

South Carolina Cooperative Fish and Wildlife Research Unit

*Report of Activities
2007-2008*

*Cooperating Agencies
U.S. Geological Survey
South Carolina Department of
Natural Resources
Clemson University
Wildlife Management Institute*

*South Carolina Cooperative Fish
and Wildlife Research Unit
G27 Lehotsky Hall
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American Oystercatcher foraging in Cape Romain NWR (see pp 19 & 20)



Jim Woodruff Dam, Apalachicola River, FL (see pp 8 & 9)



White-tailed Tropicbird with geolocator, Exuma, Land and Sea Park, Bahamas (see P 24)



Black Skimmers at Crab Bank (see P 23)



Egg incubator for Florida striped bass (see P 12)



American eel near Wateree dam, SC

*USGS South Carolina
Cooperative Fish and Wildlife Research Unit*

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Cooperating Agencies

*US Geological Survey
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Clemson University
Wildlife Management Institute
US Fish and Wildlife Service*

*South Carolina Cooperative Fish and Wildlife Research Unit
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Chechessee Creek Club
Coastal Kayak Expeditions
Georgia Sea Turtle Center
Klienschmidt and Associates
Low Country Institute
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Old Tabby Links
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St. Catherine's Island Wildlife Survival Center
U.S. Golf Association

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Shawn Young (Isely)

Projects in Fisheries Science



**Jeff Isely and Guðrún Marteinsdóttir studying cod spawning
in an Iceland Fjord**

Spawning chronology of native and introduced striped bass in two Florida drainages

Principle Investigators: J. Jeffery Isely, SCCFWRU
Matthew Noad, M.S. student
Duration: December 2004 - May 2007
Funding Source: Georgia Department of Natural Resources
U.S. Fish and Wildlife Service
Project Location: Apalachicola and Ochlockonee Rivers, Florida and Georgia
Status: Completed

We investigated the potential for temperature to serve as a mechanism for maintenance of reproductive isolation in a sympatric population of Atlantic and Gulf striped bass in the Apalachicola and Ochlockonee rivers, Florida. Adult striped bass ($n=66$, mean weight = 8.3 kg, mean total length = 780.6 mm) were collected from February to May below JWLD, on the Apalachicola River, and below JBL on the Ochlockonee River, Florida. Ancestry (Gulf or Atlantic) of specimens was determined using three diagnostic microsatellite loci: *SB 20*, *SB 1021* and *SB 111*. There was no difference between mean dates of arrival for female striped bass between strains within years. The mean date of first arrival for either strain of striped bass differed between 2003 and 2005. A comparison of the mean arrival temperature for Atlantic and Gulf striped bass also showed no difference within years. It is possible that the genetic introgression of Atlantic alleles has been so great that any difference in spawning temperature preference between strains that might have existed historically has been lost. Additional genetic material will be collected to increase sample size and evaluate year-class effects.

Population size and passage efficiency of Alabama shad reaching Jim Woodruff Lock and Dam, Florida

Principle Investigators: J. Jeffery Isely, SCCFWRU
Travis Ingram, M.S. student
Duration: January 2006 - May 2007
Funding Source: Georgia Department of Natural Resources
Project Location: Apalachicola River, Florida
Status: Completed

Historically, the Apalachicola River supported large runs of anadromous fish. The creation of Lake Seminole and subsequent flow alterations to the system significantly altered population characteristics and species distributions. Currently, it is believed that Jim Woodruff Lock and Dam on the Apalachicola River serves as a significant barrier to migration of anadromous fishes. Researchers have documented the failure of the navigation lock to pass some fish, as well as spawning activity by Gulf sturgeon in the tailrace of the dam. In this study, we estimated the population size of migrating Alabama shad below JWLD in the Apalachicola River located in the central panhandle of Northwest Florida near the Georgia border using mark recapture and relative abundance techniques. The number of marked fish was adjusted for tag loss, emigration and mortality. The population size of migrating Alabama shad near JWLD was estimated at 26,029 (95% C.I. = 15,174 - 49,040) in 2005 and as 972 (95% C.I. = 270 - 9,720) in 2006. Due to the small sample size, a relative abundance method was used to independently estimate a population size of migrating Alabama shad near JWLD in 2006 at 7,757 (95% C.I. = 5,987 – 11,012). The current population size of Alabama shad reaching Jim Woodruff Lock and Dam is relatively small when compared to both current and historic estimates of American shad population size along the Atlantic coast. We also evaluated the effectiveness of the navigational lock at JWLD for upstream passage of Alabama shad using fixed-station telemetry. About 18% of Alabama shad implanted with sonic transmitters abandoned their spawning migration. Passage efficiency of the remaining study fish was 59%. We conclude that the navigational lock at JWLD can be effective in passing migrating Alabama shad.

Age, growth and fecundity of Alabama shad in the Apalachicola River, Florida

Principle Investigators: J. Jeffery Isely, SCCFWRU
Travis Ingram, M.S. student
Duration: January 2006 - May 2007
Funding Source: Georgia Department of Natural Resources
Project Location: Apalachicola River, Florida
Status: Completed

Age and growth of Alabama shad *Alosa alabamae* were estimated by examining scales and otoliths from 203 adult fish collected on their spawning run in the upper Apalachicola River from 2005 and 2006. Ages of Alabama shad ranged from 1 – 4 years. All sampled spawning males were between 1 and 3 years old, whereas females were 2 - 4 years of age. Scales and otoliths both gave similar age estimates. Although otoliths are the preferred aging structure, scales can be removed in the field without sacrificing the specimen. Age distributions from this study differed from those of previous studies for both males and females. Female Alabama shad, on average, were found to be larger than males at age 2 and age 3. Growth of male and female Alabama shad is best described by the equations: $L_t = 359.6 [1 - e^{-2.1712(t-0.3757)}]$ and $L_t = 389.5 [1 - e^{-2.3193(t-0.6424)}]$. Mean back-calculated lengths were similar to those of observed values for males and females. Alabama shad demonstrated a positive correlation of length to fecundity, with fecundity estimates ranging from 26,095 to 208,494 eggs per female. Fecundity estimates appeared similar to other studies from the Apalachicola River. Variations in fecundity estimates may be contributed to partial spawning. Gonosomatic indices of female shad ranged from 3.6 – 24.0. In contrast to earlier studies, no spawning marks were found on scales.

Age and growth of Lake Sturgeon in the Grasse River, New York

Principle Investigators: J. Jeffery Isely, SCCFWRU
Drew Trested, Klienschmidt
Duration: January 2007 - December 2008
Funding Source: Unfunded
Project Location: Massena, New York
Status: Ongoing

Age structure and growth rate of lake sturgeon, a species of interest on the Grasse River, NY, may provide insights on the effects of the recent environmental history on migratory fish populations. Numbers at age, once adjusted for mortality, can be used as an index of relative recruitment. The effect of environmental variables such as temperature and discharge on spawning success can then be modeled. Growth rate may be used as an indicator of relative environmental quality. The objective of this study is to develop growth models and age – length keys for lake sturgeon in the Grasse River, NY. Pectoral spines collected in 2006 and 2007, will be sectioned using a low-speed saw. The thin (<1 mm) transverse sections will be mounted to glass slides using thermal cement, polished, and examined under transmitted light using a dissecting microscope. The radius to each annual growth increment will be measured electronically. Length and back-calculated length at age tables will be constructed. The relationship between length and age will be modeled with a von Bertalanffy growth equation. Sex –specific differences in growth will be evaluated statistically using analysis of covariance.

A large volume Striped Bass egg incubation chamber: design and comparison with a traditional method

Principle Investigators: J. Jeffery Isely, SCCFWRU
Chris Harper, M.S. student
Duration: January 2007 - May 2009
Funding Source: Georgia Department of Natural Resources
Project Location: Richmond Hill, Georgia
Status: Ongoing

We conducted a comparative study of a new jar design (experimental chamber) with a standard egg incubation vessel (McDonald jar). Experimental chambers measured 0.4 m in diameter by 1.3 m in height and had a volume of 200 L. McDonald hatching jars measured 16 cm in diameter by 45 cm in height and had a volume of 6 L. Post-hatch survival was estimated at 48, 96 and 144 h. Stocking rates resulted in an average egg density of 21.9 eggs ml⁻¹ (range = 21.6 – 22.3) for McDonald jars and 10.9 eggs ml⁻¹ (range = 7.0 – 16.8) for experimental chambers. We were unable to detect an effect of container type on survival to 48, 96 or 144 h. At 144 h striped bass fry survival averaged 37.3% for McDonald jars and 34.2% for experimental chambers. Survival among replicates was significantly different. Survival of striped bass significantly decreased between 96 and 144 h. Mean survival among replicates ranged from 12.4 to 57.3%. We were unable to detect an effect of initial stocking density on survival. Experimental jars allow for incubation of a larger number of eggs in a much smaller space. As hatchery production is often limited by space or water supply, experimental chambers offer an alternative to extending spawning activities, thereby reducing manpower and cost. However, the increase in the number of eggs per rearing container does increase the risk associated with catastrophic loss of a production unit. We conclude the experimental chamber is suitable for striped bass egg incubation.

High-resolution stratigraphy at a North Carolina coastal drillhole

Principle Investigators: J. Jeffery Isely, SCCFWRU
Beth M. Wrege, Ph.D. student
Duration: August 2006 – May 2009
Funding Source: Unfunded
Project Location: Cherry Point Marine Corps Air Station, North Carolina
Status: Ongoing

Lithologic descriptions of continuous core interpreted in conjunction with borehole geophysical logs were used to establish high-resolution hydro- and geostatigraphic profiles and to determine thicknesses of hydrologic and geologic units at CR-622 in the coastal plain of North Carolina. Borehole geophysics was used to adjust the position of core loss within each cored interval, and to supplement lithology to determine the stratigraphy of missing segments of core. The normal section with generalized depths has been translated to a stratigraphic profile which includes the hydrologic units, the apparent geologic formations and photographs of the core representing the principle component found at that depth. The surficial aquifer has some small inclusion of clay, and is thinner here than anticipated. The Yorktown confining unit rests on an unconformity, distinguishing the aquifer from the aquitard and corresponding to the geologic units. Borehole geophysics identified this anomaly which might have otherwise been missed. The Pungo River aquifer immediately overlies the upper Castle Hayne confining unit. The Castle Hayne confining unit is comprised of the Pungo River Formation. In other areas of the Coastal Plain, the lower part of the Pungo River Formation is a confining unit on top of the River Bend Formation and separates the Pungo River aquifer from the upper Castle Hayne aquifer. The interpretation of borehole geophysical logs in conjunction with lithology developed from continuous core can be used to produce high-resolution hydro- and geostatigraphic profiles. A resulting hydrologic and stratigraphic column of the upper Cretaceous, Tertiary and Quaternary, showing a generalized relation between geologic and hydrologic units beneath Cherry Point Air Station is presented. Present are the Yorktown, Pungo River and Castle Hayne aquifers. The geologic units are Eocene – Castle Hayne, Miocene – Pungo River, Pliocene – Yorktown, Pleistocene – James City and Flanner Beach, and the topsoil is Holocene- undifferentiated. The Oligocene – River Bend Formation is absent, and unconformity exists between the Pungo River Formation and the Castle Hayne formation. Although some geophysical logs produce non-unique lithologic solutions, a complete normal stratigraphic profile may be obtained with the addition of continuous core. Curve characteristics within geophysical logs provide precise identification of transitional sequences and can be used to calibrate lithostratigraphy.

Age and growth of an invasive snail in two South Carolina drainages

Principle Investigators: J. Jeffery Isely, SCCFWRU
Beth Wrege, Ph.D. student
Duration: January 2007 – May 2009
Funding Source: Unfunded
Project Location: Clemson, South Carolina
Status: Ongoing

The Japanese mud snail *Bellamya japonica* is a large (>5 cm SL) invasive snail that can occur in great numbers. Recently, shells of this snail was documented in a windrow 0.25 m high and over 2 km long on the shores of Lake Marion, South Carolina. Although not well documented, anecdotal observations suggest the presence of the snail is widespread throughout the state. The snail was recently documented as the source of fouling inside the water intake pipes of Clemson University. This is the first record of an industrial impact of the species. We collected specimens of from two South Carolina reservoirs. Snails were frozen, weighed and separated from their shells and opercula. Shells and opercula were measured and annuli were enumerated. A growth model will be developed.

Projects in Wildlife & Ecological Sciences



Sandwich Terns on a shrimp trawler off Cape Romain

Spatial ecology of feral hogs in the Congaree National Park

Principle Investigators: Patrick Jodice, SCCFWRU
Brad Freibel, M.S. student
Duration: January 2005 to May 2007
Funding Source: Congaree National Park
Project Location: Congaree National Park
Status: Completed

Wild hogs (*Sus scrofa*) are a widespread exotic species throughout much of the U.S. To learn more about hog movement patterns and habitat use, hogs were radio-collared and tracked from April 2005 to November 2006 in Congaree National Park (CNP). Seven male and nine female hogs were monitored and their home ranges averaged 218.2 ± 42.9 ha and 194.1 ± 31.0 ha, respectively. These home ranges proved relatively small when compared to home range sizes in other populations of feral hogs. Habitat use was analyzed using USGS vegetation maps and polytomous logistic regression (PLR) models. Habitat use models were developed separately for males and females, as well as for all individuals pooled. In each case the final model indicated a positive relationship between hog use and some measure of oak abundance, suggesting the importance of oaks in CNP. It is important to understand the movement patterns and habitat use of hogs as their destructive nature can quickly decimate large areas and destroy native flora and fauna. The Congaree National Park encompasses the largest intact tract of old-growth hardwoods in the U.S. making hog management an important issue.

Provisioning and attendance behavior in Brown Pelicans

Principle Investigators: Patrick Jodice, SCCFWRU
Elena Sachs, M.S. student
Duration: May 2006 to December 2007
Funding Source: SCDNR
SCCFWRU
Project Location: Crab Bank and Deveaux Bank, South Carolina
Status: Completed

Colonial seabirds were first surveyed intermittently along the South Carolina coast in the 1940s and select species have been monitored annually since 1969. These surveys revealed a declining trend in nest counts of Brown Pelicans (*Pelecanus occidentalis*) and Royal Terns (*Sterna maxima*) within ca. the last decade. In 2006, the South Carolina Department of Natural Resources (SCDNR) limited public access to several offshore islands that have historically provided nesting grounds for Brown Pelicans and other beach-nesting birds. This afforded us the opportunity to collect data on provisioning behavior in the absence of human disturbance.

We examined parent and nestling behavior during early chick rearing in Brown Pelicans (*Pelecanus occidentalis*) nesting at a colony in Charleston Harbor, South Carolina during the 2006 breeding season. There were significant differences in the frequency of feeding, attendance, and chick aggression relative to chick age, although the pattern differed among behaviors. The rate of adult feeding, chick feeding and adult attendance all decreased with chick age while chick aggressive behavior peaked when chicks were ca. 21 d post-hatch. We found that nests with at least one juvenile parent had a lower average clutch size, hatch rate, and number of young that survived to 21 d than pairs with two adult parents. In addition to studying provisioning behavior, we also determined the proximate composition and energy density of seven species of marine forage fish that are potential prey items of Brown Pelicans and other seabirds on the coast of South Carolina. Some of these fish species are likely only available in the seabirds' diet as discarded bycatch from commercial shrimp operations. Proximate composition and energy density differed among the species of forage fish we examined. This suggests that piscivorous seabirds may experience differences in energy intake rates dependent upon prey availability. However, the range in energy density that we observed among species was relatively narrow and hence it appears that energy values in this region may be relatively stable among prey items during the seabird breeding season.

Foraging ecology of seabirds in relation to commercial shrimp trawler activity

Principle Investigators: Patrick Jodice, SCCFWRU
David Whittaker, SCDNR
Lisa Wickliffe, M.S. student

Duration: May 2006 to May 2008

Funding Source: SCDNR Cooperative Fisheries Program

Project Location: Nearshore waters of coastal SC

Status: Completed

The interactions between seabirds and commercial fisheries have received a great deal of management research attention during the past two decades. Primarily, research and management have focused on issues pertaining to bycatch related monitoring of seabirds and competition for forage fish between seabirds and commercial fisheries. Recently, attention has been called to the potential positive impacts bycatch can have on ship-following seabirds, i.e. the role of discarded bycatch in seabird diets. Studies from Europe indicate that tens of thousands of seabirds each year may be supported by discards from a single regional shrimp fishery, and that discards from commercial fisheries may have contributed to the increase in seabird abundance and distribution in the North Sea and Northeast Atlantic. However, similar studies are rare in the U.S.

We investigated the relative abundance and distribution of ship-following seabirds at shrimp trawlers during the seabird breeding season, determined the composition of bycatch, particularly items that are appropriately sized for capture by seabirds, and also measured the consumption fate of fish species collected as bycatch. Shrimp trawlers appeared to be a strong, local attractor for seabirds out to 30km from the nesting colonies. All of the four locally breeding seabird species (Brown Pelican, Laughing Gull, Royal Tern, Sandwich Tern) attended trawlers regularly, and the most generalist of these, laughing gulls, were the most abundant and frequently observed. Trawler activity, (i.e., phase of the trawler operations) was the factor which most affected the abundance in seabirds and spatial distributions varied from species to species. Brown pelicans consumed more discards than predicted based on their frequency while the other three seabirds each consumed fewer discards than predicted based on their frequency. Seabirds selected smaller discard items compared to larger items, and selected benthic fish (i.e., drum species) that typically would not be available to this suite of seabirds. Approximately 70% of the discarded bycatch in experiments was consumed by seabirds, suggesting that bycatch possibly makes up a large part of their diet at certain times of year (i.e., breeding months). Our findings suggest that laughing gulls may be affected most strongly by the availability of additional food via discarded bycatch but that royal and sandwich terns, as well as brown pelicans, forage at trawlers frequently enough that changes in the size of the shrimp fleet would have the potential to affect their foraging ecology as well.

Breeding and foraging ecology of American Oystercatchers in the Cape Romain Region, South Carolina

Principle Investigators: Patrick Jodice, SCCFWRU
Felicia Sanders, SCDNR
Janet Thibault, M.S. student

Duration: August 2005 to December 2007

Funding Source: National Fish & Wildlife Foundation, Savannah Santee PeeDee Restoration Fund
U.S. Geological Survey Cooperative Research Units
South Carolina Department of Natural Resources
Clemson University Department of Forestry and Natural Resources
USFWS Cape Romain National Wildlife Refuge

Project Location: Cape Romain National Wildlife Refuge, SC

Status: Completed

South Carolina supports a substantial proportion of the eastern race of American Oystercatchers, and over half of the breeding population of oystercatchers in South Carolina nest within the Cape Romain Region. The majority of oystercatchers nest on shell rakes along the Atlantic Intracoastal Waterway (AICW). Disturbance from boat traffic, storm overwash and predation of nests by mammals from the mainland are suspected causes of nest failure along the AICW. In contrast, Oystercatchers that nest in Bulls Bay, which is farther from the mainland and relatively devoid of boat traffic during the nesting season, appear to achieve higher rates of reproductive success. To date, however, quantitative data for reproductive success and reasons for failure are not available in the Cape Romain Region.

We compared reproductive success of American Oystercatchers nesting along the AICW with those nesting on naturally formed shell mounds in Bulls Bay during the breeding seasons of 2006 and 2007. We identified timing and causes of nest failure and attributes of re-nesting. Hatching success (15%) and productivity estimates (0.25 chicks per pair) were low and variable between locations and between years. Productivity of oystercatchers nesting in Bulls Bay was greater compared to those nesting along the AICW. More nests hatched and more young fledged in 2006 compared to 2007. Overwash was the primary cause of nest loss (59%) followed by predation (14%). Birds re-nested frequently after nest failure.

We also examined attributes of foraging oystercatchers during the breeding season. We compared percentage of time parent oystercatchers were absent from the nest territory during low-tide foraging periods for birds nesting along the AICW with those nesting in Bulls Bay. Parents in Bulls Bay attended the nest site more frequently and fledged more chicks than parent oystercatchers nesting along the AICW. We also examined attributes of oystercatcher foraging ecology at two primary oyster reefs within the Region. More oystercatchers were observed foraging in Bulls Bay than in Sewee Bay and eastern oysters (*Crassostrea virginica*) were the primary diet item consumed during the breeding season.

Wintering ecology of American Oystercatchers in the Cape Romain Region, South Carolina

Principle Investigators: Patrick Jodice, SCCFWRU
Felicia Sanders, SCDNR
Christy Hand, M.S. student

Duration: September 2006 to August 2008

Funding Source: The National Fish and Wildlife Foundation, Savannah-Santee-Pee
Dee Resource Protection Fund
U.S. Geological Survey Cooperative Research Units
South Carolina Department of Natural Resources
Clemson University Department of Forestry and Natural Resources
USFWS Cape Romain National Wildlife Refuge

Project Location: Cape Romain National Wildlife Refuge

Status: Completed

The Cape Romain region (CRR), which encompasses the coast of South Carolina from the northern boundaries of the Cape Romain National Wildlife Refuge to Dewees Inlet, is an important wintering area for both resident and non-resident American oystercatchers (*Haematopus palliatus*). During the nonbreeding season, the CRR supports ca. one-sixth of the total population of the eastern race (*palliatus*) of the American Oystercatcher. This study was initiated because little is known about oystercatcher foraging ecology during the non-breeding season. Our objectives were to determine (1) if the quality of foraging habitat for adult oystercatchers differed among bays in the CRR and (2) if immature oystercatchers were less proficient at foraging compared to adults.

Focal observations of oystercatchers were collected in Bulls Bay, Sewee Bay, and Copahee Sound during the fall/winter of 2006/2007 and 2007/2008. During each day of sampling, we identified prey items as they were consumed by oystercatchers, estimated the size of the prey items, and timed the foraging behaviors of randomly selected oystercatchers in each bay and age class. We also measured the density, length, and spatial orientation of oysters in Bulls Bay and in Copahee Sound during November, 2007. Results indicated that prey size, prey orientation, and the foraging behaviors of American Oystercatchers differed among bays. Although American Oystercatchers appeared to have lower rates of energy intake in Bulls Bay compared to Sewee Bay and Copahee Sound, adult American Oystercatchers may have foraged in Bulls Bay during the nonbreeding season in order to occupy nesting territories, which existed in Bulls Bay but not in Sewee Bay or Copahee Sound. Copahee Sound and Sewee Bay appear to be important foraging areas for American Oystercatchers during the nonbreeding season, whereas Bulls Bay appears to be important to American Oystercatchers year-round. We also found that although the amount of time devoted to specific foraging behaviors differed among age-classes, immature American Oystercatchers were able to achieve equivalent feeding rates compared to adults. The abundance of prey in Copahee Sound may have allowed immature oystercatchers to compensate for their slightly inferior prey handling skills compared to adults. This research highlights the importance of specific bays in the CRR for wintering foraging activities.

Carolina Bogmint at Congaree National Park: distribution, mapping, and population status assessment

Principle Investigators: Craig R. Allen, NCFWRU, University of Nebraska, Lincoln, NE
(formerly Unit Leader of the SCCFWRU)
Joan Walker, USFS
Kate Manry, Ph.D. Student

Duration: January 2004 - December 2008

Funding Source: National Park Service

Project Location: Congaree National Park

Status: Ongoing

Carolina bogmint (*Macbridea caroliniana*) is a rare herbaceous mint occurring in swamp forests of mainly blackwater floodplains of the Carolinas and Georgia. The species is listed federally by the U.S. Fish and Wildlife Service and by the state of South Carolina as a species of concern. Understanding the genetic diversity found within populations of a rare species, and how genetic diversity is partitioned within and among populations, is important for conservation management decisions. Although a variety of molecular techniques are available to examine genetic variation within plant species, allozymes are often the method of choice because they are efficient and cost-effective

The objectives of this research are to: (1) describe allozyme diversity within and among populations of *M. caroliniana*; (2) compare its genetic diversity with related plants and those with similar life history traits; (3) assign conservation priorities based on genetic diversity values; and (4) make recommendations for conservation strategies based on the results.

We sampled leaves from 30-48 individuals from 11 populations across the range of the species. We resolved 12 enzyme systems and 23 loci using starch gel electrophoresis. The *M. caroliniana* populations located near the center of the species range generally exhibited the highest levels of genetic variability while many of the lowest levels of genetic diversity were found in populations on the edge of the range. We found a high degree of population differentiation and attributed most of the variation among populations to a their distribution among various watersheds. *M. caroliniana* has a much larger range than its only congener, *M. alba*, and greater genetic diversity values. The most highly ranked populations for conservation priority were Savannah River Site, Howell Woods, Aiken State Park and both populations at the Congaree National Park. If only these five highest ranking populations are protected, 90% (40 out of 44) of the total number of alleles would be captured from the 11 populations sampled. The five populations ranking the lowest in our assessment are very small with < 100 stems observed.

Roosting and foraging requirements of Rafinesque's big-eared bats in Congaree National Park

Principle Investigators: Susan Loeb, USFS
Patrick Jodice, SCCFWRU
Jessica Lucas, M.S. student
Duration: January 2006 to December 2008
Funding Source: National Park Service, USFS
Project Location: Congaree National Park
Status: Ongoing

The Rafinesque big-eared bat (*Corynorhinus rafinesquii*) is considered rare throughout its range and may be extirpated in Indiana and Ohio. In South Carolina, the species is considered endangered by the South Carolina Department of Natural Resources. Because roost structures are one of the most critical resources for bats, knowledge and understanding of roost requirements are critical for developing effective bat management and conservation policies.

The objectives for this project were to determine roost tree characteristics of Rafinesque's big-eared bats in the Congaree National Park and to determine foraging habitat requirements. In 2006-2007 (May-August), Rafinesque's big-eared bats were tagged with radiotransmitters. We located 43 roost trees (13 maternity, 30 non-maternity) from radiotagged bats and tree searches. Visual confirmation was made for all roosts.

Number of roosts per individual ranged from 1 to 7. Bats showed strong selection for tupelo (*Nyssa* sp.), particularly water tupelo *N. aquatica*. Half of the roosts used by maternity colonies were in basal cavities and the other half were in cavities with entrances in the upper bole. In contrast, the majority (73%) of roosts used by solitary individuals were in basal cavities. Both maternity colonies and solitary individuals selected large diameter trees. Maternity roost trees were taller than random trees although roost trees used by solitary individuals were not. All but one of the roost trees were located in cypress-tupelo forest types. Our data suggest that old-growth bottomland hardwood forests provide important habitat features for Rafinesque's big-eared bats. Further, trees with upper bole openings may be particularly important for successful reproduction.

Conservation and physiological ecology of seabirds in South Carolina

Principle Investigators: Patrick Jodice, SCCFWRU
Lisa Ferguson, Ph.D. student
Duration: May 2006 to December 2009
Funding Source: SCDNR
Project Location: Crab Bank, Deveaux Bank, Bird Key Stono South Carolina
Status: Ongoing

Seabirds nest in colonies on approximately nine islands along the coast of South Carolina. One of the main challenges faced by managers at these colonies is preventing disturbance to breeding seabirds caused by island visitors. Human disturbance can have numerous effects on breeding seabirds and their young. In response to disturbance in or near nesting areas entire colonies of seabirds may leave their nests and thereby expose their eggs or young to lethal temperatures and potential predators. Human disturbance is one of several factors that may be contributing to a recent statewide decline in reproductive effort of Brown Pelicans (*Pelecanus occidentalis*) and Royal Terns (*Sterna maxima*). Prior to the 2006 breeding season, SCDNR enacted new management regulations to limit public access at three nesting island and thereby reduce human activity near colonies. These new regulations provide additional protection to essential components of seabird breeding habitat including areas used for nesting, loafing, and feeding young.

The purpose of this study is to monitor seabird colonies on protected state islands and collect baseline measures of breeding parameters to better evaluate breeding performance of seabird populations. This will be accomplished using the following objectives: (1) survey intertidal habitat use by seabirds during the breeding season (2) measure reproductive and behavioral parameters of seabirds, and (3) determine condition and health of nestling seabirds. The main species of concern in this study are Brown Pelicans, Royal Terns, Sandwich Terns (*Sterna sandvicensis*), and Black Skimmers (*Rynchops niger*). Field work was initiated in 2006 and will be completed during the fall of 2008.

Health and large-scale movements of Bahamian seabirds

Principle Investigators: Patrick Jodice, SCCFWRU
Will Mackin, Elon University
Jennifer Arnold, Penn State University
Tom Barbernitz, Bahamas National Trust

Duration: January 2008 to December 2009

Funding Source: USFWS

Project Location: Exuma Islands, Bahamas

Status: Ongoing

Specific aspects of the ecology and behavior of seabirds make them particularly vulnerable to coming into contact with, carrying, or transmitting avian influenza (AI). For example, most seabirds range widely during the annual cycle and ‘wander’ extensively prior to reaching breeding age. These wide-ranging movements provide opportunities for contact with individuals and species from multiple ocean basins. Many seabirds breed in dense colonies which afford ample opportunities for transmission of viruses and diseases. Seabirds also form large foraging flocks and certain species (e.g., gulls) frequently come into contact with anthropogenic food sources.

The Bahamas are an important region for AI surveillance because of their proximity to the mainland of the United States. Seabirds breeding there move through the Caribbean Basin, the Gulf of Mexico, the South Atlantic Bight, and the western edge of the Gulf Stream. Prebreeding or wintering seabirds from the eastern and northern Atlantic, Mediterranean, Africa, and South America use some of the same foraging areas frequented by Caribbean seabirds. Hence ample opportunities exist for overlap of seabirds on a hemispheric scale and breeders from the Caribbean present an opportunity to capture some of that overlap.

During the period May – July 2008 we collected 93 AI samples from various colonies in the Exuma Cays, Bahamas. Samples were collected from Audubon’s Shearwater, White-tailed Tropicbird, Sooty Tern, Bridled Tern, and Brown Noddy. Samples were sent to the National Wildlife Health Lab in Madison, WI, and are now part of the Highly Pathogenic Avian Influenza Early Detection Data System (HEDDS) database <http://wildlifedisease.nbio.gov/ai/>. No positive cases of H5N1 AI were detected.

We also attached geolocators to 11 Audubon’s Shearwaters and 13 White-tailed Tropicbirds. Geolocators are small (2-3 g) devices that estimate location based on ambient light levels and also record salt-water immersion; hence time foraging at sea also can be estimated. The devices we used were provided by the British Antarctic Survey. These are the first efforts to deploy geolocators on these species or in The Bahamas. We recovered 2 geolocators from Audubon’s Shearwaters in early July. A preliminary assessment of these data suggests that these two brood-rearing shearwaters may have been engaging in a combination of long and short foraging trips as estimated from the proportion of time spent at-sea. Colonies will be revisited in 2009 in an attempt to retrieve the remaining geolocators.

Reproductive success of Painted Buntings on golf courses in South Carolina

Principle Investigators: Patrick Jodice, SCCFWRU
Laurel Barnhill, SCDNR
Chris Marsh, Low Country Institute
Duration: January 2008 to December 2010
Funding Source: National Fish and Wildlife Foundation
Project Location: Golf courses in Beaufort County
Status: Ongoing

Little research has been conducted on Painted Bunting nesting ecology. Nonetheless, a major portion of the species breeding range is now in habitat dominated by anthropogenic alteration. For example, data from survey efforts show that many buntings inhabit urban and agricultural landscapes in the northern coastal and southern and central inland portions of their range. Within the coastal counties of SC, golf courses and golf course communities are common and becoming more prevalent. This region was historically characterized by a mix of forest, agricultural land, and rural communities. The coastal counties are now characterized by a highly developed urban matrix with large parcels of isolated green space comprised of golf courses.

We are seeking to assess the potential conservation value of golf courses in the Beaufort County area of SC for Painted Buntings. Our goal is to develop habitat management guidelines for breeding Painted Buntings in the Carolinas. The objectives are to: (1) Locate nests of painted Buntings during two breeding seasons via nest searching and telemetry on golf courses, (2) measure various metrics of reproductive success (clutch size, daily nest survival, hatching success, brood size at fledging) and compare among study sites, (3) measure various metrics of nesting habitat at the nest, patch, and territory scale (e.g. nest substrate and height, distance to edges, canopy cover, shrub density) and relate to reproductive success, and (4) determine use of grass, out of play areas for foraging by Painted Buntings and compare availability among courses. Pilot research was conducted in 2008 with the initiation of field research planned for 2009.

Habitat use and home ranges of migratory and resident wintering Canada Geese in the Santee-PeeDee System

Principle Investigators: Patrick Jodice, SCCFWRU
Buddy Baker, SCDNR
Marc Epstein, USFWS
John Stanton, USFWS
Molly Giles, M.S. student
Duration: January 2008 to May 2010
Funding Source: SCDNR, USFWS
Project Location: Santee National Wildlife Refuge
Status: Initiation

Historically, the Canada Goose (*Branta Canadensis*) was a common winter migrant to SC, occurring in a variety of locations across the state. However, the wintering population of migratory geese in the state has declined in recent years. Counts of Canada geese observed in SC during the US Fish and Wildlife Service (FWS) mid-winter waterfowl survey declined by ca. 97% between 1964 and 2002 (from 44,400 to 1,500). These declines have occurred despite overall increases in the Atlantic Flyway Population of Canada geese. The most commonly accepted explanation for the regional decline is the “short-stopping” of geese in the northern parts of the flyway.

The population of migratory Canada geese that winter in SC originates from the breeding population in St. James Bay, Canada. Wintering populations of these geese in SC are thought to be a unique subpopulation in the Atlantic Flyway. They occur predominantly on the Santee National Wildlife Refuge (NWR). The number of Canada geese wintering at the Santee NWR has, however, declined along with the decline in state counts.

The goal of the proposed research is to examine the wintering ecology of a unique subpopulation of migratory Canada geese in the Santee NWR region. The objectives are to: (1) determine the wintering distribution of migratory Canada Geese in and adjacent to the Santee NWR, (2) measure individual movement patterns and home ranges of migratory Canada Geese in and adjacent to the Santee NWR, (3) compare habitat use of migratory and resident Canada Geese in and adjacent to the Santee NWR, and (4) assess the potential impact of land use changes on wintering populations of migratory Canada Geese in the Santee Cooper Lakes focus area. The project will contribute to the assessment of Southern James Bay Canada geese wintering in the Atlantic Flyway. Ultimately, managers and biologists will be able to use these data to make informed decisions and provide guidance to local governments, community planners, and developers on habitat management efforts for this unique subpopulation of migratory geese. Field research will begin in October 2008.

Peer Reviewed Publications:

Eggert, L.M.F., and P.G.R. Jodice. 2008. Growth of Brown Pelican nestlings exposed to sublethal levels of soft tick infestation. *Condor* 110:134-142.

Ely, P., S.P. Young, and J.J. Isely. 2008. Population size and relative abundance of Alabama shad reaching Jim Woodruff Lock and Dam, Apalachicola River, Florida. *North American Journal of Fisheries Management* 28:827–831.

Eversole, A.G., W.D. Anderson, and J.J. Isely. 2008. Age and growth of the knobbed whelk *Busycon carica* (Gmelin 1791) in South Carolina subtidal waters. *Journal of Shellfish Research* 24:423-426.

Friebel, B.A., and P.G.R. Jodice. In Press. Home range and habitat use of wild hogs in the Congaree National Park, South Carolina. *Human-Wildlife Conflicts*.

Grabowski, T.B., and J.J. Isely. 2007. Spatial and temporal segregation of spawning habitat by catostomids in the Savannah River, Georgia and South Carolina, U.S.A. *Journal of Fish Biology* 70:782–787.

Grabowski, T.B., and J.J. Isely. 2007. Effects of flow fluctuations on riverine fish spawning habitat. *Southeastern Naturalist* 6:471-478.

Grabowski, T.B., and J.J. Isely. 2008. Size of spawning population, residence time, and territory shifts of individuals in the spawning aggregation of a riverine catostomid. *Southeastern Naturalist* 7:475-482.

Grabowski, T.B., N.L. Ratterman, and J.J. Isely. 2008. Demographics of the spawning aggregations of four catostomid species in the Savannah River, South Carolina and Georgia. *Ecology of Freshwater Fish* 17:318–327.

Isely, J.J., and T.B. Grabowski. 2007. Age and growth. Pages 187-228 in M. L. Brown and C. S. Guy, editors. *Analysis and interpretation of freshwater fisheries data*. American Fisheries Society, Bethesda, Maryland.

Jodice, P.G.R., T.M. Murphy, F. J. Sanders, and L. Ferguson. 2007. Longterm Trends in Nest Counts of Colonial Nesting Seabirds in South Carolina, USA. *Waterbirds* 30:40-51.

Jodice, P.G.R., D.D. Roby, K.R. Turco, R.M. Suryan, D.B. Irons, J.F. Piatt, M.T. Shultz, D.G. Roseneau, and A.B. Kettle. In Press. Growth rates of Black-legged Kittiwake chicks in relation to delivery rate, size and energy density of meals. *Marine Ornithology*.

Young, S. P., and J.J. Isely. 2007. Summer diel behavior of striped bass using tailwater habitat as summer refuge. *Transactions of the American Fisheries Society* 136:1104-1112.

Presentations at Scientific Meetings:

Invited Seminars

Jodice, P.G.R. 2007. Energy expenditure, diet quality, and reproductive performance in piscivorous seabirds: assessing the nutritional stress and junk-food hypotheses. University of Georgia Warnell School of Forestry and Natural Resources Seminar Series, Athens, GA.

Jodice, P.G.R., L.M. Ferguson, F.I. Sanders, E. Sachs, J. Thibault, L. Wickliffe, and J. Stuckey. 2006. What factors are limiting seabirds and shorebirds in South Carolina? The role of physiological and behavioral ecology to investigate population trends. Fort Johnson Marine Science Center Seminar Series, Charleston, SC.

Invited Presentations

Jodice, P.G.R. 2008. Considerations for developing long-term monitoring plans for beach-nesting seabirds. Southeastern Seabird Working Group Annual Meeting, Charleston, SC.

Jodice, P.G.R., K. Meehan. 2007. Landscape level correlates of fox squirrel presence on golf courses in coastal South Carolina. National Fish and Wildlife Foundation, Wildlife Links Program Meeting, Washington D.C.

Contributed Papers / Presentations / Posters

Berger J., J. Stuckey, J. Pangello, J. EuDaly, T. Scott, K. Bryant, D.E. Keil, P.G.R. Jodice, and M.M. Peden-Adams. 2007. Immunological alterations in chicks following in ovo exposure to perfluorooctane sulfonate (PFOS). Society of Toxicology Annual Meeting, Charlotte, NC.

Duncan, M., B.M. Wrege, and J.J. Isely. 2008. Movement and habitat use by Gulf of Mexico sturgeon in Pensacola and Escambia Bays, Florida. 138th Annual Meeting of the American Fisheries Society. Ottawa, Canada.

Eggert, L.M.F., and P.G.R. Jodice. 2007. Seabird research on protected islands in South Carolina. Shorebird conservation workshop, Huntington Beach State Park, SC.

Eggert, L.M.F., and P.G.R. Jodice. 2008. Parasitized Brown Pelican nestlings have increased rates of growth at sublethal levels of infestation. American Ornithological Union Annual Meeting, Portland, OR.

Eggert, L.M.F., P.G.R. Jodice, and T. Norton. 2008. Health assessments of Brown Pelican nestlings at colonies in South Carolina and Georgia. Southeastern Seabird Working Group Annual Meeting, Charleston, SC.

Eggert, L.M.F., P.G.R. Jodice, and T. Norton. 2008. Health assessments of Brown Pelican nestlings. Pacific Seabird Group Annual Meeting, Blaine, WA [Poster].

Ely, P.C., and J.J. Isely. 2007. Population size and passage efficiency of Alabama shad reaching Jim Woodruff Lock and Dam. South Carolina Fisheries Workers and Georgia Chapter American Fisheries Society joint meeting, Tybee Island, GA.

Ely, P.C., and J.J. Isely. 2007. Population size and passage efficiency of Alabama shad reaching Jim Woodruff Lock and Dam. 25th Annual *Morone* Workshop, Albany, GA.

Ely, P.C., and J. J. Isely. 2008. Population size and passage of spawning Alabama shad reaching Jim Woodruff Lock and Dam, FL. South Carolina Fisheries Workers and South Carolina Chapter American Fisheries Society Annual Meeting, Santee, SC.

Ely, P.C., and J.J. Isely. 2008. Population size and passage of spawning Alabama shad reaching Jim Woodruff Lock and Dam, FL. Georgia Chapter American Fisheries Society Annual Meeting, Eatonton, GA.

Hand, C., P.G.R. Jodice, and F.J. Sanders. 2007. Foraging ecology of wintering American Oystercatchers in the Cape Romain Region. American Oystercatcher Working Group, Ocracoke, NC.

Hand, C., P.G.R. Jodice, and F.J. Sanders. 2008. Research on the half shell: diet composition of American Oystercatchers during the nonbreeding season. Wilson Ornithological Society Annual Meeting, Mobile, AL [Poster]

Ingram, T.R., P.C. Ely, and J.J. Isely. 2008. Passage and population dynamics of Alabama shad in the Apalachicola River, Florida. Spring Meeting Southern Division of the American Fisheries Society. Wheeling, WV.

Ingram, T.R., and J.J. Isely. 2007. Age, growth and fecundity of Alabama shad in the Apalachicola River, Florida. 25th Annual *Morone* Workshop, Albany, GA.

Ingram, T.R., and J.J. Isely. 2007. Age, growth and fecundity of Alabama shad in the Apalachicola River, Florida. South Carolina Fisheries Workers and Georgia Chapter American Fisheries Society joint meeting, Tybee Island, GA.

Ingram, T.R., and J.J. Isely. 2008. Age, growth and fecundity of Alabama shad in the Apalachicola River, Florida. Georgia Chapter American Fisheries Society Annual Meeting, Eatonton, GA.

Isely, J.J., P.C. Ely, M. Noad, B.M. Wrege, and S.P. Young. 2008. Movement and population dynamics of anadromous fishes near Jim Woodruff Lock and Dam. 26th Annual *Morone* Workshop, Apalachicola, FL.

Isely, J.J., P.C. Ely, M. Noad, B.M. Wrege, and S.P. Young. 2008. Movement and population dynamics of anadromous fishes near Jim Woodruff Lock and Dam. Gulf States Marine Fisheries Commission Anadromous Fish Working Group Meeting, Apalachicola, FL.

Isely, J.J., and C.J. Harper. 2008. Effect of container size on survival of striped bass eggs and larvae. 32nd Larval Fish Conference, Kiel, Germany.

Jodice, P.G.R., D.M. Epperson, and G.H. Visser. 2007. Daily energy expenditure in free-ranging gopher tortoises: first measures and a comparison with other chelonians. South Carolina Herpetology Conference, Columbia, SC.

Keil D.E., J. Stuckey, J.G. EuDaly, A.M. Lee, J. Pangello, J. Berger, P.G.R. Jodice, T.R. Scott, and M.M. Peden-Adams. 2007. Effects of PFOS on developmental immune function in rodent and avian models. Perfluoroalkyl Acids and Related Chemistries: Toxicokinetics and Mode-of-Action Workshop. Society of Toxicology – Current Concepts in Toxicology. Arlington, VA

Lucas, J.S., S. Loeb, and P.G.R. Jodice. 2007. Characteristics of Rafinesque's Big-eared Bats tree roosts in Congaree National Park. Southeastern Mammal Colloquium, Destin, FL

Noad, M.A., and J.J. Isely. 2007. Spawning chronology of native and introduced striped bass in two Gulf of Mexico drainages. South Carolina Fisheries Workers and Georgia Chapter American Fisheries Society joint meeting, Tybee Island, GA.

Noad, M.A., and J.J. Isely. 2007. Spawning chronology of native and introduced striped bass in two Gulf of Mexico drainages. 25th Annual *Morone* Workshop, Albany, GA.

Sachs, E.B., and P.G.R. Jodice. 2007. Provisioning behavior in Brown Pelicans, South Carolina Chapter of the Wildlife Society, Columbia, SC.

Sachs, E.B., L. Wickliffe, and P.G.R. Jodice. 2007. Brown Pelicans (*Pelecanus occidentalis*): provisioning and prey quality in South Carolina. Shorebird conservation workshop, Huntington Beach State Park, SC.

Stuckey J., K. Bryant, J. Pangello, J. Berger, J. EuDaly, D.E. Keil, P.G.R. Jodice, and M.M. Peden-Adams. 2007. Immunological alterations in chicks following in ovo exposure to a brominated flame retardent mixture: DE-71. Society of Toxicology Annual Meeting, Charlotte, NC.

Thibault, J., C. Hand, and P.G.R. Jodice. 2007. American Oystercatcher breeding and feeding: nesting success and foraging ecology in South Carolina. Shorebird conservation workshop, Huntington Beach State Park, SC.

Thibault, J., and P.G.R. Jodice. 2007. Reproductive success of American Oystercatchers in South Carolina. American Oystercatcher Working Group, Ocracoke, NC.

Wickliffe, L., and P.G.R. Jodice. 2008. Seabird use of bycatch from shrimp trawlers. Southeastern Seabird Working Group Annual Meeting, Charleston, SC.

Wrege, B.M., P.C. Ely, and J.J. Isely. 2008. Acoustic tracking and passage of anadromous fish at Jim Woodruff Dam, Florida, USA. International Symposium on Advances in Fish Tagging and Marking Technology. Auckland, New Zealand.

Graduate Theses and Dissertations, Clemson University:

Friebel, B.A. 2007. Home range and habitat use of feral hogs in Congaree National Park. M.S. Degree Wildlife and Fisheries Biology, Department of Forestry and Natural Resources.

Hand, C. 2008. Foraging ecology of American Oystercatchers during the nonbreeding season. M.S. Degree Wildlife and Fisheries Biology, Department of Forestry and Natural Resources.

Ely, P.C. 2007. Population size and passage efficiency of Alabama shad reaching Jim Woodruff Lock and Dam. M.S. Degree Wildlife and Fisheries Biology, Department of Forestry and Natural Resources.

Ingram, T.R. 2007. Age, growth and fecundity of Alabama shad in the Apalachicola River, Florida. M.S. Degree Wildlife and Fisheries Biology, Department of Forestry and Natural Resources.

Noad, M.N. 2007. Spawning chronology of native and introduced striped bass in two Gulf of Mexico drainages. M.S. Degree Wildlife and Fisheries Biology, Department of Forestry and Natural Resources.

Sachs, E.B. 2007. Provisioning behavior and prey quality in Brown Pelicans. M.S. Degree Wildlife and Fisheries Biology, Department of Forestry and Natural Resources.

Thibault, J.M. 2008. Nesting and foraging ecology of American Oystercatchers in the Cape Romain Region, South Carolina. M.S. Degree Wildlife and Fisheries Biology, Department of Forestry and Natural Resources.

Wickliffe, L. 2008. Foraging ecology of seabirds in relation to commercial shrimp trawler activity. M.S. Degree Wildlife and Fisheries Biology, Department of Forestry and Natural Resources.

Wrege, B.M. 2007. High-resolution stratigraphy at a coastal drillhole determined from a continuous core profile and a borehole geophysical log. M.S. Degree Wildlife and Fisheries Biology, Department of Forestry and Natural Resources.

Teaching:

Jeff Isely

WFB840 Fish Management, Summer 2008, 3 credits

WFB861 Fish Ecology, Spring 2007, 3 credits

WFB863 Fish Age and Growth, Spring 2007, 2 credits

Patrick Jodice

WFB 863, Avian Survival Modeling, Spring 2007, 3 credits

WFB 861, Foundations of Ecology, Fall 2007, 3 credits

Graduate Committee Service:

Patrick Jodice

Kathleen Clancy, Dept. Biology, M.S., College of Charleston

Chris Chumbley, Dept. Forestry & Natural Resources, M.S., Clemson University

Amanda Hackney, Dept. Forestry & Natural Resources, M.S., Clemson University

Adam Kelley, Dept. Forestry & Natural Resources, M.S., Clemson University

Stacy Stefan, Environmental Studies Program, M.S., College of Charleston

Jenn Thompsen, Dept. Forestry & Natural Resources, M.S., Clemson University

Michael Waller, Dept. Forestry & Natural Resources, M.S., Clemson University

Professional and Faculty Service:

Jeff Isely

Member, Robust Redhorse Conservation Committee

Member, SACS Assessment Committee for the Ph.D. Degree Program in WFB

Faculty Advisor, Clemson Student Subunit of the American Fisheries Society

Faculty Advisor and Coach, Clemson Offshore Fishing Team

Member, Annual Meeting Oversight Committee, American Fisheries Society

Patrick Jodice

Member, Organizing Committee, First World Seabird Conference

Member and Co-Founder, Southeastern Seabird Working Group

Founder and Facilitator, Dept. Forestry and Natural Resources Seminar, Clemson University

Member, Atlantic Marine Bird Conservation Cooperative

Publication Committee Chair, Pacific Seabird Group

Student Paper Judge, 2007 Pacific Seabird Group Annual Meeting

Professional Awards:

Jeff Isely

Headquarter's Diversity Award, US Geological Survey, 2007

Clemson University Board of Directors Outstanding Achievement Award, 2007

Patrick Jodice

Clemson University Award for Faculty Excellence, 2007

Graduate Student Awards

Lisa Ferguson Eggert, Graduate Student Travel Award, Pacific Seabird Group, 2008

Christy Hand, Graduate Student Travel Award, Clemson University, 2008

Lisa Ferguson Eggert, Wade Stackhouse Fellowship, 2007-2008

Jessica Lucas, Marion Bailey Assistantship for Research in National Parks, 2007-2008

Beth Wrege, University Fellowship recipient, Clemson University, Graduate School, 2008