State of the Reserve

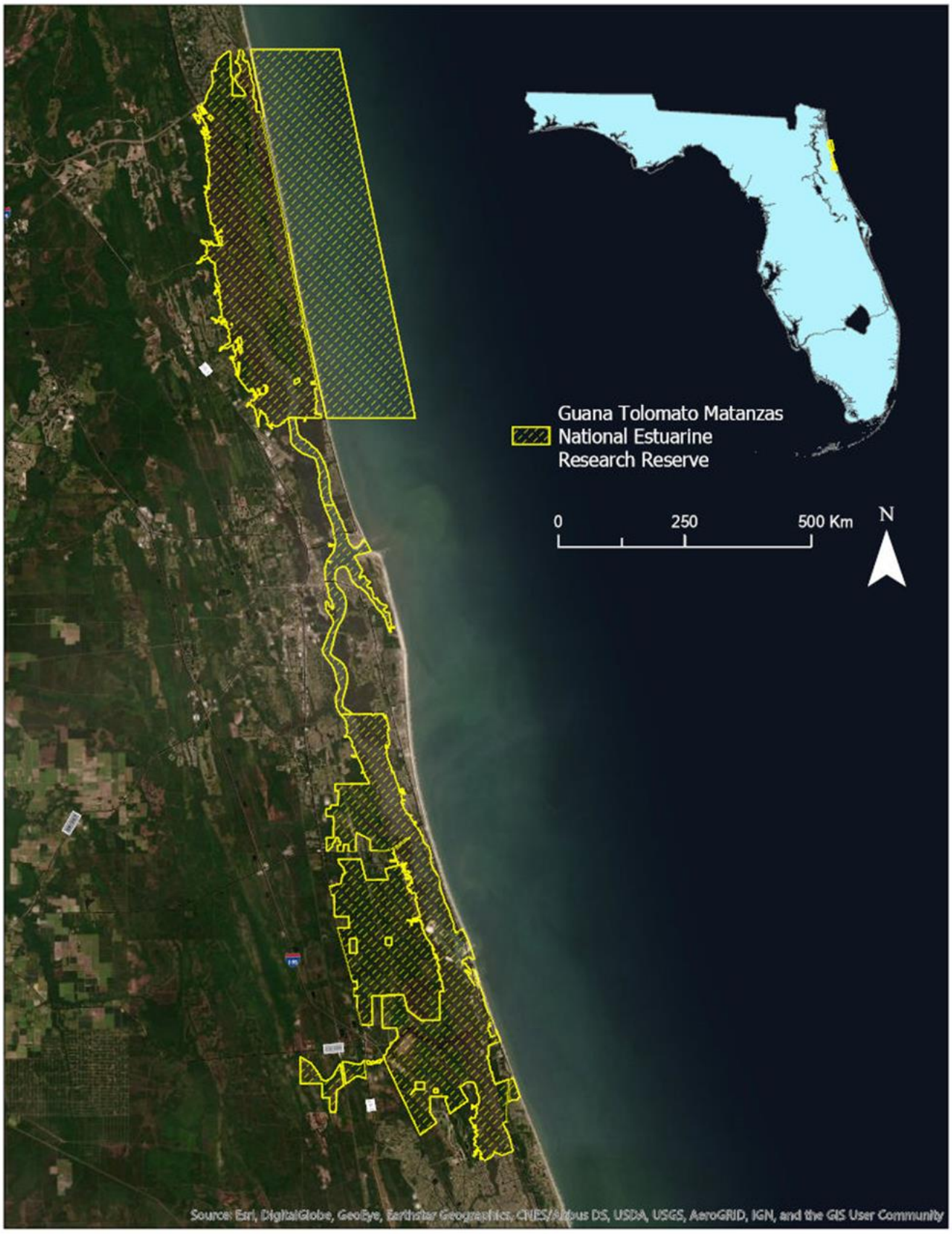
GUANA TOLOMATO MATANZAS NATIONAL ESTUARINE RESEARCH RESERVE

PRESENTATIONS AND PROGRAM SUMMARY

FEB. 22-26, 2021

The Guana Tolomato Matanzas National Estuarine Research Reserve (GTM Research Reserve) is a collaboration between the Florida Department of Environmental Protection's Office of Resilience and Coastal Protection and the National Oceanic and Atmospheric Administration. The Reserve covers 76,760 acres of coastal lands in northeast Florida from Ponte Vedra Beach to Palm Coast and is comprised of a network of public lands managed by the GTM Research Reserve, Florida Fish & Wildlife Conservation Commission, Flagler County, St. Johns River Water Management District, Florida State Parks, the Florida Forest Service, and the National Park Service.

For more information, contact the GTM Research Reserve Visitor Center.
904-823-4500 | www.gtmnerr.org | https://FloridaDEP.gov/rcp/nerr-gtm



The GTM Research Reserve was established in 1999 by the National Oceanic and Atmospheric Administration (NOAA), and is one of 29 NOAA research reserves. This document includes information representing select current and long-term research projects taking place within the GTM Research Reserve boundaries.

LETTER FROM THE REGIONAL ADMINISTRATOR

Welcome to the GTM Research Reserve's State of the Reserve!

Welcome to the 2021 State of the Reserve. This marks the 11th year we have hosted this symposium. What started out in 2010 as possibly a one-time event has developed into an incredible platform that brings together the community and offers the opportunity to gain greater insight into the research, education and stewardship activities taking place throughout the GTM Research Reserve by our staff, partners and academic institutions. In addition, this event has fostered new connections and spurred unique collaborations.

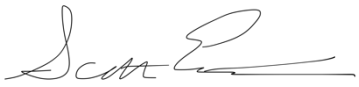
The GTM Research Reserve's mission is to achieve the conservation of natural biodiversity and cultural resources by using the results of research and monitoring to guide science-based stewardship and education strategies.

It goes without saying that 2020 was a challenging year. We are all in the midst of a global pandemic. Much of our staff, and many others, have been working remotely for almost a year now, but we have persevered and grown in many ways, and in some respects, this has brought our community closer together. A new challenge is but an opportunity for growth. Many of our programs have had to adjust their programing and have had to adapt to virtual platforms to continue supporting the Reserve's goals. In some cases, this shift to virtual programming has allowed us to reach new audiences. Ultimately, the pandemic has allowed our programs to make a greater impact and make them more resilient to future crises.

While we are all disappointed we could not meet in person this year, our team has been working diligently to ensure we will be able to foster the same sense of connectiveness and collaboration as we have experienced in past symposiums. This year's presentations cover important topics such as the current research on mangroves and salt marshes, oysters and water quality, wildlife and the use of cutting-edge technology to communicate environmental education.

Thank you for attending this year's State of the Reserve. It is through your continued support that GTM Research Reserve is able to achieve its mission and continue to foster a community approach to science-based management of our vital natural resources.

Sincerely,



Scott Eastman
Regional Program Administrator
Office of Resilience and Coastal Protection
Florida Department of Environmental Protection

TABLE OF CONTENTS

Photo taken by Alyssa Johnson, GTM Research Reserve ranger

State of the Reserve 2021 Coordinators
Event Facilitator: Kaitlyn Dietz, Coastal Training Program Coordinator
Chief Program Editor: Abigail Kuhn, Coastal Training Program Specialist
Program Editor: Patrician Price, Communications Coordinator

Special thanks to our planning committee:
Brittani Crawford, Nikki Dix, Ph.D., Scott Eastman, Ellen Leroy-Reed, Lia Sansom, and Josephine Spearman

FEATURED PROJECTS OF 2020

These projects were presented as featured projects of 2020 at the 2021 State of the Reserve.

THE STATE OF THE MARSHES IN THE GUANA TOLOMATO MATANZAS ESTUARY

Biologists Alee Knoell and Pam Marcum at a marsh monitoring site.

System Wide Monitoring Program staff Shannon Dunnigan and Silas Tanner on a marsh monitoring platform.

Coastal, intertidal wetlands (such as marshes and mangroves) make up approximately 23% of the GTM Research Reserve. The only habitat more prevalent in the Reserve is open water (24%), with upland forests coming in close third (22%). Reserve staff know that coastal wetlands are expansive, and they are also important. Marsh and mangrove habitats stabilize shorelines and protect us from storm surge, provide food and habitat for valuable fisheries, filter water and pollutants, sequester carbon from the atmosphere, and bring immeasurable enjoyment to nature-lovers. Given their prevalence and importance, how are the GTM marshes doing? Staff and volunteers at the GTM Research Reserve have been monitoring marshes since 2012. A lot is known about which vegetation species are most common, and data have been collected on how the proportions of species, plant heights and surface elevations have changed over time in six coastal wetlands. That foundational information provides context for staff and visiting scientists to conduct research on how various threats to marshes may be impacting them and the benefits they provide to society. These foundational, long-term monitoring data also give restoration practitioners, coastal managers, and local citizens information to act upon. The GTM Research Reserve long-term monitoring data can inform research and action so that our community can do our best to conserve these important habitats.

PRESENTER: Nikki Dix, Ph.D., Research Director, GTM Research Reserve

Nikki Dix, Ph.D., has been the research director at the GTM Research Reserve since 2013 through a grant from the Florida Department of Environmental Protection to the University of North Florida. Her research interests involve understanding how estuaries respond to natural and anthropogenic change with the intent of informing natural resource management. Her graduate and postdoctoral research focused on plankton ecology and drivers of primary production such as tropical storms, eutrophication, and grazing by zooplankton and bivalves. Since arriving at the GTM Research Reserve, Dr. Dix's research has expanded to intertidal habitats where she has collaborated on national grant-funded projects to study warming in the salt marsh-mangrove ecotone, new techniques for living shorelines in high-energy estuaries, and oyster population sustainability. As research director, she establishes research priorities and oversees long-term monitoring. Monitoring includes abiotic (e.g., salinity, temperature, oxygen, rainfall, nutrients) and biotic (e.g., salt marsh vegetation and elevation, mangroves, plankton, oysters) parameters within the Reserve to provide foundational information about how the ecosystem changes over space and time. She works to develop standardized methods at regional, state, and national scales, allowing for cross-system comparisons. Dr. Dix also facilitates activities of visiting researchers, advises three graduate students, and works to develop collaborations between scientists, managers, educators, and the public.

Co-authors: *Pam Marcum, Shannon Dunnigan, Silas Tanner, Alee Knoell, Katie Petrinec, and Scott Eastman, GTM Research Reserve*

WARMING AND MANGROVE ENCROACHMENT ALTER BELOWGROUND PROCESSES WITH POSITIVE IMPLICATIONS FOR SURFACE ELEVATION MAINTENANCE AT THE GTM RESEARCH RESERVE: FINDINGS FROM THE WETFEET PROJECT

An aerial view of the WETFEET project site near the Matanzas Inlet

Though research is beginning to understand some consequences of mangrove encroachment into marshes, the implications of this shift, and of sustained climatic warming, are crucial for the resilience of wetland habitats in the GTM Research Reserve. At three sites in northeast Florida, this project deployed warming chambers on both marsh-dominated and mangrove-dominated plots to investigate how warming influences plant above- and below-ground growth, organic matter decomposition and surface elevation with respect to sea level rise. The project team modified the Marsh Elevation Model to assess how wetland surface elevation will respond to sea level rise in the presence of encroaching mangroves. Warming chambers have warmed the air temperature by an average of 2°C, which is similar to the climate change that is predicted for northeast Florida. Warming increases mangrove aboveground growth after two years, especially at the most northern site. Root growth was also stimulated by both mangrove presence and warming, with potential positive effects for surface elevation. Neither warming nor mangrove presence altered organic matter decomposition rates in soils. Mangrove-Marsh Elevation Model runs show that mangroves have a higher capacity for maintaining surface elevation with respect to sea level rise than salt marshes do. Further, young mangroves may do an especially good job at building elevation in the face of sea level rise at the GTM Research Reserve. The Warming Ecosystem Temperatures in a Florida Ecotone Experiencing Transition (WETFEET) project findings described above are helping inform Reserve management in the face of climate change and sea level rise.

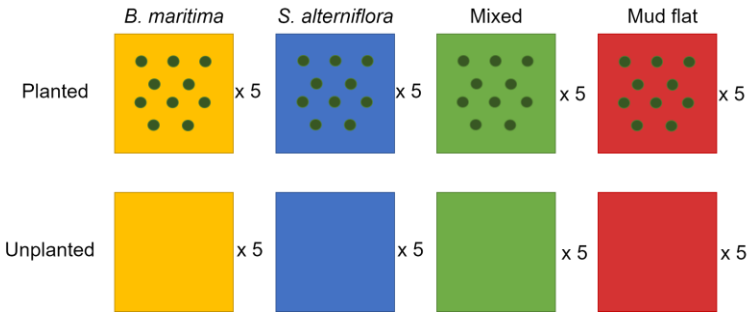
PRESENTER: Samantha Chapman, Ph.D., Associate Professor, Villanova University of Center for Biodiversity and Ecosystem Stewardship

Samantha Chapman, Ph.D., has been a professor and scientist at Villanova University in Pennsylvania since 2007. She is currently the co-director of the Center for Biodiversity and Ecosystem Stewardship (CBEST) and runs the WETFEET project (www.wetfeeproject.com). Dr. Chapman received her Ph.D. from Northern Arizona University and completed a postdoctoral fellowship at the Smithsonian Environmental Research Center. She is an ecosystem ecologist who is interested in how climate change and altered biodiversity change the services that ecosystems provide. She has received grants from NASA, the U.S. National Science Foundation, NOAA, the U.S. Forest Service and the U.S. Department of Agriculture to conduct her research. Sam and her team collaborate to understand how climate change and rising sea levels alter coastal ecosystems.

Co-authors: *Adam Langley, Ph.D., Villanova University; Gabriela Canas, University of North Florida; Emily Geoghegan, University of California Davis; Candy Feller, Ph.D., Smithsonian Environmental Research Center; Nikki Dix, Ph.D., GTM Research Reserve; Ches Vervaeke, University of Louisiana Lafayette; Mark Hester, Ph.D., University of Louisiana Lafayette; Jim Morris, Ph.D., University of South Carolina*

SALT MARSH PLANT COMMUNITY STRUCTURE INFLUENCES SUCCESS OF *AVICENNIA GERMINANS* DURING POLEWARD ENCROACHMENT

A marsh plot at the GTM Research Reserve



Methods schematic for the planting experiment

Along the Florida coast, decreasing freeze events are promoting the range shift of the mangrove species *Avicennia germinans* northward into temperate salt marsh wetlands. Although plant species' ranges are tightly linked with their climatic tolerances, there is considerable variability in the magnitude by which biotic factors like competition and facilitation may also influence range shifts. Mangroves can shade out salt marsh plants once mature, but it is largely unknown how surrounding plant community structure and associated belowground environment may influence initial mangrove encroachment. Using a planting experiment, this project investigated the impact of marsh plant community structure (*Batis maritima, Spartina alterniflora*, mixture of *B. maritima* and *S. alterniflora*, mudflat) on mangrove survivorship, percent cover, and decomposition rate. The project team hypothesized that (1) mangroves planted in communities with high percentage of *B. maritima* would exhibit lower mortality rates; (2) mangroves would exhibit low mortality in plots with high plant percent cover; and (3) plots planted with mangroves would exhibit higher decomposition rates compared to plots without mangroves. In mixed marsh plots, mangrove survivorship was 42% higher compared to survivorship in mudflat plots, and decomposition rate was 47% greater in mixed marsh plots compared to mudflat. Percent cover in mixed marsh plots was also 34% greater compared to *S. alterniflora* plots. High survivorship in mixed marsh plots is likely due to increased protection from physical stressors by the dense aboveground cover, and belowground plant root-driven effects such as nutrient availability and oxygen delivery. Findings suggest that above and below ground differences in salt marsh plant community structure can have an impact on the survival of encroaching mangroves, which may have implications for predicting future mangrove encroachment and improving mangrove restoration techniques.

PRESENTER: Tess Adgie, Technician, Villanova University

Tess Adgie recently graduated with a master's degree in biology from Villanova University where she worked with Samantha Chapman, Ph.D., as a member of the WETFEET project. Her master's work explores the impact of plant community structure on the encroachment of the black mangrove in the GTM Research Reserve. She is excited to continue working with the Chapman Lab and the GTM Research Reserve as a project technician on the NERRS Science Collaborative catalyst project, "Experimenting with Elevation: Building a new collaboration to explore management options for wetland elevation maintenance."

Co-author: *Samantha Chapman, Ph.D., Villanova University*

HOW BIG CHANGES ARE AFFECTING THE MARSH'S SMALLEST RESIDENTS: HOW WARMING AND SHIFTING VEGETATION CAN AFFECT BENTHIC ALGAE IN COASTAL MARSHES

Warming chambers at the southernmost WETFEET project site near the Matanzas Inlet

The GTM Research Reserve community is aware that mangroves are continually encroaching into salt marshes across the Reserve. Researchers are beginning to understand some consequences of more mangroves, the implications of this shift, and of sustained climatic warming, but the resilience of wetland habitats and their associated communities remains unknown. Primary producers such as benthic microalgae (BMA) are important food sources in both mangrove and saltmarsh communities and can provide insights into how changes can affect community dynamics. Algal community biomass and composition were measured within three different marsh vegetation types (*Batis maritima, Spartina alterniflora, Avicennia germinans)* and compared to assess if vegetation is a potential driver for algal community differences. Existing WETFEET warming chambers (PVC boxes surrounded by clear film) deployed on both marsh-dominated and mangrove dominated plots were used to also investigate how warming could potentially drive algal community change. Warming chambers have warmed the air temperature by an average of 2°C, which is similar to the climate change that is predicted for northeast Florida. Abiotic parameters were also measured to assess how abiotic conditions associated with vegetation can act as potential structuring forces on algal communities. It was found that algal communities differ between different vegetation types and can vary drastically by season. Certain abiotic factors like temperature and light were also found to be drivers of algal biomass. These findings suggest that changes in BMA communities should be investigated further as potential bottom-up drivers of community shifts resulting from the marsh to mangrove transition.

PRESENTER: Gabriela Canas, Graduate student, University of North Florida

Gabriela Canas is a second-year master's student in the University of North Florida's Coastal and Marine Biology Flagship Program, studying estuarine ecology under the advisement of Nikki Dix, Ph.D. She is currently a Dolores Auzenne Fellow. Her thesis is focused on the effects of climate change and shifting vegetation range on benthic algal communities. In 2016, she graduated from the University of Florida with a degree in interdisciplinary marine science. After graduating she worked as an environmental educator at Marineland Dolphin Adventure before working as an educator at the GTM Research Reserve. She is now the field technician for the WETFEET project where she is actively involved in onsite research as well as the development of virtual reality-based education content to communicate project topics.

Co-authors: *Samantha Chapman, Ph.D.,Villanova University; Dale Casamatta, Ph.D., University of North Florida; Nikki Dix, Ph.D., GTM Research Reserve*

BELOWGROUND WARMING ALTERS THE GROWTH RESPONSES OF *AVICENNIA GERMINANS* AND *SPARTINA ALTERNIFLORA*

View of tidal tank containing replicates of the four vegetation treatments

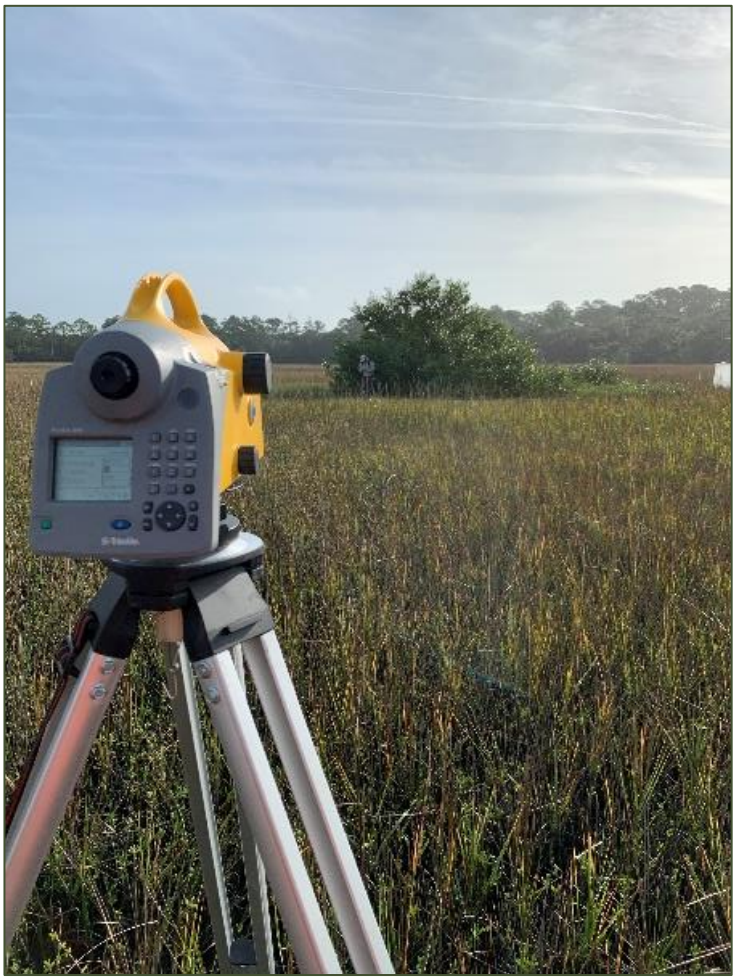
Multiple studies have investigated the effects of atmospheric warming on mangrove range expansion into salt marsh; however, little is known regarding the effects of increased estuarine water temperature, which may have pronounced effects on intertidal soil temperature, alteration of above- and belowground plant productivity, species interactions, and plant community composition. To address this data gap, a one-year tidal mesocosm experiment was established consisting of four vegetation treatments: *Avicennia germinans* and *Spartina alterniflora* grown both in monoculture and in mixture, plus unvegetated wetland soil. Three estuarine water temperature treatments were implemented to simulate current ambient seasonal water temperature fluctuations near the GTM Research Reserve, plus two elevated water temperature regimes: Moderate warming of 2.5 and 5°C above ambient summer temperatures, and high warming of 5 and 10°C above ambient winter temperatures. Biomass results revealed that *A. germinans* productivity had a non-linear response to belowground warming with *A. germinans* monoculture producing the greatest biomass under moderate warming, followed by a significant decrease in biomass under high warming. In contrast, *Spartina* displayed consistent increases in biomass with moderate and high warming. Species performance ratios revealed that both *A. germinans* and *S. alterniflora* were more productive when grown in monoculture than when grown together in mixture; however, overall productivity of the mixture community was not decreased. Decomposition rates (assessed via cotton-strip assay) were significantly greater under moderate warming in the *S. alterniflora* monoculture, mixture, and unvegetated treatments, whereas decomposition rates in *A. germinans* monoculture were not significantly affected by temperature. Overall, project findings suggest that moderate increases in estuarine water temperature, and corresponding increases in soil temperature, may be beneficial to both *A. germinans* and *S. alterniflora*, but higher increases in water temperature may suppress the productivity of *A. germinans* while *S. alterniflora* continues to benefit, illustrating the complexity of coastal plant community response to warming and climate change.

PRESENTER*:* Harris Stevens, Graduate student, University of Louisiana Lafayette

Harris Stevens, originally from Montgomery, Alabama, acquired an interest in wetland ecology while earning his bachelor's degree in marine biology at the University of West Alabama. While at the University of West Alabama, he was involved in several undergraduate research projects concerning soil dynamics and the role of elevation in salt marsh plant zonation. Additionally, he received All-American Scholar commendations as a student-athlete while at West Alabama. After earning his bachelor's degree at the University of West Alabama, Harris attended the University of Louisiana at Lafayette to pursue a master's in biology under the direction of Mark Hester, Ph.D., to examine the role of soil warming on the growth responses and species interactions of Avicennia germinans *(black mangrove) and* Spartina alterniflora *(smooth cordgrass). In his free time, Harris enjoys playing golf, fishing, or spending time with his family at Lake Martin, Alabama.*

Co-authors: *Ches Vervaeke, Mark Hester, Ph.D., University of Louisiana Lafayette*

THE ROLE OF ELEVATION IN THE NORTHWARD ADVANCE OF *AVICENNIA GERMINANS* AT THE GTM RESEARCH RESERVE



Collecting marsh elevation data at a WETFEET project site

The effects of climate change on coastal wetlands are far-reaching. Accelerated rates of sea-level rise may exceed the flood tolerance of some species, resulting in wetland loss, whereas rising temperatures and associated decreases in frequency and severity of freeze events may favor poleward expansion of tropical woody species, such as black mangrove (*Avicennia germinans*), into temperate salt marsh. This vegetation shift is occurring at the GTM Research Reserve, where black mangrove has been advancing northward at the expense of non-woody salt marsh. Although it is known that black mangrove can establish in intertidal salt marshes dominated by non-woody species, data gaps exist in understanding the role of elevation and hydrology in modulating the establishment and growth dynamics of black mangrove in these coastal wetlands and how this may affect wetland management.

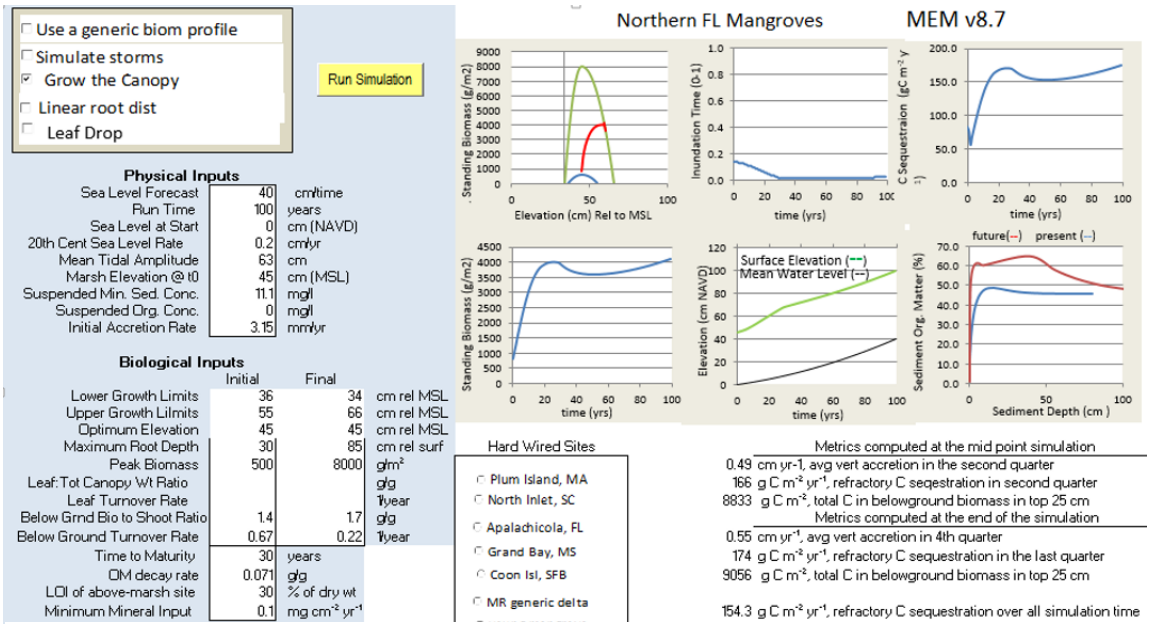
To inform the GTM Research Reserve on how and where this encroachment may occur, elevation studies are currently being conducted throughout the Reserve using a highly modified rod surface elevation table (rSET) method. Overlapping static GPS surveys were conducted using the top of the rSET receiver as the vertical point of reference (VPR), resulting in precise North American Vertical Datum of 1988 (NAVD 88) elevations. All elevations were taken relative to the VPR using a DiNi Digital Level. Initial results show differences in elevations of mangrove establishment among sites ranging from 0.515 to 0.481-m NAVD88, and a range of non-mangrove marsh elevations among sites, where mangroves are encroaching, from 0.553 to 0.475-m NAVD88. These data, combined with other ongoing research conducted in the area, will help inform managers and researchers of how this ecotonal region may be affected in the future with climate change.

PRESENTER: Ches Vervaeke, Graduate student, University of Louisiana Lafayette

Ches Vervaeke has been an ecologist with the U.S. Geological Survey in Lafayette, Louisiana since 2003. During this time, Ches has become an expert in the Surface Elevation Table (SET) technique used to measure wetland elevation change, working with and modifying both original and rod SETs. Ches also has interest and expertise in below ground processes in wetlands, specifically marsh mangrove ecotones. In 2018 Ches joined the University of Louisiana at Lafayette as a Ph.D. student investigating elevation dynamics of black mangrove at its northern limits.

Co-authors: *Samantha Chapman, Ph.D., Villanova University; Adam Langley, Ph.D., Villanova University; Mark Hester, Ph.D., University of Louisiana Lafayette*

IMPLICATIONS OF MANGROVE MIGRATION INTO SALT MARSH HABITAT: RESILIENCE TO SEA LEVEL RISE



A view of a Marsh Equilibrium Model output

The Marsh Equilibrium Model (MEM) has been successfully modified to simulate the growth of tidal mangroves. Simulations demonstrate that tidal mangroves consistently have higher rates of vertical accretion than salt marshes. Mature mangroves are more resilient to rising sea level than young mangroves. They have a significant head-start that endows them with greater vertical accretion rates. However, when mature mangroves drown, they do so with significant loss in elevation due to the large volume of labile, soil organic matter that decomposes. One limiting factor for mangrove northward migration is the rate of sea-level rise. To successfully transgress (migrate inland), growth of young mangroves will need to outpace SLR. Successful migration occurs only when juveniles mature. Juveniles that establish at the upper limit of their vertical range could mature when the regional sea level rise is 18 mm/yr or less, but no more, and juveniles that establish at lower elevations drown before maturing.

PRESENTER: Jim Morris, Ph.D., Distinguished Research Professor, University of South Carolina

Jim Morris, Ph.D., is a broadly trained environmental scientist, a distinguished professor emeritus of biological and marine sciences at the University of South Carolina, former director of the Baruch Institute for Marine & Coastal Sciences, and a Fellow of the American Association for the Advancement of Science. Honors include the USC Research Foundation Award (2011), and the Society of Wetlands Science Merit Award (2012). He holds degrees in environmental sciences (B.A., UVA), biology (M.A., Yale) and forestry and environmental studies (Ph.D., Yale), followed by a postdoctoral position at the Marine Biological Laboratory, Woods Hole. Morris has authored more than 120 publications, largely focused on coastal wetlands. He is a member of the Conservation International/UNESCO Blue Carbon Working Group. Dr. Morris has a long history of NSF-funded research at North Inlet, South Carolina, on the effects of changing sea-level on coastal wetlands. His discovery of a stabilizing feedback between marsh primary production, vertical marsh accretion, and sea-level rise has had a significant impact on the fields of biogeomorphology and marsh ecology. He is funded by NSF for a long-term research in environmental biology project at North Inlet, and he is part of the Plum Island LTER project and collaborator on other NSF and NOAA-funded projects.

Co-authors: *Samantha Chapman, Ph.D., Villanova University; Adam Langley, Ph.D., Villanova University; Gabriela Canas, University of North Florida; Emily Geoghegan, University of California Davis; Candy Feller, Ph.D., Smithsonian Environmental Research Center; Nikki Dix, Ph.D., GTM Research Reserve; Ches Vervaeke, University of Louisiana Lafayette; Mark Hester, Ph.D., University of Louisiana Lafayette*

IMPACTS OF LAND USE AND IMPOUNDMENT MANAGEMENT ON WATER QUALITY IN A COASTAL RIVER

Flowcell system with multiple water quality sensors

Estuaries around the world are experiencing the effects of anthropogenic stressors. The natural hydrology of these coastal rivers is often manipulated to manage for recreational or residential use. As urban sprawl encroaches, there is a need to better understand how current management practices of these systems in conjunction with increasing urbanization affect water quality. An increase in human impact is occurring in the Guana River Estuary (GRE). Conservation land is being converted into residential land to accommodate new housing developments. In order to maintain Guana Lake for recreational and conservational purposes, the Florida Fish and Wildlife Conservation Commission (FWC) has implemented a multitude of management practices, which include manipulating lake water levels. Current monitoring practices consist of monthly analysis of nutrient samples and water quality parameters collected from 10 sites both south (Guana River) and north (Guana Lake) of the dam. Variability between these sites is unknown, and the dam's impact on water quality is not well-established. In addition to discrete sampling, this project has been collecting continuous data using a boat-mounted flowcell system housing multiple water quality sensors (temperature, conductivity, salinity, dissolved oxygen, turbidity, and total algae) from a handheld water quality meter equipped with GPS. This technique allows for data to be collected at continuing intervals along the system, resulting in over 500 data points per each spatial survey. Using GIS, spatial visualization of present water quality conditions can be modeled. The goal of this project is to provide a holistic overview of human impact on the GRE by identifying potential pollution sources, measuring spatial and temporal water quality trends in the lake and river, and investigating the effects of management practices on water quality.

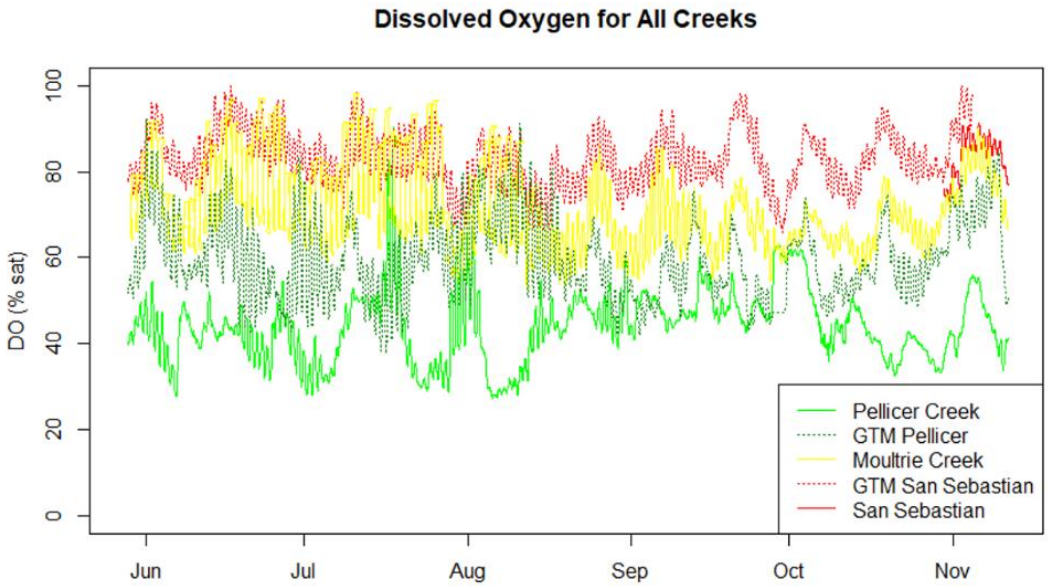
PRESENTER: Jessica Lee, Graduate student, University of North Florida

Jessica Lee is studying environmental biology as a graduate student at the University of North Florida in Dr. Nikki Dix's lab. Her interest lies in freshwater and estuarine ecology as well as the impact of anthropogenic factors on those aquatic environments. She was awarded a graduate fellowship through the Friends of the GTM Reserve so that she could run the Guana Water Quality Project at the GTM Research Reserve and conduct her research at the Reserve as well. By studying the spatial and temporal water quality trends of the Guana system, she hopes to help the Reserve continue to establish a water quality baseline for the system while investigating the downstream implications of its impounded waters.

Co-authors: *Nikki Dix, Ph.D., Shannon Dunnigan, GTM Research Reserve*

WATER QUALITY DYNAMICS IN TIDALLY INFLUENCED BLACKWATER CREEKS ALONG A RURAL-URBAN GRADIENT IN NORTHEAST FLORIDA

Reduced water quality, characterized by nutrient and contaminant loading, is a major potential consequence of urbanization. Eutrophication, toxin exposure, and shellfish degradation are problems that can arise as a result. Water quality response to urban development is often specific to a locality or region; therefore, it is important to understand how development will affect the water quality of a region's receiving waters. The goal of this research is to determine the effects of urbanization on water quality of three blackwater creeks in northeast Florida. Land use and cover were estimated for the three stream watersheds along a rural-urban gradient in St. Augustine, Florida; Pellicer Creek is most rural, Moultrie Creek intermediately urban, and San Sebastian River is highly urbanized. Turbidity, dissolved oxygen, fluorescent dissolved organic matter (fDOM), chlorophyll a, salinity, total coliform and E. coli levels were measured routinely. This project hypothesized that urbanization will negatively influence water quality dynamics, leading to more variable water quality, characterized by higher fecal bacteria concentrations, turbidity, chlorophyll a, and lower dissolved oxygen and fDOM.



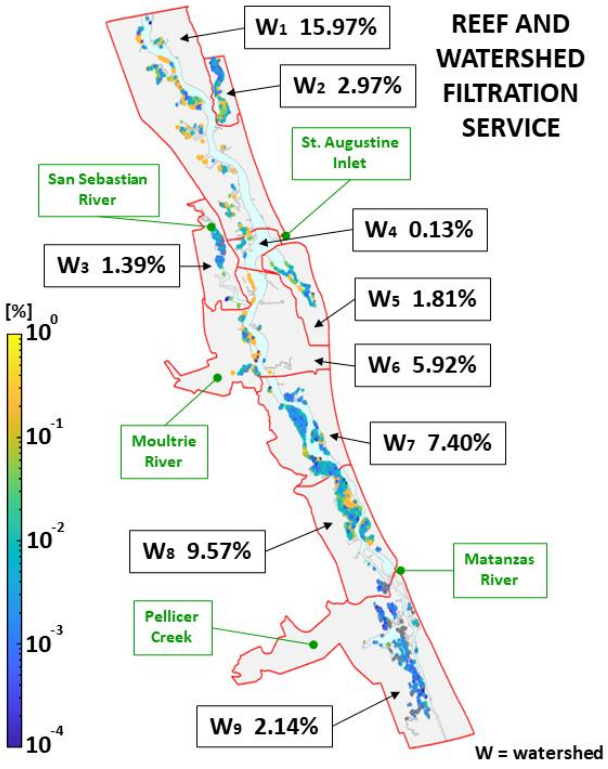
Dissolved oxygen measured at each of the tidal creek sites

PRESENTER: Taryn Chaya, Graduate student, Whitney Laboratory for Marine Bioscience

Taryn Chaya graduated from Flagler College in 2019 with a bachelor's degree in coastal environmental science and is currently pursuing a master's degree in soil and water science at the University of Florida. Her research focuses on water quality and the associated biogeochemical processes found in the local Intracoastal Waterway. In the Osborne Lab, she contributes to iCoast, an initiative that seeks to create a database of sensing information that will allow real-time management of threats to the natural and built environments of the coasts. As an iCoast team member, she calibrates and deploys twelve YSI EXO 2 water quality sondes and manages the collected data.

Co-author: *Todd Osborne, Ph.D., University of Florida Whitney Laboratory for Marine Bioscience*

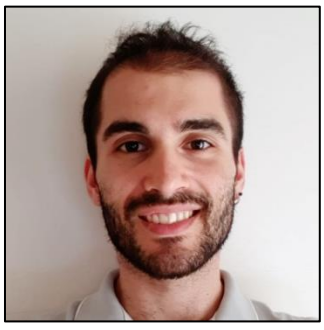
SPATIALLY EXPLICIT OYSTER BIOFILTRATION SERVICES IN A SUBTROPICAL ESTUARY



Proportion of water mass filtered in the estuary by each oyster reef within a single residence time. For each watershed, the total FS is reported.

The Guana Tolomato Matanzas system is a relatively pristine and well-flushed estuary in northeast Florida, where water quality is threatened by ceaseless urban development. The system is characterized by a high abundance of oysters, grouped in reefs that populate salt marshes, river banks, and creek banks. Oysters and the reefs they create are widely recognized for their ecological value. As oysters feed, they remove suspended microparticulate material (~2-20 μm) from the water column, improving water quality and clarity. In order to estimate oyster filtration services (FS) of eastern oysters (*Crassostrea virginica*) in the GTM Research Reserve at the estuarine scale, this project implemented a model that solves for the hydrodynamics and transport of particulate matter. We first determined oyster characteristics (spatial density, shell length, and dry weight tissue) and reef geometry from *in situ* measurement. The transport of particulate material in the estuary was then simulated using a particle-tracking model. The simulation was run for an estuary residence time, which was defined as the time for which the number of particles in the estuary reduces to 1/e of its initial value (with e≃2.7). Particles were initialized with a uniform concentration, which reduces when the particle is suspended over an oyster reef. This allowed us to compute the filtration services (FS) of each individual reef by tracking the time that each particle spent over a reef. FS was defined as the proportion of water mass filtered in the estuary within a single residence time. The model results suggested that oyster reefs populating the GTM Research Reserve significantly improve water quality by filtering 50% of the estuary within a single residence time. The filtration rates at the reef level (l/m^2/h) are both robust and rare among populations of native oysters in the United States as they resemble rates quoted for dense, pre-colonial populations.

PRESENTER: Daniele Pinton, Graduate student, University of Florida

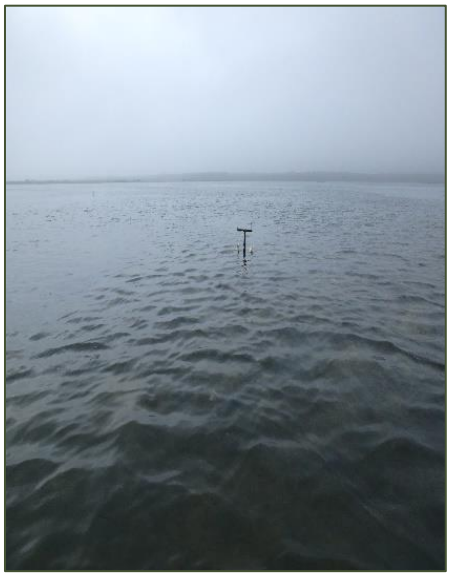


Daniele Pinton is a Ph.D. student in the Department of Civil and Coastal Engineering at the University of Florida. He previously got his bachelor's degree in civil engineering in 2015 as well as his master's degree in hydraulic engineering, and his qualification to practice as a professional engineer in 2018 at the University of Padova, Italy. After that, he worked as a numerical modeler and hydraulic engineer in an Italian office, collaborating on various local and national projects. Since Spring 2019, Daniele is part of Dr. Canestrelli's lab, which mainly focuses on improving numerical hydrodynamic and eco-morph dynamic models in coastal, estuarine, and riverine environments. His research primarily focused on implementing a numerical model to forecast the distribution of pollutants in the GTM estuary. For this research, he won a 2019 fellowship with the One Health Center of Excellence at the University of Florida. To improve the efficiency of his high-resolution numerical model, he focused on the use of new technologies, such as high-resolution UAV-based LiDARs, to describe the morphological and ecological features of coastal wetlands. He won a fellowship with the University of Florida Informatics Institute in 2020 for this research.

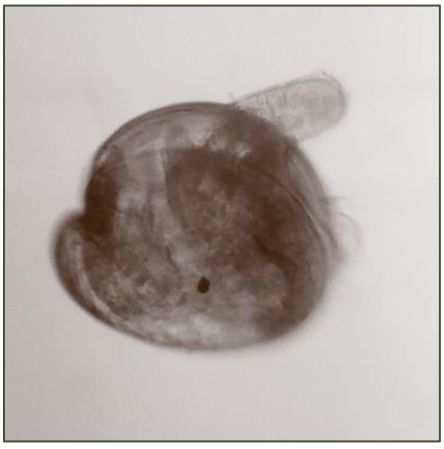
Co-authors: *Matthew W. Gray, Ph.D., University of Maryland Center For Environmental Science; Alberto Canestrelli, Ph.D., University of North Florida; Nikki Dix, Ph.D., GTM Research Reserve; Pam Marcum, GTM Research Reserve; David Kimbro, Ph.D., Northeastern University; Raymond Grizzle, Ph.D., University of New Hampshire*

OYSTER SPAT MONITORING IN THE GTM RESEARCH RESERVE

The eastern oyster, *Crassostrea virginica*, is a keystone species abundant in southeastern U.S. estuaries, providing a myriad of services, including water filtration, buffering against storm surges and wave action, and serving as a habitat for many estuarine organisms. Recent oyster population assessments and oyster restoration efforts in the GTM Research Reserve revealed the need for information on local oyster settlement dynamics. By observing numbers of newly settled oysters, called "spat," knowledge on site-specific larval availability and settlement can aid in understanding oyster population dynamics. In 2015, the GTM Research Reserve initiated a monitoring program to determine spatial and temporal patterns in oyster spat using the hanging shell method. Cleaned shells were deployed monthly in five major water bodies of the GTM estuary. Shells were evaluated under microscope and all spat settled on the inner shell surface were counted. Over the course of the study, spat settlement typically peaked in late-summer to early-fall, and overall abundance increased annually. Large variations in peak timing and abundance were observed both within and among water bodies, highlighting the need for site-specific monitoring. Monitoring data have been shared regularly with local oyster harvesters, citizens, regional resource management stakeholders, and scientists.



Spat trees in the field at the GTM Research Reserve



A microscopic view of an oyster spat

PRESENTER: Alee Knoell, Biological Scientist, GTM Research Reserve

Alee Knoell is a biologist at the GTM Research Reserve. Having harbored a vast love for the natural world from a young age, along with a strong desire to preserve and play a part in its conservation, she received her B.S. in environmental science at the University of Central Florida. During her time in Orlando, she interned with the Orange County Environmental Protection Division, focusing on aquatic vegetation. While at the Reserve, her time has been spent working on various research projects, with a primary focus on oyster spat monitoring.

Co-authors: *Pam Marcum, Nikki Dix, Ph.D., GTM Research Reserve*

MARINA OBSERVATION OF SEA TURTLES (MOST): ESTABLISHING A DATABASE OF NORTH FLORIDA GREEN SEA TURTLES

An undergraduate researcher captures a photo of a green sea turtle surfacing

Within the Matanzas River estuary, there is a lack of submerged aquatic vegetation which provides juvenile sea turtles with nutrition. Consequently, this requires sea turtles in our area to utilize alternative forage grounds. Observed forage for green sea turtles (*Chelonia mydas*) is the biofouling community present on docks, marinas, pilings, and boats. Little information is known about the population sizes marinas support, or if the same turtles remain at a marina for extended time periods. The goal of this research was to photographically document green sea turtles from above to catalogue individual's unique dorsal scale pattern on their head. This information will help identify individuals through time. Green sea turtles at Camachee Cove Yacht Harbor (CC) and Conch House Marina (CH) were photographed beginning on June 3, 2020. The entire perimeter of the marina was walked to search for turtles. Once spotted, photographs were taken of the head and shell. If a turtle dove before clear pictures could be taken, the researchers waited five minutes for the turtle to resurface. If the turtle did not resurface, a picture of the water was taken to indicate a "missed" observation. St. Augustine Municipal Marina (SAMM) was added starting on September 22, 2020. To date, a total of 63 marina days have been recorded and 481 sightings of green sea turtles have been made. A daily average of 9.2 ± 0.8 SEM turtles at CC, 9.9 ± 0.9 SEM turtles at CH, and 1.4 ± 0.9 SEM turtles at SAMM was observed throughout the experiment. Manual processing of the first seven marina days (4 at Conch House and 3 at Camachee Cove) indicate that one of 23 turtles at CH and four of 21 turtles at CC were recaptures. The program *Hotspotter* was obtained to identify "recaptured" individuals instead of manual identification.

A green sea turtle observed surfacing at a marina

PRESENTER: Ed McGinley, Ph.D., Associate Professor of Natural Sciences, Flagler College

Ed McGinley, Ph.D., grew up in Pennsylvania, where he often watched ocean documentaries with his parents. This led him to pursue marine biology at St. Francis University in Pennsylvania. After graduating, he worked as a technician on an oyster farm before knowing what he wanted to be when he grew up. His passion for the ocean was directed to the life that lived within it. He enrolled in a Master of Science wildlife and fisheries program at Frostburg State University where he researched the feeding habits of stream fish. It was during this time that he discovered teaching. He taught lab and lecture sections of human anatomy and physiology. Because of this experience, he knew he wanted to teach at a small college, so he pursued a Ph.D. from West Virginia University, also in wildlife and fisheries. Dr. McGinley's doctoral research focused on feeding habits of striped bass in the Chesapeake Bay. Between the small class sizes and the proximity to an estuary, Flagler College has been a perfect destination for him. His current research investigates ecology of estuarine species, often using marinas as study areas. Dr. McGinley involves undergraduates in all of his projects which allows them to experience the research process.

Co-authors: *Jasmine Silvennoinen, Michaela Mackey, Emma Wilkinson, Avery Cogley, Molly Gadawski, Bonnie Robertson, Chris Kao, Flagler College; Scott Eastman, GTM Research Reserve*

PLASTIC INGESTION IN POST-HATCHLING SEA TURTLES: ASSESSING A MAJOR THREAT IN FLORIDA NEARSHORE WATERS

Pollution from anthropogenic marine debris, particularly buoyant plastics, is ubiquitous across marine ecosystems. Due to the persistent nature of plastics in the environment, their buoyancy characteristics, degradation dynamics, and ability to mimic the behavior of natural prey, there exists significant opportunity for marine organisms to ingest these man-made materials. This study examined gastrointestinal (GI) tracts of 42 post-hatchling loggerhead (*Caretta caretta*) sea turtles stranded in northeast Florida. Necropsies revealed abundant numbers of plastic fragments ranging from 0.36 mm to 12.39 mm in size (length), recovered from the GI tracts of 39 of the 42 animals (92.86%), with GI burdens ranging from 0-287 fragments with a mass of up to 0.33 g per turtle. Post-hatchlings weighed from 16.0-47.59 g yielding a plastic to body weight percentage of up to 1.23%. Several types of plastic fragments were isolated, but hard fragments and sheet plastic were the most common type, while the dominant frequency of fragment color was white. Fragment size and abundance mixed with natural gut contents suggest significant negative health consequences from ingestion in animals at this life stage. Gaining greater insight into the prevalence of plastic ingestion, the types of plastic and the physiological effects of plastic consumption by multiple life-stages of sea turtles will aid the prioritization of mitigation efforts for the growing marine debris problem. This monitoring demonstrates that plastic ingestion is a critical issue for marine turtles from the earliest stages of life.

Plastic debris found in the gastrointestinal tracts of post-hatchling sea turtles

A post-hatchling Loggerhead sea turtle

PRESENTER: Catherine Eastman, Sea Turtle Program Manager, University of Florida Sea Turtle Hospital at Whitney Laboratory

Catherine Eastman is the sea turtle program manager at the University of Florida's (UF) Whitney Laboratory. She has been with the program since its inception over seven years ago. As one of the founders, she spearheaded the program from concept to reality. Prior to her work with the UF Whitney Laboratory, she incorporated a not-for-profit with her husband focused on sea turtle conservation, managed over 50 sea turtle nest monitoring volunteers, and worked to fundraise that effort. Eastman's background is in environmental education and she helped design and instruct the original education program at the GTM Research Reserve, one of three National Estuarine Research Reserves in the state of Florida. Eastman's love of nature and the outdoors fuels her passion for conservation.

Co-authors: *Jessica Farrell, Whitney Laboratory for Marine Bioscience and Sea Turtle Hospital, University of Florida; Liam Whitmore, University of Limerick; Devon Rollinson Ramia, Rachel Thomas, Jenifer Prine, Whitney Laboratory for Marine Bioscience and Sea Turtle Hospital, University of Florida; Scott Eastman, GTM Research Reserve; Todd Osborne, Ph.D., Mark Martindale, Ph.D., David Duffy, Ph.D., Whitney Laboratory for Marine Bioscience and Sea Turtle Hospital, University of Florida*

UNMANNED AERIAL VEHICLES FOR RESEARCH AND MONITORING

An aerial view of a marsh at the GTM Research Reserve

Unmanned Aerial Vehicles (UAVs) are becoming commonplace within everyday society from at-home, recreational use to large-scale commercial use. The GTM Research Reserve is laying the groundwork for the future of UAVs within the Reserve to collect high resolution imagery. This imagery will provide GTM Research Reserve staff, visiting scientists, and stakeholders the ability to gain knowledge in their desired area of interest while minimizing impacts to fragile ecosystems and providing a safe way to collect data in remote and potentially hazardous locations. Areas of interest (AOI) discussed thus far for image collection include oysters, saltmarsh/mangrove ecosystem, dune/beach structure, and fire-dependent ecosystems. Each of these AOIs have their own unique monitoring regime, data collection needs, and overall objective. GTM Research Reserve staff will create baseline imagery of each AOI based on research and upland management needs. This imagery will be assessed for accuracy based on *in situ* data from current and historic survey sites. Once this process is complete, the GTM Research Reserve will have high resolution imagery that can be used to assess future changes that have the potential to occur with climate change and sea level rise. Anticipated products created with UAV imagery include: (1) oyster reef height, area, volume, and footprint change over time; (2) saltmarsh/mangrove ecosystems movement throughout the Reserve, percent cover of key species, and vegetation change over time; (3) dune/beach structure 3-D modeling to measure erosion and accretion caused by natural and/or anthropogenic disturbance; and (4) fire dependent ecosystem vegetation change over time with the application of prescribed fire or other natural and/or anthropogenic disturbance. These objectives will be achieved using UAVs carrying an RGB camera and/or a multispectral camera payload. RGB cameras provide true color, high-resolution images while multispectral cameras collect images within 5 spectral bands (standard RGB, red-edge, and near-infrared). As this program takes flight, there is a great potential for the advancement in understanding ecological change over time.

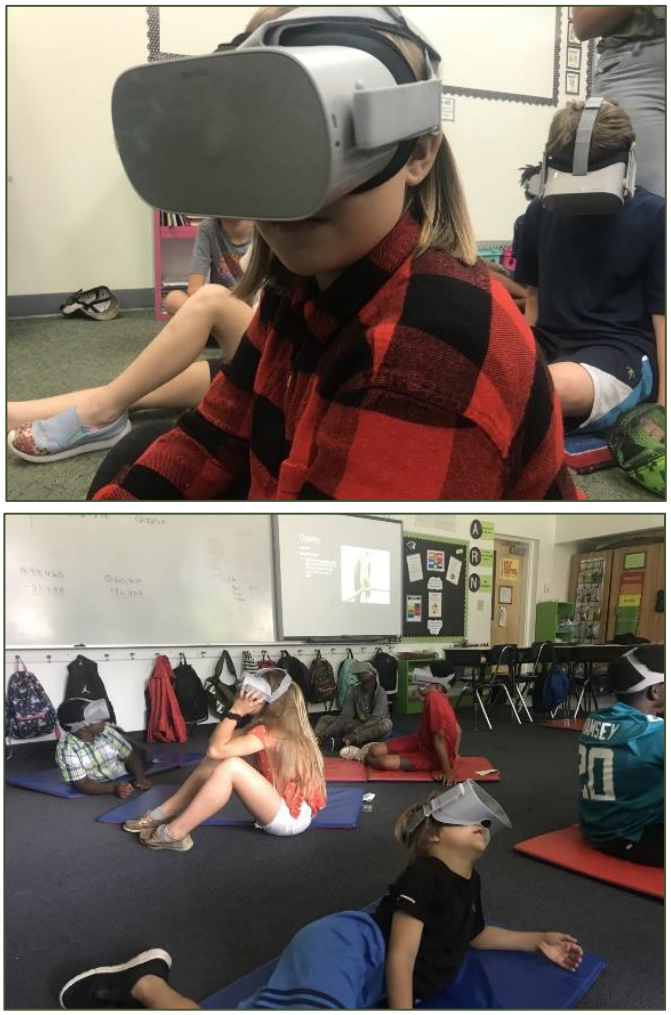
PRESENTER: Allix North, Spatial Ecologist, GTM Research Reserve

Allix North joined the GTM Research Reserve as the spatial ecologist in July 2020. She holds a UAV pilot license and is a certified prescribed burn manager. Her career interest is to use UAVs to create high-resolution aerial imagery that can be used to monitor ecological change over time, along with using active management through prescribed fire to restore Florida's uniquely pyrogenic ecosystem. Allix holds a bachelor's in natural resource conservation, with a minor in wildlife ecology, from the University of Florida (UF) School of Forest Resources and Conservation. She also obtained two master's certificates from UF in geospatial analysis and Unmanned Air Systems mapping.

Co-author: *Scott Eastman, GTM Research Reserve*

POWERPOINT PRESENTATIONS VS. VIRTUAL REALITY TECHNOLOGY: COMPARING ENVIRONMENTAL EDUCATION TEACHING TOOLS IN THE CLASSROOM

The National Estuarine Research Reserve System's (NERRS) Estuaries 101 curriculum was created as a national effort to advance estuarine literacy by integrating educational and scientific resources into the K-12 classrooms. Using surveys before and after visits, NERR staff is able to assess students' comprehension of lessons. Last year, the GTM Research Reserve's education staff brought a new teaching tool into the classroom, virtual reality (VR). VR technology provides students with a new authentic experience by facilitating a first-person perspective and holds promising potential for engaging students via distance learning. During the initial Reserve trial, it was found that VR is an effective environmental education teaching tool. To further assess its effectiveness, GTM Research Reserve staff compared VR lessons to traditional lessons such as Microsoft PowerPoint. A two-hour long program was developed by the education staff to address multiple curriculum standards for fourth-grade students in St. Johns County. Half of the students received a PowerPoint-based lesson while the other half was taught using VR headsets. Programs were assessed using pre and post surveys. Survey results indicated that students scored significantly higher when taught with VR. Students also increased their positive responses to questions focused on their environmental attitude after the program. These results show that VR technology is an effective tool for conveying environmental curriculum. Within the GTM Research Reserve, this technology has allowed educators to increase accessibility and online learning opportunities. In the future, the Reserve hopes to expand the program to include opportunities for students with special needs.



Students use virtual reality headsets to explore the GTM Research Reserve

PRESENTER: Kaitlyn Campbell, Education Specialist, GTM Research Reserve

A 2017 graduate of Allegheny College located in Meadville, Pennsylvania, Kaitlyn Campbell's studies focused on freshwater ecosystems, marsh ecology, and animal psychology. After graduation, Kaitlyn moved from Pittsburgh, Pennsylvania to Saint Augustine, Florida, to work at Marineland Dolphin Adventure. There, she was exposed to animal care and informal education. Kaitlyn has found her passion in primary and secondary educational programs, which brought her to the GTM Research Reserve in February 2019 as an environmental educator. Kaitlyn is actively involved in the Career Academies of Saint Johns County, coordinating field trips, summer camps, and internships; and now finding her niche with Virtual Reality programs in education.

Co-authors: *Gabriela Canas, University of North Florida; Josephine Spearman, GTM Research Reserve*

Thank you
GTM Volunteers
for your continued
efforts and support,
even at a distance!

We miss you!

ADDITIONAL RESEARCH AT THE GTM RESEARCH RESERVE IN 2020

These projects were presented as virtual posters at the 2021 State of the Reserve. Explore the research more at https://padlet.com/gtmresearchreserve/posterpresentations.

Analysis of long-term water quality trends in a northeastern Florida estuary system

Emma Wilkinson, Flagler College

Water quality is a key indicator of the health of an ecosystem and changes to an ecosystem should be reflected in long-term water quality trends. The Tolomato and Matanzas rivers make up an estuarine system that is part of the GTM Research Reserve. The Reserve monitors water quality at two sites, Pine Island and Pellicer Creek, which are comparable due to similar distance from inlets and primarily freshwater input. This project hypothesized that Pine Island is expected to receive a greater influx of nutrients than Pellicer Creek due to Pine Island's close proximity to urban development. Using data collected as part of the System Wide Monitoring Program between 2002 and 2020, multiple regression analysis was conducted in the statistical computation software, R. Multiple Regression analysis evaluates correlations between total dissolved inorganic nitrogen and various water quality parameters over the past 18 years. The analysis allows relationships to be drawn between anthropogenic factors and the water quality at each site. With these relationships in mind, it is possible to assess the differences in anthropogenic forcing at Pine Island and Pellicer Creek since 2002. Results will be discussed in the context of rapid population increase and changes in land use throughout northeast Florida.

Annual winter variations of ichthyoplankton family assemblage within the GTM Research Reserve

Chris Kurtz, University of North Florida

It is well documented that estuaries serve as critical habitat for a diverse array of species throughout their life history cycle. Most notably, estuaries provide shelter and productivity where larval and juvenile fish may thrive. It is for this reason that long term studies of community assemblage must be actively pursued to document any deviation from recorded baselines. From 2017-2019, a fixed sampling location within the GTM Research Reserve was used to document and quantify family abundance and composition. This project was concurrent with an annual monitoring project for the American eel. The objectives of this study were to (1) provide a preliminary analyses of baseline community assemblage throughout sample years; (2) determine if any significant annual variation in community assemblage exists; and (3) determine if the differences in community assemblage can be attributed to any local environmental variables. Throughout 86 sample nights, 153,344 organisms were collected representing 17 families. An analysis of similarity determined a slight indication of yearly variations in community composition between years (R: 0.392; p=0.001). A RELATE test determined local abiotic patterns showed little correlation in influencing patterns between yearly variations (R: 0.227; p=0.001). Conversely, there was an indication that abiotic factors played a role in the presence of the family Elopidae between sample years. Distance-based linear modelling provided evidence that salinity attributed to variations in catch data (p_s=0.428; p=.001), which was able to provide insight how local abiotic factors may influence differences in family assemblage between years.

Gathering boat wake information in the GTM Research Reserve using virtual surveys

Philip Yang, Villanova University

Coastal ecosystems like marshes and mangroves provide many ecosystem services to humans. These ecosystem services help combat storms and sea level rise through processes like wave attenuation and soil accretion. Other more local, anthropogenic ecosystem change drivers, like boat wakes, can increase processes like bank erosion that negatively impact the ability of ecosystems to maintain these important services. Boat-wake-induced bank erosion has always been a point of contention and controversy for management agencies and policy makers because of the balance one must create between eager boaters and ecosystem health. Quantifying human activities like boating is a difficult task in a normal world, and even harder in a global pandemic. This project seeks to gather information on relative boat wake activity in smaller, estuary channels of the GTM Research Reserve to contribute to a larger characterization of coastal vulnerability in this region. Originally, the research plan was to personally survey boaters and stakeholders at various locations as well as observe some estuary channels in person. Due to travel restrictions and safety concerns the project changed course and an online survey was created. In order to gather boat wake information in the region, both an expert elicitation and public survey were created using an online GIS application and Survey123. Knowledge of coastal areas with high vulnerability to boat-wake impacts will help direct targeted boating management and policy creation in the future.

Herpetofaunal monitoring at the GTM Research Reserve

Laura Suthar, GTM Research Reserve

The GTM Research Reserve resource management team has begun a long-term reptile and amphibian monitoring project in the Reserve's uplands habitats. This project has two main goals. The first goal is to conduct an initial inventory of all the reptile and amphibian species living within our managed lands. The second goal is to monitor these populations over several years in order to look for change over time. Examples of factors that could cause change over time include natural cycles, climate change, and changes in management practices such as prescribed fire. Sampling methods include drift fence surveys, dip-netting, dredging, visual surveying, and PVC refugia for tree frogs. By combining several different sampling techniques, a wider variety of species may be captured. The project team chose to focus this project on reptiles and amphibians because they are an important part of uplands food webs, they are relatively easy to capture and record, and they can act as good indictors of overall ecosystem health. The project team also hopes to identify any sensitive species and adjust the Reserve's management practices to support and protect them. For example, the striped newt (*Notophthalmus perstriatus*) has been a candidate for federal listing since 2011. The GTM Research Reserve once had an active breeding pond for striped newts but they have not been found in recent years. The Florida Fish and Wildlife Conservation Commission has listed them as extirpated from the Reserve due to fire suppression. Monitoring the reptile and amphibian populations in the Reserve's uplands habitat can help inform management practices and prevent the loss of any more priority species.

Mapping coastal protection services provided by habitats in a National Estuarine Research Reserve

Gregg Verutes, University of Santiago de Compostela

The existence of coastal ecosystems depends on their ability to gain soil and keep pace with sea level rise. Rising seas and bigger storms, coupled with the intensification of human activities, can modify the biological and physical environment, thereby increasing coastal exposure to storm-induced erosion and inundation. Using the GTM Research Reserve as a case study, this project analyzed the distribution of coastal protection services (i.e., wave attenuation and sediment control) provided by estuarine habitats inside a dynamic intracoastal waterway experiencing rapid growth and shifting wetland communities. The project team assembled available spatial layers of elevation, coastal geomorphology, storm surge potential, climatic forcing (winds), wave energy from boat wakes, and additional factors known to influence the magnitude and extent of storm-induced erosion and flooding from coastal hazards. Additionally, the project improved the existing Florida state-level inventory of estuarine habitats (mangroves, salt marshes, and oyster beds) using Random Forest, a machine-learning image classification technique. The resulting layers were used to create a spatially explicit hazard index highlighting areas most exposed to coastal hazards. Results suggest that coastal exposure is highest in the northern and southernmost extents of the Reserve, driven by low elevation and less stable geomorphology (i.e., sand and mud). Estimates of the individual and combined role of habitats in natural protection were also produced for this project. Remote sensing to characterize the current habitat distribution indicates that mangroves have not fully encroached on the northern part of the Reserve, and consequently, there are fewer biogenic habitats distributed throughout the north to buffer wave action. The potential for storm surge is greatest in the south part of the Reserve, specifically funneling through the narrowest sections of the Matanzas River. Map outputs derived from the hazard index pinpoint reserve areas to consider for rehabilitation and restoration strategies such as living shorelines, landform modification, and mangrove establishment, as these locations will likely offer the greatest risk-reduction benefits to coastal communities in the future. This work sets the stage for additional research, education, and outreach about elevation maintenance strategies that can keep pace with rising sea levels and protect valuable coastline and natural infrastructure.

Chris Kurtz collecting samples at the GTM Research Reserve

Philip Yang at the Usina Boat Ramp in St. Augustine, FL

A five-lined skink found by Laura Suthar during monitoring

The northernmost WETFEET project site, submitted by researcher Gregg Verutes

Refining techniques for high-frequency monitoring of chlorophyll-a in the NERRS

Silas Tanner, GTM Research Reserve

Concentrations of the photosynthetic pigment chlorophyll *a* are used as a proxy for phytoplankton biomass by estuarine scientists to study eutrophication, food web dynamics, and harmful algal blooms. Coastal managers use chlorophyll as an indicator of nutrient pollution and to assess trends in chlorophyll to meet Clean Water Act standards. Chlorophyll *a*, as measured in the laboratory by extraction from monthly discrete water samples, is a core component of the National Estuarine Research Reserve (NERR) System-Wide Monitoring Program (SWMP). Field-deployable sensors based on the distinctive fluorescence excitation and emission signals of *in vivo* chlorophyll have been around for some time. To date, these sensors have not been incorporated into SWMP because past studies showed sensor results to be inconsistent across reserves and thus not reliable as a quantitative measure of chlorophyll. With the transition to YSI's EXO datasonde in SWMP, the time is right to reassess the latest generation of fluorescence sensors for *in vivo* chlorophyll monitoring. Recent efforts have shown initial promise, although there are currently no standardization practices in place and several studies have shown that the measurement of *in vivo* chlorophyll fluorescence is temperature sensitive as well as subject to potential interference from the fluorescence of dissolved organic matter (fDOM) present in the water and from signal attenuation due to turbidity. With national representation of 13 NERRs of various biogeographies, this project aims to improve water quality and algal bloom management by enhancing the well-established NERRS water quality monitoring program to include tested, standardized protocols for high-frequency chlorophyll. Preliminary results include site-specific and national-scale relationships between *in vitro* extracted chlorophyll concentration and *in vivo* fluorescence along with insights into the influences of environmental variables such as temperature, turbidity, and fDOM.

Using plankton DNA to assess the impact of water quality on the base of the estuarine food web

Ashley Reaume, University of Central Florida

Plankton communities make up the base of the food chain in marine communities and are important indicators of ecosystem health. Traditional plankton monitoring techniques involve morphological identification by microscope, a process that is time-consuming and requires extensive training. This project will address these limitations by utilizing DNA metabarcoding and next generation sequencing, molecular techniques that can be used to detect multiple species within a single water sample. These techniques will be compiled into an efficient and cost-effective bioassessment "toolkit" for the GTM Research Reserve. This will be used to (1) expand the plankton surveys currently conducted within the GTM Research Reserve, and (2) synthesize these robust biological datasets with water quality data to identify the key factors driving shifts in key planktonic communities. It is anticipated that the optimized methodology within the toolkit will assist the Reserve's monitoring efforts by providing greater accuracy in terms of species identification and more complete community assessments. Furthermore, the results of this project can be used by resource managers to evaluate the impact of water quality on plankton communities specifically and on marine communities in general.

White-tailed deer survey and harvest results in the Guana River Wildlife Management Area

Justin Van Gorder, Florida Fish and Wildlife Conservation Commission

Guana River Wildlife Management Area encompasses approximately 9,822 acres of diverse, native wildlife habitats which support an array of imperiled, rare, and more common fish and wildlife species. One of the most popular game species located at Guana River is the White-tailed deer. Staff at Guana River work in conjunction with FWCs Deer Management Program in order to help meet the programs collective goal of maintaining a robust deer population that meets the public's desires for recreation while protecting property and ensuring the long-term welfare of the species. Estimating trends in deer population size and composition, as well as assessing individual animal and/or population condition is important when determining the effects of current management actions and determining future management objectives & strategies. To accomplish this, agency staff rely on multiple sources of data to help inform our understanding of the area's deer population; including but not limited to hunter harvest data, and population monitoring via spotlight surveys.

2020 NOAA-FUNDED PROJECTS AT THE GTM RESEARCH RESERVE

The National Estuarine Research Reserve System Science Collaborative is managed by the University of Michigan Water Center, through a cooperative agreement with NOAA. The Science Collaborative coordinates regular competitive funding opportunities and supports user-driven collaborative research, assessment, and transfer activities that address critical coastal management needs identified by the reserves. There are three types of grants offered:

- *Collaborative Research*: Generates new science that informs decisions
- *Science Transfer*: Promotes the use of science
- *Catalyst:* Targets investment to advance collaborative research

Reserves, nonprofit organizations, private and for-profit organizations are all eligible recipients for Science Collaborative funding, which is provided by NOAA. However, non-Reserve parties must work in partnership with one or more reserves and meet all requirements described by the proposal requests.

Last year, the Science Collaborative awarded funds to seven projects designed to improve research techniques and knowledge of sea level rise impacts on marshes, water quality, and oyster health in the GTM Research Reserve. Awardees include reserve staff, staff at other reserves, and researchers at the University of Florida, Villanova University and Woods Hole Oceanographic Institute.

The seven projects are described herein, along with another NOAA-funded project initiated in 2020, the Margaret A. Davidson Fellowship, a two-year fellowship program that placed one graduate student at each of the 29 National Estuarine Research Reserves.

National Estuarine Research Reserves strive to understand the lands and waters they steward and implement science-based conservation. That means studying the ecosystem and culture specific to each site as well as synthesizing and analyzing data regionally and nationally. Science Collaborative and Davidson Fellowship projects typically focus either on local research or on improving data syntheses and conducting analyses across the reserves and are divided as such below.

Local Projects

Guana Oysters and Water Quality: Improving water quality in the Guana River by identifying pollution sources and quantifying water filtration by oysters and mussels

Led by Ashley Smyth, Ph.D. from the University of Florida Institute of Food and Agricultural Sciences
Project Type: Science Collaborative Research Grant
Project Length: 3 years

The water quality and ecosystem health of the Guana River Estuary has been a concern of the GTM Research Reserve and many others for several years. This research project will use new strategies to identify how nitrogen enters and leaves Guana Lake and where that nitrogen comes from. Farther south along the Guana River, researchers will investigate how oysters and mussels remove nitrogen from the estuary. Using this data, local stakeholders will develop a monitoring and restoration plan to help improve the water quality in the Guana River Estuary.

Monitoring Plankton with eDNA: Using environmental DNA of plankton communities to respond to water quality changes (Davidson Fellowship)

Led by Ashley Reaume from the University of Central Florida
Project Type: Margaret A. Davidson Fellowship
Project Length: 2 years

Using next generation sequencing (NGS) technologies and DNA metabarcoding approaches, the Margaret A. Davidson fellow will monitor plankton communities at the GTM Research Reserve. Plankton respond quickly to both human induced and climatic changes in estuaries, making them excellent indicators of ecosystem health. Traditional plankton monitoring is laborious and time-intensive, as it requires visual identification of these microscopic organisms. DNA metabarcoding is a technique that allows scientists to detect multiple species within a single sample that contains DNA from mixed sources. This project will develop an efficient and cost-effective DNA metabarcoding protocol that will not only provide insights into the current health of the Reserve but will also establish a "toolkit" for long-term monitoring in estuarine ecosystems.

Experimenting with Elevation: Determining best practices for maintaining wetland surface elevation
Led by Samantha Chapman, Ph.D. from Villanova University
Project Type: Science Collaborative Catalyst Grant
Project Length: 1 year
With rising seas, coastal erosion, and storm events, land managers are seeking proactive solutions to protect land and promote tidal marsh resilience. Investigators will use a coastal vulnerability index to create a map of vulnerable marshes in the GTM Research Reserve. This map will be presented to stakeholders and other scientists to evaluate the feasibility of four management techniques for maintaining or increasing marsh resilience; thin-layer deposition, berm redistribution, living shorelines, and promoting mangrove range expansion. GTM staff and investigators will then be able to determine the next steps for implementing these management options.

Regional and National Projects
National Tidal Marsh Synthesis: Compiling existing data into a nation-wide picture of climate change impacts on our tidal marshes
Led by Chris Peter, Ph.D. from the Great Bay National Estuarine Research Reserve
Project Type: Science Collaborative Research Grant
Project Length: 3 years
Using the NERR system's long-term vegetation monitoring data, this research project will assess how climate change impacts tidal marshes by synthesizing data across latitudes and investigating changes in marsh vegetation and elevation with respect to sea level change. By compiling available data into a nation-wide picture of climate change impacts on our tidal marshes, land managers will be better able to plan for mitigating those effects. The process of compiling data will also reveal opportunities to improve standardization in data collection, management, and analysis techniques for the NERRS and other agencies collecting similar data.

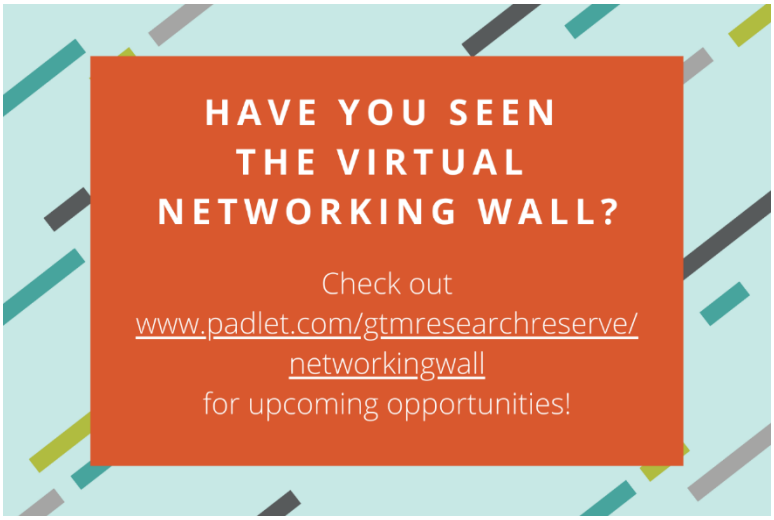
Marsh Monitoring Standards for Drones: Determining the ability of drones to improve biomonitoring of tidal wetlands
Led by Brandon Puckett, Ph.D. from the North Carolina National Estuarine Research Reserve
Project Type: Science Collaborative Catalyst Grant
Project Length: 1 year
Unmanned aerial systems, such as drones, can be used to monitor marsh vegetation and elevation with very little impact to the vegetation and sediment. In this project, staff from the southeastern NERRs will attempt to standardize monitoring protocols for using drones to monitor marsh vegetation and develop an archive of high-resolution imagery for future projects. The implementation of this project will give stewards a sense of whether using drones for this type of monitoring is the best option and determine if this methodology can be incorporated into the NERR System-Wide Monitoring Program.

Measuring Marsh Waters: Developing low-cost water level gauges to increase coverage of wetland flooding monitoring
Led by Vitalii Sheremet, Ph.D. from the Woods Hole Oceanographic Institute
Project Type: Science Collaborative Transfer Grant
Project Length: 1 year
Understanding effects of sea level rise on salt marshes requires detailed measurements of water levels. The amount of time a marsh is flooded (inundation time) has direct influence on vegetation condition and elevation maintenance. However, marshes are not uniform so water level measurements at one location do not translate to an entire marsh. A new low-cost water level logger developed at the Waquoit Bay NERR in Massachusetts has the potential to improve spatial inundation time estimates. Twelve sensors will be deployed and tested all three transects in Pellicer Creek marshes. If successful, the data gathered from these loggers could be applied to marsh and shoreline restoration efforts and used as baseline data for future monitoring.

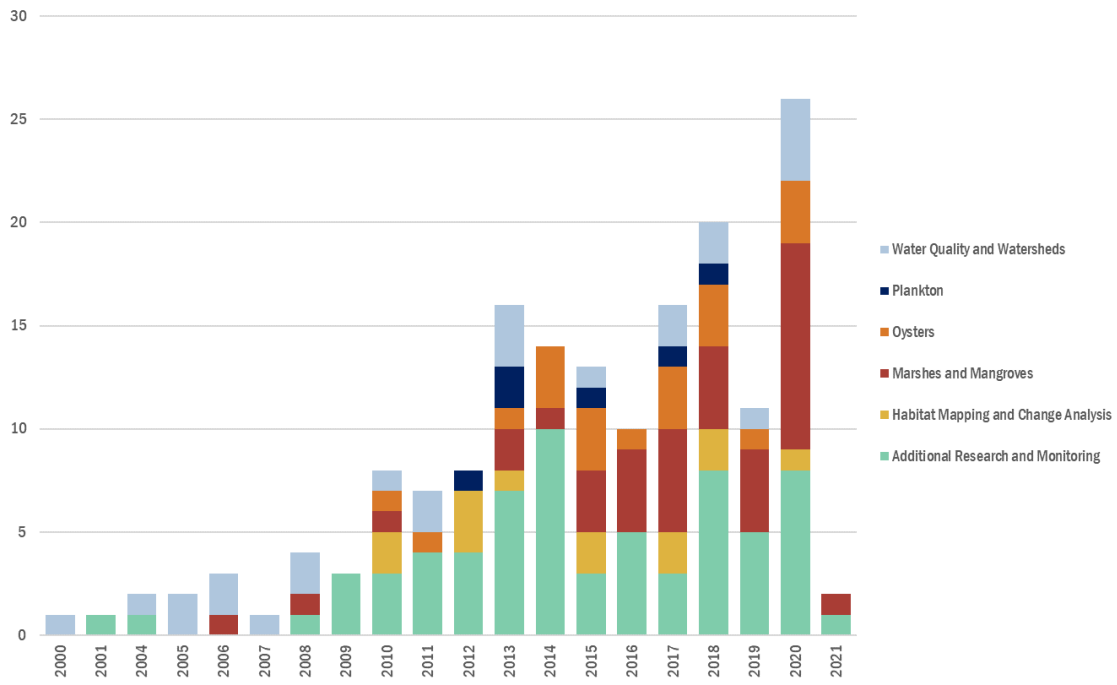
Improving Algal Bloom Detection: Utilizing SWMP technology to create the nation's most comprehensive chlorophyll monitoring program
Led by Nikki Dix, Ph.D. from the GTM Research Reserve
Project Type: Science Collaborative Catalyst Grant
Project Length: 1 year
In water quality monitoring, chlorophyll is measured as an indicator of phytoplankton biomass to study food web dynamics and detect harmful algal blooms. Chlorophyll levels can change on an hourly basis and are not adequately captured in traditional monthly water quality sampling. Quick data turnarounds and more frequent sampling are important to inform local and national responses to algal bloom events. In this project, sensors that detect chlorophyll will be attached to fixed water quality stations in 13 reserves that measure water quality parameters in 15-minute intervals. By comparing sensor measurements with traditional laboratory techniques researchers will develop protocols for the NERRs to implement this technique system-wide.

Storm Stories: Using NERRS data to communicate hurricane impacts
Led by Kaitlyn Dietz from the GTM Research Reserve
Project Type: Science Collaborative Transfer Grant
Project Length: 1 year
The NERR System-Wide Monitoring Program water quality and weather data (salinity, dissolved oxygen, wind speed, wind direction, rainfall, water depth, turbidity, and barometric pressure) can be used to illustrate hurricane and tropical storm impacts. In this project, NERRs in the southeastern US will use statistical code to create templates for hurricane-specific communication products. These templates will include pictures, hurricane path maps, and SWMP data as graphs and tables to connect data to the visual impacts observed in our coastal communities. The communication products will be shared with teachers, fisheries and land managers, and local decision makers.

To view funded projects, resources, and upcoming funding opportunities through the NERRS Science Collaborative, visit nerrssciencecollaborative.org.



GTM Publications Over Time



This graph shows the diversity of research publications published by visiting investigators and Reserve staff since 2000. To view the publications, visit www.stateofthereserve.org/publications. Graph by Alee Knoell, GTM Research Reserve.

RESOURCES AVAILABLE

When collaborating with the GTM Research Reserve, there are many resources that the Reserve can provide and/ or assist with coordinating.

1 LONG-TERM DATA

The Reserve's core monitoring program, SWMP, has been collecting water quality, meteorological, and nutrient data since 2002.

2 BASELINE HABITAT DATA

The Reserve has habitat maps and monitoring data for saltmarshes, oysters, sea turtles, butterflies, gopher tortoises, plankton, migratory birds, and fisheries.

3 BOATS & CAPTAIN SUPPORT

There are several vessels and certified boating captains that can be made available for visiting researchers.

4 TRAIL VEHICLES

The Reserve has over 15 miles of trails on the Guana Peninsula that transect several habitats. There are several trail vehicles that can be made available for visiting professionals.

5 HOUSING & FACILITES

Dorm space is available at the northern and southern offices. There is also facility space for meetings including an auditorium and classroom, as well as lab space.

6 OUTREACH & K-12 EDUCATION

The Reserve has regular programming for K-12 classes that visit the Reserve. There is also opportunity to go into classrooms with our virtual reality headsets and participate in festivals, programs, and outreach events throughout the community.

7 COMMUNITY ENGAGEMENT

The Reserve engages with the northeast Florida community though public events, stakeholder programming, quarterly newsletters, social media, the Friends of the GTM Reserve, and our over 250 volunteers.

8 INTER-AGENCY COLLABORATION

With the Management Advisory Group, the Friends of the GTM Reserve, the Coastal Training Program, and other professional workgroups such as the Oyster and Water Quality Task Force and the Northeast Estuarine Restoration Team, there are plenty of opportunities to work with other agencies and organizations.

9 PROFESSIONAL DEVELOPMENT

The Reserve provides opportunities to all staff, interns, volunteers, and visiting investigators for professional training as requested.

For more information, please contact the GTM Research Reserve's Research Coordinator, Dr. Nikki Dix (Nikki.Dix@FloridaDEP.gov).

FRIENDS OF THE GTM RESERVE

On behalf of the board of directors and members of the Friends of the GTM Reserve, I'd like to welcome you to the 2021 virtual State of the Reserve!

Since its inception, the Friends has sponsored this symposium because we believe in sharing the Reserve's findings with community stakeholders. This will ensure the decisions we make about our coastal ecosystems are based on science and fact.
A very special thank you to our donors who give generously year after year to fund programs like State of the Reserve.

The Reserve serves as a special platform for people to better understand the health of our ecosystem. Through collaboration, the GTM Research Reserve has become a leader in bringing together community stakeholders and sharing the science that our leaders need to make decisions about the health of our environment. Through programs like the State of the Reserve symposium, we continue to foster a culture of collaboration and show the value of science-based education and stewardship.

We sincerely hope you enjoy your time spent with the Reserve's staff and partners, and you end this week with a greater understanding of how valuable science and data are to all of us. There is a critical need for places like the GTM Research Reserve to exist and flourish for many decades into the future, and I encourage you to be a champion for the GTM so that it will.

Remember, this is YOUR Reserve and with your support, even more can be accomplished. Consider becoming a Friend of the GTM Reserve and pledge your commitment to science in our community.

Ellen M. Leroy-Reed, *LEED AP*
Executive Director
Friends of the GTM Reserve

ACKNOWLEDGEMENTS

Along with the GTM Research Reserve staff, the following groups aided in providing information, education and recreation to visitors, residents, and stakeholders:

The **GTM Research Reserve Management Advisory Group** (MAG) is composed of representatives from agencies affiliated with the Reserve, landowners within the Reserve, and concerned citizens. The group meets quarterly to advise, report and review activities within the Reserve. The current MAG members and their affiliations are:

Commissioner Barbara Blonder, City of St. Augustine
The Honorable Carl Blow, Florida Inland Navigation District
Wade Brenner, Florida Fish & Wildlife Conservation Commission
Commissioner Matt Brown, St. Augustine Port, Waterway, and Beach District
Commissioner Henry Dean, St. Johns County Commission
Kimberly Decker, St. Johns County Citizen
Chris Farrell, St. Johns County Citizen
Commissioner Greg Hansen, Flagler County Commission
Susie Hetrick, Florida Department of Transportation
Donald King, Florida Forest Service
Kelly Rankin Legault, Ph.D., Army Corp of Engineers
Ellen Leroy-Reed, Friends of the GTM Reserve
Jen Lomberk, St. Johns County Citizen
Maia McGuire, Ph.D., UF-IFAS SeaGrant
Todd Osborne, Ph.D., Flagler County Citizen
Renee Paolini, Florida Department of Environmental Protection, Division of Recreation & Parks
Vince Seibold, St. Johns River Water Management District
Eric J. Smith, Ph.D., St. Johns County Citizen
Kelly J. Smith, Ph.D., Duval County Citizen
Steve Swann, Duval County Citizen
Tim Telfer, Flagler County Citizen
Frank Usina, St. Johns County Citizen
Gordon J. Wilson, National Park Service
Eric Ziecheck, St. Johns County Citizen, *Chair*

The **Friends of the GTM Reserve** is a nonprofit citizen support organization established to support and enhance environmental education, stewardship of natural and cultural resources, and scientific research of the GTM Research Reserve through volunteer initiatives, citizen involvement and community partnership. The current board members are:

John Reed, President
David Green, Vice President
Steve Swann, Secretary
Chuck Snavely, Treasurer
John Anderson
Sherry David
Julie Edwards
Drew Frick
Courtney Hackney, Ph.D.
Amanda Morrow
Amanda Ryan
Eric Smith, Ph.D.
Tatum Theodore
Mark Wood

Ellen Leroy-Reed, Executive Director
Brittani Crawford, Administrative Assistant
Donna Zerbe, Bookkeeper

The research reserves cover more than 1.3 million acres of estuaries nationwide that are focused on the following:

- **Stewardship** – Each site undertakes the initiatives need to keep the estuary healthy.
- **Research** – Reserve-based research and monitoring data are used to aid conservation and management efforts on local and national levels.
- **Training** – Local and state officials are better equipped to introduce local data into the decision-making process as a result of reserve training efforts.
- **Education** – Thousands of children and adults are served through hands-on laboratory and field-based experiences. School curriculums are provided online.

Visit https://coast.noaa.gov/nerrs/about/ to learn more.