

Annual Report 2022

Florida Cooperative Fish and Wildlife Research Unit

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Cover Photos: *Tricolored Heron with a satellite transmitter* (ABBY POWELL), *Sea turtle swimming over sea grass* (RAY CARTHY), *Suwannee Bass, Santa Fe River* (ANDREW CARLSON)

COOPERATORS

Florida Fish and Wildlife Conservation Commission

United States Geological Survey

United States Fish and Wildlife Service

University of Florida

Wildlife Management Institute

TABLE OF CONTENTS

INTRODUCTION 4

In Memoriam 5

Mission 6

Diversity, Equity, and Inclusion 6

ACRONYMS 7

COOPERATORS AND PERSONNEL 8

Unit Coordinating Committee 8

Unit Scientists 8

Cooperators 9

Research Personnel 11

HONORS AND AWARDS 12

RESEARCH: FISHERIES AND AQUATIC 13

RESEARCH: WILDLIFE AND HABITAT 18

Doris Duke Conservation Scholars Program 28

PUBLICATIONS AND PRESENTATIONS 29

Publications 29

Presentations 29

2021 PHOTO CONTEST WINNERS 31

Adult Loggerhead Turtle. TRENTON AGUILAR

Sunset at Shell Mound. JEREMY MILLER

INTRODUCTION

The Florida Cooperative Fish and Wildlife Research Unit was established in 1979 as one of the first combined units. The purpose of the Florida Unit is to provide for active cooperation in the advancement, organization, and conduct of scholarly research and training in the field of fish and wildlife sciences, principally through graduate education and research at the University of Florida. The Florida Unit has the mission to study wetland ecosystems within the state. Florida is a low relief, sub-tropical peninsula that is ecologically fragile. Though abundant, Florida's water resources are under increasing pressure from a burgeoning human population. Domestic, recreational, and development needs threaten Florida's water/wetland resources. In following its program directive, the Florida Unit has developed a research program that addresses management issues with approaches spanning species to ecosystem perspectives. Specifically, this Unit conducts detailed investigations of aquatic-terrestrial ecosystem interfaces and their component fish and wildlife resources.

Between 1979 and 2022, over 330 projects totaling more than $65 million were funded through the Unit. These projects covered a wide variety of fish, wildlife, and ecosystem subjects and have involved over 50 line, affiliate, and adjunct faculty members as principal and co-principal investigators. Unit staff have their own research projects, which accounted for about 1/3 of the total effort. Projects associated with the Unit have resulted in over 450 publications, 130 technical reports, 113 theses and dissertations, and 260 presentations. Cooperation has been the Florida Unit's strength. As a Cooperative Research Unit of the U.S. Geological Survey, it serves as a bridge among the principal cooperators, such as the University of Florida, the Florida Fish and Wildlife Conservation Commission (FWC), the U.S. Geological Survey (USGS), the U.S. Fish and Wildlife Service (USFWS) and the community of state and federal conservation agencies and nongovernmental organizations. Evidence of this role is the Unit's funding which has included contributions from FWC, 12 BRD research labs and centers, 12 offices within the USFWS Southeast Region, the University of Florida, U.S. Army Corps of Engineers, U.S. Navy, U.S. Department of Agriculture, U.S. Air Force, U.S. National Park Service, Environmental Protection Agency, St. Johns River Water Management District, South Florida Water Management District, U.S. AID, World Wildlife Fund, The Nature Conservancy, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, BRD, Florida Wildlife Federation, National Audubon Society, Florida Alligator Farmers' Association, American Alligator Farmers' Association, Florida Fur Trappers' Association, and other private contributions. Many Unit projects involve multiple investigators from several agencies. This cooperative interaction stimulates continuing involvement of funding sources, provides for student contacts with potential employers and agency perspectives, and directs transfer and application of research results.

In Memoriam

The Florida Cooperative Fish and Wildlife Research Unit remembers Dr. Rob Bennetts, who passed away in June 2022. Rob received his PhD through the Florida Unit in 1998, under the guidance of Dr. Wiley Kitchens, working on conservation issues of the endangered snail kite. Rob was known for his work on the interconnections between snail kites, their obligate prey species of apple snail, and hydrological conditions in the Everglades. His PhD work included radio-tracking 300 snail kites to track their movements and exploratory behavior. His work on snail kite populations was extensive (1986-2003) and included the design and application of mark/recapture protocols that have stood the test of time; they continue twenty years later and provide critical information for snail kite conservation. Rob was an outstanding ecologist whose visionary research provided many new insights into our understanding of the population dynamics of the Florida Snail Kite. He was well respected by natural resource managers from federal and state agencies and his research was used to inform management decisions pertaining to the Florida Snail Kite and its habitat. Rob's extensive career included working with J-D. Lebreton in France and Jim Nichols at the U.S. Geological Survey. In 2003, Rob joined the National Park Service Inventory and Monitoring Division, from which he retired in 2019. In his lifetime, he authored or coauthored over 60 papers in scientific journals (including 22 papers on kites), one book, and three book chapters. He was a wonderful collaborator and influenced the works of many others. He will be missed dearly.

Mission

The mission of the Florida Cooperative Fish and Wildlife Research Unit is to conduct detailed investigation of aquatic and terrestrial resources and their component fish and wildlife populations. Our research emphasizes the interaction of biota with features of their habitat, both natural and those impacted by human activities, and ranges across state, regional, national, and international scopes.

We have wide-ranging expertise in avian ecology and conservation, endangered species monitoring and assessment, coastal ecosystems, population and ecological modeling, decision analysis, fisheries ecology and management, and coupled human and natural systems. Our research is taxonomically diverse, including but not limited to terrestrial and water birds, terrestrial herpetofauna and marine turtles, and freshwater and marine fishes. Critical components of our mission include applied research, graduate education, and technical assistance in collaboration with the Florida Fish and Wildlife Conservation Commission, U. S. Geological Survey, U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration, and many other partners. We are dedicated to training the next generation of natural resource leaders through management-relevant research, working with state, federal, and university cooperators and other stakeholders to address questions pertinent to fish and wildlife conservation in the face of environmental, demographic, and socioeconomic change.

Diversity, Equity, and Inclusion

Diversity, equity, inclusion, and justice are vital to our mission at the Florida Coop Unit. We are dedicated to building a culture of inclusivity and respect through graduate education, research, and technical assistance. Much like biodiversity imparts ecosystem resilience, we believe that human diversity enhances the resilience of the conservation community, providing pathways to engage with the world and deliver solutions to conservation, and broader societal, challenges. We oppose discrimination, inequality, and racism in all their forms, seeking to understand and abolish systems of power and privilege in our profession and our world. We believe that diversity is a source of strength, ingenuity, and inspiration. We welcome people from all backgrounds, listen to all voices without judgment, and hold ourselves accountable for building a diverse, equitable, inclusive, and just community.

ACRONYMS

CRU	Cooperative Research Units, U. S. Geological Survey
ESA	Endangered Species Act
IFAS	Institute of Food and Agricultural Sciences, University of Florida
FAS	Fisheries & Aquatic Sciences, School of Forest Fisheries, & Geomatics Sciences, Univ. of Florida
FWC	Florida Fish and Wildlife Conservation Commission
FWRI	Fish and Wildlife Research Institute, Florida Fish and Wildlife Conservation Commission
GOM	Gulf of Mexico
LRMS	Land Remote Sensing Program
NCBS	Nature Coast Biological Station, University of Florida
NERR	National Estuarine Research Reserve
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRDA	Natural Resource Damage Assessment
NSF	National Science Foundation
NWR	National Wildlife Refuge
RWO	Research Work Order
SESC	Systems Engineering Services Corporation
SFWMD	South Florida Water Management District
SFFGS	School of Forest, Fisheries, and Geomatic Sciences
SNRE	School of Natural Resources and Environment, University of Florida
UF	University of Florida
UAS	Unmanned Aircraft Systems
USACOE	United States of America Army Corps of Engineers
USFWS	U. S. Fish and Wildlife Service
USGS	U. S. Geological Survey
WCS	Wildlife Conservation Society
WEC	Department of Wildlife Ecology and Conservation, University of Florida
WMI	Wildlife Management Institute

Naty Teryda with a Green Turtle. UNKNOWN

Ke Zhang and Chris Gulick with newly named boat. ABBY POWELL

COOPERATORS AND PERSONNEL

UNIT COORDINATING COMMITTEE

Scott Angle	Vice President for Agriculture and Natural Resources, Institute of Food and Agricultural Sciences, University of Florida, Gainesville, Florida.
Thomas Eason	Assistant Executive Director, Florida Fish and Wildlife Conservation Commission, Tallahassee, Florida.
Barry Grand	Supervisor, Cooperative Research Units, U.S. Geological Survey, Auburn, Alabama.
Jonathan Gassett	Southeastern Field Representative, Wildlife Management Institute, Georgetown, Kentucky.
David Viker	Regional Refuge Chief, U.S. Fish and Wildlife Service Southeast Region, Atlanta, Georgia.

UNIT SCIENTISTS

Abby Powell – Unit Leader, Courtesy Professor, Department of Wildlife Ecology and Conservation and College of Natural Resources and the Environment at the University of Florida. Dr. Powell is an avian ecologist, with research interests in population and movement ecology of birds, including but not limited to endangered and threatened species. Her work is directly related to conservation and management issued and includes breeding and overwintering biology and habitat use, as well as migration ecology.

Raymond R. Carthy – Assistant Unit Leader, Courtesy Assistant Professor, Department of Wildlife Ecology and Conservation and College of Natural Resources and the Environment at the University of Florida. Dr. Carthy's research centers on the ecology of endangered species, including reproductive ecology and physiology of coastal and wetland herpetofauna, with a current focus on marine and freshwater turtles. He is also involved in research on threatened upland species, conservation management-oriented studies, and the Program Director/Wildlife Lead for the UF Unmanned Aircraft Systems Research Program.

Conor McGowan – Assistant Unit Leader, Courtesy Associate Professor, Department of Wildlife Ecology and Conservation and College of Natural Resources and the Environment at the University of Florida. Dr. McGowan's research and teaching interests are in decision support science (especially endangered species decision making), population dynamics, predictive modeling of species status, harvest decision modeling, and quantitative methods for population assessment.

Andrew Carlson – Assistant Unit Leader, Courtesy Assistant Professor, Fisheries and Aquatic Sciences at the University of Florida. Dr. Carlson explores fisheries as ecosystems, human systems, and coupled human-natural systems. From sport fish to imperiled species, his lab studies fishes and their habitats to develop strategies for sustaining fish production and biodiversity, particularly amid stressors such as land-use change, species invasion, and groundwater withdrawal. He also studies other aquatic organisms, human systems, and coupled human-natural systems to design aquatic resource management approaches that incorporate perspectives of diverse user groups.

COOPERATORS

Nathan Allan, *U.S. Fish and Wildlife Service*

Michael S. Allen, *University of Florida*

Gretchen Anderson, *U.S. Geological Survey*

Christine Angelini, *University of Florida*

Joe Aufmuth, *University of Florida*

Nick Aumen, *U.S. Geological Survey*

Ian Bartoszek, *Conservancy of Southwest Florida*

Tyler Beck, *Florida Fish and Wildlife Conservation Commission*

Mo Bennett, *University of Florida*

Arthur Bernhardt, *Florida Fish and Wildlife Conservation Commission*

Scott Bisping, *Florida Fish and Wildlife Conservation Commission*

Karen A. Bjorndal, *University of Florida*

Sean Blomquist, *U.S. Fish and Wildlife Service*

Rena Borkhataria, *University of Florida*

Robin Boughton, *Florida Fish and Wildlife Conservation Commission*

Laura Brandt, *U.S. Fish and Wildlife Service*

Anna Braswell, *University of Florida*

Billy Brooks, *U.S. Fish and Wildlife Service*

Janell Brush, *Florida Fish and Wildlife Conservation Commission*

Heather Bulger, *U.S. Army Corps of Engineers*

Kathleen Burchett, *U.S. Fish and Wildlife Service*

Matt Burgess, *U.S. Geological Survey*

Ed Camp, *University of Florida*

Cameron Carter, *University of Florida*

Michael Cherkiss, *U.S. Geological Survey*

Matt Chopp, *Florida Fish and Wildlife Conservation Commission*

Chuck Cichra, *University of Florida*

Roger Clay, *Alabama Department of Conservation and Natural Resources*

Lew Coggins, *National Oceanic and Atmospheric Administration*

Andrew Cox, *Florida Fish and Wildlife Conservation Commission*

Chelsey Crandall, *Florida Fish and Wildlife Conservation Commission*

Andrea Currylow, *U.S. Geological Survey*

Wes Daniel, *U.S. Geological Survey*

Tylan Dean, *National Park Service*

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Jason Dotson, *Florida Fish and Wildlife Conservation Commission*

David Duffy, *University of Florida*

Drew Dutterer, *Florida Fish and Wildlife Conservation Commission*

Michelina Dziadzio, *Florida Fish and Wildlife Conservation Commission*

Ian Easterling, *Conservancy of Southwest Florida*

Catherine Eastman, *University of Florida*

Cailin Ervin, *Conservancy of Southwest Florida*

Bryan Falk, *National Park Service*

Nick Farmer, *National Oceanic and Atmospheric Administration*

Austin Fitzgerald, *U.S. Geological Survey*

Robert Fletcher, *University of Florida*

Brian Folt, *U.S. Geological Survey*

Bradley Fontaine, *Florida Fish and Wildlife Conservation Commission*

Dewayne Fox, *Delaware State University*

Karen Frutchey, *U.S. Fish and Wildlife Service*

Mariana Fuentes, *Florida State University*

Sarah Funck, *Florida Fish and Wildlife Conservation Commission*

Victoria Garcia, U*.S. Fish and Wildlife Service*

Brian Garrett, *South Florida Management District*

Kelly Gestring, *Florida Fish and Wildlife Conservation Commission*

Rebekah Gibble, *U.S. Fish and Wildlife Service*

Jeff Gleason, *U.S. Fish and Wildlife Service*

David Godfrey, *Sea Turtle Conservancy*

Heather Goston, *Florida Department of Environmental Protection*

Andrew Gude, *U.S. Fish and Wildlife Service*

Darby Guyn, *City of Gainesville*

Dianne Hall, *St. Johns Water Management District*

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Ryan Hamm, *Florida Fish and Wildlife Conservation Commission*

Kristen Hart, *U.S. Geological Survey*

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Brian Healy, *National Park Service*

Eric Hellgren, *University of Florida*

Joe Heublein, *National Oceanic and Atmospheric Administration*

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Joyce Kleen, *U.S. Fish and Wildlife Service*

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Alyssa Jordan, *Florida Fish and Wildlife Conservation Commission*

Jillian Josimovich, *U.S. Geological Survey*

Margaret Lamont, *U.S. Geological Survey*

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Marcus Lashley, *University of Florida*

Summer Lindelien, *Florida Fish and Wildlife Conservation Commission*

Ken Lohmann, *University of North Carolina, Chapel Hill*

Cully W. Lord, *City of Gainesville*

Kai Lorenzen, *University of Florida*

Andy LoShiavo, *U.S. Army Corps of Engineers*

James Lyons, *U.S. Geological Survey*

Michael Marshall, Texas A&M University

Julien Martin, *U.S. Geological Survey*

Jenna May, *U.S. Army Corps of Engineers*

Frank Mazzotti, *University of Florida*

Robert McCleery, *University of Florida*

Gil McRae, *Florida Fish and Wildlife Conservation Commission*

Lourdes Mena, *U.S. Fish and Wildlife Service*

Debbie Miller, *University of Florida*

Melissa Miller, *University of Florida*

Karl Miller, *Florida Fish and Wildlife Conservation Commission*

Barron Moody, *Florida Fish and Wildlife Conservation Commission*

Clinton Moore, *U.S. Geological Survey*

Keith Morin, *Florida Department of Environmental Protection*

Melia Nafus, *U.S. Geological Survey*

Eric Nagid, *Florida Fish and Wildlife Conservation Commission*

Melissa Nasuti, *U.S. Army Corps of Engineers*

Dan Nelson, *Florida Fish and Wildlife* ***Conservation Commission***

Bryan Nuse, *University of Georgia*

Katherine O'Donnell, *U.S. Geological Survey*

Bradley O'Hanlon, *Florida Fish and Wildlife Conservation Commission*

Madan Oli, *University of Florida*

Todd Osborne, *University of Florida*

Joyce Palmer, *U.S. Fish and Wildlife Service*

Geoff Parks, *City of Gainesville*

Kevin Patton, *Florida Department of Environmental Protection*

Charmaine Pedrozo, *U.S. Fish and Wildlife Service*

Ramesh Paudyal, *Florida Fish and Wildlife Conservation Commission*

Bill Pine, *University of Florida*

Bill Pouder, *Florida Fish and Wildlife Conservation Commission*

Gregg Poulakis, *Florida Fish and Wildlife Conservation Commission*

Candice Prince, *University of Florida*

Laura Prosdocimi, *National Scientific and Technical Research Council, Argentina*

Raya Pruner, *Florida Fish and Wildlife Conservation Commission*

Erin Ragheb, *Florida Fish and Wildlife Conservation Commission*

Robert Reed, *U.S. Geological Survey*

Lindsey Reisinger, *University of Florida*

Ken Rice, *U.S. Geological Survey*

Steve Rider, *Alabama Department of Conservation and Natural Resources*

Erin Rivenbark, *U.S. Fish and Wildlife Service*

Charlotte Robinson, *U.S. Geological Survey*

LeRoy Rodgers, *South Florida Management District*

Christina Romagosa, *University of Florida*

J. Perran Ross, *University of Florida*

Amy Schwarzer, *Florida Fish and Wildlife Conservation Commission*

Jesse Senko, *Arizona State University*

Donna Shaver, *National Park Service*

Katie Sieving, *University of Florida*

David Smith, *U.S. Geological Survey*

Sandra Sneckenberger, *U.S. Fish and Wildlife Service*

Kristen Sommers, *Florida Fish and Wildlife Conservation Commission*

Channing St. Aubin, *U.S. Fish and Wildlife Service*

Courtney Stachowiak, *Florida Fish and Wildlife Conservation Commission*

David Steen, *Florida Fish and Wildlife Conservation Commission*

Taylor Stein, *University of Florida*

Eric Suarez, *Florida Fish and Wildlife Conservation Commission*

John Sweka, *U.S. Fish and Wildlife Service*

Jessica Swindall, *Florida Coastal Conservancy*

Brandon Thompson, *Florida Fish and Wildlife Conservation Commission*

Melissa Tolbert, *City of West Palm Beach*

Robin Trindell, *Florida Fish and Wildlife Conservation Commission*

Nick Trippel, *Florida Fish and Wildlife Conservation Commission*

Anna Tucker, *U.S. Geological Survey*

Quenton Tuckett, *University of Florida*

Travis Tuten, *Florida Fish and Wildlife Conservation Commission*

Hannah Vander Zanden, *University of Florida*

Gabriela Velez-Rubio, *KARUMBE, Uruguay*

Maureen Walsh, *U.S. Fish and Wildlife Service*

Marsha Ward, *Florida Fish and Wildlife Conservation Commission*

Zach Welch, *South Florida Management District*

Stasey Whichel, *Florida Fish and Wildlife Conservation Commission*

Benjamin Wilkinson, *University of Florida*

Randy Wilson, *U.S. Fish and Wildlife Service*

Sam Wisely, ***University of Florida***

Blair Witherington, *Inwater Research Group*

David Witmer, *City of West Palm Beach*

Chris Wynn, *Florida Fish and Wildlife*

Amy Yackel-Adams, *U.S. Geological Survey*

RESEARCH PERSONNEL

(Names in green are supervised by Powell, Carlson, Carthy, or McGowan)

University of Florida Cooperating Faculty

Robert Fletcher, *WEC*
Deah Lieurance, *Agronomy*
Charles Martin, *Nature Coast Biological Station*
Robert McCleery, *WEC*
Bill Pine, *WEC*
Christina Romagosa, *WEC*
Hannah Vander Zanden, *Biology*

Support Staff

Lisa Burnett, Administrative Support Assistant
Ben Kahler, Research Administrator
Jeremy Miller, Research Administrator

Postdoctoral Research Scholars

Riley Andrade
Natalie Claunch
Joshua Cullen
Brian Folt
Ashley Goode
Caroline Poli

Graduate Students

Trenton Aguilar, *Ph.D., FAS*
ADVISOR: Raymond Carthy

Christopher Anderson, *Ph.D., FAS*
ADVISOR: Andrew Carlson

Carson Arends, *M.S., Biology*
ADVISOR: Hannah Vander Zanden

Marion Baker, *MFAS, FAS*
ADVISOR: Andrew Carlson

Kimberly Bonvechio, *Ph.D., FAS*
ADVISOR: Andrew Carlson

Tyler Steven Coleman, *Ph.D., WEC*
ADVISOR: Andrew Carlson

Alfredo Gonzalez, *M.S., WEC*
ADVISOR: Robert Fletcher

Kaili Gregory, *M.S., WEC*
ADVISOR: Conor McGowan

Chris Gulick, *Ph.D., WEC*
ADVISOR: Abby Powell

Daniel Haro, *Ph.D., WEC*
ADVISOR: Christina Romagosa

Madison Harman, *M.S., WEC*
ADVISOR: Christina Romagosa

Kodiak Hengstebeck, *Ph.D., SNRE*
ADVISOR: Christina Romagosa

Richard Herren, *Ph.D., WEC*
ADVISOR: Raymond Carthy

Brian Jeffrey, *Ph.D., WEC*
ADVISOR: Rob Fletcher

Diego Juárez-Sánchez, *Ph.D., WEC*
ADVISOR: Christina Romagosa

Costanza Manes, *Ph.D., WEC*
ADVISOR: Raymond Carthy

Logan Masterson, *M.S., FAS*
ADVISOR: Andrew Carlson

Kyle Miller, *M.S., FAS*
ADVISOR: Andrew Carlson

Stephen Parker, *Ph.D, FAS*
ADVISOR: Bill Pine

Arianna Paul, *M.S., WEC*
ADVISOR: Christina Romagosa

Jaren Serano, *M.S., WEC*
ADVISOR: Raymond Carthy

Rachel Smith, *Ph.D., SNRE*
ADVISOR: Raymond Carthy

Natalia Teryda, *Ph.D., WEC*
ADVISOR: Raymond Carthy

Josh Vine, *Ph.D., WEC*
ADVISOR: Bill Pine

Andrew Wooley, *M.S., FAS*
ADVISOR: Andrew Carlson

Ke Zhang, *Ph.D., WEC*
ADVISOR: Abby Powell

HONORS AND AWARDS

Decision Analysis Practice Award (Finalist). Awarded to B. Nuse, C. T. Moore, A. M. Tucker, and C. McGowan, by the Decision Analysis Society and Society of Decision Professionals.

Group STAR Award. Awarded to A. Powell, A. Rosenberger, W. Turner, A. K. Fuller, G. DiRenzo, M. J. Henderson, M. Scheuerell, R. Patiño, P. Angermeier, D. Magoulick, R. Carthy, M. Culver, and K. L. Pope, for Webinar on Recruiting and Retaining Students from Diverse Backgrounds, USGS Cooperative Fish and Wildlife Research Unit Program.

Doris and Earl Lowe and Verna Lowe Scholarship. Awarded to **Tyler Steven Coleman**, University of Florida.

Early Career Fellow. Awarded to Andrew Carlson by the Aquatic Ecosystem Health and Management Society.

Florida Wildlife Federation Scholarship. Awarded to **Tyler Steven Coleman** by the Florida Wildlife Federation.

George Snow Graduate Student Scholarship. Awarded to **Bethany Gaffey,** by the George Snow Scholarship Fund.

Jennings Scholarship. Awarded to **Jaren Serano, Kaili Gregory,** and **Constanza Manes** by the Wildlife Ecology and Conservation Department Grants Committee. University of Florida.

Roger Rottmann Memorial Scholarship. Awarded to **Tyler Steven Coleman,** by the Florida Chapter of the American Fisheries Society.

Student Travel Award. Awarded to **Tyler Steven Coleman** by the Florida Chapter of the American Fisheries Society.

Undergraduate Travel Assistance Award.
Awarded to Mariaguadalupe Vilchez, by the American Fisheries Society, Education Section.

Tyler Steven Coleman, Jaren Serano, Kaili Gregory, and Constanza Manes receive awards at the annual WEC picnic, 2022. ANDREW CARLSON

RESEARCH: FISHERIES AND AQUATIC

Investigating Grass Carp movement, habitat use, emigration, and natural mortality after stocking in the Harris Chain of Lakes, Florida 13

Informing Gulf Sturgeon population status and trends as a baseline to measure PDARP actions to promote species recovery 14

Evaluating a habitat suitability index for Bluenose Shiner populations in peninsular and panhandle Florida rivers 14

Lessons from a long-term fisheries monitoring program: The Florida experience 15

Informing invasive species management amid climate and land-use change to build social-ecological resilience 15

Using long-term monitoring data to evaluate Largemouth Bass and Black Crappie population dynamics amid environmental change 16

Abiotic and biotic factors affecting fish occurrence, abundance, and growth in sixty Florida lakes 16

Effects of Spotted Bass on Shoal Bass and Largemouth Bass in the Flint River 17

Ecology and conservation of endangered Smalltooth Sawfish 17

Fellsmere Reservoir, Indian River County, FL. TYLER STEVEN COLEMAN

Logan Masterson, M.S. student. FWC

Investigating Grass Carp movement, habitat use, emigration, and natural mortality after stocking in the Harris Chain of Lakes, Florida

Water quality has improved in Florida's Harris Chain of Lakes over the last two decades, creating favorable conditions for expansion of hydrilla, an invasive plant. Herbicide treatments of hydrilla are controversial and expensive, with treatments in the Harris Chain of Lakes accounting for up to 25% of the statewide budget of the FWC Invasive Plant Management section. Given the cost and controversy associated with herbicide application, there is a need to explore alternative control techniques to reduce reliance on chemical treatments. Grass Carp are herbivorous fish that can be efficient, cost-effective consumers of hydrilla, but research on Grass Carp movement and habitat use is needed to identify appropriate stocking rates for the Harris Chain of Lakes. Our objectives are to evaluate stocking mortality and first-year survival of juvenile triploid Grass Carp stocked into lakes Apopka and Yale; assess Grass Carp movement, habitat use, and emigration rates; and investigate mortality and emigration of adult Grass Carp translocated into Lake Apopka. We will use radio telemetry to evaluate Grass Carp movement, habitat use, emigration, and natural mortality. We will use telemetry data to build population models and identify stocking rates that balance the need to reduce herbicide treatment while minimizing consumption of native vegetation by Grass Carp. Our research will provide management-relevant information about the utility of Grass Carp for controlling hydrilla in the Harris Chain of Lakes. Data on Grass Carp movement, habitat use, emigration, and natural mortality will inform population modeling to determine appropriate Grass Carp stocking rates. Hydrilla management is a costly, controversial topic in Florida. Our research on Grass Carp population characteristics and stocking rates will provide important information for integrating herbicide treatments with cost-effective biological control options.

INVESTIGATOR	Andrew Carlson
STUDENTS	Logan Masterson (M.S., FAS)
DURATION	Oct 2021 - Jun 2024
FUNDING	FWC
IN-KIND SUPPORT	Research assistance provided by FWC

Josh Vine, holding a juvenile Gulf Sturgeon STEPHEN PARKER. *Right: Stephen Parker holding an adult Gulf sturgeon.* JOSH VINE

Informing Gulf Sturgeon population status and trends as a baseline to measure PDARP actions to promote species recovery

Gulf Sturgeon, *Acipenser oxyrinchus desotoi*, currently listed as "threatened" under the ESA, are of conservation concern in the GOM because of their long lifespan and slow population recovery rate. We are working to determine Gulf Sturgeon movement patterns and estimate over-winter survival of Age-1 individuals in the Choctawhatchee River and assessing Gulf of Mexico wide status in the species. We are developing tools designed to improve data collection efforts and assist resource managers with evaluating tradeoffs among management actions designed to promote population recovery and facilitate shared research objectives among collaborators. In the US GOM, Gulf Sturgeon supported a short-lived commercial fishery in the early 20th century. Despite fishery closure since 1985, the stock has not recovered. We are determining the status and basic population demographic variables to help inform decision-making for this species at a range-wide level and assessing fine scale site occupancy and movement patterns at a local (single river) scale. We are currently using multi-state models to determine differences in mortality rates between eastern and western populations and using a detailed data simulation framework linked to multi-state models to inform ongoing and planned monitoring efforts. During 2021 we conducted field sampling to monitor age-1 sturgeon to estimate over-winter survival in the Choctawhatchee River, developed and field-tested our electronic data entry system, and compiled all available monitoring data from the past decade for integration into the Gulf Sturgeon database. Preliminary analyses from multi-state models suggests adult sturgeon mortality may be higher in the western Gulf than elsewhere. Simulated data reveal we can successfully estimate over-winter survival given high capture probabilities and sample sizes. We are monitoring the movements of 16 sub-adults and 20 juveniles using an array of acoustic receivers in the Choctawhatchee River. Our research seeks to help define future realistic population benchmarks based on population ecology and pair these benchmarks with monitoring programs to measure population response and progress to recovery goals.

INVESTIGATOR	Bill Pine
STUDENTS	Stephen Parker (Ph.D., FAS), Joshua Vine (Ph.D., WEC)
DURATION	Aug 2019 – Dec 2023
FUNDING	USGS/USFWS and NOAA-Fisheries (RWOs 308 and 313)
IN-KIND SUPPORT	Research assistance provided by USFWS

Kyle Miller, M.S. student. FWC

Evaluating a habitat suitability index for Bluenose Shiner populations in peninsular and panhandle Florida rivers

The Bluenose Shiner is a threatened species in the state of Florida that is vulnerable to water quality degradation and habitat loss. Despite the imperiled status of Bluenose Shiner and imminent conservation threats, the species has received relatively little research attention. Bluenose Shiners have a spatially disjointed range in Florida, with populations concentrated in rivers of the north-central peninsula and western panhandle and no documented populations elsewhere. Researchers recently developed a Habitat Suitability Index (HSI) for Bluenose Shiners based on expert opinion, but the HSI has not been empirically validated. The objectives of this project are to (1) develop range-wide water velocity, water depth, and cover/substrate HSIs for Bluenose Shiners in Florida; (2) provide updated information on the spatial distribution of Bluenose Shiners in Florida; and (3) identify key Bluenose Shiner habitats for protection and rehabilitation. Our research will combine fish sampling in rivers where Bluenose Shiners have been previously documented (e.g., Alexander Springs Creek, Rock Springs Run, portions of the Escambia and Yellow rivers) with GIS analysis and HSI modeling. Our research will provide updated information on Bluenose Shiner distribution in Florida and yield new insights into how environmental conditions influence Bluenose Shiner population demographics. This project will provide aquatic resource managers with important information for conserving Bluenose Shiner populations and their habitats while informing establishment of statutory minimum flows and levels (MFLs) for key water bodies.

INVESTIGATOR	Andrew Carlson
STUDENTS	Kyle Miller, (M.S., FAS)
DURATION	Jul 2022 – Dec 2024
FUNDING	FWC

Kimberly Bonvechio, Ph.D. student at the Florida Unit, holds an American Eel. KIMBERLY BONVECHIO

Lessons from a long-term fisheries monitoring program: The Florida experience

In 2006, the Florida Fish and Wildlife Conservation Commission (FWC) implemented a Freshwater Fisheries Long-term Monitoring (LTM) Program to assess temporal trends in freshwater fish population distribution and community structure in 29 lakes and reservoirs across the state. However, the LTM Program has yet to be comprehensively evaluated, and implications of such an evaluation for fisheries management are unknown. Evaluating the LTM Program through consideration of multiple perspectives and tradeoffs (e.g., ecological, statistical, resource availability) will help guide fisheries management decision-making in Florida's freshwater ecosystems. Our objectives are to assess temporal trends in fish population distribution and community structure in 29 Florida lakes and reservoirs since 2006, determine the efficacy of various fish sampling protocols for achieving LTM Program objectives, and develop recommendations for LTM Program delivery and associated fisheries management efforts in Florida. We will evaluate trends in fish population and community metrics within and across lakes over 15 years. We will also identify optimal combinations of sampling gears, locations, and sample sizes for achieving LTM Program objectives and develop recommendations for maximizing the efficiency and continued effectiveness of the program. Our analyses and statistical modeling will yield insights for understanding drivers of fish population distribution and community structure across Florida, as well as potential shifts in these parameters amid natural and anthropogenic changes (e.g., hurricanes, large-scale habitat manipulations). This project will allow fisheries managers to track the success of the LTM Program in achieving its objectives, identify areas for improvement, and showcase the relevance of the program for fisheries management, conservation, and public engagement.

INVESTIGATOR	Andrew Carlson
STUDENTS	Kimberly Bonvechio (Ph.D., FAS)
DURATION	Jul 2021-Jun 2026
FUNDING	FWC and USGS (RWO 321)
IN-KIND SUPPORT	Research assistance provided by FWC

Lexie Scott, undergraduate researcher. UNKNOWN PHOTOGRAPHER

Informing invasive species management amid climate and land-use change to build social-ecological resilience

Florida contains more than 200 nonnative fishes that cause major ecological and societal consequences. Florida faces diverse challenges in nonnative fish management—challenges that may be exacerbated by climate change and associated effects on water temperature, a "master variable" affecting the bioenergetics of individual fish and the dynamics of fish populations and communities. As such, there is a need to understand water temperature variability (e.g., daily, seasonal, annual) and the effects of climate change on aquatic thermal regimes to inform nonnative fish management in Florida. Our objective is to predict survival, reproduction, recruitment, and dispersal of priority nonnative fishes in Florida over the next 50 years to develop science-driven approaches for managing these species. We will also experimentally evaluate the effects of Tilapia Oreochromis spp. on population dynamics of Largemouth Bass and Bluegill. We will supplement an existing network of 300 water temperature loggers distributed across Florida by deploying 75 additional loggers in key rivers and canals that are not currently monitored. Water temperature monitoring and climate change forecasting will allow us to develop models to predict nonnative fish survival, reproduction, recruitment, and dispersal based on multiple potential climatic scenarios in 2021–2070. Experimental work will occur collaboratively with USGS-WARC. Our analysis will yield life-stage-specific information about the thermal habitat suitability of Florida rivers and canals for nonnative fish in 2021–2070. Our research will generate predictive distribution maps, decision support tools, and stakeholder engagement activities to help manage nonnative fishes and inform the public about fisheries conservation. This project will allow fisheries managers to develop robust, spatially explicit programs for preventing the introduction, slowing the spread, eradicating, and controlling nonnative fishes in Florida.

INVESTIGATOR	Andrew Carlson
STUDENTS	Chris Anderson (Ph.D., FAS)
DURATION	Jul 2021 - Jun 2026
FUNDING	FWC, USFWS, USGS-WARC
IN-KIND SUPPORT	Research assistance provided by FWC, USGS-WARC

Mariaguadalupe Vilchez, undergraduate researcher. UNKNOWN PHOTOGRAPHER

Using long-term monitoring data to evaluate Largemouth Bass and Black Crappie population dynamics amid environmental change

Largemouth Bass and Black Crappie are popular sport fishes that are widely distributed across Florida and most of the United States. However, there is limited information about how long-term environmental alterations (e.g., changes in climate, aquatic vegetation coverage, lake trophic status) affect these species and the valuable fisheries they support. This knowledge gap, combined with the ecological and socioeconomic significance of centrarchid fisheries, makes it important to study the effects of environmental alterations on Largemouth Bass and Black Crappie population dynamics (e.g., growth, survival). Such information will fulfill a management need for these high-profile species in Florida. Our primary objective is to evaluate if and how climate change, hydrilla expansion, and cultural oligotrophication have affected Largemouth Bass and Black Crappie population dynamics in lakes across Florida over the last 15 years. We will develop a variety of statistical models to understand historical trends in Largemouth Bass and Black Crappie population dynamics using data from the FWC Freshwater Fisheries Long-term Monitoring Program. We will also conduct a detailed investigation of Fellsmere Reservoir, a system managed by FWC that is renowned for Largemouth Bass abundance and size structure, to understand interactions among Largemouth Bass populations, aquatic habitats, and fisheries stakeholders in this unique, nationally recognized fishery. Our research will yield insights for understanding long-term trends in Largemouth Bass and Black Crappie population dynamics across Florida, and interrelationships among Largemouth Bass populations, habitats, and anglers in Fellsmere Reservoir. Largemouth Bass and Black Crappie are some of Florida's highest-profile freshwater fishes. This project will expand the knowledge base on these species via long-term assessment of population trends and short-term evaluation of a nationally recognized reservoir fishery, yielding management-relevant information for FWC and other partners in fisheries management.

INVESTIGATOR	Andrew Carlson
STUDENTS	Tyler Steven Coleman, (Ph.D., WEC)
DURATION	Aug 2021 - Aug 2023
FUNDING	UF Ph.D. Fellowship, FWC
IN-KIND SUPPORT	Research assistance provided by FWC

Clockwise from top left: Andrew Carlson, Bethany Gaffey, Katrina Rossos, and Josh Vine. TYLER STEVEN COLEMAN

Abiotic and biotic factors affecting fish occurrence, abundance, and growth in sixty Florida lakes

Studying the effects of abiotic and biotic factors on fish populations is a long-standing tradition in fisheries science. However, there is less information on how fish populations and communities respond to abiotic and biotic factors across broad spatial extents, diverse lake types, and associated gradients in lake surface area, trophic state, and aquatic macrophyte coverage, particularly in Florida. There is a need to evaluate how environmental factors varying across large regions affect fish populations, fish communities, and fisheries management. Addressing these knowledge gaps could reveal useful information for managing fish populations and communities in regions with wide-ranging environmental conditions, and predicting how fish populations and communities may respond to environmental changes (e.g., land-use alteration, eutrophication, water diversion). The objective of this study is to investigate fish population and community characteristics in relation to abiotic and biotic factors across wide-ranging conditions of lake surface area, trophic state, and macrophyte abundance in Florida. We will use univariate and multivariate statistical approaches and population models to evaluate relationships between fish population and community metrics and abiotic and biotic factors in Florida lakes. We will integrate these analyses with existing management information to make recommendations for fisheries management now and in the future, in the context of expected environmental changes. Our research will generate data summaries and statistical models to quantify and predict fish occurrence, abundance, growth, and related population/community characteristics in Florida lakes. As environmental changes affect fish populations across Florida and the world, there is a need to understand and predict how fisheries are affected by wide-ranging abiotic and biotic factors in diverse water bodies. Our research will help fill these knowledge gaps and yield practical information for fisheries management in Florida.

INVESTIGATORS	Andrew Carlson, Mark Hoyer
STUDENTS	TBD
DURATION	Oct 2021 - Jun 2026
FUNDING	UF LAKEWATCH program, FWC
IN-KIND SUPPORT	Research assistance provided by UF LAKEWATCH program, FWC

Marion Baker, MFAS student. GEORGIA DNR

Effects of Spotted Bass on Shoal Bass and Largemouth Bass in the Flint River

Shoal Bass are endemic to the Apalachicola–Chattahoochee–Flint (ACF) River basin in Florida, Georgia, and Alabama and support a socioeconomically important fishery. Introduction of nonnative Spotted Bass into the ACF basin is cause for concern due to potential negative interactions with Shoal Bass and Largemouth Bass. The Georgia DNR maintains robust, long-term data on population demographics of Shoal Bass, Largemouth Bass, and Spotted Bass in the Flint River, information that has yet to be comprehensively analyzed. We are forming a tri-state collaboration (Florida, Georgia, Alabama) to assess how Shoal Bass and Largemouth Bass have responded to the introduction of Spotted Bass in the Flint River. We will also evaluate how quickly Spotted Bass have spread throughout the system and identify how environmental conditions influence their establishment and population demographics. We will supplement a long-term database on population demographics of Shoal Bass, Largemouth Bass, and Spotted Bass in the Flint River with contemporary field sampling and statistical modeling. Our analyses will reveal if and how Shoal Bass and Largemouth Bass been affected by the introduction of Spotted Bass in the Flint River. This project will provide new insights for managing native bass species and associated fisheries in the ACF basin.

INVESTIGATOR	Andrew Carlson
STUDENTS	Marion Baker, MFAS, FAS
DURATION	Nov 2022 – Dec 2025
FUNDING	Georgia DNR
IN-KIND SUPPORT	Research assistance provided by Georgia DNR

Andrew Wooley, M.S. student. FWC

Ecology and conservation of endangered Smalltooth Sawfish

The Smalltooth Sawfish is a Federally endangered species that is confined to a small portion of Florida's coast. Despite active research on Smalltooth Sawfish by multiple organizations across Florida, key knowledge gaps remain. More information is needed on Smalltooth Sawfish habitat use and movement in Charlotte Harbor—an area that contains critical habitats for the species across its life history—to inform management and conservation programs. Our objectives are to (1) identify ontogenetic shifts in habitat use of Smalltooth Sawfish in Charlotte Harbor and (2) evaluate residency of juvenile fish by quantifying patterns in habitat use and home range as related to sex, size, and environmental factors. We will use acoustic telemetry and catch data to assess the duration and timing of Smalltooth Sawfish habitat use in Charlotte Harbor, with emphasis on nursery, refuge, and foraging areas and other high-priority locations. We will give special emphasis to characterizing ontogenetic habitat shifts at size classes that have historically been most difficult to monitor (i.e., intermediate-sized fish and the very largest individuals). Our analyses and statistical modeling will yield insights for understanding what habitats are most important for Smalltooth Sawfish across their life history in Charlotte Harbor. We will also characterize when and why shifts in habitat use occur. This project will provide fisheries managers with key information on Smalltooth Sawfish habitat use and movement that will allow them to prioritize habitats and management strategies to promote conservation of this endangered species.

INVESTIGATOR	Andrew Carlson
STUDENTS	Andrew Wooley
DURATION	Jul 2022 – Dec 2024
FUNDING	FWC, NOAA
IN-KIND SUPPORT	Research assistance provided by FWC

RESEARCH: WILDLIFE AND HABITAT

National horizon scan of terrestrial and aquatic plants in the Organisms in Trade Pathway 19

Understanding Greater Everglades mammal communities adjacent to and within the ARM Loxahatchee National Wildlife Refuge 19

Colonial nesting wading bird tracking and habitat use assessment 20

Movements and overwinter survival of juvenile Red Knots (Calidris canutus rufa) in Southeast US: Information needs for recovery planning 20

Green turtles and vessel interactions: size class specific response ranges, interaction-likelihood modeling, and predictive population modeling 21

Tidally-driven gas exchange: Effects on loggerhead sea turtle (*Caretta caretta*) hatchling emergence 21

Integrative assessment of Fibropapillomatosis dynamics in free-roaming green turtles (*Chelonia mydas*) living in the Northeastern Gulf of Mexico 22

Green turtle spatial distribution, demographics, and movements in the Northeastern Gulf of Mexico 22

Conducting a gap analysis for invasive species pathways to determine where prevention measures may be lacking 23

Planning for a fresh future: Implications of river management practices on brackish wetland restoration projects in coastal Louisiana 23

Modeling Tools for Species Status Assessments 24

PSSA prioritization and science needs 24

Alligator snapping turtle species status assessment 25

Puerto Rican boa species status assessment 25

Bird conservation classification and assessment for the Southeastern United States 26

Ecology, physiology, and control of invasive reptiles in Florida . 26

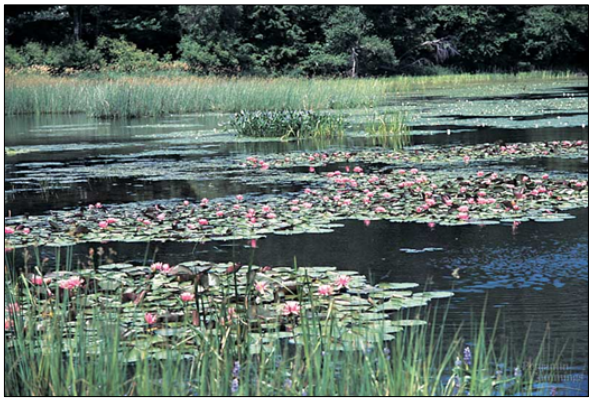
Modeling Burmese python abundance using data from removal efforts 27

Invasive reptile adaptations and impacts 27

Ke Zhang holds a Tricolored Heron. CHRIS GULICK

UF students measuring green turtles. SEA TURTLE CONSERVANCY

DDCSP Graduate Student Mentor Jaren Serano. D. SCOTT



Florida Fish and Wildlife Conservation project on East Lake Toho. FWC.

National horizon scan of terrestrial and aquatic plants in the Organisms in Trade Pathway

Biological invasions are one of the main drivers of biodiversity decline and have resulted in $1.26 trillion of economic losses in North America over the past 50 years. Early evaluation of a species' potential invasiveness can aid in prevention or early detection and rapid response by prioritizing the allocation of scarce management resources. International trade in agriculture, horticulture, and forestry species is the dominant pathway invasive plants have been introduced world-wide. With thousands of imported plants being brought into the U.S. each year through live plant trade, the U.S. needs a systematic examination of all plants in trade to anticipate which of these species have the potential to become invasive and cause future impacts. We will conduct a complete a horizon scan of Plants in Trade to provide a ranked list of potentially invasive aquatic and terrestrial plants, catalogue their primary ecological and socioeconomic impacts, and create habitat suitability models for high-risk species. We will also document management difficulty (e.g., herbicide resistance, lack of natural enemies). The end product will inform invasive species prevention and management prioritization (e.g., policymaking, early detection, rapid response). We will first pull a full list of aquatic and terrestrial plants that are currently in trade to the U.S. Species will be then organized by growth habit (e.g., trees and shrubs, aquatic floating, grasses/sedges, etc.). We currently have a list of over 70,000 plants in trade sourced from LEMIS, Dave's Garden, and PlantInfo.org. This list will be processed to remove species without a climate match, species with no naturalization or invasion history, and synonym correction. The resulting list will be distributed to working group participants. The working group will be comprised of a team leader and expert participants from research and management perspectives with a goal of 6-10 experts per group. Groups will complete rapid risk assessments, peer review, and within group consensus on rankings. Each teams list will be organized in a master list and sorted by score. All participants will meet to cross check rankings and reach a final consensus on the ranked list of invasive species threats. The final list can be used to prioritize species for full risk analysis (including comprehensive risk assessment and risk management), addition to watch lists, and possible regulation (e.g., noxious weed listing) to prevent import. Taxa ranked as low risk should not be considered for "whitelisting" as many of these species will require more research and pre- and post-border invasion risk assessment.

INVESTIGATOR	Deah Lieurance
STUDENTS	Christian Wannamaker
DURATION	August 2022 – June 2023
FUNDING	USGS (RWO 326)

Top: Cotton rats and raccoons foraging at giving-up-densities (GUD) patches. Bottom: Decoys presented at GUD patches to assess animal fear response to different predators.

Understanding Greater Everglades mammal communities adjacent to and within the ARM Loxahatchee National Wildlife Refuge

With no indication that the Burmese python (*Python molurus bivittatus*) invasion has abated, there are several critical information gaps with regards to mammals. Specifically, we need to know 1) are communities that were once unaltered now showing declines, changing, or adapting, and 2) why do some smaller species appear to be more resilient to the invasion. First, we replicated an earlier study that quantified variation in mammal community composition across a gradient of python density using a combination of camera trapping and scat surveys. We observed little evidence of resilience among mammals within the invasion core. Of the 15 mammal species detected in 2019, rodents were the only species to increase in occurrence within the invasion core. Next, to understand rodents' resilience we radio tagged and tracked cotton rats. Finding no difference in cotton rat's rates of survival, despite differences in the rates of predation from pythons across our study sites, we believe that cotton rats' resilience to an invasive predator was a function of compensatory mortality. Next to understand if resilient and vulnerable mammals have different innate and generalizable responses to large snakes, we have been conducting experiments with decoys and measuring their fear response using giving-up-densities (GUDs). Ph.D. student Rebecca McKee's preliminary results have been striking and clear. Cotton rats, still commonly found in the Everglades, showed a fear response to large snakes, while raccoons, once common and now exceedingly rare, showed no evidence of recognizing pythons as a threat.

INVESTIGATORS	Robert McCleery, Andrew Watson
POST-DOC	Rebecca McKee, Marina McCanbell
DURATION	Sep 2018 - Dec 2023
FUNDING	USGS (RWO 305)
IN-KIND SUPPORT	SFWMD, FWC

Doris Duke Scholar, Otto Alvarez, holds a juvenile white ibis fitted with a satellite transmitter. KE ZHANG

Colonial nesting wading bird tracking and habitat use assessment

Key information is missing from populations of coastal-dwelling wading birds that may have been damaged by the Deepwater Horizon oil spill in the northern Gulf of Mexico. To better conserve these populations, we require an understanding of the movements, connectivity, survival, and health metrics of key coastal wading bird species to guide future restoration efforts for these species. We need to understand the movement capacity of individuals from both populations, and the drivers underlying these movement patterns. Further, we need to understand limitations on the survival and reproduction of each species in coastal areas of the Northern Gulf of Mexico. In so doing, we will better understand the capacity of each population to recover from future environmental degradation. Our objectives are to determine dispersal patterns and seasonal movements of colonial nesting wading birds (white ibises and tricolored herons), as well as the health and survival of each species in Mobile Portersville bays, Alabama. To date we have deployed transmitters on 50 white ibis and 49 tricolored herons over three breeding seasons, 2020-2022. An additional 119 white ibis and 123 tricolored herons were marked with unique color bands. We measured morphological characteristics of each captured bird, and collected blood, feathers, feces, and arthropod parasites for further analysis on the gender and fitness of each bird. Preliminary analyses indicate that, following the breeding season, white ibises established more home ranges during the nonbreeding season, and exhibited lower philopatry than tricolored herons. Argos data indicate that tricolored herons move greater distances to nonbreeding ranges and show connectivity with populations in Central America. Most white ibises remained in Portersville Bay or moved west to coastal Louisiana, while several individuals moved east into Florida. As of December 2022, 45 birds were still transmitting data, and we continue our analyses of movements and site fidelity. This research will be useful to managers as they develop conservation plans, preserve critical habitats, and assess each species' ability to respond to environmental disasters like catastrophic oil spills.

INVESTIGATOR	Abby Powell
STUDENTS	Ke Zhang (Ph.D., WEC), Chris Gulick (Ph.D., WEC)
DURATION	Sep 2019 -Dec 2024
FUNDING	USGS (RWO 307)

Juvenile Red Knot fitted with a nanotag. ABBY POWELL

Movements and overwinter survival of juvenile Red Knots (*Calidris canutus rufa*) in Southeast US: Information needs for recovery planning

Research and conservation on Red Knots over the past twenty years has focused on adult birds using only a few sites, primarily in the mid-Atlantic region. However, by focusing on just one stage in their annual cycle there is a chance that factors that are driving Red Knot populations are being missed. For example, we currently do not fully know the distribution of juvenile Red Knots or have estimates of their first-year survival. We need to better understand the juvenile life stage to ensure that conservation actions to recover the species are appropriately directed to the areas that have the most significant impact on population growth. We aim to identify the main areas in the Southeast US and Caribbean where juvenile Red Knots occur during their first two years of life, determine how long they survive, and whether they recruit into the adult population. Field work was delayed for two years due to covid-19, but in February 2022 we captured, banded, and flagged 123 red knots at Fort DeSoto, Florida. We deployed 19 nanotags and three pinpoint ARGOs transmitters on birds identified as second-year age classes. Unfortunately, the GPS transmitters we deployed failed, but one of the birds carrying a transmitter was resighted in South Carolina in May and back in Florida in September. Preliminary data show that a 40-71% of flagged birds that were resighted were seen in coastal South Carolina from March through June 2022 and then resighted in the Tampa Bay area from August through December. The only flagged birds remaining around Tampa Bay in June and July were juveniles. We are planning to capture and tag more birds in spring/summer 2023. Once we better understand the distribution of juvenile Red Knots, the areas they prefer, and the threats and stressors they are under, we will be able to develop management and protection measures that, when implemented, should increase recruitment into the adult population and increase the population overall. This project could provide the critical information needed to lead the species to recovery.

INVESTIGATOR	Abby Powell
STUDENTS	TBD
DURATION	Aug 2019 - Dec 2024
FUNDING	USGS (RWO 309)
IN-KIND SUPPORT	USFWS

Adult loggerhead turtle. TRENTON AQUILAR

Green turtles and vessel interactions: size class specific response ranges, interaction-likelihood modeling, and predictive population modeling

Vessel strikes have become a greater threat as an increasing number of sea turtles around the world, and especially in Florida, are stranded (injured or killed) due to strikes by recreational or commercial vessels. For effective management strategies to be established, threats to sea turtles must be thoroughly understood. To more fully understand and thus mitigate this threat, we are studying how vessel strikes with turtles occur, predicting areas of high vessel and turtle encounter rates, and how growing turtle and human populations may affect this mortality concern in the future. We observed how green turtles (Chelonia mydas) react to oncoming vessels at varying speeds, by conducting observational boat surveys to measure turtle response and flight initiation distance from the vessel and comparing behaviors of turtles of differing size classes. We then created an encounter rate model between green turtles and recreational boaters in Florida coastal waters to show where these two groups are most likely to interact. Finally, we will develop a population growth model to predict how, with growing human and green turtle populations in Florida, green turtles may be affected by increasing interactions with vessels. Observational data from the field was collected in the fall of 2021 and the spring and summer of 2022. The encounter rate model has been shown to be useful in predicting areas of high turtle and boater interaction and with future applications towards more localized use where turtle density data is available. The encounter rate model alone could be used for future management planning as more data is collected on both recreational boater registrations locally and around the state of Florida as well as green turtle or other sea turtle species density data becomes available. This model will be able to predict areas of interaction concern and can help management allocate resources to limit potential vessel strikes.

INVESTIGATORS Trenton Aguilar, Raymond Carthy, Mike Allen
STUDENTS Trenton Aguilar (Ph.D., FAS)
DURATION Aug 2018 - Aug 2023
FUNDING NSF, Florida Education Fund, UF Graduate School, McKnight Doctoral Fellowship, Sea Turtle Conservancy
IN-KIND SUPPORT UF FAS

Otto Alvarez taking gas efflux measurements at Salinas Beach, Cape San Blas, FL. JERAN SERANO

Tidally-driven gas exchange: Effects on loggerhead sea turtle (*Caretta caretta*) hatchling emergence

Florida's coastline is constantly reworked by long and short-term climatic cycles. Shifts in the frequency and intensity of those cycles due to global change, in conjunction with anthropogenic alterations, are affecting the resilience of coastal habitats and the species that rely on them. This research is integrating existing approaches with novel techniques to examine the coupling of oceanographic and onshore processes and their effects on sea turtle nest incubation and dune stabilization. Sea turtles nest in a variety of beach environments, and the success of an individual nest is influenced by its location on the beach and the resulting incubation micro-environment. Some of the factors affecting sea turtle nest incubation include moisture, rainfall, sand particle size, temperature, tides, and gas exchange. We are evaluating how beach incubation dynamics and productivity respond to altered gaseous environments. The objectives of this study included investigating how gas exchange on beaches fluctuates throughout the tidal cycle by using CO2 efflux as a proxy to quantify this exchange. Followed by examining sediment particle size to determine correlations with gas exchange. Those findings were then compared with the most recent hatchling emergence success data from the beaches observed, to deduce the effects these factors likely have on hatchling emergence success over time. The effects of the tidal cycle on gas efflux readings in the study system were examined using an infrared trace gas analyzer. Sand samples from each beach were collected and then processed using a graduated series of U.S standard sieves. Results revealed that higher emergence success occurred at the beach possessing the finer sand particle size and a higher, more stable CO2 efflux. However, due to additional variables involved in incubation and successful emergence, further investigation is required to better comprehend the relationship between emergence success and tidally-driven gas exchange. Results from this work can identify habitat suitability issues and inform conservation planning measures and better nourishment practices, including mitigation and alternative actions.

INVESTIGATOR Ray Carthy
STUDENTS Jaren-Claude Serano
DURATION Sep 2020 - Aug 2023
FUNDING USGS (RWO 316)

Costanza Manes holding a healthy juvenile green turtle sampled from the field. EVAN COOPER

Integrative assessment of Fibropapillomatosis dynamics in free-roaming green turtles (*Chelonia mydas*) living in the Northeastern Gulf of Mexico

Fibropapillomatosis is a neoplastic epizootic of sea turtles. Green turtles (*Chelonia mydas*) are the most heavily affected species, with prevalence of over 60% in Florida. This debilitating disease forms tumor growths on the turtle bodies, preventing them from seeing, swimming, and feeding properly. Fibropapillomatosis incidence is increasing, and its threat to the conservation of green turtle populations needs to be better understood. Because of the unknown factors in the etiology of this disease, we must look at viral (herpesvirus ChHV5 associated with fibropapillomatosis) and host factors, as well as environmental factors that might exacerbate severity and spread of the disease in wild green turtle populations. We will capture animals in coastal ecosystems areas and investigate patterns between disease severity, viral load, and environmental variables, such as marine pollution levels. We will compare viral load with disease severity, as well as disease severity with seawater levels of PCBs, PAHs, and pesticides. Thus, our proposed project offers a greater understanding of the disease, and findings will be applicable to fibropapillomatosis-afflicted sea turtle populations globally. Our goal is to enhance sea turtle health by improving our understanding of fibropapillomatosis through a highly multifactorial assessment. We will address our objectives by carrying health assessment of green turtle populations in the Northeastern Gulf of Mexico and deploying passive environmental samplers for the measurement of seawater pollutant concentrations. Fieldwork started in 2021 and will continue throughout the duration of the project. We currently have data on fibropapillomatosis incidence and body-mapping for the individuals analyzed in the field season. This project will elucidate possible viral and environmental drivers behind the severity and propagation of fibropapillomatosis. Data on environmental correlations will be utilized to inform coastal managers and policymakers on the best potential changes to be applied to relieve green turtle population from disease burden and aid their recovery and conservation.

INVESTIGATORS	Costanza Manes, Raymond R. Carthy, and Ilaria Capua
STUDENTS	Costanza Manes
DURATION	Jan 2021 – Jan 2025
FUNDING	One Health Center of Excellence, National Save the Sea Turtle Foundation

Rick Herren (right), PhD Candidate and Project Director, and David Godfrey (left), Sea Turtle Conservancy Executive Director, release one of the many satellite-tagged juvenile green turtles captured in the Big Bend since 2019. EVAN COOPER

Green turtle spatial distribution, demographics, and movements in the Northeastern Gulf of Mexico

The purpose of this study is to describe the abundance and distribution of sea turtles in the Big Bend, and the demographics, health and seasonal movements of juvenile green turtles. We conducted region-wide vessel surveys covering 1,644 km2 (635 mi²) of seagrass and hardbottom habitat in the Big Bend. We then estimated abundance using distance sampling methods and identified numerous abundance "hotspots" that are consistent over time. The Big Bend is developmental habitat for at least four sea turtle species and green turtles are by far the most common turtle found in nearshore waters. To date, 231 green turtles have been captured at hotspots, ranging in size from 27.8 cm to 78.7 cm straight carapace length. Significant differences in habitat, size, and the proportion with the disease fibropapillomatosis have been found between juvenile green turtle foraging aggregations. We deployed 23 satellite transmitters on green turtles and obtained five to seven months of tracks, water temperatures and dive profiles from most of the turtles (78%). The majority of tracks showed movement offshore and south during the winter and then back to their original warm-water foraging site in the spring. We also found evidence of brumation during the coldest months relatively close to their original capture site. These patterns demonstrated strong site fidelity to warm-water foraging sites. While the results of three studies are being prepared for publication, we have started two new studies on green turtle health assessments and Kemp's ridley overwintering movements. All of this research is part of a long-term effort to study sea turtles in the northeastern Gulf of Mexico in partnership with the Sea Turtle Conservancy. The results are important given concerns over vessel strikes, climate change, water quality, and the global loss of seagrass beds. They can also be valuable decision-making tools for establishing marine protected areas, understanding human impacts to nearshore environments, and generating new questions for future research and conservation.

INVESTIGATORS	Raymond Carthy, Rick Herren
POST-DOC	Rick Herren (Ph.D., WEC)
DURATION	Sep 2016 - Present
FUNDING	NCBS, Sea Turtle Conservancy
IN-KIND SUPPORT	Sea Turtle Conservancy

Zoey Hendrickson presenting at the annual National Aquatic Invasive Species Management Association Conference in Orlando, Florida in November 2022. CHARLES MARTIN

Conducting a gap analysis for invasive species pathways to determine where prevention measures may be lacking

Once an aquatic invasive species becomes established, it is rarely possible to eradicate. The best way to avoid the negative impacts that invasive species can cause is to prevent their initial entry. Although thirteen federal agencies have a role in preventing new introductions, new species are found every year indicating that current prevention measures are not entirely successful. This project uses recent aquatic invasive species introductions as case studies to determine pathways and highlight critical gaps in regulation. We will provide metrics to improve regulation of aquatic invasive species. The objective of this study is to review recent introductions and their invasion pathways to determine if and where regulations are lacking or could be improved. To address this question, we are conducting a gap analysis to evaluate the prevention measures and policies currently in place by federal agencies, and reviewing the actual performance with what was expected or desired. Using a systematic review of recent AIS introductions into the United States via the USGS Nonindigenous Aquatic Species (NAS) database, we are addressing how prevention measures may have been lacking, ineffective, or resulting from gaps in authority. Results to date have highlighted numerous gaps in authority that have led to species introductions. Continued work will provide a more detailed list of metrics for federal managers. Federal partners will use this research to enact more effective regulations to prevent additional aquatic invasive species introductions.

INVESTIGATORS	Charles W. Martin (UF), Wesley Daniel (USGS)
STUDENTS	Zoey Hendrickson, MS, FAS
DURATION	Mar 2022 – Mat 2023
FUNDING	USGS (RWO 324)

Sampling in Louisiana salt marshes. CHARLES MARTIN

Planning for a fresh future: Implications of river management practices on brackish wetland restoration projects in coastal Louisiana

Land in Louisiana is being lost at an alarming rate. To combat these losses, managers use multiple approaches, including Mississippi River reintroduction and active dredging for marsh creation. However, knowledge of the interactions resulting from these approaches, and realized field patterns are lacking, and addressed in this study. Because marsh creation is a key goal of management, this work will provide important evidence on empirical patterns in field vegetation and nekton needed to create more productive wetlands. The objective of this study is to quantify the influence of freshwater management (i.e., river siphon operations and adaptions to climate-related changes in freshwater supply) on the ecological trajectory and functionality of restored and natural coastal wetlands and their associated marsh-dependent species. Specifically, we seek to quantify marsh geomorphology and vegetation dynamics, the relationship between marsh interspersion and nekton abundance and diversity, and occurrences of species of conservation concern. We use unmanned aircraft systems (UAS) and active sampling of fishes using traps and trawls in created and restored marshes to quantify the influence of freshwater management in South Louisiana. To date, we have sampled annually over the past four years with and without freshwater influence (river siphon). Preliminary results indicate that fish community structure is highly variable and most influenced near the siphon outflow. Sampling to date indicates that key estuarine species (e.g., brown shrimp, hardhead catfish) were replaced by freshwater counterparts (e.g., Ohio river shrimp, blue catfish). Managers will use these results to more effectively plan restoration timing and locations (i.e., considering freshwater introductions) and marsh designs (creeks, ponds, etc.). This project provides empirical evidence of fish and invertebrate abundance and will be especially useful when habitat enhancement is a key goal of restoration.

INVESTIGATORS	Charles W. Martin (UF), Mike Polito (LSU), Paola Lopez-Duarte (UNCC), Brian Roberts (LUMCON)
STUDENTS	Scott Alford, PhD, FAS
DURATION	Jul 2022 – Nov 2024
FUNDING	Southcentral Climate Adaptation Science Center

Roundtail Chub. USFWS

Modeling Tools for Species Status Assessments

The USFWS has a significant workload for conducting species status assessments to support listing, reclassification and recovery planning decisions under the Endangered Species Act (ESA). In many cases they lack the expertise or the tools to conduct the necessary scientific analyses and they need support in developing generalizable and transferrable tools to facilitate SSA analyses. We will work with the service to devise modeling tools that support SSA completion and work with the service specifically on two SSAs, the Texas Spot-tailed Earless Lizard and the Round-tailed Chub. Develop methods to analyze species status with sparse data, focusing on the utility of occupancy modeling and expert elicitation methods. We completed work on the Roundtail Chub viability assessment in June 2021. We developed a stochastic simulation model to predict stream occupancy in the future based on current occupancy and expert elicited parameters. We have been working with the USFWS Austin and Corpus Christi field offices in Texas to develop analyses to support the Spot-tailed Earless Lizard SSA. Post-doc, Ashley Goode, designed a sized-based life table analysis to use single capture event data to estimate survival and recruitment of the two species. Dr. Goode completed a threats-link stochastic viability model for the species and devised several scenarios based on cooperator input. Results are still forthcoming from this project. We have used a species distribution model to estimate current abundance with a population density estimate and have drafted a simulation model for predicting future status. The future viability results predict low viability for the species in areas high road density and urban growth. The Roundtail Chub analyses are complete and the modeling that we did directly informed the pending listing decisions. The service will likely use the results of the work to directly inform the listing decisions for two lizards in Texas. Further, the tools we develop should be applicable to a variety of future SSAs with sparse data.

INVESTIGATOR	Conor McGowan
STUDENTS	Ashley Goode
DURATION	Jul 2020 – Jul 2022
FUNDING	USGS/USFWS
IN-KIND SUPPORT	Personnel provided by USFWS

PSSA prioritization and science needs

The USFWS has a significant workload for conducting species status assessments to support listing, reclassification, and recovery planning decisions under the Endangered Species Act (ESA). There are hundreds of pending decisions that require a science-based assessment of the species status before making ESA decisions. We will work with the service to devise an objectives hierarchy and tradeoffs analysis to develop a prioritization system for identifying which SSAs tasks require the most attention or effort and when to do them. We will develop an objectives hierarchy, identify measurable attributes, and design a multi-criteria decision analysis value function to rank the >300 SSA project in the Southeast Region. In 2020 we sought and hired a post doc to fill the position and we initiated meetings with the management partners. We are taking a standard PROACT structured decision-making approach to solve this problem and are guiding the Service through the decision analysis steps. In spring of 2020, we conducted a series of team meetings to elicit the prioritization objectives from field office supervisors and regional office deputies. Dr. Goode has developed an optimization analysis that optimally schedules SSAs to maximize information quality, minimizes controversy constrained by court ordered deadlines and staffing capacity. Thus far we have a working analytical tool that address the project needs. We have tested output sensitivity to value function formulation and competing objective weights. We have also tested and demonstrated that the court-ordered deadlines imposed by lawsuits against the service to force decision deadlines, reduce overall value. As a result of this work, the Service will redesign their 5- and 10-year work plans for scheduling SSA work in the field offices.

INVESTIGATOR	Conor McGowan
POST-DOC	Ashley Goode
DURATION	Jul 2020 – Jul 2023
FUNDING	USGS/USFWS
IN-KIND SUPPORT	Personnel provided by USFWS

Alligator Snapping Turtle. GARRY TUCKER/USFWS

Alligator snapping turtle species status assessment

Assessing the status of a species and predicting its future trajectory is a vital part of classification decisions under the endangered species act. The alligator snapping turtle is a widespread species that is very difficult to monitor and assess, and predicting its future status offers significant challenges. We worked with the service to devise data analyses and conduct expert elicitation workshops to inform modeling. These analyses and modeling exercise directly informed the classification decision (i.e., does the species need protection under the Endangered Species Act). We will develop a PVA model for Alligator Snapping Turtle to predict future abundance, population growth, and extinction risk under a variety of different threats and conservation actions and conduct sensitivity analysis to assess the importance of uncertain parameters effects on decision making. Much of the work on this project was completed prior to 2020. We worked with the USFWS, state agencies and researchers to design the analysis and projection models. The modeling was completed in R and in 2019 we attended and presented at the recommendation team meeting to present our analysis and model. The Suwanee alligator snapping turtle was recommended for listing as threatened under the ESA and the remainder of the range was recommended for listing as threatened as well, but the rule has not been finalized and we are reevaluating some of the previous modeling. Our modeling predicted steep declines for alligator snapping turtles in the coming decades unless significant conservation management was enacted. Declines were most strongly influenced by threats such as incidental hook ingestion and illegal poaching. The USFWS decided to list both alligator snapping turtle species as threatened in 2021, in part based on the modeling results we provided. These management actions have significant implications for wetland management in the Southeastern US. The USFWS has received new data on AST distributions and genetic delineations and we are working with the service to determine if the models require revisions.

INVESTIGATOR	Conor McGowan
STUDENT	Post-doc, TBD
DURATION	Jul 2020 – Sep 2022
FUNDING	USGS/USFWS
IN-KIND SUPPORT	Personnel provided by USFWS

Puerto Rican boa. JAN ZEGARRA/USFWS

Puerto Rican boa species status assessment

Assessing the status of a species and predicting its future trajectory is a vital part of classification decisions under the Endangered Species Act. The Puerto Rican boa is an island endemic snake species that was scheduled to undergo a 5-year review and potential reclassification and the Eastern Black Rail (added in a later modification) was proposed for listing. Even though the decision at hand was different, the information needs of the decision makers was similar. For each species, we worked with the USFWS to devise data analyses and conduct expert elicitation workshops to inform modeling. These analyses and modeling exercise directly informed the classification decisions (i.e., does the species need protection under the ESA). We developed a PVA model for Puerto Rican boa to predict future abundance, population growth, and extinction risk for each species and conduct sensitivity analysis to assess the importance of uncertain parameters effects on decision making. Much of the work on this project was completed prior to 2020. We worked with the USFWS, state agencies and researchers to design the analysis and projection models. For the rail, dynamic occupancy analyses were completed in the UnMarked package and the future status simulation model was designed in R. The modeling was also completed in R and we designed a Shiny App to facilitate manager interactions with the model. In 2019, we added and presented at the recommendation team meeting for the Black Rail to present our analysis and model and in August 2020 we did the same for the Puerto Rican boa. Our modeling predicted steep declines for Black Rails in the coming decades unless significant conservation management was enacted so the USFWS decided to list the species as threatened. The decision meeting for the Puerto Rican boa was held in late 2020 and the species was recommended for delisting based in part on our model predictions that the population is likely stable or increasing despite expected further urbanization. As a result of this work, the Eastern Black Rail was listed as threatened under the ESA and the Puerto Rican Boa will potentially be delisted. These management actions have significant implications for wetland management in the Southeastern US and for Forest Management in Puerto Rico. The Puerto Rican boa classification decision is still pending at this time and we continue to respond to information requests from the USFWS to support their decision process.

INVESTIGATOR	Conor McGowan
POST-DOC	Post-doc, TBD
DURATION	July 2020 – July 2023
FUNDING	USGS (RWO 317)
IN-KIND SUPPORT	Personnel provided by USFWS

Bird conservation classification and assessment for the Southeastern United States

The USFWS is increasingly concerned with the loss of wild animals, contracting ranges, and abundance declines. The Southeast Region of the USFWS sought to develop a process of evaluating the success of conservation actions and make decisions about wildlife conservation prioritization (focusing on birds) going forward. In other words, how can they allocate time, effort, and money towards conservation that maximize conservation impact while meeting other agency objectives? We developed methods for aligning conservation actions to agency objectives to maximize impact of the agency's effort. With the results of this project, the service can evaluate alternative funding allocations within the migratory bird and science applications programs with respect to bird conservation impact and other agency goals. Use decision analysis and group facilitation techniques to link agency actions to agency objectives and develop a framework for prioritizing actions and funding allocations within the program. We have conducted a series of virtual structured decision-making workshops to elicit a problem statement, an objectives hierarchy, and conceptual systems model. Results are still forthcoming from this project. We have developed an objectives hierarchy and a conceptual model of agency operations. We have also developed a list of measurable attributes of the objectives and evaluated the metrics using Gregory and Keeney's "5 criteria." Our next steps are to link the agency operations model to the objectives hierarchy. The Assistant Regional Director and the Deputy Assistant Regional Director will use the prioritization framework to assess budget allocation options each fiscal year. Also, the Migratory Birds Office in the southeast will be able to use the results of this work to evaluate proposals and projects annually to chose projects that best address bird conservation priorities.

INVESTIGATOR	Conor McGowan
POST_DOCS	Riley Andrade, Ellen Pero
DURATION	Apr 2021 – Sep 2023
FUNDING	USGS/USFWS
IN-KIND SUPPORT	Personnel provided by USFWS

Tegu at baited trap in Miami-Dade County. CAMERA TRAP

Ecology, physiology, and control of invasive reptiles in Florida

Florida has four established populations of invasive Argentine giant tegus, located in Miami-Dade, Hillsborough/Polk, Charlotte, and St. Lucie Counties. As generalist omnivores, tegus represent a threat to many of Florida's native animals. Tegus are known to consume a variety of eggs, fruits, and small vertebrates in their native range. However, we do not know their specific impacts on Florida native fauna and flora. One study in Hillsborough County, FL documented tegus feeding on juvenile gopher tortoises. Our objectives are to: 1) enumerate the diet of Florida's invasive tegus in Miami-Dade and Charlotte Counties, 2) examine potential influence of population, month, and tegu attributes on diet composition. We obtained diet contents from the National Park Service, United States Geological Survey, and the Florida Fish and Wildlife Conservation Commission. We washed the gastrointestinal contents and identified diet items to the lowest possible taxonomic level. We analyzed potential factors influencing diet composition using a distance-based redundancy analysis. We looked at 275 tegus, with 214 from Miami-Dade County and 61 from Charlotte County. We identified roughly 3,600 diet items. Invasive tegu diet was incredibly broad in both populations. We found mammals, reptiles, amphibians and to a lesser extent, birds and fish. Eggs of reptiles and birds were common within the diet. We also documented a range of arthropods and numerous snails. We found many fruiting plant species, including agricultural crops, ornamentals, natives, and invasives. Analysis showed that diet composition was best predicted by habitat, followed by month, tegu size, and tegu sex. We found that invasive tegus ate an incredible variety of plants and wildlife. Tegus were modestly influenced by external factors, such as habitat and month, but were successful at foraging regardless of environmental characteristics, disturbance level, etc. This demonstrates that tegus are extremely hardy and will be difficult to extirpate. Based on their consumption of small vertebrates and ground-nesting bird eggs, we maintain that invasive tegus pose a threat to vulnerable native wildlife.

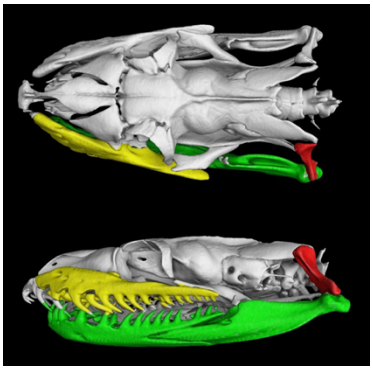
INVESTIGATOR	Christina Romagosa
STUDENTS	Diego Juárez-Sánchez, PhD, WEC, Keara Clancy MS Postdoctoral Associate: Natalie Claunch
DURATION	Aug 2017-Jul 2022
FUNDING	USGS (RWO 302)
IN-KIND SUPPORT	UF WEC

2022 Interns with radio-tagged python. From left to right: Brandon Gross, Marcellus Murray, Kendra Treichel, Jose Torres, Teah Evers, Kyra Woytek, Enrique Ribas, Shannon Glosenger-Thrasher, Peter Crawford. GRETCHEN ANDERSON, USGS.

Modeling Burmese python abundance using data from removal efforts

Burmese pythons in Florida are costly and difficult to manage due to their cryptic nature and to the difficulty of navigating the Everglades ecosystem. Impacts of management programs are also difficult to evaluate because of low detection probability and because of the challenges associated with release and recapture. In addition, little is known about many life-history and demographic attributes of the species, which hinders the ability to effectively assess population sizes and its potential impacts on native wildlife. This project aims to fill information gaps on python life history and demographics, and improve novel modeling methods to infer demographic traits, such as population size, using radio-tagged and opportunistically-collected python specimens. Our objectives are to (1) better understand python life history and demographics, and (2) use these data to investigate the use of novel modeling methods to infer python abundance. The ultimate aim is to provide realistic abundance estimates so that the impacts of management can be better assessed. In an effort to better understand how python populations respond to removal programs, we will use known-fate models to estimate python survival over the first years of life in the wild. Radio- tagged individuals will be monitored to collect survival as well as information on growth, movement, dispersal, and habitat selection. We will make use of counts and genetic data from pythons collected through removal programs to estimate python population abundance through two general methods: one uses repeated sampling to infer a total population size, and the other uses genetic data to model pairs of individuals in ways analogous to traditional mark-recapture methods. Our team tracked 40 juvenile pythons from 5 different python nests. Survivorship was low, but we are still gathering data. We also tracked 15 adult snakes and continue to track many of those individuals. Invasive species management is a multi-million-dollar burden to the United States and to the Florida government. Without a proper understanding of python abundance, the impacts of costly management programs cannot be known.

INVESTIGATOR	Christina Romagosa
Students	Daniel Haro, PhD Student, WEC
DURATION	Aug 2021-Present
FUNDING	USGS (RWO 322)
IN-KIND SUPPORT	NPS, housing in Big Cypress



A CT scan of a skull from a Burmese python captured in southern Florida. Skull features to be assessed for signs of dietary-associated morphological change are highlighted in red (quadrate), yellow (maxilla), and green (mandible). SCAN BY KODIAK HENGSTEBECK.

Invasive reptile adaptations and impacts

Burmese pythons have established a breeding population in southern Florida and are negatively impacting native wildlife across their range. Pythons in Florida have a broad diet, but the species composition of their prey has changed over time and differs across the landscape. Changes in life history traits of a species can result in plastic or adaptive responses such as morphological or behavioral change. Whether changes in prey species composition could result in phenotypic plasticity or adaptation in pythons is uncertain. The potential for rapid adaptation by an invasive species is thought to be a driving factor that can affect not only successful establishment, but also proliferation. Morphological adaptations can improve energy acquisition and aid in a species' establishment potential. If these changes in morphology occur in a short evolutionary timespan, the impact of the invader on natural resources may be dynamic. Furthermore, morphology, especially of the skull, is often linked to resource use and can be used to predict shifts in resource availability. Relating morphology to prey use over time and space can thus help predict consequences of invaders on the ecosystem and identify native animals that may be at higher risk. The objective of this study is to assess plastic or adaptive responses by Burmese pythons to environmental change. Specifically, we will assess python skull morphology to explore any potential spatial or temporal variation. Data collected from >500 specimens, including both archived specimens and recent specimens collected from the wild, will be used to document the amount of variation in phenotypic traits. All specimens will be analyzed digitally using nano-CT technology. We will use landmark-based geometric morphometrics to evaluate plastic or adaptative variations in python head shape over time and space. Through UF College of Engineering, we used computed tomography to produce high resolution 3-D digital models of >500 that can be used for detailed morphometric analyses related to this study, and permanently stored for future research projects. Understanding the drivers and impacts of rapid morphological change of invasive species to introduced environments may justify intensive rapid response efforts for new species or populations before impact assessment can occur.

INVESTIGATOR	Christina Romagosa
STUDENTS	Amy Yackel-Adams, Robert Reed, Kodiak Hengstebeck, PhD, SNRE
DURATION	Sep 2019-Aug 2024
FUNDING	USGS (RWO 310)

Doris Duke Conservation Scholars Program

The Doris Duke Conservation Scholars Program provides students from diverse backgrounds that are usually under-represented in the wildlife field with a better understanding of the research process, exposing them to a variety of research and field techniques, and helping to develop a deeper understanding of and appreciation for a topic of their interest through independent projects. In the summer of 2022, the eighth and ninth cohorts of undergraduate scholars and their mentors were able to resume semi-normal operations despite the continuing challenges imposed by the COVID-19 pandemic. Through creative accommodations and hard work by dedicated graduate student mentors, cohort eight was able to participate in ecological projects at various sites in North Central Florida, the Panhandle, and Alabama. Cohort nine engaged in internships with a variety of conservation agencies. The program continues to be a standout among the various mentoring programs administered by the Doris Duke Charitable Foundation, and many program alumni are now enrolled in advanced degree programs or employed in natural resource conservation capacities.

CHOMP! - Multiple generations of UF Doris Duke Conservation Scholars and mentors at Colorado State Mountain Campus Retreat. W. XIONG

INTERN COHORTS		
Year 1	**Year 2**	**Year 3**
Alex Cronin	Jeanette Brisbane	Modeline Celestin
Nadia Kemal	Megan Ely	Camille DeJesus
Jaclyn Selden	Charmaine Pedrozo	Hannah Innocent
Adreenah Wynn	Monica Quintiliani	Elizabeth Sherr
Xue "Jackie" Zhang	Sharmin Siddiqui	
Year 4	**Year 5**	**Year 6**
Amy Almond	Keara Clancy	Jacob Hornfeldt
Joelle Carbonell-Bierbaum	Faith Morgan	Gabriela Obando
Tre'nard Morgan	Kristina Rodriguez	Eric Trotman
Marcela Mulholland	Desiree Smith	Herby Zephir
Camya Robinson		
Year 7:	**Year 8**	**Year 9: (2020)**
Jazmyn Broxton	Maya Encinosa	Otto Alvarez
Juliemar Cuevas-Hernandez	Maiya Lester	Jesus Rodriguez-Riverol
Aleidys Lopez Romero	Sebastian Summo	Logan Stratton
Mariaguadalupe Vilchez	Nimsi Trujillo	Vanessa Rood
		Spencer Zeitoune

INVESTIGATORS Christina Romagosa, Raymond Carthy, and Rena Borkhataria (Doris Duke Charitable Foundation)
MENTORS Christopher Gulick (Ph.D., WEC), Jaren Serano (M.S., WEC), and Rebecca McKeee (Ph.D., WEC)
DURATION Sep 2013 - Sep 2024
FUNDING Doris Duke Conservation Scholars Program Partnership with University of Florida, USGS

PUBLICATIONS AND PRESENTATIONS

PUBLICATIONS

Bishop, N., J. Polisar, P. J. Eliazar, R. R. Carthy, and K. A. Bjorndal. 2022. Diet of *Dermatemys mawii*, an aquatic turtle that relies heavily on terrestrial vegetation. Chelonian Conservation and Biology 21 (1): 37–45. https://doi.org/10.2744/CCB-1467.1.

Boonstra, W. J., N. Boucquey, A. K. Carlson, L. Drakopulos, J. Fly, S. Joosse, S. Panchang, M. N. Marjadi, A. Rieser, and H. C. Wernersson. 2022. Urban fishing reveals underrepresented diversity. Nature Food 3:295(2022). https://doi.org/10.1038/s43016-022-00501-2

Carlson, A. K., W. J. Boonstra, S. Joosse, D. I. Rubenstein, and S. A. Levin. 2022. More than ponds amid skyscrapers: Urban fisheries as multiscalar human-natural systems. Aquatic Ecosystem Health & Management 25:49–58. https://doi.org/10.14321/aehm.025.01.49

Carlson, A. K., and M. V. Hoyer. 2022. Redear Sunfish occurrence, abundance, growth, and size structure as related to abiotic and biotic factors in Florida lakes. 2022. North American Journal of Fisheries Management 42:775–786. https://doi.org/10.1002/nafm.10764

Carlson, A. K., W. W. Taylor, D. R. DeVries, C. P. Ferreri, M. J. Fogarty, K. J. Hartman, D. M. Infante, M. T. Kinnison, S. A. Levin, R. T. Melstrom, R. M. Newman, M. L. Pinsky, D. I. Rubenstein, S. M. P. Sullivan, P. A. Venturelli, M. J. Weber, M. R. Wuellner, and G. B. Zydlewski. 2022. Stepping up: A U.S. perspective on the Ten Steps to Responsible Inland Fisheries. Fisheries 47:68–77. https://doi.org/10.1002/fsh.10695

Diaz, A. L., A. E. Ortega, H. Tingle, A. Pulido, O, Cordero, M. Nelson, N. Cocoves, J. Shin. R. R. Carthy, B. E. Wilkinson, and P. G. Ifju. 2022, The Bathy-drone: An autonomous Uncrewed drone-tethered sonar system. Drones 6(10), 294; https://doi.org/10.3390/drones6100294.

Goforth, K. M. and R.R. Carthy. 2022. Tidally-driven gas exchange in beaches: implications for sea turtle nest success. Journal of Coastal Research 38 (3): 523-537, https://doi.org/10.2112/JCOASTRES-D-21-00082.1

Gonzalez Perez, A., B. Wilkinson. A. Abd-Elrahman, R. R. Carthy, and D.J. Johnson. 2022. Deep and machine learning image classification of coastal wetlands using unpiloted aircraft system multispectral images and lidar datasets. Remote Sensing 14(16), 3937; https://doi.org/10.3390/rs14163937.

Jensen, M.B., S. K. Willson and A. N. Powell. 2022. How effective is the Birdsbesafe cat collar at reducing bird mortality by domestic cats? Journal of Fish and Wildlife Management 13(1)182–191; e1944-687X. https://doi.org/10.3996/JFWM- 21-055

Poli, C., E. P. Robertson, J. Martin, A. N. Powell, and R. J. Fletcher Jr. 2022. An invasive prey provides long-lasting silver spoon effects for an endangered predator. Proc. R. Soc. B 289: 20220820. https://doi.org/10.1098/rspb.2022.0820.

Twardek, W. M., I.G. Cowx, N. Lapointe, C. P. Paukert, T. D. Beard, E. M. Bennett, D. Browne, A. K. Carlson, K. D. Clarke, Z. Hogan, K. Lorenzen, A. J. Lynch, P. B. McIntyre, P. Pompeu, M. Rogers, A. Sakas, W. W. Taylor, T. D.Ward, Z. Basher, and S. J.Cooke. 2022. Bright spots for inland fish and fisheries to guide future hydropower development. Water Biology and Security. https://doi.org/10.1016/j.watbs.2022.100009.

Vitale, N., J. Brush, and A. Powell. 2022. Factors limiting reproductive success of American Oystercatchers (*Haematopus palliatus*) in Florida's Southern Big Bend. Waterbirds 44(4): 449-462.

PRESENTATIONS

Invited Seminars

Carthy, R. R, P. J. Ifju, B. E. Wilkinson, A. Ortega, and M. Burgess. 2022. Overview of the University of Florida Uncrewed Aircraft Systems Research Program (UFUASRP): Two decades of drones for natural resource applications. 29th Meeting of The Wildlife Society Drone Symposium, Spokane, WA.

Coleman, T., and A. Carlson 2022. Fisheries management: an overview. University of Florida, Gainesville, FL.

McGowan, C .P. 2022. Decision Analysis Applications in Wildlife conservation, Florida Wildlife Research Institute seminar series, Gainesville, FL.

Oral Presentations

Anderson, C. C. and A. K. Carlson. 2022. Thermal habitat suitability for non-native fish in Florida's lotic systems. Florida Chapter of the American Fisheries Society Annual Meeting, Haines City, FL.

Anderson, C. C. and A. K. Carlson. 2022. Thermal habitat suitability for non-native fish in Florida's lotic systems. Fisheries and Aquatic Sciences Graduate Student Symposium, University of Florida, Gainesville, FL.

Bonvechio, K. I. and A. K. Carlson. 2022. Lessons from a long-term fisheries monitoring program: Florida's freshwater experience. Fisheries and Aquatic Sciences Graduate Student Symposium, University of Florida, Gainesville, FL.

Carlson, A. K. and M. V. Hoyer. 2022. Shellcracker occurrence, abundance, growth, and size structure as related to abiotic and biotic factors in Florida lakes. Florida Chapter of the American Fisheries Society annual meeting, Haines City, FL.

Coleman, T. S., A. K. Carlson, R. W. Eckelbecker, K. I. Bonvechio. 2022. Using long-term monitoring data to evaluate Largemouth Bass and Black Crappie growth in a changing climate. Annual Meeting, Southern Division of the American Fisheries Society, Charleston, SC.

Coleman, T. S., A. K. Carlson, R. W. Eckelbecker, K. I. Bonvechio. 2022. Fisheries monitoring as a catalyst for cooperative research. Florida Chapter of the American Fisheries Society annual meeting, Haines City, FL.

Coleman, T. S., B. C. Thompson, T. J. Knight, A. R. Hyle, T. R. Lange, B. Fontaine, A. Bernhardt, M. Vilchez, and A. K. Carlson. 2022. Volunteer angler data reveal social-ecological effects of reservoir creation in Florida. 152nd Annual Meeting, American Fisheries Society, Spokane, WA.

Coleman, T. S., R. W. Eckelbecker and A. K. Carlson. 2022. Long-term evaluation of Black Crappie growth in a changing climate. 152nd Annual Meeting, American Fisheries Society, Spokane, WA.

Folt B., and C. P. McGowan. 2022, Using predictions from multiple anthropogenic threats to estimate future population persistence of an imperiled species, 29th Meeting of The Wildlife Society, Spokane, WA.

Goode, A., C. P. McGowan, and E. Rivenbark. 2022, Triage of Endangered Species assessment work to effectively support decision making, 29th Meeting of The Wildlife Society, Spokane WA.

Gregory K. M., C. P. McGowan, C. Darst, and R. McMorran. 2022, Population Viability Analysis as decision support science for two species of imperiled freshwater turtle, 29th Meeting of The Wildlife Society, Spokane WA.

Gulick, C. K., K. Zhang, and A. N. Powell. 2022. Breeding season selection of anthropogenic resources varies across age and pre-breeding movement modes in the American white ibis. 46th Annual Meeting of The Waterbird Society, Corpus Christi, TX.

Lawson, A. J., E. Rivenbark, C. P. McGowan. 2022. Reconciling and propagating uncertainty from expert elicited data into decision support population viability analyses. The Wildlife Society Annual Conference; Spokane, WA.

McGowan C. P., A. J. Lawson, R. A. Katz, and B. A. Crawford., 2022, Expert judgement in wildlife science and decision making, 29th Meeting of The Wildlife Society, November 2022, Spokane, WA.

Nuse, B., A. Tucker, J. Sweka, K. Anstead, C. Moore, J. Lyons, D. Smith, and C. McGowan. 2022, Updating the adaptive management plan for horseshoe crab harvest and red knot conservation in Delaware Bay. Joint meeting of the American Ornithological Society and Birds Caribbean, San Juan, Puerto Rico.

Parker, S., J. Moore, A. Breton, K. Wilkinson, A. K. Carlson, and W. E. Pine. 2022. Maximizing learning opportunities in conservation: integrating range-wide data to inform Gulf Sturgeon management. 152nd Annual Meeting, American Fisheries Society, Spokane, WA.

Silver-Gorges, I., J. Becker, R. R. Carthy, S. A. Ceriani, M. Lamb, M. M. Lamont, C. Matechik, J. Mitchell, M. Reynolds, B. Smith, C. Snyder, M. Ware, M. M. P. B. Fuentes. 2020. Maximizing loggerhead turtle (Caretta caretta) hatchling production in light of disturbances in Northern Gulf of Mexico. Gulf of Mexico Oil Spill & Ecosystem Science Conference (GoMOSES), Tampa, FL.

Taylor, W. W., A. K. Carlson, A. Bennett, J. Liu. 2022. Fisheries as coupled human and natural systems. Joint Aquatic Sciences Meeting, Grand Rapids, MI.

Taylor, W. W., A. K. Carlson, A. Bennett, J. Liu, and M. Good. 2022. Evaluating Great Lakes fisheries ecosystems as coupled human and natural systems (CHANS). Ecosystem Approach Conference. University of Windsor, Windsor, Ontario.

Vine, J., D. Fox, S. Rider, A. K. Carlson, and W. E. Pine. 2022. Differential seasonal occupancy patterns of Gulf Sturgeon inform definition of habitat use. 152nd Annual Meeting, American Fisheries Society, Spokane, WA.

Wooley, A., M. McCallister, M. Ajemian, S. Webb, J. Whittington, R. Scharer, L. Heath, D. Yakich, A. Carlson and G. Poulakis. 2022. Preliminary smalltooth sawfish data from the southern Indian River Lagoon: is a nursery re-establishing? Fisheries and Aquatic Sciences Graduate Student Symposium, University of Florida, Gainesville, FL.

Zhang, Ke, C. K. Gulick, and A. N. Powell. 2022. Non-breeding utilization ranges of white ibis and tricolored herons in the Gulf of Mexico region. 46th Annual Meeting of The Waterbird Society, Corpus Christi, TX.

Posters

Encinosa, M., L. Nicholson, C. Romagosa, and R.R. Carthy. 2022. Investigating the impact of roadway type and proximity on bat activity within a restoration context. 29th Meeting of The Wildlife Society, Spokane, WA.

Gaffey, B. M. and A. K. Carlson. 2022. Cold blood in warming waters: Conserving Gulf Sturgeon using precipitation and groundwater models. University of Florida Water Institute Symposium, Gainesville, FL.

Gaffey, B. M. and A. K. Carlson. 2022. Cold blood in warming waters: Conserving Gulf Sturgeon using precipitation and groundwater models. Fisheries and Aquatic Sciences Graduate Student Symposium, University of Florida, Gainesville, FL.

Gulick, C.K., K. Zhang, and A. N. Powell. 2022. Movements of two differently adapted wading bird species during the nonbreeding season. American Ornithological Society Annual Meeting, San Juan, Puerto Rico.

Prosdocimi, L., N. S. Teryda, G. M. Velez-Rubio, and R. R. Carthy. 2022. Unmanned Aerial Vehicles: Assessing use for surveys of sea turtle populations in feeding areas. 40th International Symposium on Sea Turtle Biology and Conservation, Cartagena, Colombia.

Summo, S., L. Nicholson, C. Romagosa, and R.R. Carthy. 2022. Watering holes - An exploration of the relationship between proximity to different types of open water bodies and bat activity in south Florida. 29th Meeting of The Wildlife Society, Spokane, WA.

Teryda, N., S., L. Prosdocimi, G. M. Velez-Rubio, and R. R. Carthy. 2020. Unmanned aircraft system surveys target leatherback conservation in the Rio de la Plata Estuary, AR/UR. 40th International Symposium on Sea Turtle Biology and Conservation, Cartagena, Colombia.

Trujillo, N., M. McCampbell, C. Gulick, C. Romagosa, and R. R.

Carthy. 2022. Assessment of cotton rat (Sigmodon hispidus) home range sizes in the Greater Everglades Ecosystem. 29th Meeting of The Wildlife Society, Spokane, WA.

Vilchez, M., T. S. Coleman, and A. K. Carlson. 2022. Social responses to habitat manipulation in a new water management area. 152nd Annual Meeting, American Fisheries Society, Spokane, WA.

2021 PHOTO CONTEST WINNERS

ANIMALS
Bad Hair Day – Jaren Serano

LANDSCAPE
Iron Shore – Ashley Goode

PEOPLE
The Art of Hunting – Keara Clancy

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