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Implementation of the Modular Breakwater for Living Shorelines

Matthew Ninesling & Darin Hiraldo

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Implementation of the Modular Breakwater for Living Shorelines

Matthew Ninesling and Darin Hiraldo
Faculty Advisors: Dr. Emily Ralston and Dr. Ken Lindeman,
Dept. of Ocean Engineering and Marine Sciences, Florida Institute of Technology

Introduction

The Marine Resources Council[1] (MRC) is a non-profit that installs living shorelines in the Indian River Lagoon (IRL) to mitigate erosion and enhance marine ecosystems. They want to utilize the Modular Breakwater for Living Shorelines (MBLS) design for its modularity and favorable hydrodynamic properties. However, an efficient and scalable construction method for the breakwater does not exist. Therefore, in collaboration with the MRC, a method for molding the individual concrete prisms that comprise the breakwater was developed with an emphasis on accessibility and scalability.

Objectives

1. To design a concrete mold for constructing the MBLS prisms
2. To create a construction manual and video detailing the prism fabrication process

Methods

Design and Production of MBLS Prisms

The goal was to design a concrete mold that could efficiently produce entire prisms. It was essential that the mold be simple to construct, easy to replicate, and composed of readily available materials. These principles guided the iterative design process and acted as a problem-solving lens.

Construction Manual and Video Creation

Each step was documented throughout the design and construction process to create a detailed construction manual. A video demonstrating the construction process was also produced. With thorough documentation, the MRC can smoothly take over the project and ensure its development and implementation.

Results

The final mold consists of three exterior plates that are bolted together. The plates have cylindrical protrusions that define holes in the side of the prism (Fig. 1). Three plates are fastened to the cylinders on the interior to define the central void space (Fig. 2).

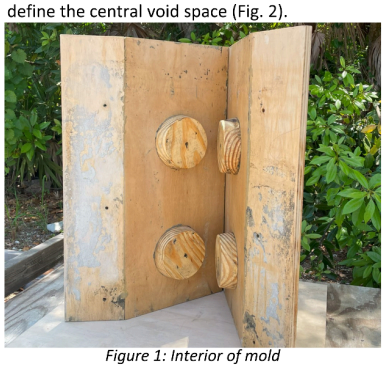

Figure 1: Interior of mold

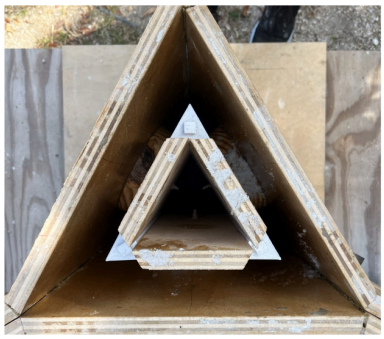

Figure 2: Top-view of assembled mold

Results cont.

Figure 3: MBLS concrete prism

Conclusion

The finalized mold could produce entire concrete prisms (Fig. 3) in a simple manner with readily available materials. In the future, the prism construction method needs to be streamlined to build the breakwater efficiently. Smooth knowledge transfer via the construction manual and video will ensure the project's future development. Although the mold was successfully produced during this project, significant investment must be made to optimize the mold design and prepare for mass production. Additionally, an adequate concrete mixture must be determined so that the prisms can withstand the IRL's aquatic environment and organisms can settle on the surface.

References

[1] https://lovetheirl.org

Acknowledgments

Mara Skadden, Marine Resources Council
Keith Richardson, Hendrick Brothers Environmental
Sarah Brooks, Florida Institute of Technology

Project Summary

The Marine Resources Council (MRC) is a non-profit that installs living shorelines on the Indian River Lagoon to mitigate erosion and enhance marine ecosystems. The living shoreline consists of a breakwater to reduce incoming wave energy, red mangrove trees to naturally stabilize the shoreline and create habitat, and other native plants to help with stabilization and runoff water filtration. The Modular Breakwater for Living Shorelines (MBLS) was designed to specifically create a more favorable hydrodynamic environment for mangrove vegetation by reducing incoming wave energy to levels appropriate for mangrove establishment. The MBLS design

comprises individual concrete prisms that stack to create a larger breakwater structure. Due to the favorable hydrodynamic properties and modularity, the MRC sought to utilize the MBLS design for their living shoreline projects. However, due to the complex structure of each prism, an efficient and scalable construction method for the breakwater does not exist. Therefore, in collaboration with the MRC, a method for molding the individual concrete prisms that comprise the breakwater was developed with an emphasis on accessibility and scalability. The finalized mold could produce entire concrete prisms in a simple manner with readily available materials. The mold needed to be composed of easily obtainable materials to reduce production limitations for the MRC. Although the mold was successfully produced during this project, the prism construction method needs to be streamlined, and significant investment must be made to optimize the mold design and prepare for mass production.

Fished Reefs Benefit From Marine Protected Areas

Nathaniel Isabella, Noel Casanova, Declan O'Leary, and Allyah Vega

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Fished Reefs Benefit from Marine Protected Areas

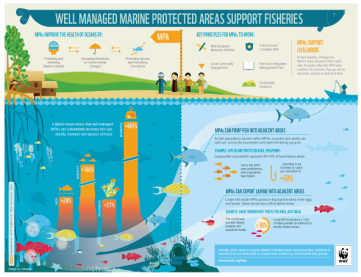
Nathaniel Isabella, Noel Casanova, Declan O'Leary, Allyah Vega
Faculty Advisor: Dr. Ralph Turingan, Deptartment of Ocean Engineering and Marine Sciences, Florida Institute of Technology

Background and Rationale

Marine protected areas (MPAs) are subsets of traditional fishing grounds that have been closed to fishing as a major component of fisheries management and sustainability programs worldwide. It is hypothesized that MPAs help sustain exploited stocks by either or both mechanisms: (1) larvae spawned in MPAs recruit into the Adjacent Fished Reefs (AFR); and (2) juveniles and adults emigrate from MPAs into AFRs. Evidence show that (1) although fish density is higher in MPAs than in AFRs at a given sampling period, in general, reef-wide fish density either increases or remains stable over time, and (2) large-bodied fish become increasingly abundant in AFRs over time. These results suggest that, over relatively few years of protection, MPAs promote beneficial shifts in fish population structure throughout the entire reef systems rather than simply maintaining stable populations within their borders. In this study we examine two metrics of fish performance (1. Age and Growth, and 2. Condition Factor) to further provide evidence that MPAs benefit AFRs through spill-over mechanisms.

Research Question

Is there a difference in growth rate and condition factor of fish between MPAs and AFRs?



Research Hypothesis

Growth rate and condition factor of fish are statistically similar between MPAs and AFRs.

Age and Growth of Fish

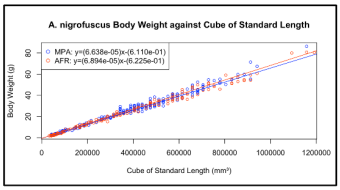


Figure 1. Comparison of *A. nigrofuscus*' body weight to the cube of their standard length between MPA and AFR.

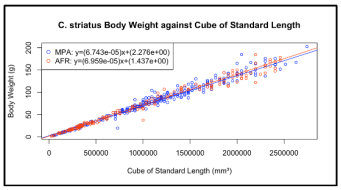


Figure 2. Comparison of *C. striatus*' body weight to the cube of their standard length between MPA and AFR.

Table 1. Statistical comparison of growth coefficients for six fish species between MPAs and AFRs.

		Regression Coefficients				Slope Similarity	
Species	In/Out	a	b	r^2	P-value	T	P-value
A. nigrofuscus	MPA	-0.61	6.64E-05	0.9878	<0.01	8.40E-07	>0.99
	AFR	-0.62	6.89E-05	0.9796	<0.01		
C. binotatus	MPA	0.43	7.19E-05	0.9872	<0.01	1.05E-06	>0.99
	AFR	-0.22	7.65E-05	0.9757	<0.01		
C. striatus	MPA	2.28	6.74E-05	0.9872	<0.01	1.90E-07	>0.99
	AFR	1.44	6.96E-05	0.9678	<0.01		
P. lacrymatus	MPA	-0.29	8.90E-05	0.9588	<0.01	8.90E-07	>0.99
	AFR	-0.25	9.10E-05	0.941	<0.01		
P. multifasciatus	MPA	-0.73	2.98E-05	0.9882	<0.01	1.70E-07	>0.99
	AFR	-0.55	2.88E-05	0.9749	<0.01		
Z. scopas	MPA	0.79	6.64E-05	0.9876	<0.01	6.00E-08	>0.99
	AFR	0.45	6.60E-05	0.9519	<0.01		

Fish Condition Factor

Fish Species	Median K in MPA	Median K in AFR
A. nigrofuscus	5.46	5.66
C. binotatus	6.25	6.56
C. striatus	6.02	6.18
P. lacrymatus	7.42	7.71
P. multifasciatus	2.70	2.58
Z. scopas	5.51	5.56

Conclusions and Implications

1.Growth rate of fish is statistically similar between MPA and AFR.
2. Fish health (Condition Factor) is statistically similar between MPA and AFR.

Acknowledgements

We would like to thank Dr. Robert Fidler and the Fulbright Program for assistance in data collection.

Project Summary

Marine protected areas (MPAs) are subsets of traditional fishing grounds that have been closed to fishing as a major component of fisheries management and sustainability programs worldwide. It is hypothesized that MPAs help sustain exploited stocks by either or both mechanisms: larvae spawned in the MPAs recruit into the Adjacent Fished Reefs (AFR), and juveniles and adults emigrate from MPAs into AFRs. Evidence shows that, between MPAs and AFRs, general reef-wide fish density either increases or remains stable over time, and large-bodied fish become increasingly abundant in AFRs over time. These results suggest that, over relatively few years of protection, MPAs promote beneficial shifts in fish population

structure throughout the entire reef systems rather than simply maintaining stable populations within their borders. In this study we examined two metrics of fish performance — the trend between a fish's age and growth, and their condition factor. It was found that in all measured species, both the condition factors and estimated age to growth regressions were extremely similar between MPAs and AFRs, with no significant differences being found. These findings support the idea that spill-over mechanisms allow MPAs to benefit nearby areas that aren't under their restrictions, allowing for sustainable fishing to occur while populations still remain stable and capable of replenishment.

Mitigating global climate change by targeting greenhouse-gas emissions at a local scale

Liana van Woesik

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FLORIDA TECH

Mitigating Global Climate Change by Targeting Greenhouse Gas Emissions at a Local Scale

Liana van Woesik

Faculty Advisors: Dr. Ken Lindeman and Dr. Emily Ralston
Department of Ocean Engineering and Marine Sciences, Florida Institute of Technology

Introduction

Climate change caused by Greenhouse Gas (GHG) emissions is one of the greatest environmental challenges faced in modern times.[1] There is substantial scientific evidence to prove that GHG emissions are a leading cause of a rapidly warming climate.[2] Therefore, it is essential to implement GHG reduction strategies and policy across scales to mitigate the detrimental consequences of climate change. Inventories of GHG emissions at a local scale will help drive effective policy for local-scale change that catalyzes a global impact.

Objectives

1) Create a Greenhouse Gas Inventory and Report for the City of Melbourne, Florida, USA for 2021.
2) Identify key sectors for GHG emission reduction.
3) Visualize the effects of GHG emissions relating to climate change on a global scale.

Methods

Greenhouse Gas Inventory

Data was sourced from government operations within the City of Melbourne for 3 key sectors of: Energy, Transportation, and Water and Wastewater Treatment. The data was processed in ClearPath software to calculate Carbon Dioxide (CO_2) equivalents for all parameters to make a comparable inventory analysis.

Identify Key Sectors

The results of the Inventory Report were used to pinpoint focus areas where emissions could be most effectively reduced within the municipality.

Global Scale Visualization

The coding language R was used to create a map of global-temperature anomalies for the last 142 years from NASA record data.[3] An original graphic was also created to show the global effects of GHGs.

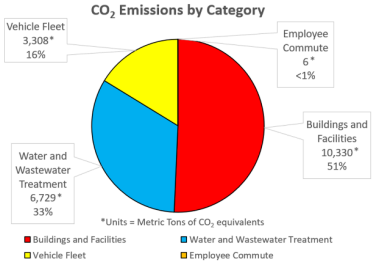

Figure 1: City of Melbourne 2021 GHG Inventory

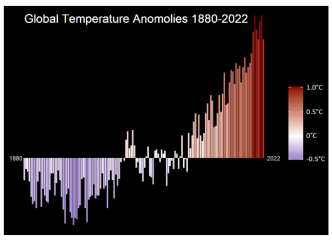

Figure 2: Global Temperature Anomalies 1880-2022

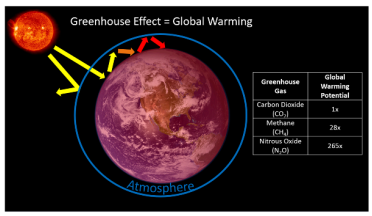

Figure 3: Global effects of Greenhouse Gases

Results

Buildings and Facilities, which are part of the Energy sector in the City of Melbourne, accounted for the vast majority (51%) of GHG emissions, followed by water and wastewater treatment (33%), vehicle fleet (16%), and then employee commute (<1%) (Fig. 1). A 19-page Inventory Report was written on experimental findings and recommendations for the City of Melbourne. A visualization of global-temperature anomalies for the last 142 years was created to show a heat increase of 1°C above the average global temperature in recent decades (Fig. 2). An explanatory visual was created to depict the effects of GHG emissions on warming global temperatures (Fig. 3).

Conclusions

Actions to reduce GHG emissions from the key sectors defined in this study will be the focus of present and future climate-action plans for the City of Melbourne. The Inventory Report was provided to the City of Melbourne Beautification and Energy Efficiency Board who brought it forward to the town council as a source of recommendations and baseline data for policy. Clear visuals on global-temperature trends were also produced to highlight the importance of implementing policy to help fight climate change by reducing GHG emissions at local and national scales.

References

1. IPCC. (2021). Special Report on Global Warming.
2. Millar et al. (2017). Emission Budgets and Pathways Consistent with Limiting Warming to 1.5°C, *Nature Geoscience*, 10, 741-747.
3. GISTEMP Team (2024). Surface Temperature, NASA Goddard Institute for Space Studies.

Acknowledgements

Thank you to Jennifer Wilster and Bruce Lindsay from the City of Melbourne for their data contributions, Jake Leech from ICLEI for providing the ClearPath analysis software, and the Florida Tech faculty advisors for their support.

Project Summary

Climate change caused by Greenhouse Gas (GHG) emissions is one of the greatest environmental challenges faced in modern times. There is substantial scientific evidence to prove that GHG emissions are a leading cause of a rapidly warming climate. Therefore, it is essential to implement GHG reduction strategies and policy across scales to mitigate the detrimental consequences of climate change. Inventories of GHG emissions at a local scale, such as the one conducted here for the City of Melbourne, will help drive effective policy for local-scale change that catalyzes a global impact.

Project Objectives

1) Create a Greenhouse Gas Inventory and Report for the City of Melbourne, Florida, USA for 2021. 2) Identify key sectors for GHG emission reduction. 3) Visualize the effects of GHG emissions relating to climate change on a global scale.

Manufacturing Design Methods

Greenhouse Gas Inventory Data was sourced from government operations within the City of Melbourne for 3 key sectors of: Energy, Transportation, and Water and Wastewater Treatment. The data was processed in ClearPath software to calculate Carbon Dioxide (CO2) equivalents for all parameters to make a comparable inventory analysis. Identify Key Sectors The results of the Inventory Report were used to pinpoint focus areas where emissions could be most effectively reduced within the municipality. Global Scale Visualization The coding language R was used to create a map of global-temperature anomalies for the last 142 years from NASA record data. An original graphic was also created to show the global effects of GHGs.

Analysis

Buildings and Facilities, which are part of the Energy sector in the City of Melbourne, accounted for the vast majority (51%) of GHG emissions, followed by water and wastewater treatment (33%), vehicle fleet (16%), and then employee commute.

Future Works

Actions to reduce GHG emissions from the key sectors defined in this study will be the focus of present and future climate-action plans for the City of Melbourne. The Inventory Report was provided to the City of Melbourne Beautification and Energy Efficiency Board who brought it forward to the town council as a source of recommendations and baseline data for policy. Clear visuals on global- temperature trends were also produced to highlight the importance of implementing policy to help fight climate change by reducing GHG emissions at local and national scales.

Growth and Survival of Manatee Grass at Different Salinities: A Mesocosm Experiment to Assess Restoration Potential

Alicia Lopez, Sailor Scheinkman, and Natalie Sperry

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Growth and Survival of Manatee Grass at Different Salinities: A Mesocosm Experiment to Assess Restoration Potential

Alicia Lopez, Sailor Scheinkman, and Natalie Sperry
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Introduction

Manatee grass *(Syringodium filiforme)* is a common seagrass found in the Indian River Lagoon (IRL)[1]. It is understudied and provides many ecosystem services[2]. Increased freshwater input has decreased the salinity throughout the IRL[3]. A deeper understanding of the lower salinity tolerances of *S. filiforme* can increase the utility of this species for restoration and salinity shifts.

Objectives

- What is the response of *S.filiforme* to lower salinities with regard to shoot count and canopy height?
- What is the response of *S.filiforme's* color in relationship to health with lower salinity?

Methods

Manatee grass was hand-planted in separate mesocosm tanks (Figure 1). After a ten-week acclimation at 26 ppt a seven-week treatment was conducted. Salinity was maintained at 10, 15, 20, and 26 ppt. Seagrass growth and survival was monitored using blade and shoot count, color, and canopy height.

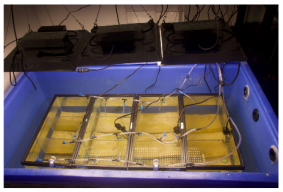

Figure 1: Mesocosm setup in Florida Institute of Technology's Aqualab

Results

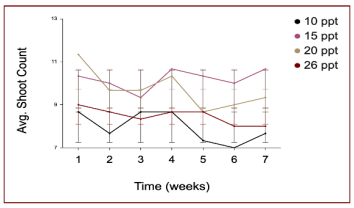

Figure 2: Average shoot count across varied salinity levels.

Table 1: Post hoc comparative analysis of salinity treatments.

	Treatment Comparison (ppt)	P-unadjusted	P-adjusted
Shoot Count p = 0.026	20 - 26	0.008	0.046
Canopy Height (cm) p = 0.005	10 - 20	3.9 x 10^-4	0.002

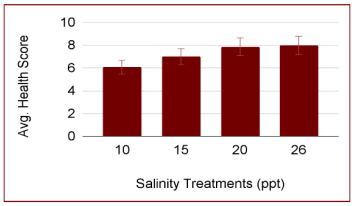

Figure 3: Assessment of seagrass health through blade color-scoring.

Discussion

As expected, shoot counts across treatments varied significantly with the highest found in 20 ppt (Figure 2). In contrast, 26 ppt had the lowest average shoot count. Canopy height also varied significantly across treatments (Table 1). Contrary to predictions, 10 ppt had the highest average canopy height. This may be attributed to a lack of wave action in the mesocosms. The lowest average shoot and blade counts were observed in the same treatments, 26 ppt. Grasses in the salinity level of 10 ppt exhibited the poorest health in terms of color (Figure 3).

Conclusion

- Low salinity levels have less of an impact on manatee grass than expected with significant implications for restoration.
- Future research can focus on other environmental factors that may be inhibiting growth in the northern IRL.

Acknowledgements

We would like to thank Dr. Ken Lindeman, Sean Crowley, Tyler Provoncha, and Sarah Brooks for their support, knowledge and help in the contribution of this study. We would also like to thank Brevard Zoo's Restore Our Shores, Florida Oceanographic Society and Florida Institute of Technology for giving us the resources to conduct this experiment.

Literature Cited

1. Buzzelli, C., and others (2012). Est. Coasts, 35, 1401-1415.
2. Morris, L., and others (2021). Fl. Sci., 84(2/3), 119–137.
3. Lirman, D., & Cropper, W. (2003). Estuaries, 26, 131-141

Project Summary

Manatee grass (Syringodium filiforme) is a common seagrass found in the Indian River Lagoon (IRL). Up to this point, there has been limited research examining the effects of different environmental parameters on manatee grass growth and survival. Salinity has been decreasing in the IRL due to changing climate conditions (Lirman and Cropper, 2003). Examining the tolerance of S. filiforme to lower salinity conditions, may expand their utility in future restoration efforts.This study evaluated the growth and survival of S. filiforme in salinities found throughout the IRL: 10, 15, 20 and 26 ppt. The objectives for this study aimed to uncover the

response of S. filiforme to lower salinites with regards to shoot and canopy height and the response of color in relationship to health. Twelve mesocosms were established, each planted with 9-13 shoots of manatee grass in quarry sand. Mesocosms were illuminated with full spectrum 1000W grow lights matched to sunrise and sunset times during the growing season. Seagrass growth and survival was monitored using blade count, shoot count, canopy height, color scoring and chlorophyll concentrations. Shoot count and canopy height varied significantly across the treatments. Twenty ppt had the highest average shoot count and 26 ppt the lowest. Contrary to predictions, 10 ppt had the highest average canopy height. The lowest average shoot and blade counts were observed in the same treatments. Ten ppt had the lowest health in relationship to color and 26 ppt had the highest level of health. This study is important for future restoration efforts as low salinity levels had a lower impact on S. filiforme than expected. Further research on Manatee Grass can focus on other environmental factors that may inhibit its growth in the Northern Indian River Lagoon.

Indialantic Emissions Inventory & Reduction Strategies

Sara Lail

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Indialantic GHG Emissions Inventory & Reduction Strategies

Sara Gabby Lail
Faculty Advisors: Dr. Emily Ralston, Dr. Ken Lindeman, Dept. of Ocean Engineering and Marine Sciences, Florida Institute of Technology

Introduction

Climate change is a growing issue affecting humanity and the global environment. Its primary cause is the anthropogenic emission of greenhouse gases (GHGs) such as CO2[1]. Reducing emissions on every possible scale is thus a crucial step in combatting climate change[2]. This project aims to identify feasible and effective means of reducing GHG emissions on a local government scale in the Town of Indialantic, FL.

Objectives

1. To assemble a GHG emissions inventory and report for the Town of Indialantic.
2. To identify feasible emissions reduction strategies in town hotspots.

Methods

Emissions Inventory

- Electricity consumption and approximate employee fuel use data were provided by Florida Power & Light (FPL) and Indialantic.
- Inventory construction was performed using ICLEI'S ClearPath software with built-in emissions equivalent calculators.
- A summarizing report was written using a template provided by ICLEI.

Reduction Strategies

- Data was gathered from relevant businesses and local government, including FPL, NovaCharge, First Light Technologies, and the City of Cape Canaveral.
- Options were then compared based on cost, potential savings or revenue, and calculated CO2 reduction capability.

Results

Emissions Inventory

Figure 1 shows emissions by sector for Indialantic local government operations (LGO) in 2021. The greatest contributors were streetlights, employee commute, and buildings & facilities.

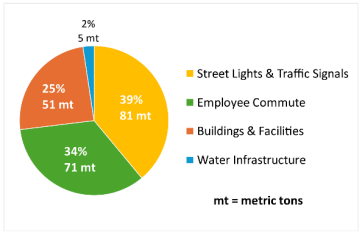

Figure 1: 2021 CO2 emissions by sector for Indialantic LGO.

Reduction Strategies

Based on Figure 1 and the interests of Indialantic, the investigation of solutions focused on electric vehicle (EV) and solar-related town upgrades. Figure 2 compares the approximate initial costs and annual GHG reductions from implementing 15 solar streetlights, one 10 kW rooftop array, one 25 kW solar canopy, and two dual-port EV chargers from three different brands.

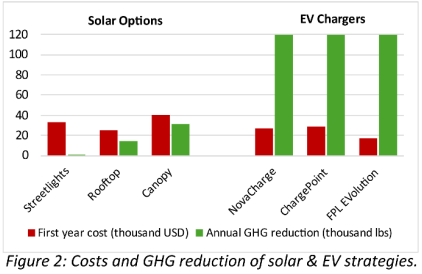

Figure 2: Costs and GHG reduction of solar & EV strategies.

Results (cont.)

Installation of EV chargers was shown to have the greatest potential impact on GHG emissions. This was also the most profitable option, as shown in Figure 3.

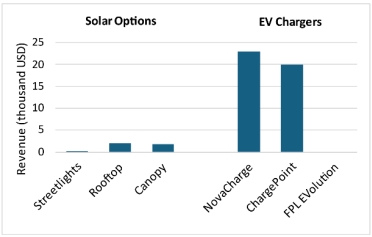

Figure 3: Potential revenue from solutions reviewed.

Conclusion

Local governments must move toward renewable and efficient technology whenever possible. For Indialantic, installing NovaCharge EV charging stations (Figure 4) is a feasible and effective next step. Moving forward, funding prospects will be reviewed. Once approved by the Mayor and Town Council, a NovaCharge representative will be brought out for site assessment.

Figure 4: NovaCharge NC8000 station.

References

1. IPCC, 2023. Climate Change Synthesis Report.
2. Ou et al., 2021. Deep mitigation of CO2 and non-CO2 greenhouse gases toward 1.5°C & 2°C futures.

Acknowledgements

M. Casey, V. Taranto, Indialantic SC&RC, ICLEI, Audubon FL, S. Brooks, & Z. Eichholz.

Project Summary

Climate change is a growing issue affecting humanity and the global environment. Its primary cause is the anthropogenic emission of greenhouse gases (GHGs) such as CO2. This project aims to identify feasible and effective means of reducing GHG emissions on a local government scale in the Town of Indialantic, FL. The objectives of this project were to assemble a GHG emissions inventory and report for the Town of Indialantic, and to identify feasible emissions reduction strategies in town hotspots. Data for the emissions inventory was provided by Florida Power & Light (FPL) and the Town of Indialantic. The inventory was constructed using ICLEI's ClearPath software, and a report was written using a template provided by ICLEI. Potential means of reducing town emissions were then investigated and compared based on cost and effectiveness.

Data for this objective was gathered from relevant businesses and local government, including FPL, NovaCharge, First Light Technologies, and the City of Cape Canaveral. Results from the emissions inventory showed that streetlights were the town's greatest source of emissions, generating 81 metric tons of CO_2 yearly. The next largest contributors were employee commute and buildings & facilities. Based on these results and town interests, research of potential reduction strategies focused on electric vehicle (EV) and solar energy-related upgrades. These potential solutions included a 10-kW rooftop solar array, a 25kW solar canopy, 15 solar streetlights from First Light Technologies, and two dual-port EV charging stations sourced from NovaCharge, ChargePoint, or FPL. The best option was determined to be installation of EV chargers, with NovaCharge being the recommended company due to low costs, reliability, and potential revenue. Moving forward, grants and other funding opportunities will be considered, and permission to continue with the project will be sought from the Mayor and Town Council.

Sustainable Practices for Golf Courses on the Space Coast

John Yates

Sustainable Practices for Golf Courses on the Space Coast
John Yates
Faculty Advisors: Dr. Ken Lindeman; Dr. Emily Ralston.
Dept. of Ocean Engineering and Marine Science, Florida Institute of Technology

Intro: You Like Golf? Your Kids Will Too!

Golf course systems require crucial resources like fertilizers, pesticides, water, and waste management in-flows and out-flows to meet the aesthetic and functional standards expected by players. The purpose of this project is to address these challenges by proposing methods to meet the requirements for golf course management, while minimizing or mitigating financial disadvantages for the courses. By fostering cooperation between environmental experts, course groundskeepers, and local course management, my plan advocates for the adoption of more eco-friendly practices, while saving the industry money/resources. According to Rutgers if management does not follow more sustainable practices, then groundwater pollution caused by fertilizers and pesticides may follow[1].

Objectives:

- Survey local golf courses about sustainable practices.
- Develop recommendations for the reduction of the amount/cost of fertilizers/water used on current/future golf course grounds on the space coast.
- Develop recommendations for the use of better waste management capabilities.

Methods:

- Conducted a literature review to develop a table of golf course fertilizer reduction for the final report.
- Compared sustainable practices from gathered information among multiple courses through talking with managers/maintenance grounds employees.
- Created cost/benefit analysis for fertilizer inflows/outflows for local courses.
- Compared data & developed recommendations

References:

1. Rutgers, The State University of New Jersey, 2024

Acknowledgements:
Steve Lamontagne (Spessard); Kieth Pope (Mallards); Eric Hintz (Crane); Jon Cockerhamn (Suntree); Person (Aquarina)

Abstract

Results:

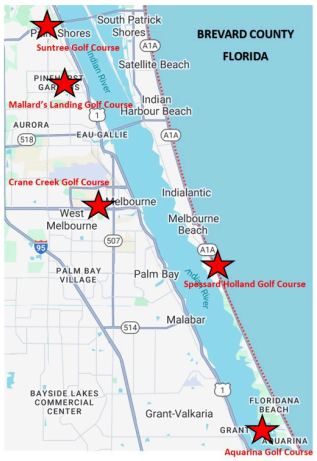

Figure 1: Map of courses contacted on the Space Coast:

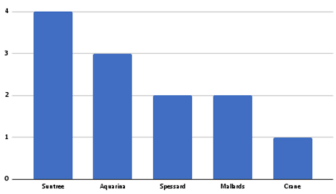

Figure 2: Sustainability Positions of the courses via # of practices

In figure 2, each # represents a separate sustainable practice that each course uses. The 4 factors include: Fertilizer usage, Pesticide usage, Water Usage, & Waste Management.

Results Continued:

Table 1:Comparison of Organic and Synthetic Fertilizers

Fertilizer Name/Brand	Type	Primary Ingredients	N-P-K Ratio	Carbon Footprint	Water Quality Impact	Soil Health	Efficiency	Cost	Certifications
EcoGreen BioFertilizer	Organic	Seaweed, Fish Emulsion	4-2-3	Low	Minimal to None	Enhances microorganism diversity	3 months	Higher upfront, lower long-term	Organic Materials Review Institute (OMRI)
Popular Synthetic Brand X	Synthetic	Urea, Ammonium Phosphate	10-5-5	High	High risk of runoff	Can degrade soil health over time	1 month	Lower upfront, higher long-term	None

Table 1 shows the benefits of the organic, more sustainable fertilizer compared to the synthetic one courses currently use.

Table 2: Fertilizer Brands Price Comparison

All Organic Brands both Granular/Liquid	Estimated Cost per 30 lb bag covers 2,500 - 5,000 square feet	All synthetic Brands currently in use	Cost same coverage
Espoma (granular)	$15 - $40	Roundup	$20 to $60
Dr. Earth (granular)	$10 - $50	ScottsMiracle-Grow	$20 to $50
BioBizz (liquid)	$20 - $60		
FoxFarm (both organics)	$30 - $70		
Neptune's Harvest (liquid)	$20 - $50		
Milorganite (organic)	$15 - $30		

Table 2 lists the sustainable fertilizer/pesticides that are currently available for golf courses to start using. Synthetic brands are not a substantially cheaper option when compared to the organic mixes. This is contrary to expectations. Rather than cost benefits, it may be the result of the idea that "this is how we have done it in the past, this is how we will do it in the future" mentally. This can be changed through the education of better products golf courses now have the access to.

Recommendation for Sustainable Waste Management Trash Bins for Local Courses:

Implement multi-functional waste bins on all unsustainable courses in contact by working with waste management trash and recycling services. This will allow for a more efficient garbage system for all courses that do not have one.

Discussion:

I have compiled all results and created a more detailed report of the comparisons of the sustainable practices. For the future, I plan to travel to each course and provide them a list of recommendations that include reasons to switch from their current maintenance practices to more sustainable ones that will provide a brighter future for their course without creating new expenses that would hurt their profits.

Project Summary

Golf courses require crucial resources like fertilizers, pesticides, water, and waste management to meet the aesthetic and functional standards expected by players. The purpose of this project is to address these challenges by proposing methods to meet the requirements for golf course management, while minimizing or mitigating financial disadvantages for the courses. By fostering cooperation between environmental experts, course groundskeepers, and local course management, my plan advocates for the adoption of more eco-friendly practices, while saving the industry money and resources. The objectives were to 1) survey local golf courses about their sustainable practices; 2) develop recommendations for reducing the amount and cost of fertilizers and water used; and 3) develop recommendations for better waste management

practices. Through literature survey and discussions with managers and employees of the golf courses, I developed recommendations for more sustainable fertilizer/pesticide brands that courses can use without spending more money. Effective waste management practices, including a recycling program turned out to be imperative for local courses in terms of sustainability and reputation with customers. These practices provide golf courses with a more viable solution to long term prosperity.

Project Objective

Find more sustainable ways that golf courses can maintain their courses without costing the company money.

Climate Action Plan Outline & Motivation Survey

Anya Johnson and Erin Graham

NORTHROP GRUMMAN
ENGINEERING & SCIENCE
STUDENT DESIGN SHOWCASE
FLORIDA TECH

Climate Action Plan Outline & Motivation Survey

Anya Johnson & Erin Graham
Dr. Emily Ralston, Dept. of Ocean Engineering & Marine Science, Florida Institute of Technology
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INTRODUCTION

Brevard County ranks in the 99.36 percentile in FEMA's National Risk Index[1], demonstrating its risk to hazards. These hazards are expected to worsen in a changing climate. Safety concerns aside, investing in climate mitigation and adaptation may help the Florida Institute of Technology (FIT) gain a competitive edge, save money, and adapt to changing policies. Many institutions are responding with detailed GHG reduction plans, called Climate Action Plans (CAPs). CAPs set target goals, introduce policies, and encourage behavior change[2]. This project's aim is to create a CAP blueprint for FIT administration to further develop.

Objectives

1. Conduct a **motivation survey** to determine campus readiness for sustainable changes
2. Provide a **CAP outline** to university staff for investing in and implementing climate action

METHODS

Motivation Survey

1. Developed topics focused on climate perception, sustainability (SUS) education, and SUS engagement among students

2. Drafted survey with 16 Likert scale questions and 2 open-ended questions

3. Distributed through Student Government Association email to the FIT student body

4. Identify trends in responses using statistics

CAP Outline

1. Literature review: examined other university CAPs and guides; identified potential themes

2. University analysis: mapped influential stakeholders, operations, and academics

3. Prepared recommendations based on literature review and feasibility

RESULTS: Motivation Survey

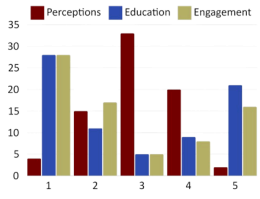

Figure 1: Climate Perception, SUS education, SUS engagement count

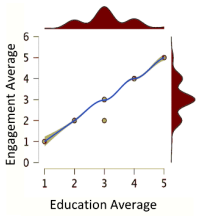

Figure 2: education and engagement, compared

The survey showed a consistent desire for more climate initiatives among Florida Tech students. Figure 1 shows the combined results of questions within each survey topic using the Likert scale. The most frequent response for two categories was strongly disagree, implying the CAP outline should promote campus perceptions and engagement.

The most significant correlation was between SUS education and SUS engagement, which can be seen in Figure 2. It shows that **the more educated a student is about sustainability, the more likely that the student will engage in climate-friendly behaviors.** Additionally, survey results suggest that younger students are more likely to engage in sustainable efforts.

RESULTS: CAP Outline

The report incorporated five subjects:

1. **Basic terminology and concepts**
2. **FIT connections** to explain relevance of CAP to the university
3. **Climate action planning steps** like GHG audits, reporting, and targets
4. **Emissions reduction strategies** as shown in Figure 3
5. **Recommendations** and additional resources

Figure 3: GHG Mitigation, prioritized from the base to the top

DISCUSSION

Bounds Most case studies came from Association for the Advancement of Sustainability in Higher Education member institutions, potentially omitting climate-forward universities. Staff were not surveyed. We were unable to collect information from all FIT departments about their capabilities and current operations. The scope of the 2019 GHG inventory was limited.

Figure 4: Climate action solutions process

Impact The survey results indicate a need for more sustainability education and initiatives at FIT. Future student projects and university programs can incorporate mechanisms and suggestions from the CAP outline into their daily operations using the process in Figure 4. Further, university administration and department heads can use the CAP outline while designing their climate commitments. This outline may be the foundation of a future, formal FIT CAP.

References

[1] FEMA National Risk Index Map
[2] IUPUI Sustainability (2021). Beginner's Guide

Acknowledgements

Jessica Burpee | Abby Zabrodsky | Sarah Brooks | Brooke Wheeler | Ashley Bennett | Troy Nguyen Chelsea Lewis | Cat Nanney | John Fonseca

Project Summary

Climate change is a global problem requiring commitment at all scales of society, but current commitments are insufficient. This project encourages and advises Florida Institute of Technology's (FIT's) administration on reducing the institution's climate footprint. It synthesizes a literature review and student survey to offer FIT-centric climate solutions. The survey results and analysis, FIT's vulnerability to disaster, general planning steps, and example action items are provided in the final report. Students, staff, and faculty should find the document helpful in reducing emissions in their realm of influence. This report will lay the foundations for a future, university-backed mitigation plan.

Project Objective

This project's aim is to create a CAP blueprint for FIT administration to further develop. Therefore, the objectives are twofold: First, describe students' baseline readiness for and interest in climate action through a survey of the student body. Second, integrate the survey responses and other resources into a CAP outline document for FIT personnel to use in future planning.

Analysis

The survey results indicate a need and desire for more sustainability education and climate initiatives at FIT. Students demonstrated skepticism of FIT's climate action, with more than 50% disagreeing or strongly disagreeing that FIT does enough to promote climate action. Most respondents displayed willingness to include climate-friendly practices in their own life. Sustainability engagement scores correlated linearly with sustainability education scores; the more educated someone is, the more likely they are to make climate-conscious decisions. In the free-response sections, students connected climate action to their daily concerns such as safety and comfort. Students had many ideas for the university to improve. The most frequent frustration was uncertainty about campus recycling. These and other conclusions are noted in the CAP outline. The CAP outline is written assuming the audience is unfamiliar with climate change response but proficient in their current fields. FIT's vulnerability to climate change is explored along with climate-related terminology, mitigation frameworks, and climate action commitments necessary to understand climate action planning. Recommendations for decision makers are provided in the executive summary, discussing solutions to difficult to manage emissions and top-level response. With the basics established, the CAP outline shifts to describing the process and efforts behind creating a climate action document. Finally, mitigation measures spanning 18 classifications are discussed. Some examples can be implemented in conjunction with or without a CAP.

Future Works

Future student projects and university programs can incorporate mechanisms and suggestions from the CAP outline into their daily operations. Students and faculty may be able to conduct research addressing problems and solutions posed in the CAP outline. Further, university administration and department heads can use the CAP outline while initiating their climate commitments. This outline could form the foundation for a future, formal FIT CAP.

Space Coast Sustainable Business Guide

Mary Renaud, Joshua Howell, and Erin Graham

NORTHROP GRUMMAN
ENGINEERING & SCIENCE
STUDENT DESIGN SHOWCASE
FLORIDA TECH

Space Coast Sustainable Business Guide

Mary Renaud, Joshua Howell, Erin Graham

Faculty Advisor(s): Dr. Emily Ralston & Dr. Ken Lindeman, Dept. of Ocean Engineering and Marine Sciences, Florida Institute of Technology

Introduction

This project aims to promote sustainability in the Space Coast through the development of a comprehensive web-based document. Drawing from definitions in the Brundtland Report[1] and Harvard Business School[2], sustainability is defined as doing business in a way that meets present needs without compromising future economic, social, and environmental practices. The document, designed to be consumable and engaging, compiles resources and information for businesses in the Space Coast. The goal is to emphasize adaptable implementation tactics for businesses and professionals interested in becoming intentionally sustainable.

Objectives

- To develop a sustainability toolkit in the form of a web-available resource.
- To analyze and synthesize the sustainability needs and interests of Space Coast professionals.

Methods

Develop Web-based Doc

- Identified gaps in the readily available information.
- Researched example toolkits, definitions, sustainable companies, sustainability literature, and research articles.
- Conducted a literature review to identify document themes.
- Synthesized and utilized literature review data to support document creation.
- Integrated resources and information for businesses from the following sections within sustainability: business, social, environmental, and innovation.

Identify Key Space Coast Needs

- Created a survey to identify the Space Coast's needs and interests in learning about and implementing sustainability into their business and professional lives.

Results

Develop Web-based Document

The literature review revealed that information was limited for certain sustainability topics/themes. Figure 1 shows themes covered in the reviewed literature. The smaller the word, the less frequently it appeared in the literature. This document focuses on addressing these information gaps.

Figure 1 Matrix of Main Topics in Literature Review

The document is based around the 3 pillars of sustainability (Figure 2). It provides resources for each capital and educates about their significance.

Figure 2 Three Pillars of Sustainability

The document will be tailored to the results of the survey when it is distributed (Figure 3). This will aid in adjusting the document to best target the Space Coast.

Results cont.

Identify Space Coast Needs

The document was split into 5 sections of content indicated by the colors (Figure 3). The creation of the survey helped in the division of content and distribution to each section.

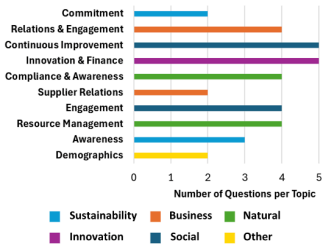

Figure 3 Sustainability Survey Topics

Discussion

The baseline resources and information that businesses may need to become more sustainable have been aggregated into one place through this project. We found a higher need for business, social, and innovative sustainability content than environmental through the literature review, which led to the refining of our document. This resource is a preliminary step in the effort to promote sustainability implementation and education. The next steps include refining the document based on survey results and distributing it through the Marine Resources Council to local Space Coast Businesses. This project's limitations have been time constraints, narrowing the scope, Space Coast connections, and Survey Distribution.

Literature Cited

[1] United Nations (1987), *The Brundtland Report*
[2] Harvard Business School (2018), *What does "sustainability" mean in business?*

Acknowledgments

Sarah Brooks – GSA, Dr. Abram Walton, Marine Resources Council

Project Summary

In business, sustainability often has a negative connotation due to the lack of knowledge on the subject. One of the main issues with this is the widespread idea that if a company is sustainable, it won't be as profitable. This notion isn't correct or constructive in the long term due to the fact that sustainability in business is a continuous commitment and investment. This document provides a comprehensive list of resources and information that'll be able to aid businesses in the Space Coast in becoming more sustainable in every area. Research was performed to identify the Space Coast's sustainability needs and develop the web-based business guide. A survey was created for the purpose of identifying and understanding the Space Coast's

sustainability needs. Through the creation of this survey, we were able to outline the topics and resources included in the document. The areas of research include Business, Social, Environmental, and Innovation sustainability. A literature review was conducted to aggregate the resources and information used in the creation of the sustainability document. The Business Guide contains broad resources for education on sustainability tailored to the Space Coast. The promotion of this material will be done through the Marine Resources Council to best target the Space Coast. This will be one of the first steps in educating the public and professional workforce about sustainability and how it can be profitably implemented in more businesses. The next step that will be taken soon is the distribution of the survey. This will lead to narrowing down the topics and resources included in the Business Document.