? On a scale of 1 to 5, 1 being “Not at all”, and 5 being “Great experience".

Answered: 14 Skipped: 0



ANSWER CHOICES	RESPONSES	
1	7.14%	1
2	0.00%	0
3	0.00%	0
4	71.43%	10
5	21.43%	3
6	0.00%	0
7	0.00%	0
8	0.00%	0
9	0.00%	0
10	0.00%	0

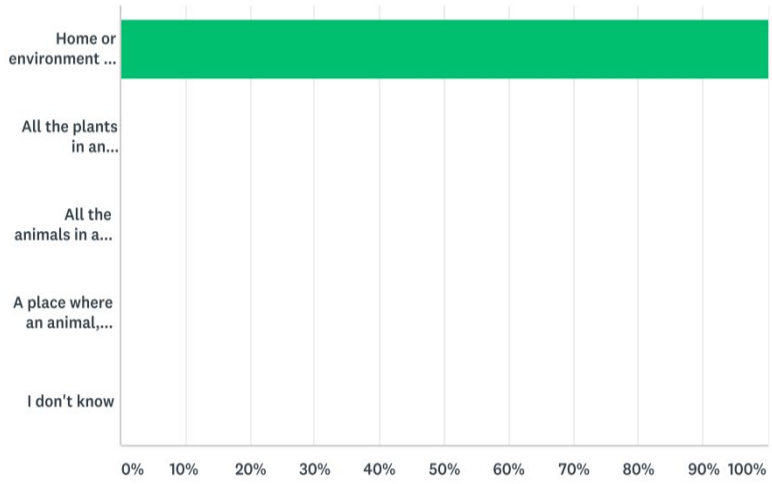
Pre Test 2



ANSWER CHOICES	RESPONSES	
Variety of life in an area	95.00%	19
Variety of people	0.00%	0
A group of organisms that can breed with each other	0.00%	0
I don't know	5.00%	1
TOTAL		20

Q2 What is a habitat?

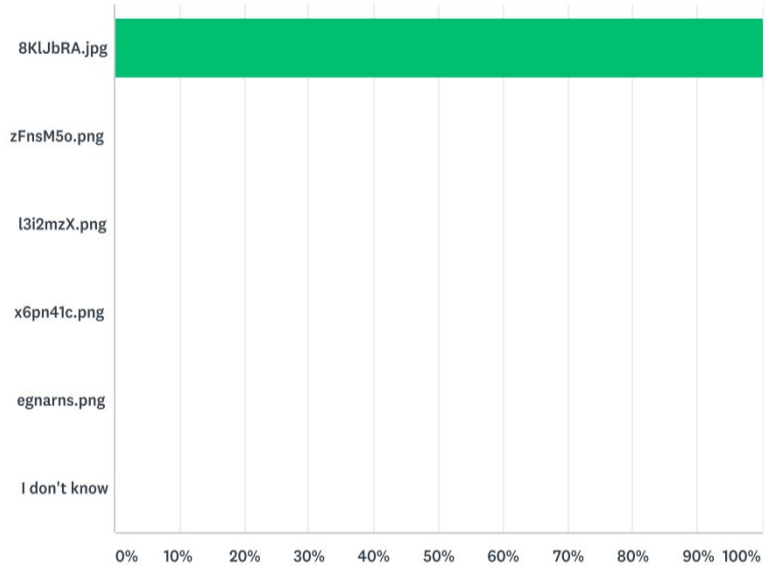
Answered: 20 Skipped: 0



ANSWER CHOICES	RESPONSES	
Home or environment of an animal, plant, or other organism	100.00%	20
All the plants in an environment	0.00%	0
All the animals in an environment	0.00%	0
A place where an animal, plant, or other organism doesn't live	0.00%	0
I don't know	0.00%	0
TOTAL		20

Q3 Select the Barracuda

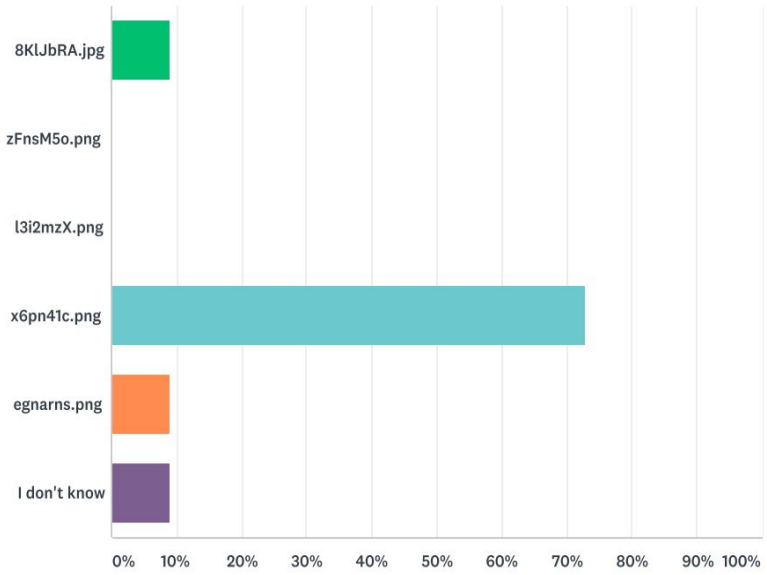
Variable: 1 Answered: 9 (45%)



ANSWER CHOICES	RESPONSES	
	100.00%	9
	0.00%	0
	0.00%	0
	0.00%	0
	0.00%	0
I don't know	0.00%	0
TOTAL		9

Q3 Select the Angelfish

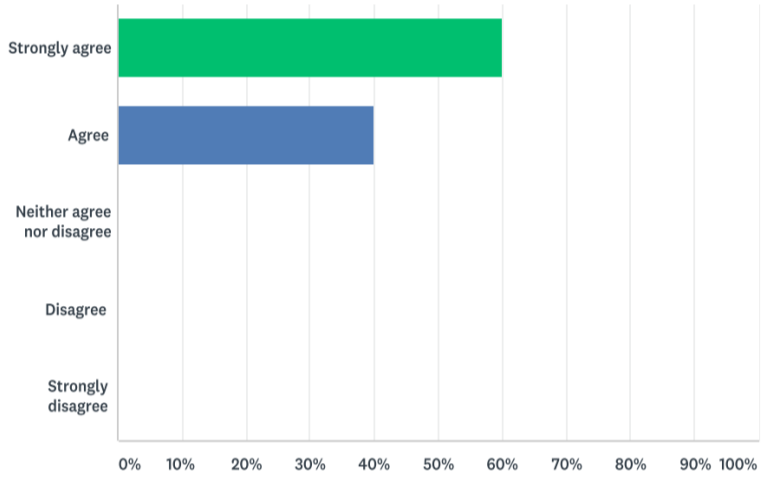
Variable: 2 Answered: 11 (55.00%)



ANSWER CHOICES	RESPONSES	
	9.09%	1
	0.00%	0
	0.00%	0
	72.73%	8
	9.09%	1
I don't know	9.09%	1
TOTAL		11

Q4 Agree or disagree? Marine animals are important for the entire planet.

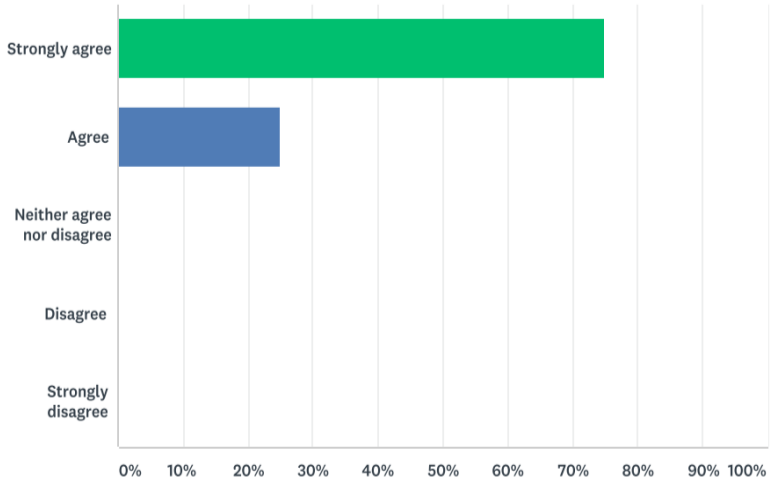
Answered: 20 Skipped: 0



ANSWER CHOICES	RESPONSES	
Strongly agree	60.00%	12
Agree	40.00%	8
Neither agree nor disagree	0.00%	0
Disagree	0.00%	0
Strongly disagree	0.00%	0
TOTAL		20

Q5 Agree or disagree? Humans actions can negatively affect animals in the marine environment.

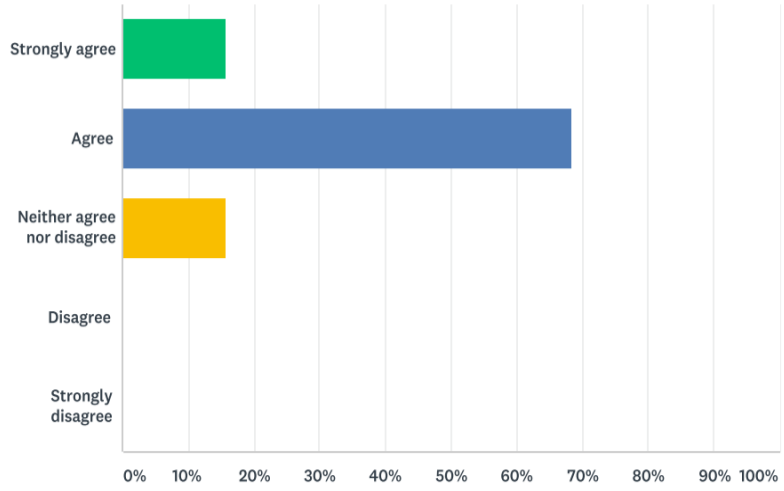
Answered: 20 Skipped: 0



ANSWER CHOICES	RESPONSES	
Strongly agree	75.00%	15
Agree	25.00%	5
Neither agree nor disagree	0.00%	0
Disagree	0.00%	0
Strongly disagree	0.00%	0
TOTAL		20

Q6 Agree or disagree? The loss of marine animals affect me personally.

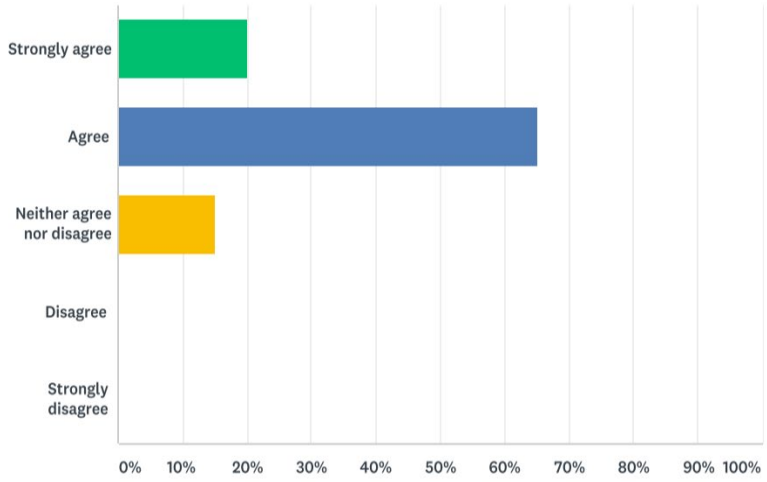
Answered: 19 Skipped: 1



ANSWER CHOICES	RESPONSES	
Strongly agree	15.79%	3
Agree	68.42%	13
Neither agree nor disagree	15.79%	3
Disagree	0.00%	0
Strongly disagree	0.00%	0
TOTAL		19

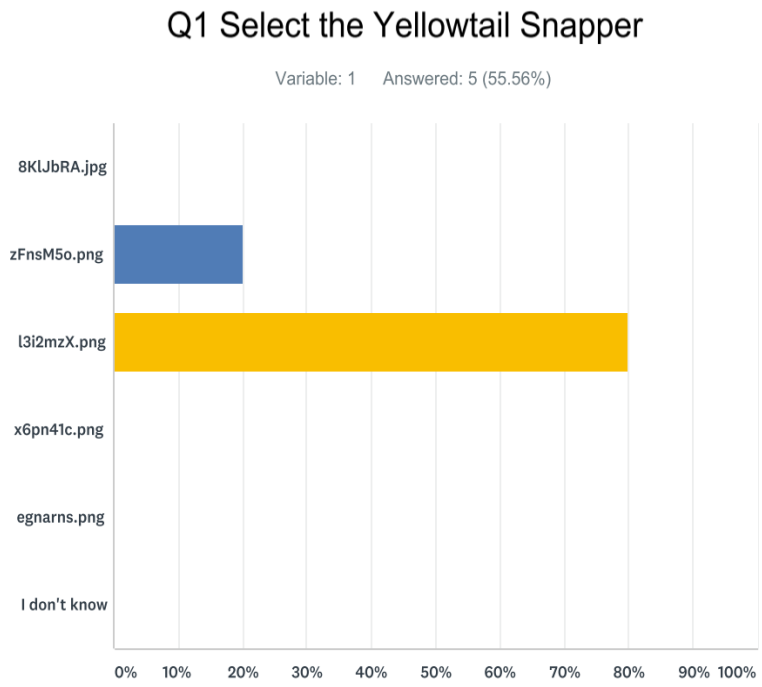
Q7 Agree or disagree? The ocean is an important part of my life.

Answered: 20 Skipped: 0



ANSWER CHOICES	RESPONSES	
Strongly agree	20.00%	4
Agree	65.00%	13
Neither agree nor disagree	15.00%	3
Disagree	0.00%	0
Strongly disagree	0.00%	0
TOTAL		20

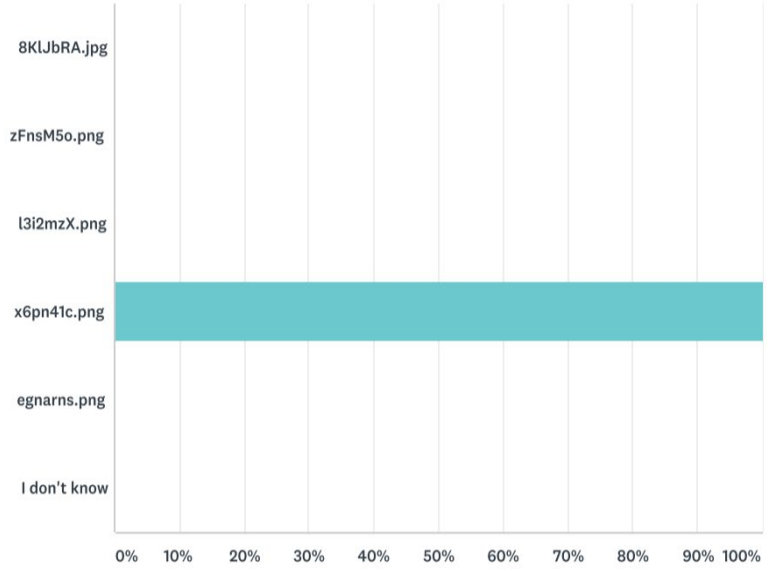
Post Test 2



ANSWER CHOICES	RESPONSES	
	0.00%	0
	20.00%	1
	80.00%	4
	0.00%	0
	0.00%	0
I don't know	0.00%	0
TOTAL		5

Q1 Select the Angelfish

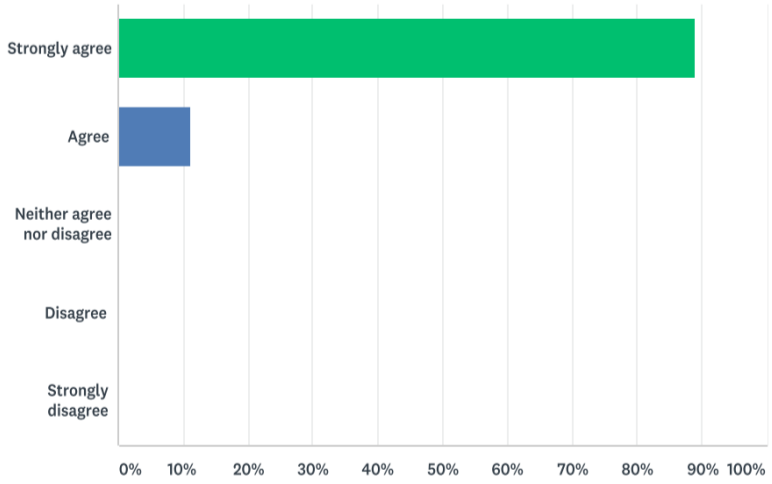
Variable: 2 Answered: 4 (44.44%)



ANSWER CHOICES	RESPONSES	
	0.00%	0
	0.00%	0
	0.00%	0
	100.00%	4
	0.00%	0
I don't know	0.00%	0
TOTAL		4

Q2 Agree or disagree? Marine animals are important for the entire planet.

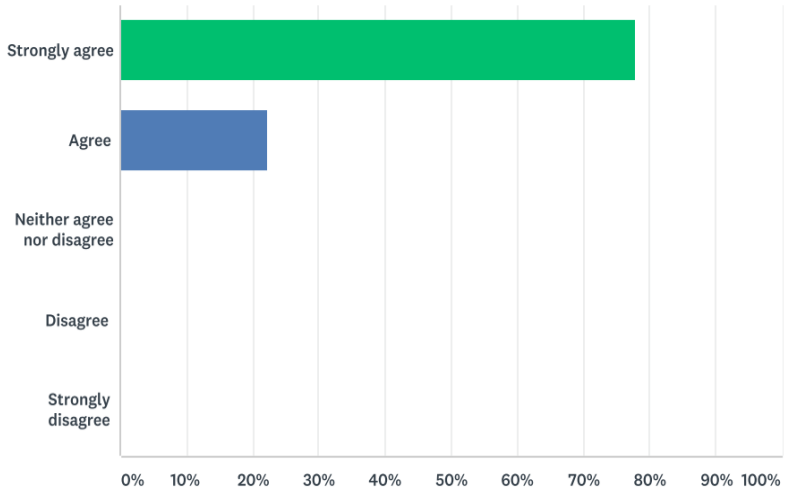
Answered: 9 Skipped: 0



ANSWER CHOICES	RESPONSES	
Strongly agree	88.89%	8
Agree	11.11%	1
Neither agree nor disagree	0.00%	0
Disagree	0.00%	0
Strongly disagree	0.00%	0
TOTAL		9

Q3 Agree or disagree? Humans actions can negatively affect animals in the marine environment.

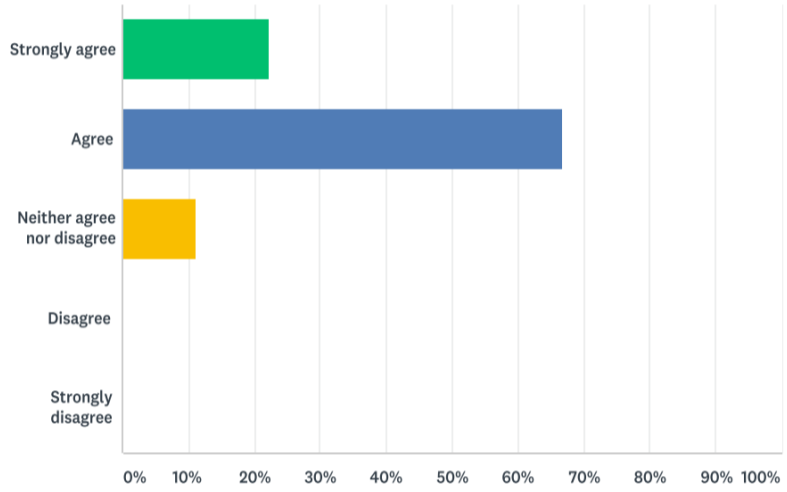
Answered: 9 Skipped: 0



ANSWER CHOICES	RESPONSES	
Strongly agree	77.78%	7
Agree	22.22%	2
Neither agree nor disagree	0.00%	0
Disagree	0.00%	0
Strongly disagree	0.00%	0
TOTAL		9

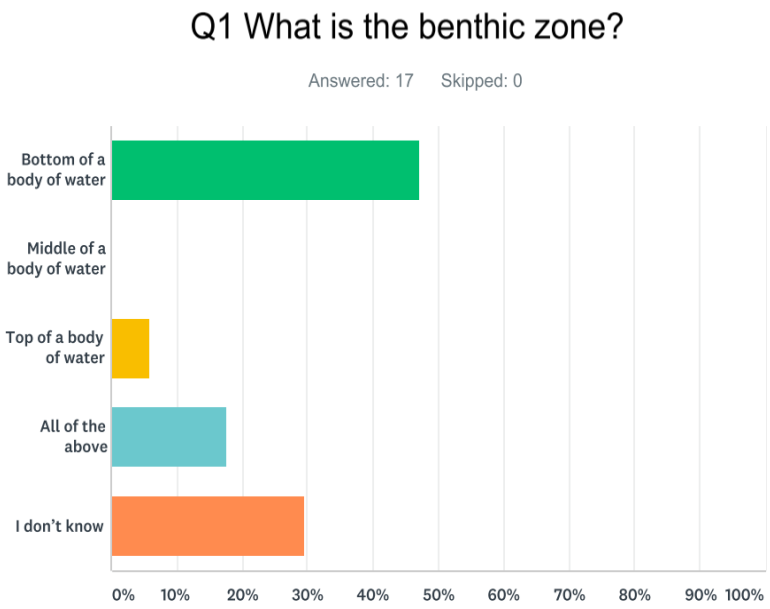
Q4 Agree or disagree? The loss of marine animals affect me personally.

Answered: 9 Skipped: 0



ANSWER CHOICES	RESPONSES	
Strongly agree	22.22%	2
Agree	66.67%	6
Neither agree nor disagree	11.11%	1
Disagree	0.00%	0
Strongly disagree	0.00%	0
TOTAL		9

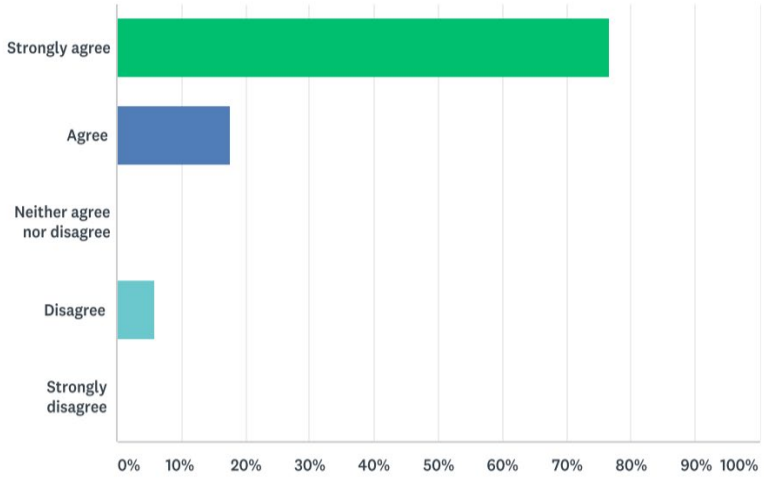
Pre Test 3



ANSWER CHOICES	RESPONSES	
Bottom of a body of water	47.06%	8
Middle of a body of water	0.00%	0
Top of a body of water	5.88%	1
All of the above	17.65%	3
I don't know	29.41%	5
TOTAL		17

Q2 Agree or disagree? Overfishing is bad for the environment.

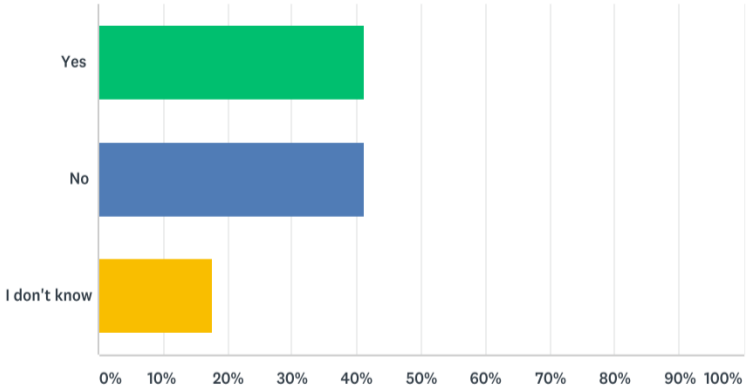
Answered: 17 Skipped: 0



ANSWER CHOICES	RESPONSES	
Strongly agree	76.47%	13
Agree	17.65%	3
Neither agree nor disagree	0.00%	0
Disagree	5.88%	1
Strongly disagree	0.00%	0
TOTAL		17

Q3 Do harmful algal blooms or red tides (too much algae) affect you personally?

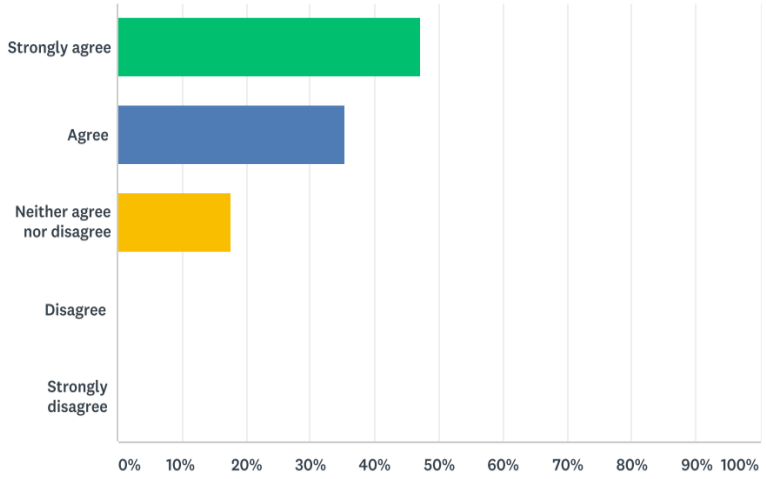
Answered: 17 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	41.18%	7
No	41.18%	7
I don't know	17.65%	3
TOTAL		17

Q4 Agree or disagree? We should limit the amount of fish/invertebrates that people can collect from the ocean.

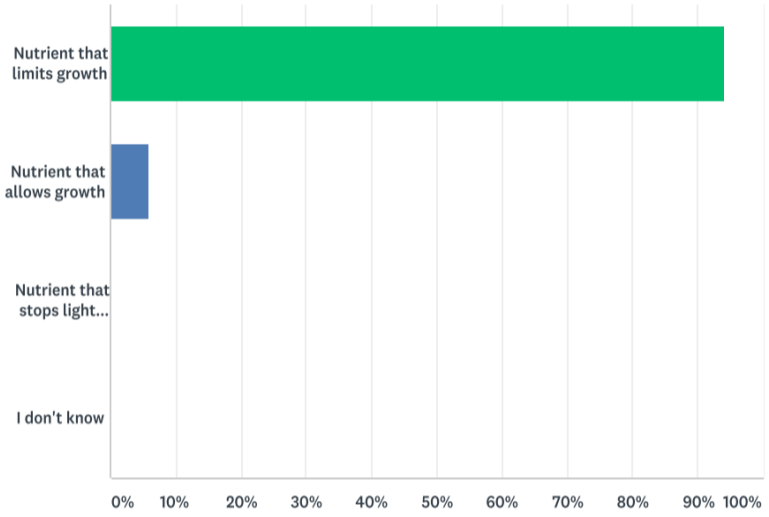
Answered: 17 Skipped: 0



ANSWER CHOICES	RESPONSES	
Strongly agree	47.06%	8
Agree	35.29%	6
Neither agree nor disagree	17.65%	3
Disagree	0.00%	0
Strongly disagree	0.00%	0
TOTAL		17

Q5 What does it mean to have a limiting nutrient in an environment?

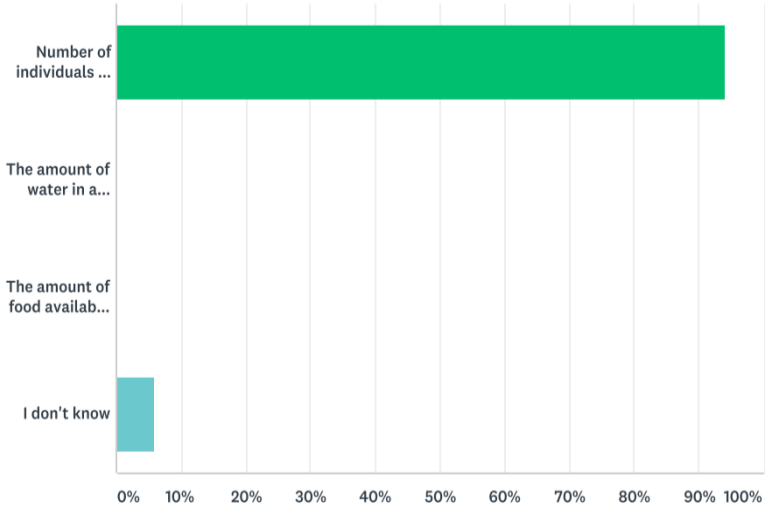
Answered: 17 Skipped: 0



ANSWER CHOICES	RESPONSES	
Nutrient that limits growth	94.12%	16
Nutrient that allows growth	5.88%	1
Nutrient that stops light from entering the water	0.00%	0
I don't know	0.00%	0
TOTAL		17

Q6 What does carrying capacity mean for a population?

Answered: 17 Skipped: 0

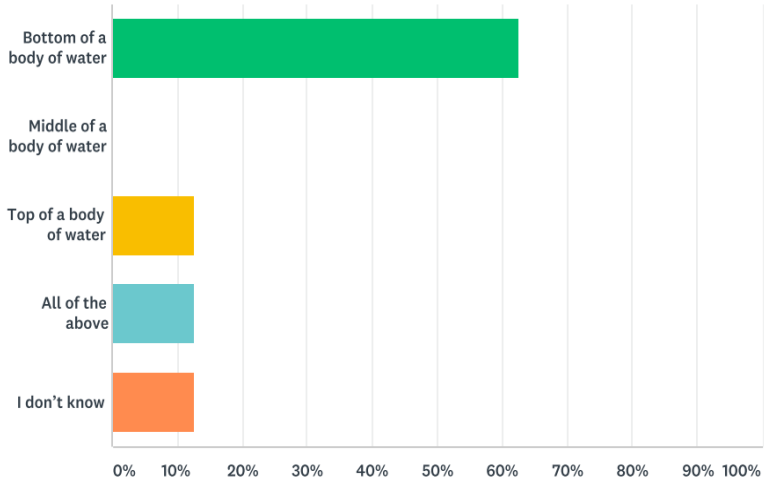


ANSWER CHOICES	RESPONSES	
Number of individuals in an area that can be supported due to food, shelter, and competition	94.12%	16
The amount of water in a certain area	0.00%	0
The amount of food available for an animal	0.00%	0
I don't know	5.88%	1
TOTAL		17

Post Test 3

Q1 What is the benthic zone?

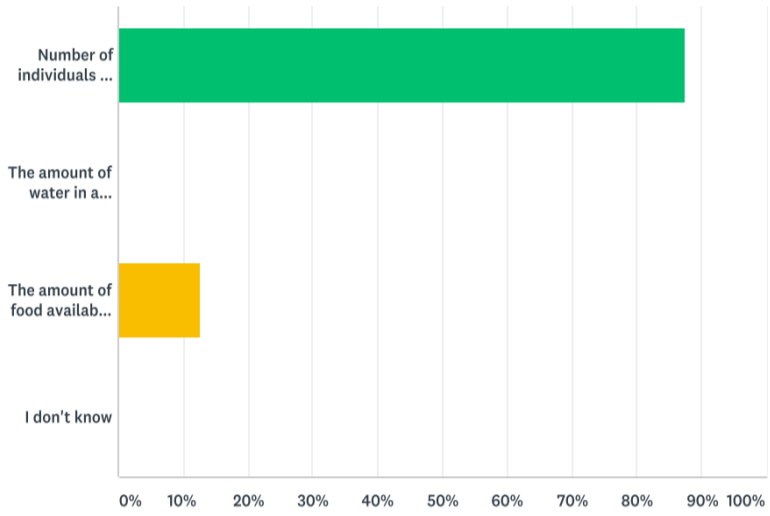
Answered: 8 Skipped: 0



ANSWER CHOICES	RESPONSES	
Bottom of a body of water	62.50%	5
Middle of a body of water	0.00%	0
Top of a body of water	12.50%	1
All of the above	12.50%	1
I don't know	12.50%	1
TOTAL		8

Q2 What does carrying capacity mean for a population?

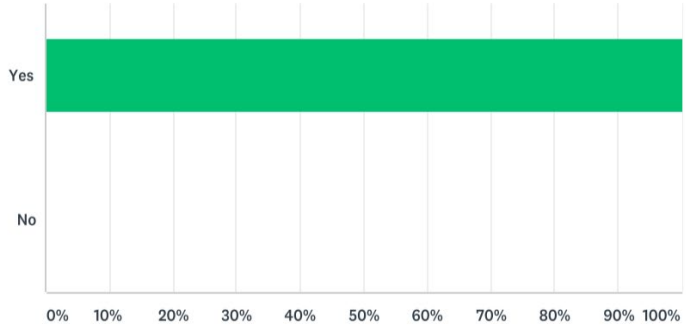
Answered: 8 Skipped: 0



ANSWER CHOICES	RESPONSES	
Number of individuals in an area that can be supported due to food, shelter, and competition	87.50%	7
The amount of water in a certain area	0.00%	0
The amount of food available for an animal	12.50%	1
I don't know	0.00%	0
TOTAL		8

Q3 Did you enjoy the session today?

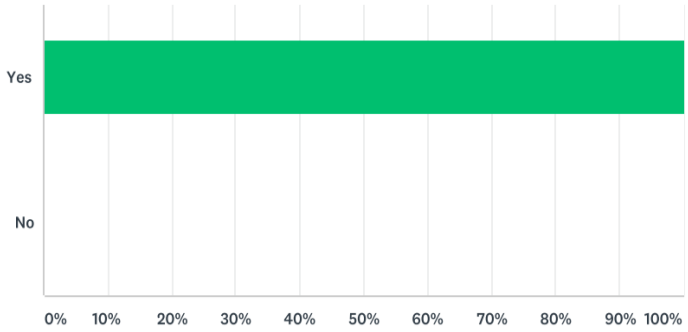
Answered: 8 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	100.00%	8
No	0.00%	0
TOTAL		8

Q4 Did you learn anything new from the sessions so far?

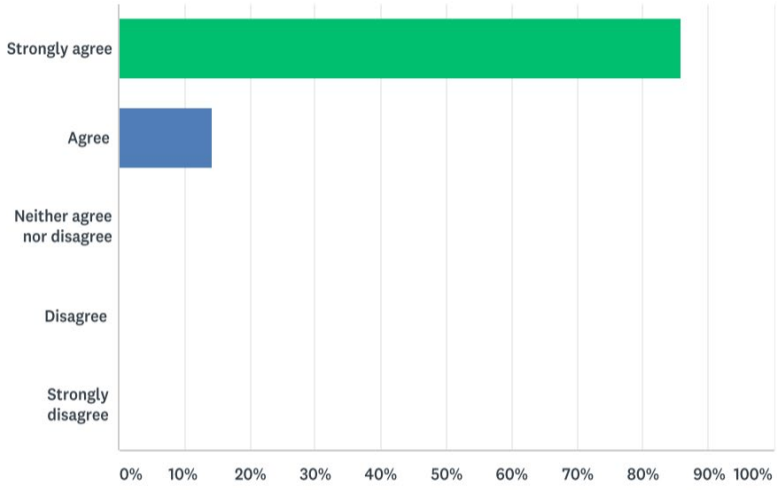
Answered: 8 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	100.00%	8
No	0.00%	0
TOTAL		8

Q5 Agree or disagree? Restoration is important for South Florida.

Answered: 7 Skipped: 1

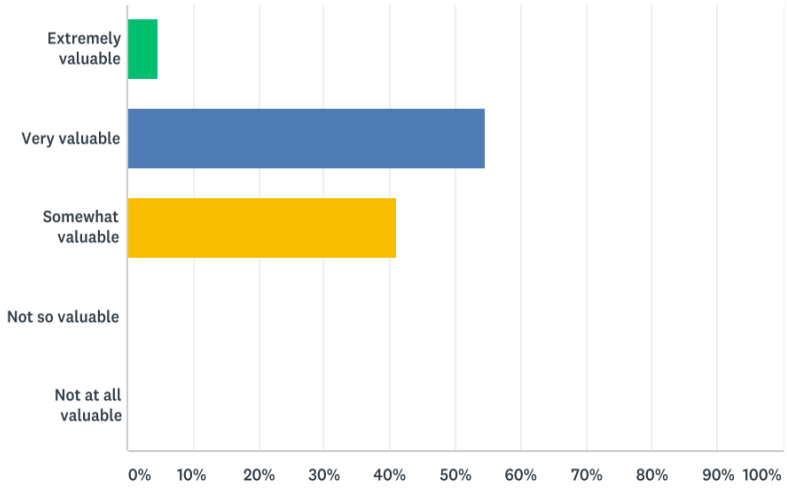


ANSWER CHOICES	RESPONSES	
Strongly agree	85.71%	6
Agree	14.29%	1
Neither agree nor disagree	0.00%	0
Disagree	0.00%	0
Strongly disagree	0.00%	0
TOTAL		7

Pre Test 4

Q1 How valuable is Biscayne Bay to you?

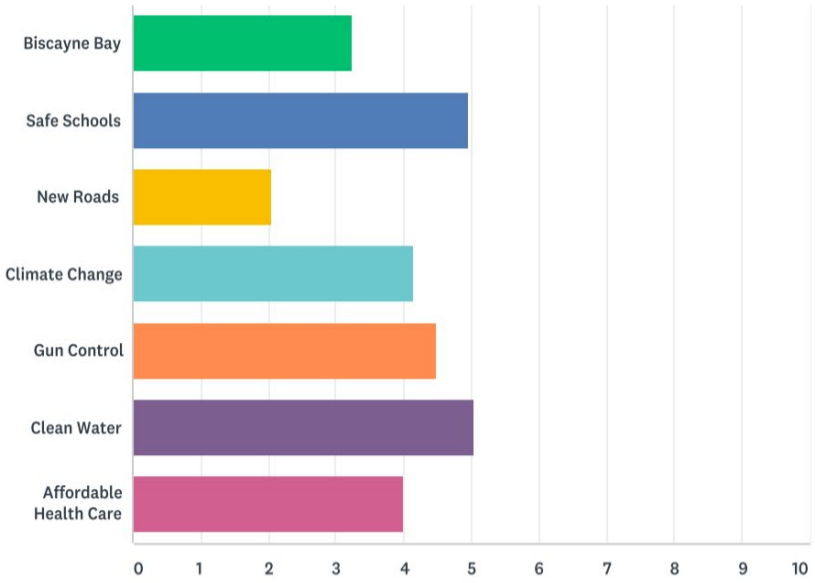
Answered: 22 Skipped: 0



ANSWER CHOICES	RESPONSES	
Extremely valuable	4.55%	1
Very valuable	54.55%	12
Somewhat valuable	40.91%	9
Not so valuable	0.00%	0
Not at all valuable	0.00%	0
TOTAL		22

Q2 In your opinion prioritize these choices in the order of importance.

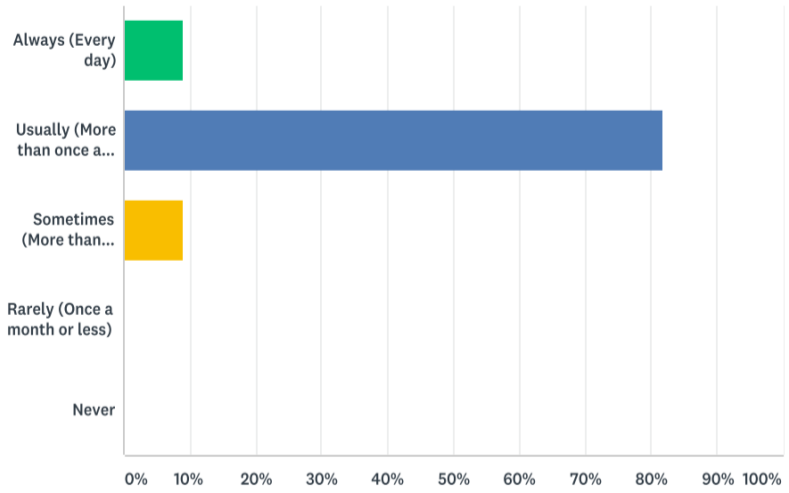
Answered: 22 Skipped: 0



	1	2	3	4	5	6	7	TOTAL	SCORE
Biscayne Bay	9.52% 2	4.76% 1	9.52% 2	14.29% 3	9.52% 2	42.86% 9	9.52% 2	21	3.24
Safe Schools	14.29% 3	23.81% 5	28.57% 6	19.05% 4	9.52% 2	0.00% 0	4.76% 1	21	4.95
New Roads	4.55% 1	4.55% 1	0.00% 0	9.09% 2	9.09% 2	9.09% 2	63.64% 14	22	2.05
Climate Change	23.81% 5	4.76% 1	4.76% 1	23.81% 5	19.05% 4	19.05% 4	4.76% 1	21	4.14
Gun Control	9.52% 2	23.81% 5	28.57% 6	4.76% 1	19.05% 4	4.76% 1	9.52% 2	21	4.48
Clean Water	31.82% 7	9.09% 2	18.18% 4	13.64% 3	27.27% 6	0.00% 0	0.00% 0	22	5.05
Affordable Health Care	4.55% 1	27.27% 6	9.09% 2	18.18% 4	9.09% 2	27.27% 6	4.55% 1	22	4.00

Q3 How often do you make sustainable (reduce, reuse, or recycle materials) choices?

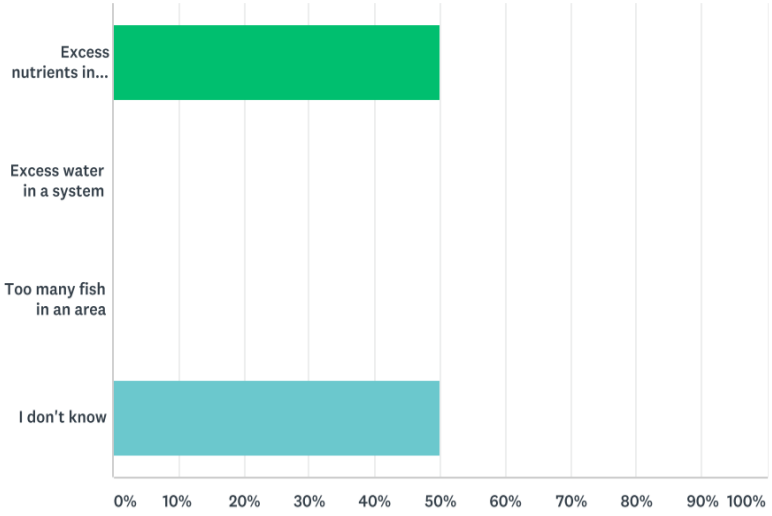
Answered: 22 Skipped: 0



ANSWER CHOICES	RESPONSES	
Always (Every day)	9.09%	2
Usually (More than once a week)	81.82%	18
Sometimes (More than twice a month)	9.09%	2
Rarely (Once a month or less)	0.00%	0
Never	0.00%	0
TOTAL		22

Q4 What is eutrophication?

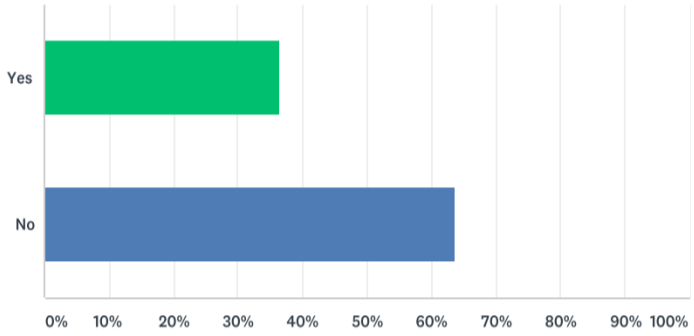
Answered: 22 Skipped: 0



ANSWER CHOICES	RESPONSES	
Excess nutrients in a body of water	50.00%	11
Excess water in a system	0.00%	0
Too many fish in an area	0.00%	0
I don't know	50.00%	11
TOTAL		22

Q5 Have you talked to anyone outside the classroom about the importance of Biscayne Bay?

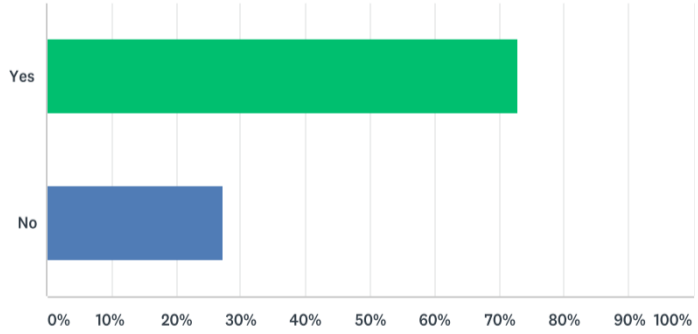
Answered: 22 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	36.36%	8
No	63.64%	14
TOTAL		22

Q6 Do you feel these sessions changed your opinion on Biscayne Bay?

Answered: 22 Skipped: 0

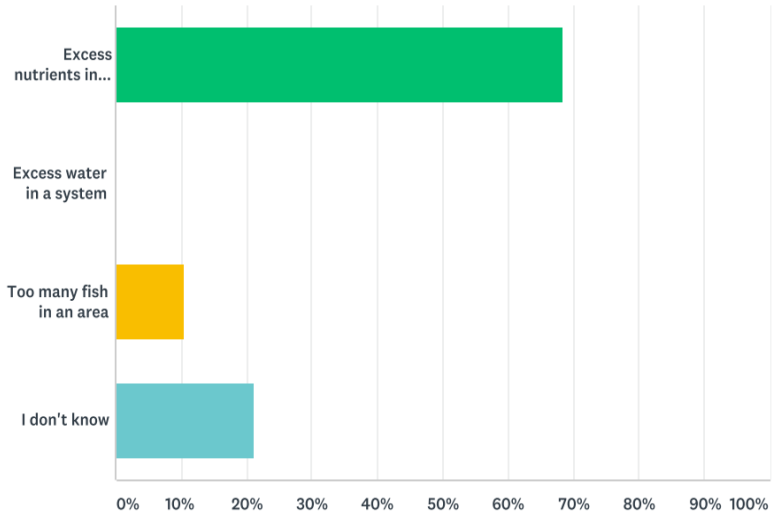


ANSWER CHOICES	RESPONSES	
Yes	72.73%	16
No	27.27%	6
TOTAL		22

Post Test 4

Q1 What is eutrophication?

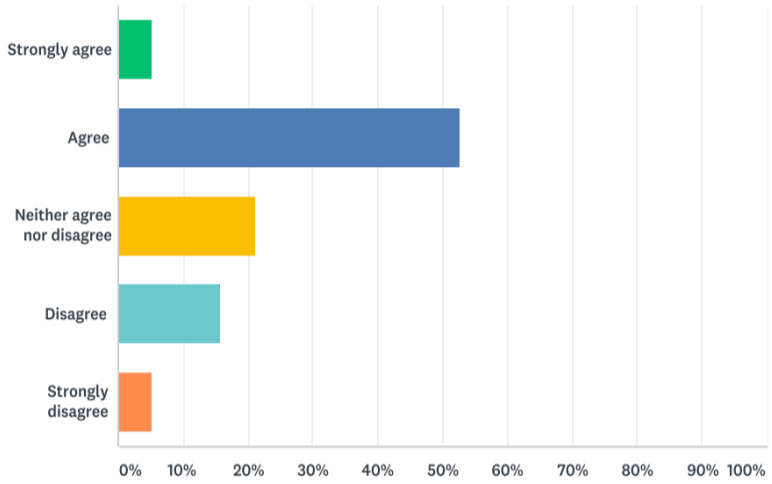
Answered: 19 Skipped: 0



ANSWER CHOICES	RESPONSES	
Excess nutrients in a body of water	68.42%	13
Excess water in a system	0.00%	0
Too many fish in an area	10.53%	2
I don't know	21.05%	4
TOTAL		19

Q2 Agree or disagree? I enjoyed working with the sediment and sieves.

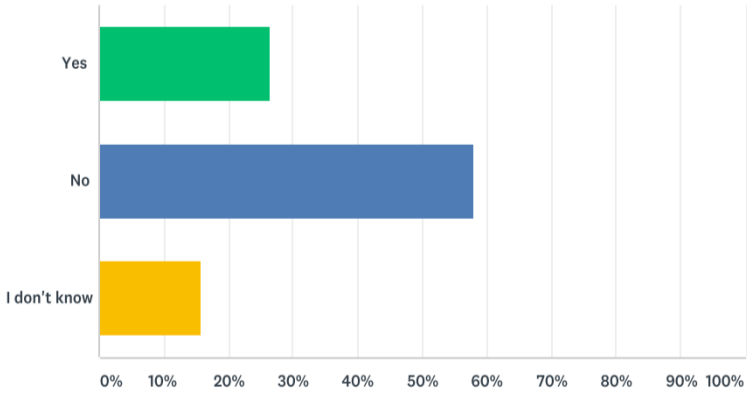
Answered: 19 Skipped: 0



ANSWER CHOICES	RESPONSES	
Strongly agree	5.26%	1
Agree	52.63%	10
Neither agree nor disagree	21.05%	4
Disagree	15.79%	3
Strongly disagree	5.26%	1
TOTAL		19

Q3 Do you think hotels close to the beach are beneficial for everyone living in Miami?

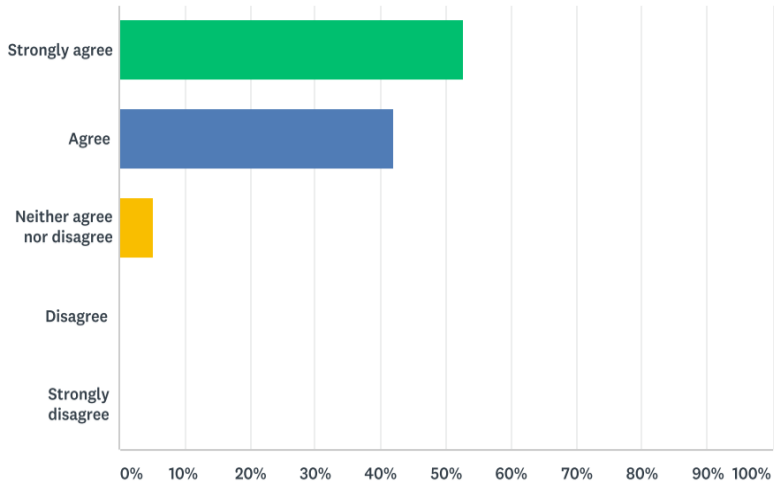
Answered: 19 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	26.32%	5
No	57.89%	11
I don't know	15.79%	3
TOTAL		19

Q4 Agree or disagree? Restoration is important for South Florida.

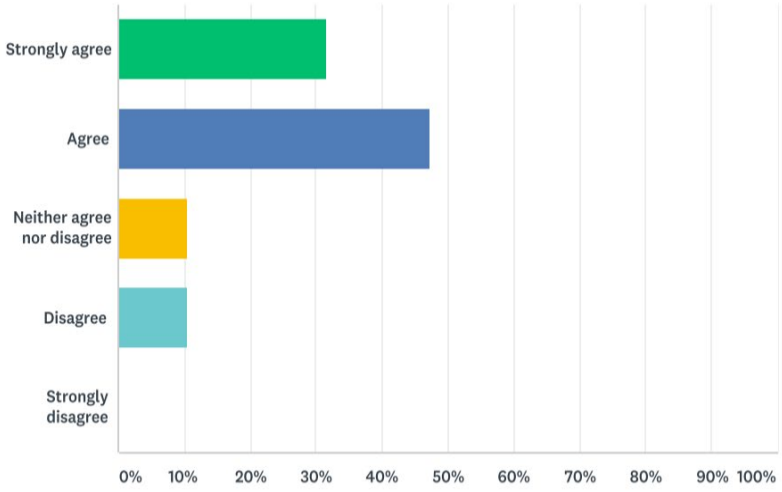
Answered: 19 Skipped: 0



ANSWER CHOICES	RESPONSES	
Strongly agree	52.63%	10
Agree	42.11%	8
Neither agree nor disagree	5.26%	1
Disagree	0.00%	0
Strongly disagree	0.00%	0
TOTAL		19

Q5 Agree or disagree? Restoration is important to me.

Answered: 19 Skipped: 0

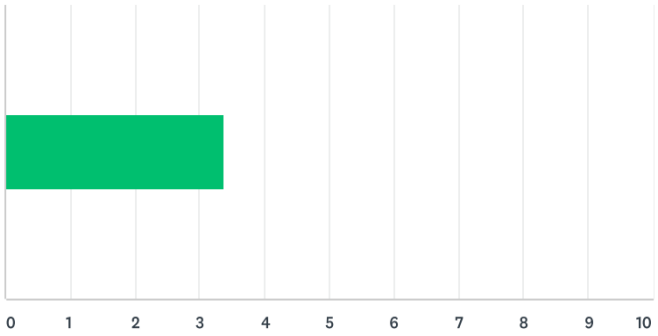


ANSWER CHOICES	RESPONSES	
Strongly agree	31.58%	6
Agree	47.37%	9
Neither agree nor disagree	10.53%	2
Disagree	10.53%	2
Strongly disagree	0.00%	0
TOTAL		19

Post Test 5

Q1 How likely do you feel you will talk to someone else about Biscayne Bay? 0 being not at all likely and 5 being very likely.

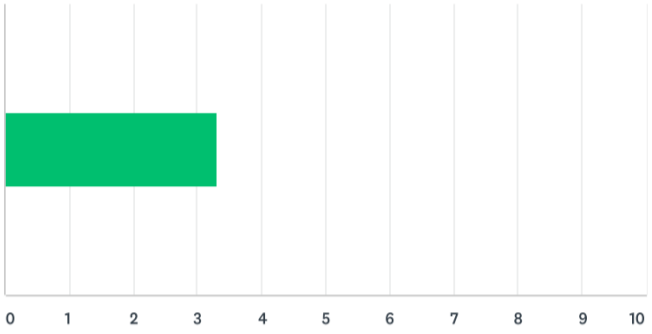
Answered: 16 Skipped: 0



ANSWER CHOICES	AVERAGE NUMBER	TOTAL NUMBER	RESPONSES
	3	54	16
Total Respondents: 16			

Q2 How likely will you talk about restoration of the Everglades with someone else? 0 being not all likely and 5 being very likely.

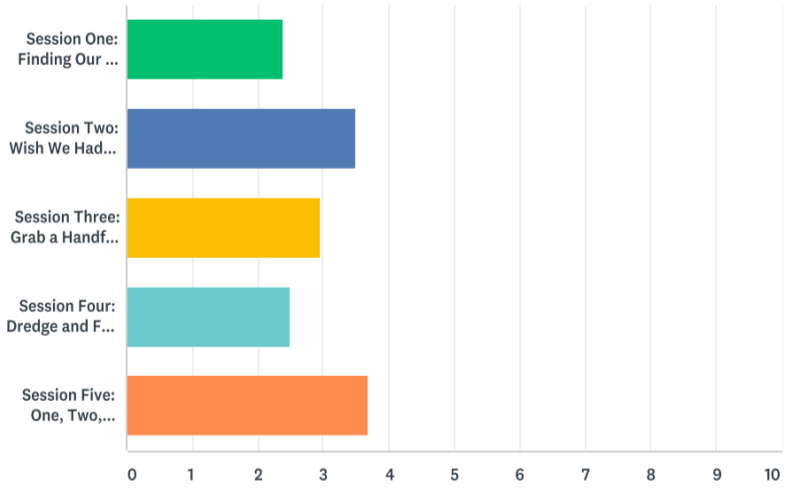
Answered: 16 Skipped: 0



ANSWER CHOICES	AVERAGE NUMBER	TOTAL NUMBER	RESPONSES
	3	53	16
Total Respondents: 16			

Q3 Rank your favorite sessions in order, with 1 being favorite and 5 being least favorite.

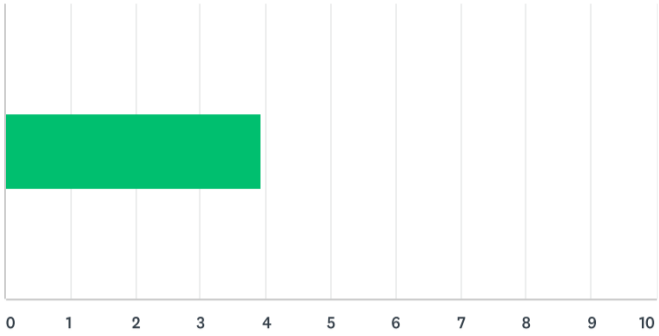
Answered: 16 Skipped: 0



	1	2	3	4	5	TOTAL	SCORE
Session One: Finding Our Way to Biscayne Bay - Concept Maps	12.50% 2	12.50% 2	18.75% 3	12.50% 2	43.75% 7	16	2.38
Session Two: Wish We Had More Fish - Fish Matching Game	25.00% 4	43.75% 7	0.00% 0	18.75% 3	12.50% 2	16	3.50
Session Three: Grab a Handful of Crabs - Carrying Capacity Game with Legos	12.50% 2	18.75% 3	37.50% 6	12.50% 2	18.75% 3	16	2.94
Session Four: Dredge and Fill Up a Sieve - Sieved Sediments Outside	0.00% 0	12.50% 2	31.25% 5	50.00% 8	6.25% 1	16	2.50
Session Five: One, Two, Trees, and Other Coastal Plants - Created Bumper Stickers	50.00% 8	12.50% 2	12.50% 2	6.25% 1	18.75% 3	16	3.69

Q4 How valuable is Everglades restoration to you, 5 being very valuable and 0 being not at all valuable.

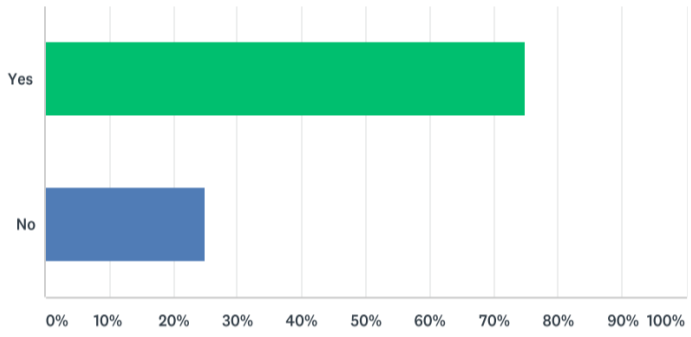
Answered: 16 Skipped: 0



ANSWER CHOICES	AVERAGE NUMBER	TOTAL NUMBER	RESPONSES
	4	63	16
Total Respondents: 16			

Q5 Would you try to visit Biscayne Bay to make your own observations in the next two months?

Answered: 16 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	75.00%	12
No	25.00%	4
TOTAL		16