# SOUTH CAROLINA COOPERATIVE FISH & WILDLIFE RESEARCH UNIT


## ANNUAL REPORT
## 2023

In 2023, the South Carolina Cooperative Fish & Wildlife Research Unit continued to engage our cooperators to address pertinent issues in the conservation and management of our natural resources. Unit scientists advised and mentored graduate students in both M.S. and Ph.D. programs, taught graduate classes, and provided technical assistance to cooperators.

# South Carolina Cooperative Fish & Wildlife Research Unit

260 Lehotsky Hall
Clemson University
Clemson, SC 29634
Phone: 864-656-0168
www1.usgs.gov/coopunits/unit/SouthCarolina

## Cooperators:

**U. S. Geological Survey**
**Clemson University**
**South Carolina Department of Natural Resources**
**U. S. Fish and Wildlife Service**
**Wildlife Management Institute**

# TABLE OF CONTENTS



# COOPERATORS AND PERSONNEL

## COORDINATING COMMITTEE

### United States Geological Survey

**Jonathan Mawdsley,** Chief, Cooperative Research Units

**John Thompson**, Deputy Chief, Cooperative Research Units

**Barry Grand**, Regional Supervisor, Cooperative Research Units

### South Carolina Department of Natural Resources

**Robert Boyles**, Director, South Carolina Department of Natural Resources

**Emily Cope**, Deputy Director for Wildlife and Freshwater Fisheries, South Carolina Department of Natural Resources

**Billy Dukes**, Chief of Wildlife, South Carolina Department of Natural Resources

**Ross Self**, Chief of Fisheries, South Carolina Department of Natural Resources

### Clemson University

**Keith Belli**, Dean, College of Agriculture, Forestry and Life Sciences, Clemson University

**Greg Yarrow,** Interim Dean, College of Agriculture, Forestry and Life Sciences, Clemson University

**Paula Agudelo,** Associate Dean of Research, College of Agriculture, Forestry and Life Sciences, Clemson University

**Todd Petty**, Chair, Forestry and Environmental Conservation, Clemson University

### Wildlife Management Institute

**Tony Wasley**, President, Wildlife Management Institute

## UNIT PERSONNEL

*Patrick Jodice,* Unit Leader, U.S. Geological Survey, and Professor, Department of Forestry and Environmental Conservation, Clemson University

*Luke Bower,* Assistant Unit Leader-Fisheries, U.S. Geological Survey, and Assistant Professor, Department of Forestry and Environmental Conservation, Clemson University

*Erin Buchholtz,* Assistant Unit Leader-Wildlife, U.S. Geological Survey, and Assistant Professor, Department of Forestry and Environmental Conservation, Clemson University

*Brenna Byler,* Administrative Assistant, South Carolina Cooperative Fish & Wildlife Research Unit, Clemson University

*Joe Mruzek,* Post-Doctoral Research Associate, South Carolina Cooperative Fish & Wildlife Research Unit and Department of Forestry and Environmental Conservation, Clemson University

*Anje Kidd-Weaver,* Post-Doctoral Research Associate, South Carolina Cooperative Fish & Wildlife Research Unit and Department of Forestry and Environmental Conservation, Clemson University

*Pamela Michael,* Post-Doctoral Research Associate, South Carolina Cooperative Fish & Wildlife Research Unit and Department of Forestry and Environmental Conservation, Clemson University

*Yvan Satgé,* Research Specialist, South Carolina Cooperative Fish & Wildlife Research Unit and Department of Forestry and Environmental Conservation, Clemson University

*Kathy Hixson,* Research Associate, South Carolina Cooperative Fish & Wildlife Research Unit and Department of Forestry and Environmental Conservation, Clemson University

**COLLABORATORS**

## Clemson University

**Robert Baldwin**, Department of Forestry and Environmental Conservation
**Kyle Barrett,** Department of Forestry and Environmental Conservation
**Troy Farmer,** Department of Forestry and Environmental Conservation
**Cathy Jachowski,** Department of Forestry and Environmental Conservation
**David Jachowski,** Department of Forestry and Environmental Conservation
**Brandon Peoples,** Department of Forestry and Environmental Conservation
**Robert Powell**, Parks, Recreation and Tourism Management
**Matt Brownlee,** Parks, Recreation and Tourism Management
**Shari Rodriguez,** Department of Forestry and Environmental Conservation
**Greg Yarrow,** Department of Forestry and Environmental Conservation

## South Carolina Department of Natural Resources Cooperators

**Jason Bettinger,** Fisheries Biologist
**Jay Cantrell**, Assistant Big Game Program Coordinator
**Jamie Dozier**, Tom Yawkey Wildlife Center
**Christy Hand,** Wildlife Biologist
**Morgan Hart**, Wildlife Biologist
**Michael Hook**, Small Game Program Coordinator
**Molly Kneece,** Waterfowl Biologist
**Mary Catherine Marin,** Wildlife Biologist
**Mark McAlister**, Wildlife Biologist, Tom Yawkey Wildlife Center
**Charles Ruth**, Big Game Program Coordinator
**Felicia Sanders**, Wildlife Biologist
**Mark Scott**, Fisheries Biologist
**Michael Small**, Assistant Small Game Program Coordinator
**Amy Tegeler**, Bird Conservation Coordinator
**Janet Thibault**, Wildlife Biologist
**Scott Harder**, Hydrology Section Chief
**Tammy Waldrop,** Wildlife Biologist

## Federal Agency Cooperators

**Cameron Aldridge,** USGS FORT
**Laurel Barnhill**, USFWS
**Sarah Dawsey**, USFWS Cape Romain Natural Wildlife Refuge
**Dean Demarest,** USFWS
**Deborah Epperson**, USGS WARC
**Lance Garrison,** NOAA/NMFS
**Jeff Gleason**, USFWS
**Kristin Hart,** USGS
**Sarah Janssen,** USGS
**Scott Johnston**, USFWS
**Mona Kalil,** USGS
**Meg Lamont,** USGS
**Susan Loeb**, Southern Research Station, USFS
**Jim Lyons,** USGS
**Joe Madison**, USFWS
**Noel Myers**, USDA
**Michael O'Donnell,** USGS FORT
**John Stanton**, USFWS
**Melanie Steinkamp**, USGS
**Craig Watson**, USFWS Ecological Services, Charleston, SC
**Tim White,** BOEM
**Barry Wilson,** USFWS
**Randy Wilson,** USFWS
**Morgan Wolf**, FWS
Bureau of Ocean Energy Management
USFWS Region 4, Cape Romain Natural Wildlife Refuge
USFWS Migratory Bird Program
USFWS Ecological Services
USFS Southern Forest Experiment Station
National Park Service, Congaree National Park
Smithsonian Migratory Bird Center

## Private Sector Cooperators

**Lisa Ferguson,** Wetlands Institute
**Chris Haney,** Terra Mar, LLC Nemours Wildlife Foundation
**Juliet Lamb,** The Nature Conservancy
**Eric Krueger**, The Nature Conservancy
**Brad Keitt,** American Bird Conservancy
**Ernst Rupp,** Grupo Jaragua, the Dominican Republic
**Adam Brown,** Environmental Protection in the Caribbean
**Daniel Hanks**, Weyerhaeuser Company
BirdsCaribbean
Weyerhaeuser Company

## Cooperating Scientists from other Colleges, Universities, and Institutes

**Beau Bauer,** Nemours Wildlife Foundation
**Gemma Clucas,** Cornell University
**Auriel Fournier,** Illinois Natural History Survey
**Jacob Gonzalez-Solis**, University of Barcelona
**Autumn-Lynn Harrison,** Smithsonian Institute
**Julie Heinrichs,** Colorado State University
**Rainer Lohman,** University of Rhode Island
**Hannah Madden,** Wageningen University, Netherlands
**Brad Wilkinson,** Assoc. of Fish & Wildlife Agencies
**Mark Woodrey,** Mississippi State University
**Elise Zipkin,** Michigan State University

# GRADUATE EDUCATION

## CURRENT GRADUATE STUDENTS AND POST DOCS

**Jacob Daley,** Ph.D. Wildlife & Fisheries Biology (Advisor: Bower)
**Samantha Smith,** Ph.D. Wildlife & Fisheries Biology (Advisor: Buchholtz)
**Jacob Hill,** M.S. Wildlife & Fisheries Biology (Advisor: Bower)
**Tyler Tobias,** M.S. Wildlife & Fisheries Biology (Advisor: Buchholtz)
**Madison Niles**, M.S. Wildlife & Fisheries Biology (Advisor: Bower)
**Joseph Mruzek**, Post Doc, Dept. Forestry & Environmental Cons. (Advisor: Bower)
**Anje Kidd-Weaver,** Post Doc, Dept. Forestry & Environmental Cons. (Advisor: Jodice)

## STATUS OF RECENT STUDENTS & POST DOCS

**Mike Adams (MS),** Furbearer & Small Game Biologist
**Pam Michael (Post Doc),** Ecological Modeler, Terra Mar LLC
**Mikayla Thistle (MS),** Wildlife Biologist, SC DNR
**Brad Wilkinson (PhD),** Bird Conservation Program Mgr., Assoc. Fish & Wildlife Agencies
**Jesse Woodsmith (MS),** Director of Conservation & Stewardship, Southern Conserv. Trust

# CURRENT & RECENTLY COMPLETED RESEARCH

### *Determining Flow-Ecology Relationships to Inform Flow Standards*

Principal Investigator: Luke Bower (SC CRU), Joseph Mruzek (SC CRU), and Brandon Peoples (Clemson University)
Sponsors: SC DNR
Dates: 2022-2024

### *Edisto River Flow Effects on Summertime Water Temperatures: Are Thermal Tolerances of SWAP Fishes Exceeded at Low Flows?*

Principal Investigator: Luke Bower (SC CRU)
Student: Search underway
Sponsors: SC DNR
Dates: 2023-2025

### *Environmental and temporal patterns of larval fish communities and American Shad spawning in the lower Broad River*

Principal Investigator: Luke Bower (SC CRU)
Student: Search underway
Sponsors: Dominion Energy
Dates: 2023-2025

### *Spatial & Disturbance Ecology of Eastern Brown Pelicans in the South Atlantic Bight*

Investigators: Patrick Jodice (SC CRU)
Student: Bradley Wilkinson (Ph. D., Clemson University)
Sponsors: USGS and Bureau of Ocean Energy Management
Dates: 2017–2023

### *Gulf of Mexico Marine Assessment Program for Protected Species*

Principal Investigator: Patrick Jodice (SC CRU)
Collaborators: Jeff Gleason (USFWS), Chris Haney (Terra Mar LLC)
Post-Doctoral Research Associate: Pamela Michael (Clemson University)
Research Associates: Yvan Satgé (SC CRU & Clemson University), Kathy Hixson (SC CRU & Clemson University)
Sponsors: US FWS and Bureau of Ocean Energy Management
Dates: 2017-2023

### *Ecology and Conservation of the Endangered Black-capped Petrel*

Principal Investigators: Patrick Jodice (SC CRU) and Yvan Satgé (SC CRU & Clemson University)
Sponsors: US FWS, BirdsCaribbean, SC CRU
Dates: 2018-2024

### *Seabird Colony Atlas for the Northern Gulf of Mexico*

Principal Investigator: Patrick Jodice (SC CRU)
Collaborator: Jeff Gleason (USFWS)
Research Associates: Kathy Hixson (SC CRU & Clemson University) and Yvan Satgé (SC CRU & Clemson University)
Sponsors: Gulf Coast Joint Venture, US FWS
Dates: 2022-2024

### *Accumulation of Per- and Polyfluoroalkyl Substances (PFAS) in Coastal Birds and Food Webs in South Carolina*

Principal Investigator: Patrick Jodice (SC CRU)
Collaborators: Rainer Lohman (URI), Juliet Lamb (TNC), Anna Robuck (EPA)
Sponsors: US DoD (SERDP)
Dates: 2023-2024

### *Understanding Connectivity Patterns for Sagebrush Habitat and Associated Wildlife*

Principal Investigator: Erin Buchholtz (SC CRU)
Collaborators: Julie Heinrichs (Colorado State Univ), Michael O'Donnell & Cameron Aldridge (USGS-FORT)
Sponsor: Bureau of Land Management - Wyoming State
Dates: 2021-2024

### *Resource Use and Movement Ecology of Invasive Wild Pigs (Sus scrofa) in the Clemson Experimental Forest*

Principal Investigator: Erin Buchholtz (SC CRU)
Collaborators: Greg Yarrow (Clemson Univ)
Students: Andrew Jamison (MS, Clemson University); Justin Allen, Michael Belanger, Taryn Brazell, Tucker Cribb, Lynsey Dawkins, Jim Farrell, Maya Fink, Kyle Lentz, Drake Powell, Gabi Sapp, and Nick Sparano (Undergraduates, Clemson University)
Sponsor: CU Creative Inquiries Program, CU Institute for Parks
Dates: 2023-2025

### *Herpetofaunal Spatial Ecology in South Carolina*

Principal Investigator: Erin Buchholtz (SC CRU)
Collaborators: Beau Bauer (Nemours)
Students: Tyler Tobias & Samantha Smith (SC CRU, Clemson University)
Sponsor: Clemson University (start-up funds & FEC assistantship)
Dates: 2023-2028

## Environmental and temporal patterns of larval fish communities and American Shad spawning in the lower Broad River

The management and conservation of riverine fishes has primarily focused on adult life stages, generally ignoring the early life stages of many fishes (Raborn et al. 2001). Yet, the population dynamics, community structure, and year-class strength of adult fishes are strongly influenced by the response of early life stages to environmental stresses such as alteration of instream flow. Understanding the temporal patterns of larval fish abundance is crucial to predicting when fish populations may be most sensitive to instream flow alterations and other environmental stressors. However, research on larval fish in freshwater rivers is extremely limited with only two freshwater larval fish studies conducted in South Carolina (SC), highlights the need for research on early life stages of fishes in SC. For many fish the timing of life cycle events is driven by environmental cues, such as instream flow and temperature, that vary throughout the year. Instream flow and temperature are generally the most influential environmental factors affecting riverine fish diversity and play a key role in the life cycle of fishes by influencing timing of spawning, egg and larval survival, and dispersal of young. Little is known about the environmental drivers of early life stage dynamics, particularly in SC. Understanding the relationship between environmental variables and temporal patterns of larval fish abundance will allow us to better predict the impacts of different discharge regimes on fish populations, manage our environmental resources, and help protect fish populations in SC.

Anadromous species, such as American Shad (*Alosa sapidissima*), are ecologically and economically important species in SC that migrate from the ocean to spawn in rivers. Accordingly, American Shad are particularly sensitive habitat fragmentation resulting from dam construction that block migratory pathways and are also being threatened by overfishing, flow alteration, and habitat loss. Due to these threats, the American Shad has been listed as a species of high conservation need on SCDNR's State Wildlife Action Plan. Historically, anadromous species used much of the Broad River, but dams have since blocked upstream migration, resulting in the loss of spawning habitat for many species. In 2007, the construction of a fish ladder at the Columbia Diversion Dam opened access to 24 miles of potential spawning habitat for anadromous species. However, it is still unknown if or where spawning occurs between Columbia Diversion Dam and Parr Hydroelectric Dam (SCDNR personal communication). Therefore, this project aims to determine whether American Shad are spawning in this river section as well as identify potential spawning habitat sites.

The objectives of this project are to: 1) identify the temporal patterns of egg and larval fish abundance of the fish community to better understand when fish populations may be most sensitive to environmental disturbance such as large water releases; 2) determine if American Shad are spawning between the Columbia Canal Diversion Dam and Parr Reservoir; and 3) identify potential spawning and nursery habitats for American Shad. This project will deliver crucial information on spawning and migration activity of American Shad in the lower Broad River. Additionally, this project will provide managers with a better understanding of temporal patterns of larval fish and the environmental variables driving these patterns in the lower Broad River. The results of this project will also allow managers to evaluate the potential benefits of the Columbia Fishway for American Shad and the impacts of different discharge regimes and environmental alteration more effectively on fish populations.

# Determining Flow-Ecology Relationships to Inform Flow Standard

Natural flow regime (i.e. magnitude, frequency, duration, timing and rate of change of flow events) is crucial for maintaining freshwater biodiversity and ecological integrity. Appropriation of water resources will continually increase with the rapidly growing human population in South Carolina, increasing 11.3% from 2010 to 2019. Protecting instream flows for ecosystem services will be one of society's great challenges this century. South Carolina is a water-rich state that will face unique challenges and opportunities as demand increases. Protecting instream flow from anthropogenic alterations and maintaining ecosystem services of water resources first requires an understanding of the relationship between aquatic organisms and instream flow. Accordingly, the goal of the proposed project is to identify key relationships between flow metrics and biotic response (flow-ecology relationships) in the State's eight, major river basins and to use these relationships to predict the response of aquatic organisms to changes in streamflow and water withdrawals to inform river basin planning across the State.

The South Carolina State Water Planning Framework, released in October 2019, describes the process for developing a stakeholder-driven water supply plan (River Basin Plan). A major component of the Planning Framework is the convening a River Basin Council (RBC) in each of the eight planning basins (Broad, Catawba, Edisto, Pee Dee, Salkehatchie, Saluda, Santee, and Savannah) to develop a River Basin Plan that addresses anticipated water needs and water-related issues. One of the key guiding principles for RBCs and River Basin Plan is that water is a limited natural resource and a major factor for economic development and environmental protection. Specifically, River Basin Plans should 1) "strive for the equitable use of water resources with the goal of ensuring water is available for all uses, when and where needed, throughout the Planning Horizon and under drought conditions", and 2) "protect the public's health and well-being and should balance social, economic, and environmental needs." Protecting instream flows for ecosystem services will be one of the many challenges RBCs will face during the development of a River Basin Plan. To address these challenges, we will: 1) determine key relationships between instream flow and biotic responses in all major SC river basins; and 2) predict the biological response of aquatic organisms to estimated changes of instream flows due to water withdrawals.

# Edisto River Flow Effects on Summertime Water Temperatures: Are Thermal Tolerances of SWAP Fishes Exceeded at Low Flows

The Edisto River supports an immense diversity of aquatic species, including fifteen freshwater fish species listed as species of greatest conservation need in the South Carolina 2015 State Wildlife Action Plan (SWAP). Despite a lack of dams and low development in the watershed, aquatic species of greatest conservation need in the Edisto River Basin face a severe threat from increasing water withdrawals for agriculture and public use. The Edisto River has the highest number of water withdrawal registrations and the highest maximum monthly withdrawals of any river basin in the state of South Carolina. High levels of recent water withdrawals have resulted in declining flows, especially during dry summer months when water demand for agricultural uses peaks. Comparing historical (1932-1985) to recent (1986-2015) flow data from the South Fork of the Edisto River, the median days per year with extremely low flows had increased to 60 days per year (Figure 2). Decreased flow during summer may cause water temperatures to exceed thermal tolerances of SWAP species, such as Striped Bass (*Morone saxatilis*) and Bannerfin Shiner (*Cyprinella leedsi*) and could result in a reduction in critical habitat as the volume or numbers of coolwater refuges declines. Therefore, this project aims to: 1) Monitor Edisto River water temperature at 40 sites from the freshwater-brackish water interface to the headwaters in the North and South fork of the Edisto River for three years; 2) Conduct laboratory experiments quantifying Edisto River Striped Bass and Bannerfin Shiner thermal tolerance under a range of acclimation temperatures; 3) Develop a statistical model to predict Edisto River mean and maximum daily summer water temperature in response to flow and regional air temperature; 4) Develop a spatially structured model to forecast the effects of climate change and water withdrawals on Edisto River Striped Bass, Bannerfin Shiner, and juvenile Shortnose Sturgeon (*Acipenser brevirostrum*) summertime thermal habitat under differing downscaled climate projections.

This project will provide critical information necessary for protecting SWAP listed freshwater and diadromous fish species in the Edisto River Basin. Specifically, this project will determine maximum thermal tolerances for two SWAP freshwater fish species in the Edisto River Basin (Bannerfin Shiner [high priority], Edisto River Stiped Bass [moderate priority]) and create detailed maps of available thermal habitat under a range of current and projected, future flow scenarios for the two SWAP fish species listed above as well as the Shortnose Sturgeon). This project will provide critical information that will help anticipate and plan adaptive management strategies in the face of climate change and increasing water demand in the Edisto River Basin. Additionally, once thermal thresholds are quantified and field work identifies the locations of critical summertime thermal refuges, on-the-ground habitat restoration and enhancement efforts can be planned to protect these critical thermal refuges.

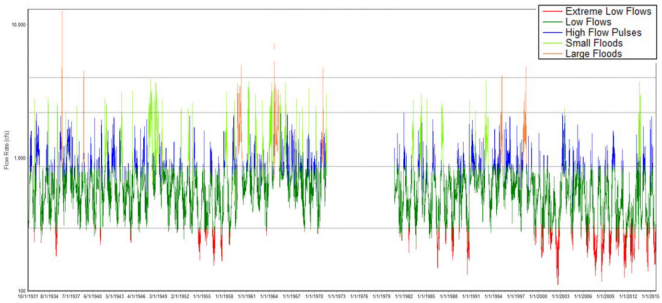



**Figure 2.** Mean daily flow in the Edisto River from 1932-2015 at USGS station 02173000 on the South Fork of the Edisto River at the Highway 321 bridge near Denmark, South Carolina. Flow data from 1972-1980 is missing from the historical record. Colors in the legend represent Environmental Flow Components (EFCs) that represent ecologically relevant hydrological patterns. An increasing prevalence of low flows have been observed since 2000. Figure from Berzinis 2016.

# Accumulation of Per- and Polyfluoroalkyl Substances (PFAS) in Coastal Birds and Food Webs in South Carolina

PFAS are anthropogenic pollutants that are ubiquitous in human and natural environments, highly persistent, and associated with impacts at low levels of exposure in humans. PFAS are released into the environment via a number of pathways, including use and disposal of consumer products, manufacturing activities, and application of aqueous fire-fighting foam (AFFF), particularly at DoD sites. The complex composition of AFFF limits understanding of its environmental fate and potential bioaccumulation impacts.

Joint Base Charleston is a known location of AFFF contamination, with high concentrations of PFOS, PFOA, and PFBS previously observed in soil, surface water, and groundwater on or surrounding the base. It is unclear if or to what extent PFAS from this site migrate into the adjacent Ashley River and into downstream estuarine and marine habitats. Multiple taxa within Charleston Harbor, including both prey and predator species, have been documented to contain elevated concentrations of PFOS, and recent work from our group likewise identified high levels of PFOS and other PFAS in the eggs of brown pelicans from the region for the first time.

We will investigate the bioaccumulation and biomagnification of a wide range of PFAS in coastal birds that rely on environments and food webs downstream from Joint Base Charleston within the Charleston, SC region, using a unique combination of a field sampling campaign paired with biologging efforts, targeted terminal PFAS, environmental precursor, EOF, and stable isotope analysis. The species included in the study possess unique life history and foraging preferences, and therefore reflect unique but intertwined food webs across the estuarine continuum representative of the Charleston, SC region.

To accomplish these objectives, we will (1) collect spatially-explicit environmental and biological samples (e.g., sediment, water, eggs, prey) and measure PFAS, EOF, and stable isotope ratios in biological samples, (2) deploy satellite tags to collect habitat use data describing the movements and behavior of focal species, (3) pair geospatial data and PFAS measurements to constrain high-use foraging areas that may be driving PFAS accumulation in birds, and (4) quantitatively describe the bioaccumulation and biomagnification of PFAS and precursors. Focal species will include American Oystercatcher, Black Skimmer, and Brown Pelican.

Due to funding delays, field work has been postponed until the 2024 breeding season although we did collect preliminary samples of eggs, sediment, vegetation, and water during Spring 2023.

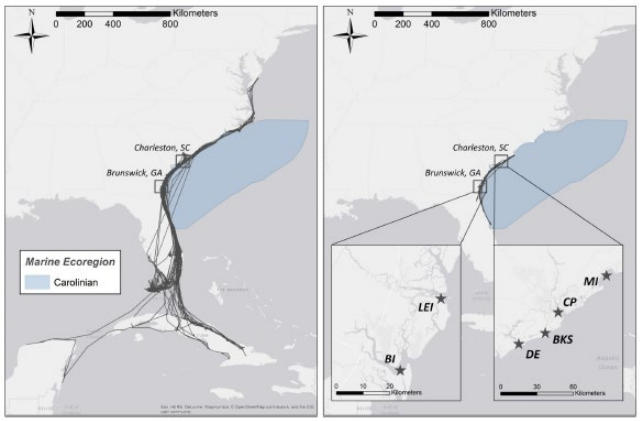
# Spatial & Disturbance Ecology of Eastern Brown Pelicans in the South Atlantic Bight

As a nearshore marine predator and species of conservation concern, Brown Pelicans (*Pelecanus occidentalis*) in the southeastern United States constitute a valuable study population for investigating coastal ecological systems. Despite occupying a highly visible and elevated trophic position in estuarine and oceanic ecosystems, movement parameters describing habitat use patterns, foraging behaviors, and migratory corridors are undeveloped at multiple spatial and temporal scales. The goal of this dissertation was to identify important drivers of movement behavior and to describe the ecological outcomes of movement decisions in Eastern brown pelicans (*Pelecanus occidentalis carolinensis*) from the South Atlantic Bight.

A total of 96 individual pelicans were outfitted with solar-powered GPS satellite transmitters in coastal South Carolina, Georgia, North Carolina, and Virginia, from 2017 – 2023. Two cohorts of pelicans tracked during the passage of three tropical cyclones demonstrated a reduction in movement correlated with anomalies in barometric pressure and wind speed relative to ambient conditions, indicating a shelter-and-wait strategy for increasing survival during these extreme weather events. By measuring the concentrations of an environmental contaminant, poly- and perfluoroalkyl substances, in the eggs of pelicans from three colonies located near Charleston, South Carolina, we demonstrated that eggs contained relatively elevated concentrations of chemicals regardless of proximity to likely point sources. GPS tracking of adults from the same colonies further suggested that variations in urban habitat use for foraging adults during the breeding season were also not reflected in egg contaminant concentrations.

These results led to a new project studying PFAS in the Charleston Harbor system.

We also assessed the relative risk to foraging adult pelicans of encountering surface oil from a hypothetical ship-based spill near Charleston Harbor and found risk was significantly influenced by location, as demonstrated through the use of an oil spill modeling toolkit combined with pelican telemetry data. Finally, we investigated the partial migration strategy of brown pelicans in the South Atlantic Bight and determined it is likely maintained by the ontogenetic migration of their primary prey, Atlantic menhaden (*Brevoortia tyrannus*), and aligns with the fasting endurance hypothesis of partial migration. Understanding the causes and consequences of movement in brown pelicans in the South Atlantic Bight has important implications for the ecology and conservation of this species throughout their range. Additional analyses of home ranges and habitats used during the breeding and non-breeding seasons are underway.




*Movements of migrant (left) v. resident (right) Brown Pelicans. Inset maps show locations of breeding colonies. From Wilkinson and Jodice 2022.*

# Gulf of Mexico Marine Assessment Program for Protected Species

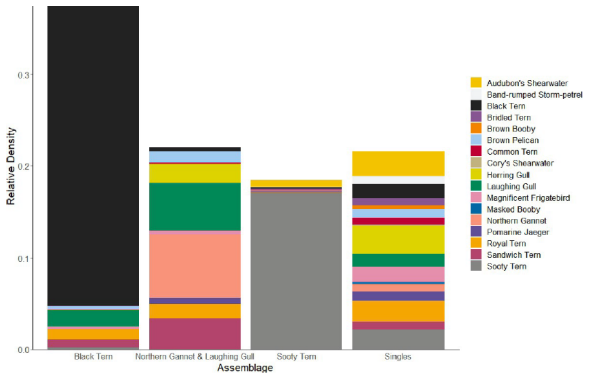
The Gulf of Mexico is simultaneously one of the most ecologically important and industrialized marine ecosystems globally, yet limited seabird research has occurred in this region. The Gulf of Mexico Marine Assessment Program for Protected Species (GoMMAPPS) is a federal partnership between the Bureau of Ocean Energy Management, the U.S. Fish and Wildlife Service, the U.S. Geological Survey, and the National Oceanic and Atmospheric Administration that seeks to fill historic information gaps regarding species composition, distribution, and abundance in the northern Gulf.

From April 2017 to September 2019, we conducted seabird surveys on 14 pelagic cruises as a part of GoMMAPPS. Surveys took place on 293 ship days representing 2,300 hours of observer effort and 41,700 km of transects during all four seasons. GoMMAPPS surveys substantially enhanced seabird survey coverage of northwest and southwest regions of the Gulf in spring and southwest and south-central regions in the summer.

We tallied 9,347 detections of 44,029 seabirds representing 44 species and identified 85.9% of observed seabirds as species. We characterized the origins of species using the northern Gulf and found that most were not locally breeding. The majority breed in locations within the northern interior of continental North American, the southern Gulf, or the Caribbean, demonstrating that the northern Gulf supports both local and migratory species from distant ecosystems throughout the year.

We developed an oil vulnerability index for seabirds in the northern Gulf. We found that the percent of seabirds' habitat defined as highly suitable within 10 km of an O&G platform ranged from 0%-65% among 24 species. Though O&G platforms only overlap with 15% of highly suitable seabird habitat, overlap occurs in areas of moderate to high vulnerability of seabirds, particularly along the shelf-slope. Highly vulnerable species (e.g., Northern gannet (*Morus bassanus*)) tended to have high exposure to the water surface via foraging behaviors (e.g., plunge-diving), older age at first breeding, and an extended incubating and fledging period compared to less vulnerable species (e.g., Pomarine jaeger (*Stercorarius pomarinus*)). As offshore energy development in the Gulf continues, managers and researchers could use these vulnerability ranks to identify information gaps to prioritize research and focal species.

We also characterized assemblages of seabirds in the Gulf as a means to better understand the composition of seabird species and their interaction with the marine environment. We identified four assemblages and these were differentiated by migratory patterns, residency, and breeding location. We determined that seasonal patterns of occurrence and dynamic marine features shaped these assemblages. These data are being used to inform marine spatial planning throughout the region.




*Relative density of each assemblage, with assemblages identified by k-means clustering. From Michael et al. 2023.*

# Ecology and Conservation of the Endangered Black-capped Petrel

The Black-capped Petrel (*Pterodroma hasitata*) has a fragmented and declining population, is considered Endangered throughout its range, and is under consideration for listing under the Endangered Species Act by the U.S. Fish and Wildlife Service. The only confirmed breeding sites have been located in the mountain ranges of Hispaniola, where habitat loss and degradation are continuing threats. Other nesting populations may still remain undiscovered but, to locate them, laborious in situ nest searches must be conducted over expansive geographical areas. We have partnered with agencies and both national and international NGOs to conduct various studies of the species in both its terrestrial breeding habitat and its marine foraging range.

Marine Habitats: We used tracking data from petrels captured at sea off the coast of Cape Hatteras to assess their distribution in the western North Atlantic. Petrels were tracked for 11 – 255 d ($\bar{x}$ = 102.1 d ±74.2; n = 10). Phenotypic differences in the Black-capped Petrel were linked to differences in nesting phenology, non-breeding marine distribution, and at-sea threat exposure. For example, our data showed potential overlap between non-breeding Black-capped Petrels and proposed offshore wind areas in the US Central Atlantic BOEM planning area. We shared results with BOEM to inform area siting, and the US FWS to inform ESA listing.

In the Gulf of Mexico, we used data from GoMMAPPS and previous NRDA survey efforts to propose a revision of the Black-capped Petrel marine range, suggesting that the northern Gulf be included on the marine range of the species.

Analyses of Total mercury in Black-capped Petrel feathers showed high concentrations, with mean concentrations of 30.3 ppm (range: 15.2-53.9 ppm ± 10.8, n = 20). These results confirm earlier suggestions of high susceptibility of mercury by Black-capped Petrels but the mechanisms of bioaccumulations remain to be investigated.

Preliminary analyses of fecal DNA (n = 5 samples collected at burrow entrances, and 6 samples collected from captured adults), showed a higher occurrence of fish than cephalopods, and more diversity of prey during breeding than non-breeding. Fish prey included myctophids, a group of pelagic fish species which perform vertical diel migrations.

Nesting Habitats: We initiated a new research effort (funded through the Quick Response program) to assess the nesting status of Black-capped Petrels following acute predation and fire events at key nesting area in the Dominican Republic. We are also evaluating the deployment of artificial burrows as a recovery technique. Such an assessment of resiliency is consistent with objectives of the 2018 SSA developed for the species.

In 2022, we confirmed the presence of Black-capped Petrel in Dominica and, in 2023, we surveyed several potential courtship and nesting areas on the island. Despite sustained effort, we did not observe petrels or locate nesting areas.

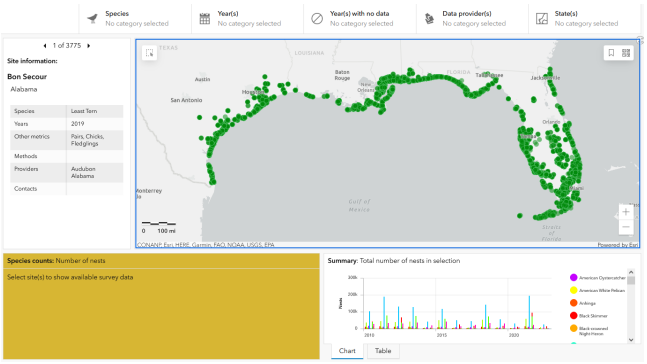

*Black-capped Petrels use artificial burrows deployed in the Dominican Republic during the 2021-2022 breeding season*.

# An Atlas and Registry for Seabird Colonies and Associated Habitats in the Northern Gulf of Mexico

The coastal zone of the northern Gulf of Mexico supports a diverse array of breeding nearshore seabirds. Most of these species are colonial and nest on islands although some may also nest in marshes, on mainland beaches, or human-made structures. Although nest-site fidelity is common among seabirds, the dynamic nature of the coastal zone in the northern Gulf can result in inter-annual shifts in the locations of colonies and in the existence, size, or stability of the islands or habitats that support them. Overlaid on this dynamic system is a stakeholder network responsible for management of these species and their breeding habitats that includes natural resource agencies from five states, multiple federal agencies (e.g., USFWS, NPS, BLM, DOD, ACOE), and numerous private organizations (e.g., National Audubon Society, Nature Conservancy).

In an effort to coordinate and facilitate the management and conservation of avian taxa throughout this wide range of habitats and across this complex network of stakeholders in the northern Gulf, the Gulf of Mexico Avian Monitoring Network (GoMAMN) released strategic monitoring guidelines (Wilson et al. 2019). The Guidelines highlighted the need for a spatial inventory of breeding sites for seabirds. Currently, there is no single source of information for seabird nesting sites in the northern Gulf of Mexico that is current or readily accessible. Instead, information and data regarding the location and status of colonies of nearshore seabirds in the northern Gulf of Mexico is scattered among numerous agencies and web locations and difficult to source.

We gathered data from stakeholders throughout the region to develop an atlas and registry for colonies. The atlas will include data from colonies (seabirds and wading birds) within the coastal zone of the northern Gulf from 2010 – 2022. We currently have amassed ~ 48k records representing ~ 50 species from Texas, Louisiana, Mississippi, Alabama, and Florida. We have developed a user-friendly dashboard using Arc GIS online that will be accessible to stakeholders and be able to be sorted by location (e.g., colony) and species. Completion of the atlas is scheduled for Spring 2024.




*Example of data view from the atlas showing colony information and species counts. From Jodice et al. In prep.*

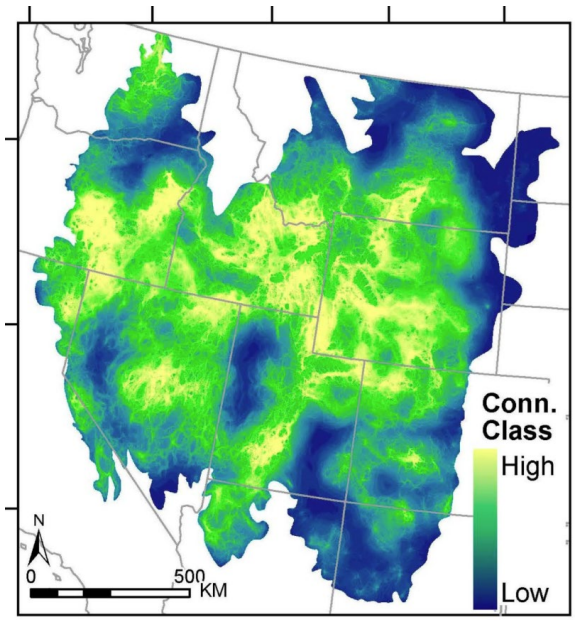
# Understanding Past and Present Connectivity Patterns for Sagebrush Habitat and Associated Wildlife

Connectivity is a key component of functioning ecosystems, and there has been an increasing emphasis on management actions to maintain, restore, or increase connectivity. For restoration and management actions to succeed, it is crucial to understand how the spatial patterns of landscape connectivity may vary over time and how such structural changes may affect wildlife with different needs.

We investigated temporal connectivity patterns for the sagebrush biome of the western United States using an omnidirectional circuit theory approach. We identified regions of the sagebrush biome that indicated lost connectivity, persistent connectivity, and changes in relative flow patterns for connectivity among sagebrush patches from 1985 to 2020.

This work is being used to support prioritization of sagebrush management actions in Wyoming with the PReSET 2.0 tool. This work is ongoing in collaboration with the USGS FORT Science Center. Connectivity is just one of the inputs to help consider where to restore sagebrush (e.g., where it used to be connected but now is fragmented) and where to conserve sagebrush (e.g., where it contributes to important existing connectivity among sage grouse leks).

Upcoming work will compare sagebrush connectivity for wildlife with different needs. We will investigate how pinch points from circuit-based analyses can identify areas for maintaining connectivity that are consistent for different species with diverse movement types and habitat needs. Our findings could help characterize opportunities for proactive conservation of remaining sagebrush structural connectivity and identify degraded areas where targeted management could increase connectivity, benefiting multiple wildlife species.



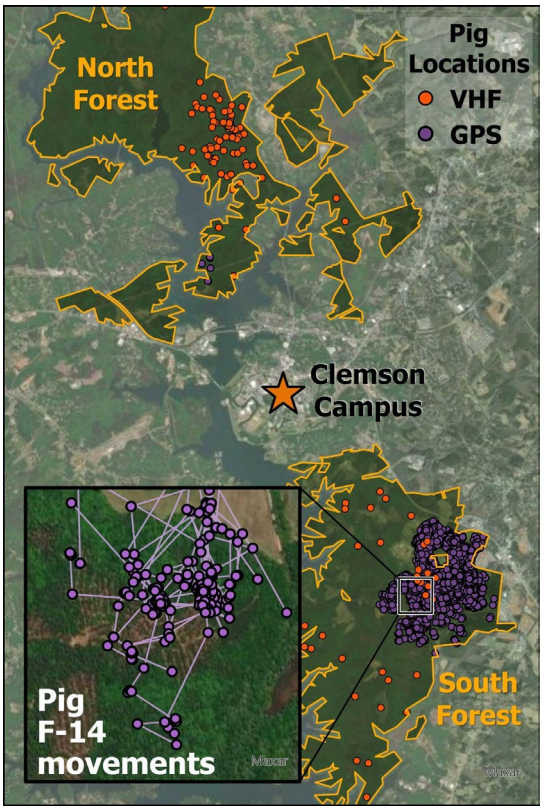

*Overall structural connectivity patterns in the sagebrush biome of the western United States, which was based on omnidirectional cumulative current density outputs. Here, the structural sagebrush connectivity is displayed for 2020. Figure from Buchholtz et al., 2023.*

# Resource Use and Movement Ecology of Invasive Wild Pigs (*Sus scrofa*) in the Clemson Experimental Forest

Wild pigs are an invasive species that cause a significant amount of environmental damage and economic costs across North America. They are particularly prevalent in the southeastern US and have been estimated to cause over 115 million dollars of damage in South Carolina. Despite this, there is little information on the resource use and movement ecology of pigs on recreational land, and no studies of the population of wild pigs in the Clemson Experimental Forest. The goal of this research is to investigate these topics to inform our understanding of the wild pig ecology, the potential impacts on public lands and recreational resources, and inform management.

This research project is in the data collection phase. To date, 12 VHF and 8 GPS collars have been deployed on adult wild pigs in the Clemson Experimental Forest (CEF), located in upstate South Carolina. Clemson University undergraduate students have collected VHF telemetry data since Spring 2023 through the Creative Inquiries Program. GPS data is collected at 1-hour intervals starting Spring 2023. We will also be deploying an array of 16 camera traps in the CEF in Fall 2023 to assess activity of wild pigs relative to human recreation (e.g., mountain bike trails, hiking trails, horseback riding, etc.).

We will use resource selection functions to model the relationship between wild pig movement and the land use and habitat within the CEF. Our predicted results include maps of individual pig home ranges and spatiotemporal patterns for preferred habitat use. This information will help inform actions on the CEF to manage and mitigate costs and risks associated with wild pigs.




*Example of some of the data collected for wild pig locations in the Clemson Experimental Forest, 2023.*

# Herpetofaunal Spatial Ecology in South Carolina

The southeastern US is a biodiversity hotspot, and South Carolina has a broad diversity of herpetofauna species. However, some species of snakes, lizards, and amphibians are overlooked, despite their ecological importance. This research topic aims to address what we know and can learn about herpetofauna in South Carolina from a spatial ecology perspective.

The associated research is starting in Fall 2023. It includes a master's student investigating amphibian community assemblages in historic rice fields and wetlands and a PhD student studying multi-scale movement of reptiles.

For the amphibian assemblage, we will investigate the composition of the communities and their spatial turnover. This will be accomplished through sampling herpetofauna communities across a salinity gradient in wetlands in coastal South Carolina using visual and acoustic surveys as well as trapping efforts. This work will be paired with a GIS-based investigation of land-use legacies, including historic rice fields associated with enslaved African labor, the Gullah Geechee communities and natural resource use, as well as pre-Clean Water Act wetlands and other more recent dredging activities. Further development of this research will continue through Fall 2023 and Spring 2024 and run through at least Fall 2025.

The reptile multi-scale movement modeling research will begin in Fall 2023 and continue over the next four years.

*An Eastern Box Turtle in upstate South Carolina. Just one of the many reptile species in this biodiverse region.*

# PUBLICATIONS

## JOURNAL ARTICLES and TECHNICAL REPORTS

*Graduate student author, ^PostDoc or RA, †Undergraduate student author

Alves, F, N Queiroz, PGR Jodice. 2023. Ecological and behavioral traits of apex predators in oceanic insular ecosystems - Advances and challenges in research and conservation. *Frontiers in Marine Science* 10.1252360.

Bower, LM, & BK Peoples. 2022. Microhabitat use of larval fish in a South Carolina Piedmont stream. *Journal of Freshwater Ecology*, 37: 583-596.

Bower, LM, L Stoczynski, BK Peoples, CJ Patrick, & BL Brown. 2023. Multiple dimensions of functional diversity affect stream fish taxonomic β-diversity. *Freshwater Biology* 68: 437-451.

Buchholtz, EK, MS O'Donnell, JA Heinrichs, & CL Aldridge. 2023. Temporal Patterns of Structural Sagebrush Connectivity from 1985 to 2020. *Land*: 12: 1176.

Buchholtz, EK, J Kreitler, D Shinneman, M Crist, & J Heinrichs. 2023. Assessing large landscape patterns of potential fire connectivity using circuit methods. *Landscape Ecology* 38: 1663-1676.

Buchholtz, EK, M McDaniels^, G McCulloch, A Songhurst, & A Stronza. 2023. A mixed-methods assessment of human-elephant conflict in the Western Okavango Panhandle, Botswana. *People and Nature* 5: 557-571.

Buchholtz, EK, J Heinrichs, & M Crist. 2023. Landscape and connectivity metrics as a spatial tool to support invasive annual grass management decisions. *Biological Invasions* 25: 637-644.

Clark, B et al. 2023. Global assessment of marine plastic exposure for oceanic birds. *Nature Communications* (2023)14:3665.

Danielson-Oweczynsky, H, H Madden, PGR Jodice. In press. Parental infanticide by egg destruction in Red-billed Tropicbirds on the Caribbean Island of Sint Eustatius. *Marine Ornithology.*

Fournier, AMV, JE Lyons, RR Wilson et al. 2023. Structured decision making to establish regional bird monitoring priorities. *INFORMS Journal of Applied Analytics* 53:207-217.

Jodice, PGR, JS Lamb*, YG Satgé^, C Perkins. 2023. Spatial and individual factors mediate exposure to polycyclic aromatic hydrocarbons in adult and chick brown pelicans in the northern Gulf of Mexico. *Frontiers in Ecology and Evolution* 11:1185659.

Lawson, AJ*, PGR Jodice, TR Rainwater, KD Dunham, M Hart, JW Butfiloski, PM Wilkinson, KW McFadden, CT Moore. 2022. Hidden in plain sight: integrated population models to describe partially observable latent demographic structure. *Ecosphere* 13(12): e4321.

Madden, H*, M Leopold, F Rivera-Milan, K Verdel, E Eggermont, PGR Jodice. 2022. Reproductive success of Red-billed Tropicbirds on St. Eustatius, Caribbean Netherlands is affected by temporal and oceanographic factors, but not by factors at the nest site. *Waterbirds* 45:39-50.

Madden, H*, YG Satgé^, BP Wilkinson, PGR Jodice. 2022. Foraging ecology of Red-billed Tropicbirds in the Caribbean during early chick-rearing revealed by GPS tracking. *Marine Ornithology* 50:165-175.

Michael, PE^, KM Hixson^, JS Gleason, JC Haney, YG Satgé^, PGR Jodice. 2023. Migration, breeding area, and seascape features shape seabird communities in the northern Gulf of Mexico. *PLoS ONE* 18(6): e0287316.

Rogan, JE, MR Parker, ZB Hancock, AD Earl, EK Buchholtz, K Chyn, J Martina, & LA Fitzgerald. 2023. Genetic and demographic consequences of range contraction patterns during biological annihilation. *Scientific Reports* 13: 1691.

Satgé, YG^, A Brown, J Wheeler, and K Sutherland. 2023. Black-capped Petrel (*Pterodroma hasitata*), version 2.0. In *Birds of the World* (T. S. Schulenberg, Editor). Cornell Lab of Ornithology, Ithaca, NY, USA.

Satgé, YG^, BS Keitt, CP Gaskin, JB Patteson, and PGR Jodice. 2023. Spatial segregation between phenotypes of the Diablotin Black-capped Petrel *Pterodroma hasitata* during the non-breeding period. *Endangered Species Research* 51:183-201.

Sofaer, HR, CS Jarnevich, EK Buchholtz, BS Cade, JT Abatzoglou, CL Aldridge, PJ Comer, D Manier, LE Parker, and JA Heinrichs. 2022. Potential cheatgrass abundance within lightly invaded areas of the Great Basin. *Landscape Ecology* **37**, 2607–2618.

Stoczynski, L, MC Scott, LM Bower, & BK Peoples. 2023. Effects of environment and metacommunity delineation on multiple dimensions of stream fish beta diversity. *Frontiers in Ecology and Evolution* 11:1077994.

Wilkinson, BP*, and PGR Jodice. 2023. Support for the fasting endurance hypothesis of partial migration in a nearshore seabird. *Ecosphere* 14:e4365.

Winemiller, KO, MC Andrade, CC Arantes, T Bokhutlo, LM Bower, ER Cunha, & CR Robertson. 2023. Can spatial food web subsidies associated with river hydrology and lateral connectivity be detected using stable isotopes? *Food Webs*, 34:e00264.

## DATA RELEASES

Buchholtz, EK, MS O'Donnell, JA Heinrichs and CL Aldridge. 2023, Sagebrush structural connectivity yearly and temporal trends based on RCMAP sagebrush products, biome-wide from 1985 to 2020: U.S. Geological data release, https://doi.org/10.5066/P9ED3OHH.

Buchholtz, EK and JR Kreitler. 2023. Circuit-based potential fire connectivity and relative flow patterns in the Great Basin, United States, 270 meters: U.S. Geological Survey data release, https://doi.org/10.5066/P9EA3E00.

Buchholtz, EK and JA Heinrichs. 2023, Landscape and connectivity metrics based on invasive annual grass cover from 2016-2018 summarized at 15 kilometer grid cells in the Great Basin, USA: U.S. Geological Survey data release, https://doi.org/10.5066/P9B4H00Q.

Gleason, J, RR Wilson, PGR Jodice, Y Satgé^, PE Michael^, K Hixson^, A. Sussman, Bureau of Ocean Energy Management. 2022. Seabird visual surveys using line-transect methods collected from NOAA vessels in the northern Gulf of Mexico for the Gulf of Mexico Marine Assessment Program for Protected Species (GoMMAPPS) project from 2017-07-21 to 2019-09-25 (NCEI Accession 0247206). NOAA National Centers for Environmental Information. Dataset. https://doi.org/10.25921/afrq-h385.

Satgé YG^, BS Keitt, CP Gaskin, JB Patteson, and PGR Jodice. 2023. Data from: Study "Satellite tracking of black-capped petrels, 2019". Movebank Data Repository. https://doi.org/10.5441/001/1.0786vv78.

Wilkinson, BP*, PGR Jodice. 2022. Movement data of partially migratory Brown Pelicans in the South Atlantic Bight. U.S. Geological Survey data release, https://doi.org/10.5066/P9YH2U8D.

Wilkinson, BP*, PGR Jodice. 2022. Interannual Breeding Movements of Brown Pelicans in the South Atlantic Bight: U.S. Geological Survey data release, https://doi.org/10.5066/P9BZ5TL9.

# ACTIVITIES

## TEACHING

L. Bower, Creative Inquiry: Fish Ecology and Morphometrics, Fall 2022 and Spring 2023
L. Bower, Readings in Ecology, Fall 2022
E. Buchholtz, Spatial Analysis for Wildlife and Landscape Ecology, Spring 2023
E. Buchholtz, Creative Inquiry: Wild hogs on the Clemson Experimental Forest, Spring 2023, Fall 2023
P. Jodice, Physiological Response of Wildlife to Global Change, Fall 2022 w/ Dr. Kyle Barret.

## PRESENTATIONS AND SEMINARS

### Invited presentations

Buchholtz, EK. 2023. Assessing large landscape patterns of potential fire connectivity using circuit methods. Invited symposium presentation. The Society for Rangeland Management Annual Meeting, Boise, ID.

Buchholtz, EK. 2023. Understanding past & present connectivity patterns for sagebrush habitat and wildlife, US Geological Survey Information Transfer Workshop. Virtual seminar, invited speaker.

Buchholtz, EK. 2022. Understanding past and present connectivity patterns for habitat and wildlife in the sagebrush biome. Invited symposium presentation. The Wildlife Society Annual Conference, Spokane, WA.

Jodice, PGR 2023. Conservation issues for seabirds in the Gulf of Mexico: from physiology to geographic range. Louisiana Tech University.

### Contributed papers / Presentations / Posters

Mruzek, JL, K Kubach, MC Scott, BK Peoples, LM Bower. 2023. Role of flow, environmental and anthropogenic factors on fish biodiversity. The American Fisheries Society Meeting. Grand Rapids, Michigan.

Bower, LM. Stream fish assemblage and functional trait responses to dam removal. 2023. The Southern Division of the American Fisheries Society. Norfolk, Virginia.

Mruzek, JL, BK Peoples, LM Bower. 2023. Role of flow and environmental variables on stream biodiversity. The Southern Division of the American Fisheries Society. Norfolk, Virginia.

Conway, KW, KM Kubicek, LM Bower, EW Carson, AK Pinion, EP Hunt, and DS Portnoy. 2022. Integrative Taxonomic Investigation of Cyprinella sp. Nueces, a Putative Undescribed Species of Greatest Conservation Need in Texas. Desert Fishes Council Annual Meeting.

Buchholtz, EK, JA Heinrichs, AL Whipple, MS O'Donnell, and CL Aldridge. 2023. Capturing variation in functional connectivity for data-deficient wildlife species in Wyoming. Annual Conference, International Association for Landscape Ecology - North America, Riverside, CA.

Buchholtz, EK. 2022. Elephants, fire, and the sagebrush sea: making and breaking connections for conservation and management. Department of Forestry & Environmental Conservation Seminar Series, Clemson University.

Haney, JC, J Gleason, PGR Jodice, PE Michael, KM Hixson, Y Satgé, RR Wilson. 2022. Research applications from GoMMAPPS wildlife surveys to offshore wind energy development in the Gulf of Mexico. Atlantic Marine Bird Cooperative Annual Meeting (virtual).

Hixson, KM^, Y Satgé^, J Gleason, PGR Jodice. 2022. The northern Gulf of Mexico seabird colony atlas and registry: a forthcoming resource. Atlantic Marine Bird Cooperative Annual Meeting (virtual).

Hixson, KM^, Y Satgé^, J Gleason, PGR. Jodice. 2022. An atlas and registry for seabird colonies and associated habitats in the northern Gulf of Mexico. Waterbird Society 45th Annual Meeting, Corpus Christi, Texas, USA.

Roche, M, J Saher, EK Buchholtz, M Crist, D Shinneman, C Aldridge, B Brussee, P Coates, C Roth, J Heinrichs. 2022. A Spatial Data Synthesis of Fuel Breaks in the Sagebrush Biome in Relation to Wildfire, Invasive Annual Grasses, and Sagebrush Obligate Wildlife. Oral presentation, North American Congress for Conservation Biology. Reno, NV.

Roche, M, J Saher, EK Buchholtz, M Crist, D Shinneman, C Aldridge, B Brussee, P Coates, C Roth, J Heinrichs. 2022. A spatial synthesis of fuel breaks in the sagebrush biome in relation to wildfire, invasive annual grasses, and Greater Sage-Grouse. Western Agencies 33rd Sage & Columbian Sharp-tailed Grouse workshop. Logan, UT.

Shyvers, JE, BC Tarbox, CJ Duchardt, AP Monroe, DR Edmunds, BS Robb, NJ Van Lanen, EK Buchholtz, JA Heinrichs, CL Aldridge. 2022. Optimizing conservation and restoration of imperiled sagebrush ecosystems to benefit multiple avian species. Oral Presentation. American Ornithological Society and BirdsCaribbean Ornithological Conference, Puerto Rico.

Shyvers, JE, BC Tarbox, CJ Duchardt, AP Monroe, DR Edmunds, BS Robb, NJ Van Lanen, EK Buchholtz, MS O'Donnell, ND Van Schmidt, JA Heinrichs, CL Aldridge. 2022. Optimizing conservation and restoration of imperiled sagebrush ecosystems to benefit multiple species. Lightning Talk. WAFWA - 33rd Sage and Columbian Sharp-tailed Grouse Workshop, Hybrid format, Logan, UT.

## SERVICE

L. Bower, Awards Committee, Clemson University, 2023-present.
E. Buchholtz, Councilor-at-Large, Executive Committee, International Association for Landscape Ecology – North America Chapter, 2023 – current.
E. Buchholtz, Associate Editor, Tropical Conservation Science Journal, 2020 – current.
P. Jodice, Graduate Coordinator, Dept. Forestry & Environmental Conservation, 2022 – current.
P. Jodice, Past Chair, World Seabird Union, 2022 – 2025.
P. Jodice, Steering Committee Member, Atlantic Marine Bird Cooperative, 2015 – present.
P. Jodice, Planning Committee Member, Cooperative Research Units All-Hands Meeting, 2022-2023
P. Jodice, Topic Editor, Frontiers in Marine Science, Special Issue Ecological and Behavioral Traits of Apex Predators in Oceanic Insular Ecosystems: Advances and Challenges in Research and Conservation
Y. Satgé, Co-Chair, BirdsCaribbean Seabird Working Group, 2020 – 2025.
Y. Satgé, Board Member, Environmental Protection in the Caribbean, 2021-2026.
Y. Satgé, Associate Editor, Journal of Caribbean Ornithology, 2023 – 2026.

## AWARDS AND HONORS

P. Jodice, USGS Special Achievement Award, March 2023 (All Hands Meeting Plenary Session)
P. Jodice, USGS Special Achievement Award, March 2023 (All Hands Meeting Planning Team)


USGS
science for a changing world


CLEMSON
UNIVERSITY


U.S.
FISH & WILDLIFE
SERVICE
DEPARTMENT OF THE INTERIOR


SOUTH CAROLINA
DEPARTMENT OF NATURAL RESOURCES


WILDLIFE MANAGEMENT INSTITUTE
WASHINGTON, D.C.