A Comprehensive List of SCCF Research
April 2020

SHOREBIRDS

Publications

Faillace, C.A., and **B.W. Smith**. **2016**. Incubating Snowy Plovers (*Charadrius nivosus*) exhibit site-specific patterns of disturbance from human activities. Wildlife Research. https://doi.org/10.1071/WR15194.

Many shorebirds are threatened by human-caused disturbance. For snowy plovers, disturbance within nesting habitats has been implicated as a major contributing factor in their population decline through deleterious effects on breeding success. Very little is known about site specificity of disturbance from human activities for this species. We examined the disturbance of incubating snowy plovers to determine if nesting shorebirds within one breeding population exhibited site-specific patterns of disturbance from human activities. We recorded flush (i.e. flight or escape from a perceived threat) distances and time spent off the nest following approach by a single person on Sanibel and Cayo Costa Islands, two islands in south-west Florida that differ in daily human visitation, and by a person walking a dog on Sanibel. We used a Bayesian model framework to determine effects of location and approach type on flush distance and time spent off of the nest. Birds nesting on Sanibel flushed at shorter distances from a solitary person without a dog than did birds nesting on Cayo Costa, but spent similar amounts of time off of nests following a flush. On Sanibel, nesting birds also flushed at significantly greater distances and spent significantly more time off of nests when flushed by a person walking a dog rather than by a person alone. Within a population, nesting snowy plovers exhibit site- and stimulus-dependent patterns of disturbance. The intraspecific variation falls within the range of variation recorded among species of birds studied elsewhere. Although we cannot determine causation, we suggest habituation to human activities from a combination of high beach usage, smaller nesting exclusion zones, and narrower beach width on Sanibel compared to Cayo Costa as a likely explanation for this difference. Set-back distances for symbolic fencing have been generalised across species and nesting locations. Our results suggest that disturbance of nesting shorebirds can be site-dependent even within one breeding population of a species. Set-back distances around shorebird nests must account for location and types of activities encountered, implying the need for more conservative implementation of set-back distances.

Books, Reports, & Symposia

Smith, B.W. 2008. Productivity and nest habitat preferences of Snowy Plovers (*Charadrius alexandrinus*) on Sanibel Island, Florida. Masters Thesis. Florida Gulf Coast University.

MAMMALS

Publications

Hernandez, S., M. Yabsley, S. Webster, **K. Sloan**, H. Milbrandt, R. Beasley, H. Barron, and J. Beasley. **2020**. Abundance and population genetic structure of coyotes on a newly colonized barrier island wildlife research (in review).
Understanding the number and distribution of coyotes on barrier islands is key to enacting their management, because they are known to have significant effects on sensitive species. Using fecal genotyping, we studied the number individuals and the population structure of coyotes on Sanibel Island, FL. We found that there are more coyotes on the island than previously estimated by observations and camera traps and that they belong to two genetic clusters, one of which appears to be a resident population, highlighting the complex population biology of invasive predators, even on small barrier islands.

Books, Reports, & Symposia

Glinksy, A., **B. Quirk-Royal**, and **K. Sloan**. **2018**. Non-lethal techniques for managing coyote depredation on Sanibel Island, FL. Thirty-eighth Annual Symposium on Sea Turtle Biology and Conservation.

Sloan, K., and **B. Quirk-Royal**. **2016**. Through the lens: understanding the ecology and impacts of *Canis latrans* on Sanibel Island, Florida. Thirty-sixth Annual Symposium on Sea Turtle Biology and Conservation.

Tucker, M., J. Stout, and **A. Bryant**. **2011**. Sanibel Island Rice Rat biological status review report. Florida Fish & Wildlife Conservation Commission. Tallahassee, FL.

REPTILES & AMPHIBIANS

Publications

Donini, J.T., **C.J. Lechowicz**, and R.A. Valverde. **2018**. Comparisons of summer and winter patterns in ovarian development, plasma vitellogenin, and sex steroids in female Diamondback Terrapins (*Malaclemys terrapin*) in southern Florida. Chelonian Conservation and Biology 17(2):227–235.
The reproductive cycles of turtles are linked to environmental factors, such as photoperiod and temperature. Currently, the reproductive physiology of diamondback terrapins (*Malaclemys terrapin*) is poorly understood, especially in Gulf of Mexico. The reproductive cycles of terrapins are thought to follow typical seasonal patterns. However, latitudinal variations in temperature regimens lead to longer-lasting warm periods, which can facilitate extended reproductive periods in some turtle species. This suggests that terrapins may show a similar change in the southern parts of their range. To elucidate aspects of the terrapin reproductive cycle, we sampled during the known reproductive season of a southern population of terrapins (May–July), as well as during the winter in late December and early January. We used enzyme-linked immunosorbent assays to quantify concentrations of the plasma sex hormones estradiol and testosterone, and the egg yolk protein precursor vitellogenin. Additionally, we used radiography and ultrasonography to monitor the ovarian status and egg development in females. Follicles showed no significant difference in average diameter across sampling periods with preovulatory class follicles existing in both summer and winter. Eggs were only detected from May to July, with radiographic data showing second clutches

in 4 individuals. Testosterone and estradiol showed elevated concentrations throughout the nesting season, coinciding with multiple clutches of eggs, before both showed a significant decrease in winter. Vitellogenin showed peak concentrations in June with other months showing lower but detectable concentrations. Our results suggest that in southwestern Florida, terrapins may have extended reproductive potential and continuous vitellogenic cycles given the presence of preovulatory follicles and high quantities of vitellogenin found in summer and winter. However, true continuous reproduction was not detected in this study.

Krysko, J.I., L.A. Somma, D.C. Smith, C.R. Gillette, D. Cueva, J.A. Wasilewski, K.M. Enge, S.A. Johnson, T.S. Campbell, J.R. Edwards, M.R. Rochford, R. Tompkins, J.I. Fobb, S. Mullin, **C.J. Lechowicz**, D. Hazelton, and A. Warren. **2016**. New verified nonindigenous amphibians and reptiles of Florida through 2015, with a summary of over 152 years of introductions. IRCF Reptiles and Amphibians 23(2):110–143.
More nonindigenous species occur in Florida, USA, than any other region worldwide and may threaten many of Florida's natural resources. The frequency of new reports mandates the need for regular updates. Herein, we use photographic and specimen vouchers in addition to literature records to provide updated information on verified nonindigenous amphibians and reptiles in Florida. Between our most recent summary in 2012 and the end of 2015, 38 additional species are known to have been intercepted (n=2) or introduced (n=36). We also update the invasion stage of seven species previously reported from Florida and report that five additional taxa are now established. In total 191 independent known introductions of 180 herpetofaunal taxa led to the establishment of 63 taxa. This suggests that one in three introduced herpetofaunal species becomes established in Florida. The pet trade represents the most common introduction pathway among these species and a single animal importer in Hollywood, Broward County, is the probable source for introduction of a quarter of all herpetofauna introduced to Florida.

Godwin, J.C, J.E. Lovich, J.R. Ennen, B.R. Kreiser, B. Folt, and **C.J. Lechowicz**. **2014**. Hybridization of two megacephalic map turtles (Testudines: Emydidae: *Graptemys*) in the Choctawhatchee River drainage of Alabama and Florida. Copeia 4:725–742.
Map turtles of the genus *Graptemys* are highly aquatic and rarely undergo terrestrial movements, and limited dispersal among drainages has been hypothesized to drive drainage-specific endemism and high species richness of this group in the southeastern United States. Until recently, two members of the megacephalic “pulchra clade,” *Graptemys barbouri* and *Graptemys ernsti*, were presumed to be allopatric with a gap in both species' ranges in the Choctawhatchee River drainage. In this paper, we analyzed variation in morphology (head and shell patterns) and genetics (mitochondrial DNA and microsatellite loci) from *G. barbouri, G. ernsti*, and *Graptemys* sp. collected from the Choctawhatchee River drainage, and we document the syntopic occurrence of those species and back-crossed individuals of mixed ancestry in the Choctawhatchee River drainage. Our results provide a first counter-example to the pattern of drainage-specific endemism in megacephalic Graptemys. Geologic events associated with Pliocene and Pleistocene sea level fluctuations and the existence of paleo-river systems appear to have allowed the invasion of the Choctawhatchee system by these species, and the subsequent introgression likely predates any potential human-mediated introduction.

Books, Reports, & Symposia

Lechowicz, C. 2019. Habitat use and island movements in the jewel of Sanibel, the Florida box turtle (*Terrapene carolina bauri*). Exploring Florida's Rich Turtle Diversity Symposium, Native Florida Birding and Nature Festival.

Gibson, N., **C.J. Lechowicz**, and E.E. Everham III. **2017**. Habitat use of the Florida Box Turtle (*Terrapene carolina bauri*) on a barrier island: Sanibel, FL. Charlotte Harbor National Estuary Program, Fort Myers, FL. Poster Presentation.

Donini, J., **C. Lechowicz**, W. Selman, and R. Valverde. **2016**. Reproductive physiology of diamondback terrapins (*Malalclemys terrapin*) at two latitudes in the Gulf of Mexico. Turtle Survival Alliance Symposium.

Lechowicz, C. 2016. Update on the recent introduction of the giant toad (*Rhinella marina*) on Sanibel Island, FL. CISMA Invasive Species Symposium.

Lechowicz, C. 2015. Possible introduction methods, movement patterns, and control efforts of the giant toad (*Rhinella marina*) on Sanibel Island, FL. CISMA Invasive Species Symposium.

LeBuff, C.A., and **C.J. Lechowicz**. **2014**. Amphibians & Reptiles of Sanibel & Captiva Islands, FL: A Natural History. Amber Publishing. Ralph Curtis Publishing, Fort Myers, FL.

Lechowicz, C. 2014. Terrapin nesting habitat discovery using satellite telemetry. Turtle Survival Alliance Symposium.

Lechowicz, C., P. Meylan, P. Moler, T. Thomas, and W. Turner. **2011**. Barbour's Map Turtle biological status review report. Florida Fish & Wildlife Conservation Commission. Tallahassee, FL.

Lechowicz, C. 2009. Population structure and trends in Barbour's map turtles (*Graptemys barbouri*), Escambia map turtles (*Graptemys ernsti*), and the hybrid (*Graptemys barbouri x ernsti*) in Alabama and Florida. Turtle Survival Alliance Symposium.

SEA TURTLES

Books, Reports, & Symposia

Addison, D., **A. Glinsky**, and **K. Sloan**. **2020**. Using satellite telemetry to reveal green inter-nesting movements and migratory pathways in SW Florida. Fortieth Annual Symposium on Sea Turtle Biology and Conservation.

Sloan, K., **A. Glinsky**, **R. Bartleson**, and J. Perrault. **2020**. Evaluating the sublethal effects of red tide blooms and brevetoxin exposure on nesting sea turtles. Fortieth Annual Symposium on Sea Turtle Biology and Conservation.

Bartleson, R., **K. Sloan**, T. Leighfield, H. Barron, J. Schmid, **J. Brzoza**, **A. Glinsky**, and A. Gosset. **2019**. What is safe for sea turtles to eat during an extreme southwest Florida red tide? Tenth US HAB Symposium.

Bartleson, R., and **K. Sloan**. **2019**. Evaluation of brevetoxin accumulation in tissues of red tide strandings. Thirty-ninth Annual Symposium on Sea Turtle Biology and Conservation.

Brzoza, J., and **K. Sloan**. **2019**. The influence of elevation on loggerhead (*Caretta caretta*) hatching success on Sanibel Island, FL, USA. Thirty-ninth Annual Symposium on Sea Turtle Biology and Conservation.

Shamblin, B., K. Hart, S. Ceriani, M. Lamont, Z. Bass, W. Katz, K. Mazzarella, **K. Sloan**, and C. Nairn. **2019**. Preliminary inferences of stock structure among Florida's Gulf of Mexico green turtle rookeries. Fifth Southeast Regional Sea Turtle Network (SERSTN).

Thomson, C., **K. Sloan**, **A. Martignette**, and J. Wyneken. **2019**. Characterizing the effects of groundwater on soil moisture and temperature of loggerhead sea turtle nests on Sanibel Island, FL. Thirty-ninth Annual Symposium on Sea Turtle Biology and Conservation.

Sloan, K., D. Addison, and **A. Glinksy**. **2018**. Inter-nesting movements and migratory pathways to foraging areas by satellite tagged green sea turtles (*Chelonia mydas*) in southwest Florida. Thirty-eighth Annual Symposium on Sea Turtle Biology and Conservation.

INVASIVE & AGGRESSIVE FLORA

Books, Reports, & Symposia

Lechowicz, C. 2020. When natives become invasive: Battle of the buttonwood (*Conocarpus erectus*). CISMA Invasive Species Symposium.

Ceiley, D.W., G.G. Buckner II, J.R. Schmid, and **B.W. Smith**. A survey of the effects of invasive exotic vegetation on wetland functions: aquatic fauna and wildlife. **2005**. Charlotte Harbor National Estuary Program. Fort Myers, FL. Final Report.

MANGROVES

Publications

Lewis, R.R., **E.C. Milbrandt**, B. Brown, K.W. Krauss, A.S. Rovai, J.L. Beever, and L.L. Flynn. **2016**. Stress in mangrove forests: early detection and preemptive rehabilitation are essential for future successful worldwide mangrove forest management. Marine Pollution Bulletin 109:764–771. Mangrove forest rehabilitation should begin much sooner than at the point of catastrophic loss. We describe the need for "mangrove forest heart attack prevention", and how that might be accomplished in a general sense by embedding plot and remote sensing monitoring within coastal management plans. The major cause of mangrove stress at many sites globally is often linked to reduced tidal flows and exchanges. Blocked water flows can reduce flushing not only from the seaward side, but also result in higher salinity and reduced sediments when flows are blocked landward. Long-term degradation of function leads to acute mortality prompted by acute events, but created by a systematic propensity for long-term neglect of mangroves. Often, mangroves are lost within a few years; however, vulnerability is re-set decades earlier when seemingly innocuous hydrological modifications are made (e.g., road construction, blocked tidal channels), but which remain undetected without reasonable large-scale monitoring.

Milbrandt, E.C., **M. Thompson**, **L.D. Coen**, R.E. Grizzle, and K. Ward. **2015**. The benefits of a multiple habitat restoration strategy by combining hydrologic restoration, mangrove propagule

plantings and oyster substrate additions in a semi-enclosed Florida embayment. Ecological Engineering 83:394-404.
Habitat loss and disturbance are ranked globally as the greatest threats to biodiversity. Development and coastal population growth are the leading causes for habitat losses. Recently, the restoration of marine habitats has increased, especially with the goal of increasing non-consumptive ecosystem services derived from mangrove and submerged aquatic vegetation (SAV) along with biogenic oyster reefs. Habitats reside in landscapes dominated by multiple species. Rather than focusing on a single habitat such as oysters or mangroves or SAV, we took an approach restoring multiple adjacent habitats to accelerate restoration in a Florida embayment that had been significantly degraded prior to the restoration of natural tidally generated flows. After a multiple habitat die-off, a project was initiated in 2006 to reintroduce tidal flushing. The re-introduction of tidal flushing, however, did not result in immediate recovery of mangrove shorelines or oyster-dominated reefs. There was a lack of mangrove propagule production and significant substrate limitation in areas with appropriate salinity, sediment and tidal flows. From 2009–2012, red mangrove (*Rhizophora mangle*) propagules were collected (over 500,000) and planted for a total area of 3.24 ha. From 2009–2010, five intertidal reefs were constructed by adding bagged and fossil shell (54 MT) for *Crassostrea virginica* larvae to recruit onto totaling over 779 m^2. Monitoring of planted mangrove versus unplanted shorelines demonstrated that prop root and drop root densities were higher where propagules were planted (28 m^{-2}) versus unplanted (2.3 m^{-2}). Oyster densities and mean sizes (multiple year classes) at new and natural reefs were measured after 8, 12, and 24, and 36 months. An initial settlement pulse was observed in the first 8 months followed by an increase in the density of greater than 1-year old oysters. Xanthid crab densities (*Eurypanopeus depressus* and *Panopeus* spp.) in restored reefs and natural reefs were similar, while *Petrolisthes armatus* densities were lower in restored reefs. Whole reef seston filtration rates over restored reefs were −26 to 157 L m^{-2} h^{-1} when measured at 4, 15, 28, and 40 months. A multiple habitat approach may be useful in accelerating the natural ecological succession, especially if the project site has reached a degraded, alternate ecological state. These results suggest a multiple habitat approach can be useful in providing non-provisioning ecosystem services to a Florida embayment.

Harris, R.J., **E.C. Milbrandt**, B. Brovard, E. Everham. **2010**. The effects of reduced tidal flushing on mangrove structure and function across a disturbance gradient. Estuaries and Coasts 33:1176–1185.
The effects of reduced tidal flushing on post-hurricane mangrove recovery were measured across a gradient of hurricane disturbance (in order of decreasing wind intensity: Captiva, North Sanibel, Central Sanibel, and East Sanibel). Each region consisted of replicate study plots with either reduced tidal exchange (tidally restricted location) or an open tidal connection (tidally unrestricted location). Locations with reduced tidal exchange displayed significantly lower (two-way ANOVA, $p \leq 0.0001$) tidal amplitude, decreased seedling densities, and decreased productivity (recruitment, growth, and litter fall) when compared to the tidally unrestricted locations. Results also indicated significant regional variations in measures of mangrove stand structure (seedlings and canopy) and productivity (recruitment, growth, and litter fall) up to 4-years post-hurricane disturbance. These findings suggest that the legacy effects from hurricane disturbance vary with degree of wind intensity, acting both independently and synergistically with the effects of tidal restriction to influence post-hurricane mangrove structure and function.

Milbrandt, E.C., and **M.L. Tinsley**. **2006**. The role of saltwort (*Batis maritima*) on mangrove forest succession. Hydrobiologia 568:369–377.
While saltwort (*Batis maritima* L.) is common in the fringe mangrove forests of southwest Florida, its role in regeneration of degraded mangrove communities is not known. Given the potential encroachment and subsequent degradation of mangrove communities by sea-level rise, it is important to quantify the effect of early-colonizing vegetation to early mangrove seedling survival. A greater number of mangrove seedlings were observed in existing *B. maritima* patches compared to surrounding mudflats. A planting experiment was designed to determine whether *B. maritima* was

responsible for the observed pattern. Black mangrove (*Avicennia germinans* L.) seedlings, raised in a nursery, were planted in previously established *B. maritima* patches and on mudflats with and without nursery-raised *B. maritima*. There was significantly lower mortality of *A. germinans* seedlings when planted in existing *B. maritima* patches (69%), compared to seedlings planted on the mudflats (93%), demonstrating that existing B. maritima improved A. germinans seedling survival. Nursery-raised *B. maritima* had lower mortality on open mudflats (28%), suggesting that it can tolerate conditions, which make it an early colonizer of newly available habitats. The primary mechanism proposed for improving seedling success is a slight increase in elevation provided by the dense root network of established *B. maritima*. These findings have implications for scientists and managers anticipating the response of mangroves to sea-level rise.

Milbrandt, E.C., **J.M. Greenawalt-Boswell**, **P.D. Sokoloff,** and **S.A. Bortone**. **2006**. Impact and response of southwest Florida mangroves to the 2004 hurricane season. Estuaries and Coasts 29:979–984.

Although hurricane disturbance is a natural occurrence in mangrove forests, the effect of widespread human alterations on the resiliency of estuarine habitats is unknown. The resiliency of mangrove forests in southwest Florida to the 2004 hurricane season was evaluated by determining the immediate response of mangroves to a catastrophic hurricane in areas with restricted and unrestricted tidal connections. The landfall of Hurricane Charley, a category 4 storm, left pronounced disturbances to mangrove forests on southwest Florida barrier islands. A significant and negative relationship between canopy loss and distance from the eyewall was observed. While a species-specific response to the hurricane was expected, no significant differences were found among species in the size of severely impacted trees. In the region farthest from the eyewall, increases in canopy density indicated that refoliation and recovery occurred relatively quickly. There were no increases or decreases in canopy density in regions closer to the eyewall where there were complete losses of crown structures. In pre-hurricane surveys, plots located in areas of management concern (i.e., restricted connection) had significantly lower stem diameter at breast height and higher stem densities than plots with unrestricted connection. These differences partially dictated the severity of effect from the hurricane. There were also significantly lower red mangrove (*Rhizophora mangle*) seedling densities in plots with restricted connections. These observations suggest that delays in forest recovery are possible in severely impacted areas if either the delivery of propagules or the production of seedlings is reduced by habitat fragmentation.

Proffitt, C.E., **E.C. Milbrandt**, and S.E. Travis. **2006**. Reproduction and recruitment of *Rhizophora mangle* (Red Mangroves) in Charlotte Harbor following hurricane Charley. Estuaries and Coasts 29:972–978.

Reproductive aspects of life history are known to be important in recovery following disturbance in many
plant species although this has not been well studied in mangroves. Hurricane Charley devastated large areas of mangroves in Charlotte Harbor, Florida, in August 2004. We surveyed 6 forests in Charlotte Harbor (2002, 2003, and 2005) and 16 in Tampa Bay, Florida (2001, 2002, 2003, and 2005) for total numbers of reproducing trees and trees heterozygotic for albinism that produce both normal and albino propagules. Tree size (estimated height and diameter at breast height) was also recorded for sentinel heterozygotic trees. Total number of reproducing trees km^{-1} was used as an index of reproductive
output of the population, and deviation from the 3:1 (normal:albino propagules) ratio on heterozygotic trees expected with 100% selfing was used to estimate outcrossing. Numbers of *Rhizophora mangle* reproducing trees km^{-1} of shoreline in Charlotte Harbor were reduced by an order of magnitude following Hurricane Charley, while numbers of reproducing trees in Tampa Bay were similar to those of previous years. Reduced reproduction in Charlotte Harbor was accompanied by fewer new recruits in plots on Sanibel and Captiva Islands. Numbers of new recruits after the storm also tended to be fewer in plots where canopy loss was greater. More new recruits occurred in sites that had higher densities of pre-storm *Rhizophora* seedlings and greater relative dominance by

Rhizophora. Outcrossing of sentinel trees was 2.5 times greater in Charlotte Harbor (mean site21 5 33.6 6 6.7%; with 17% of forest sites completely selfing) than in Tampa Bay (mean site^{-1} = 13.4 ± 4.7%; with 40% of sites completely selfing), although the implications for seedling recruitment of this difference are not known.

Books, Reports, & Symposia

Milbrandt, E.C. 2011. Enhancement of mangrove shorelines and habitat after hydrological restoration in Clam Bayou. Final Report to the Gulf of Mexico Foundation. 23 pp.

SEAGRASS, SUBMERGED AQUATIC VEGETATION, MACROALGAE, & PROP-SCARRING

Publications

Milbrandt, E.C., **L. Reidenbach**, and M. Parsons. **2019**. Determining the sources of macroalgae during beach stranding events from species composition, stable isotope analysis, and laboratory experiments. Estuaries and Coasts 42(3):719–730.

Large accumulations of stranded macroalgae on the beaches of Sanibel Island from 2004 to 2007 were unusual and thought to be driven by high rainfall and river flows stemming from a high frequency of hurricanes. The southwest Florida shelf was thought to be isolated from far-field effects such as high river flows and urbanization but field- and laboratory-based studies suggest that nitrogen enrichment, fragmentation, and species composition of macroalgal communities on the shelf and in the estuary contribute to beach stranding events. Macroalgae were sampled using a belt transect method to determine species distribution and abundance. Macroalgae were abundant (1) in the lower estuary with abundant seagrass and (2) on limestone outcroppings in the Gulf of Mexico. An MDS analysis of the quadrat samples indicated two distinct macroalgal community types, a “Sound” assemblage around Pine Island Sound and a “Gulf” assemblage, associated with a live bottom and patch reef in the Gulf of Mexico. Peak abundances for the two community types differed with the Gulf having peak abundances from July to November, while peak abundances in the Sound occurred from January to July. Sound macroalgal tissue had significantly enriched δ15N compared to Gulf tissue when all species were combined and in five of six species collected at both locations suggesting that stable isotope analysis could be useful in combination with species composition in determining the source of macroalgae during stranding events. In addition, a laboratory study was conducted on four species that were sampled and frequently collected as a result of stranding events. Laboratory growth experiments demonstrated the potential for three of four common species (*Solieria filiformis, Gracilaria tikvahiae, Agardhiella subulata*) to fragment and grow significantly more under elevated nitrate conditions.

Milbrandt, E.C., **and J. Siwicke**. **2016**. Leaf growth rates (*Thalassia testudinum*, Banks ex Koning) as an indicator of seagrass responses to regulated freshwater discharges. Gulf of Mexico Science 2016(1):38–46.

In southwest Florida, changes in hydrology have fundamentally changed the timing and amount of freshwater delivered to the estuarine ecosystem. Biological indicators such as oyster and submerged aquatic vegetation distribution and abundance have been used to establish minimum and maximum discharges to the estuary. These indicators are robust long-term indicators for comparing interannual and climatological changes; however, they lack sensitivity to variable freshwater flows that occur over the course of months or seasons. Seagrass leaf growth rates could provide an integrated biological response for evaluating events caused by climatological shifts (e.g., El Niño) or to evaluate the biological responses to management actions (e.g., flood control releases

of freshwater from Lake Okeechobee). Leaf growth rates for *Thalassia testudinum* were determined monthly across a gradient of increasing distance from the mouth of the Caloosahatchee estuary. Leaf growth at sites near the Caloosahatchee (within 5 km) had significantly lower growth rates during the April–June period. Salinity was also significantly lower, while light attenuation and temperature were not significantly different. High discharges for flood control caused lower salinities and significantly slowed leaf growth rates. Leaf growth can be a sensitive indicator to water management and climatological events and can show an integrated biological response to high flows.

Bartleson, R.D., M.J. Hunt, and P.H. Doering. **2014**. Effects of temperature on growth of *Vallisneria americana* in a sub-tropical estuarine environment. Wetlands Ecology and Management 5:571–583.
The submersed aquatic vegetation (SAV) species *Vallisneria americana* Michx. (tape grass) is a valuable resource in the Caloosahatchee estuary and in many other aquatic systems. Given the variable nature of freshwater inflows and environmental conditions in the Caloosahatchee, it is necessary to understand how tape grass will respond to high and low salinity conditions at different light and temperature levels. Specifically, quantitative information is needed as input to modeling tools that can be applied to predict growth and survival of tape grass under a range of environmental conditions present in the estuary. We determined growth rates for small and medium sized tape grass plants obtained from the Caloosahatchee estuary, southwest coastal Florida, USA in freshwater (0.5 psu) under high (331 μE m−2 s−1) and low light (42 μE m−2 s−1) and at 10 psu under high light conditions. We ran six treatments at five temperatures spanning 13–32 °C for 8–9 weeks. The optimum temperature for growth was roughly 28 °C, with a minimum threshold temperature of 13 °C and a maximum threshold temperature of 38 °C. Plants grew fastest in freshwater, at high light and temperatures greater than 20 °C. The slowest growth rates were observed at 13 °C regardless of salinity, light or plant size. Our results suggest that tape grass growth is strongly influenced by water temperature and that additional stressors such as low light and elevated salinity can reduce the range of temperature tolerance, especially at colder water temperatures.

Provost, K., **A.J. Martignette**, **E.C. Milbrandt**, and **J. Siwicke**. **2013**. Quadrat vs. video assessment of macroalgae cover: a methods comparison. Florida Scientist 76(2):249–258.
In 2004–2007, the beaches of Sanibel Island, Florida, were affected by large drifts of macroalgae that accumulated on shore. The adjacent seafloor is composed of three ecoregions: inshore, nearshore and offshore. To measure attached and unattached macroalgae on various substrata, two field survey methods were compared from 2008 to 2010 along thirteen 100 m long transects. One method used visual assessments of macroalgae in 1 m^2 quadrats along the transects and one used an underwater camcorder to capture video footage along the transects. Results of each method were converted to percent cover of the transect and compared for each sampling date. The results showed that digital video observations were not significantly different than diver assessments for two of three ecoregions. Sparse amounts of macroalgae were underestimated nearshore using visual SCUBA, due to the inconsistent, but high percentage, of algae cover. Uses, advantages, disadvantages, and time-effectiveness of the two methods were compared. Natural resource managers can choose which survey method meets their scientific, management and budget needs. Based on these results, it is suggested that video analysis of bottom cover is a practical method for rapid, widespread assessment of macroalgae abundance surrounding Sanibel Island.

Milbrandt, E.C. 2009. The effects of root zone manipulation of microcosm Turtlegrass (*Thalassia testudinum*) transplants. Florida Scientist 72:406–419.
The objective of this research was to determine whether the survival and growth rate of transplanted seagrasses is hindered by sediment sulfide addition and bacterial community disruption. A microcosm experiment was designed to control for temperature, salinity, and light availability. Bare root transplanted seagrass shoots were exposed to one of four treatments; plus sulfide, plus autoclave; minus sulfide, plus autoclave; plus sulfide, unmanipulated (not autoclaved); and minus

sulfide, unmanipulated. Bare root transplants had less than half the rate of growth of the control that was transplanted as a plug with sediments, demonstrating the sensitivity of root disturbance in *Thalassia testudinum*. Bare root transplants in autoclaved sediments grew slower than in unmanipulated sediments regardless of sulfide treatments. The greatest amount of extractable DNA was measured in bare root transplanted treatments that had not been autoclaved. Standard diversity indices along with a Bray-Curtis similarity index of Terminal Restriction Fragment Length Polymorphism in a MDS were used to assess community composition. The MDS showed no significant differences, while comparisons of diversity indices indicated differences between transplants and control. The results support the conclusion that an intact sediment bacterial community increases transplant success, but the nature of the interaction (e.g., functional, structural) remains unclear.

Milbrandt, E.C., **J.M. Greenawalt**, and **P.D. Sokoloff**. **2008**. Short-term indicators of seagrass transplant stress in response to rhizosphere and bacterial community disruption. Botanica Marina 51:103–111.

Bacterial communities in sediments engage in activities that determine the pathways and rates of organic matter remineralization. Changes in bacterial community composition might result in greater restoration success if interactions among seagrasses, sediment, and bacterial communities were elucidated. A manipulative experiment that disrupted the sediment bacterial community examined the response of Thalassia testudinum transplants. Planting units were transported to a suitable location and replanted with either autoclaved, transplant, or donor site sediments. Sediments from the rhizosphere were sub-sampled for analysis of the 16S rDNA gene. The autoclave treatment group had significantly lower bacterial diversity than the other treatments, as measured with terminal restriction fragment length polymorphism. Significantly higher mortality of the transplants was observed in the autoclave treatment group, while mortality in the donor and transplant treatment groups was low relative to the control group. Rhizosphere disruption through the removal of surrounding sediments did not increase mortality, while manipulating the composition of the bacterial community increased mortality in transplants. A native bacterial community was a critical component for minimizing short-term stress associated with a seagrass transplant, which suggests a tighter coupling between seagrasses and sediment bacterial communities than previously thought.

Greenawalt-Boswell, J., J.A. Hale, K.S. Fuhr, and J.A. Ott. **2006**. Seagrass species composition and distribution trends in relation to salinity fluctuations in Charlotte Harbor. Florida Scientist 69(S2):24–35.

Seagrass species composition and distribution reflect environmental changes, making these measures potentially useful estuarine indicators. An annual seagrass transect and quadrat monitoring survey program including 50 locations in Charlotte Harbor, Florida, began in 1999. This six-year data set was analyzed in conjunction with a monthly water quality monitoring program covering the same time period to examine trends in seagrass species composition and distribution. Analyses of the maximum depth of seagrass distribution for each transect did not indicate any large-scale changes in seagrass depth distribution. This suggests a stable overall area of seagrass distribution in the Charlotte Harbor area during the study period. However, abundance of Halodule wrightii and Thalassia testudinum has significantly declined, along with the overall frequency of seagrass occurrence among quadrats. Finally, the distribution of the three dominant seagrass species, *H. wrightii, T. testudinum*, and *Syringodium filiforme*, appear to be influenced by low, wet-season salinity and high variation. This study highlights the value of research into seagrass species abundance and distribution on a meter-to-meter scale to recognize the effects of water quality or environmental variables such as salinity on a small scale, prior to large scale loss.

Books, Reports, & Symposia

Milbrandt, E.C., **M. Thompson**, R.E. Grizzle, and K. Ward. **2018**. The effects of long-term mooring and anchoring by vessels in shallow water on the benthic environment. A report to the West Coast Inland Navigation District. SCCF Marine Laboratory. Grizzle Coastal Engineering LLC.

Thompson, M.A. 2015. Before after control intervention (BACI) analysis of prop scars in Wulfert Flats as a result of implementation of a No Motor Zone, October 2015. SCCF Marine Laboratory report to Ding Darling National Wildlife Refuge. Sanibel, FL.

Thompson, M.A. 2015. Prop scar density in Ding Darling NWR, Sanibel; a brief survey of the wildlife refuge and Ladyfinger Lakes. SCCF Marine Laboratory. Sanibel, FL.

Milbrandt, E., R. Bartleson, A.J. Martignette, M. Thompson, and J. Palmer. **2014**. The cumulative effects of regulated discharges on seagrass density and community composition around Sanibel Island. Charlotte Harbor Watershed Summit, March 25-27, 2014, Punta Gorda, FL.

Bartleson, R.D., E.C. Milbrandt, and **M.A. Thompson**. **2014**. Restoration of propeller-scarred seagrass beds near Sanibel using *Halodule wrightii* Year 3 Progress Report to Keewaydin Island Community Association, and Humiston and Moore Engineers, Inc. November, 2014 Naples.

Flynn, R.L., R.D. Bartleson, and **E.C. Milbrandt**. **2013**. Seston removal by a tunicate *Didemnum duplicatum* in a seagrass meadow. 2013 Benthic Ecology Meeting, Savannah GA.

Milbrandt, E.C., **R.D. Bartleson**, D. Fugate, **A. Rybak**, **M. Thompson**, and **L. Coen**. **2011**. Reopening a tidal pass: implications for changes in water column optical properties and seagrass habitats FINAL REPORT. SCCF Marine Laboratory, Florida Gulf Coast University. Florida Seagrant. Sanibel, FL.

Bartleson, R.D., **E.C. Milbrandt**, and **Mark A. Thompson**. **2010**. Feasibility of *Ruppia* restoration in the Caloosahatchee Estuary using grazer exclosures. Benthic Ecology Meeting, Wilmington, NC, March 2010.

Bartleson R.D., E.C. Milbrandt, and **M.A. Thompson**. **2010**. Feasibility of *Ruppia* restoration in the Caloosahatchee Estuary. Final Report to Lee County. 52 pp.

Bartleson, R.D. 2009. Caloosahatchee submersed plant restoration using grazer exclosures. CHNEP Science Forum, Arcadia, Florida. July, 2009.

Bartleson, R.D. 2008. Growth and photosynthesis of Caloosahatchee tape grass: effects of light, temperature and salinity. Final Report to SFWMD. 44 pp.

Milbrandt, E.C. 2008. An assessment of the effect of water quality on seagrasses in the Caloosahatchee River/estuary and Pine Island Sound using optical properties to predict light levels and thresholds. Final report to SFWMD, 49 pp.

Bartleson, R.D. 2008. Growth and photosynthesis of Caloosahatchee tape grass: effects of light, temperature and salinity. Final Report to SFWMD, 44 pp.

Bartleson, R.D., and **J.G. Guinn**. **2007**. Submerged Aquatic Vegetation Monitoring – Caloosahatchee Estuary. Report to SFWMD for 6 month extension (December).

Bartleson, R.D., and **J.G. Guinn**. **2007**. Submerged Aquatic Vegetation Monitoring – Caloosahatchee Estuary. Report to SFWMD for 6 month extension (June).

Bartleson, R.D. 2007. Effect of light and salinity on growth and photosynthesis of tape grass (*Vallisneria americana*) at 32°C. Report to the SFWMD May 2008.

Bartleson, R.D. 2007. Effect of light and salinity on growth and photosynthesis of tape grass (*Vallisneria americana*) at 30°C. Report to the SFWMD January 2008.

Bartleson, R.D. 2007. Effect of light and salinity on growth and photosynthesis of tape grass (*Vallisneria americana*) at 20°C. Report to the SFWMD June 2007.

Bartleson, R.D. 2007. Effect of light and salinity on growth and photosynthesis of tape grass (*Vallisneria americana*) at 25°C. Report to the SFWMD September 2007.

Bartleson, R.D., and **J.G. Guinn**. **2006**. Submerged Aquatic Vegetation Monitoring – Caloosahatchee Estuary. Report to SFWMD Final Report (December).

Bartleson, R.D., **E.D. Berris**, **L.B. Linsmeyer**, **M.P. Hannan**, and **J. Siwicke**. **2006**. Final Report: Macroalgae and seagrass monitoring during spring and summer of 2006. Report to City of Sanibel, 54 pp.

Milbrandt, E.C. 2006. Determining the effects of root zone manipulation on seagrass transplants to enhance restoration projects. Final Report to CHNEP, 34 pp.

OYSTERS & SHELLFISH

Publications

Grizzle, R.E., **A. Rasmussen**, **A.J. Martignette**, K. Ward, and **L.D. Coen**. **2018**. Mapping seston depletion over an intertidal Eastern Oyster (*Crassostrea virginica*) reef: implications for restoration of multiple habitats. Estuarine, Coastal and Shelf Science 212:265–272.
Research on the effects of bivalve filtration emphasizing oysters has mainly involved extrapolations from laboratory based measurements on individual oysters to potential whole-ecosystem impacts, with only a few studies on reef-scale processes and less using direct measurements. This study characterized spatial effects of whole-reef (oysters, *Crassostrea virginica*, and other filter feeders on the reef) filtration in the water immediately above and adjacent to a small (~300 m^2) intertidal reef in Tarpon Bay, Sanibel, Florida. Changes in water column parameters were measured in 2010 (chlorophyll a only) and 2013 (chlorophyll a and turbidity) by slowly paddling a kayak back-and-forth across the reef while logging position and water data. Although oysters were the dominant filter feeder, mussels, slipper shells, sponges, and a filter-feeding crab also occurred on the reef. Ambient water flow speed and direction were concurrently determined in 2013 by an acoustic-doppler current profiler. Measurements were made on two days (1–2 June) in 2010, and two days (November 15 and December 9) in 2013. ArcGIS software was used to plot the data and construct two-dimensional maps showing changes in chlorophyll a and turbidity, which clearly indicated the spatial extent of decreases in both as water flowed across the reef. Seston decrease (interpreted as depletion) levels were spatially variable, averaging 23–25% but as high as 68% in some areas directly over the reef. The extent of detectable depletion usually extended 10–20 m beyond the edge of the reef, potentially

increasing light levels and thereby providing enhanced growth conditions for adjacent seagrasses and algae, suggesting that restoration success of macrophyte habitats could be enhanced by close spatial coupling with oyster reef restoration.

Beck, M.W., R.D. Brumbaugh, L. Airoldi, A. Carranza, **L.D. Coen**, C. Crawford, O. Defeo, G.J. Edgar, B. Hancock., M.C. Kay, H.S. Lenihan, M.W. Luckenbach, C.L. Toropova, G. Zhang, and X. Guo. **2011**. Oyster reefs at risk and recommendations for conservation, restoration and management. BioScience 61:107–116.
Native oyster reefs once dominated many estuaries, ecologically and economically. Centuries of resource extraction exacerbated by coastal degradation have pushed oyster reefs to the brink of functional extinction worldwide. We examined the condition of oyster reefs across 144 bays and 44 ecoregions; our comparisons of past with present abundances indicate that more than 90% of them have been lost in bays (70%) and ecoregions (63%). In many bays, more than 99% of oyster reefs have been lost and are functionally extinct. Overall, we estimate that 85% of oyster reefs have been lost globally. Most of the world's remaining wild capture of native oysters (> 75%) comes from just five ecoregions in North America, yet the condition of reefs in these ecoregions is poor at best, except in the Gulf of Mexico. We identify many cost-effective solutions for conservation, restoration, and the management of fisheries and nonnative species that could reverse these oyster losses and restore reef ecosystem services.

Hadley, N.H., M. Hodges, D.H. Wilber, and **L.D. Coen**. **2010**. Evaluating intertidal oyster reef development in South Carolina using associated faunal indicators. Restoration Ecology 18(5):691–701.
Eastern oyster (*Crassostrea virginica*) habitat is increasingly being restored for the ecosystem services it provides rather than solely as a fishery resource. Community-based projects with the goal of ecological restoration have successfully constructed oyster reefs; however, the habitat benefits of these restoration efforts are usually not assessed or reported. In this study, we examined oyster habitat development at five community-based oyster restoration sites in South Carolina using oyster population parameters, resident fauna densities, and sedimentation (percent sediment coverage) as assessment metrics. All sites included multiple-aged reefs (1–3 years old) at the time of the fall 2004 sampling. Resident crabs and mussels were abundant at all five sites and crab assemblages were related to the size structure of the oyster microhabitat. Scorched mussel (*Brachidontes exustus*) abundances were most frequently correlated with oyster and other resident species abundances. Associations among oysters and resident crabs and mussels were not evident when analyses were conducted with higher level taxonomic groupings (e.g., total number of crabs, mussels, or oysters), indicating that species-level identifications improve our understanding of interactions among reef inhabitants and oyster populations. Community-based restoration sites in South Carolina provide habitat for mussels and resident crabs, in some cases in the absence of dense populations of relatively large oysters. Monitoring programs that neglect species-level identifications and counts of mussels and crabs may underestimate the successful habitat provision that can arise independent of large, dense oyster assemblages.

Brumbaugh, R.D., and **L.D. Coen**. **2009**. Contemporary approaches for small-scale oyster reef restoration to address substrate versus recruitment limitation: a review and comments relevant for the Olympia Oyster, *Ostrea lurida* (Carpenter, 1864). Journal of Shellfish Research 28:1–15.
Reefs and beds formed by oysters such as the Eastern oyster, Crassostrea virginica and the Olympia oyster, *Ostrea lurida* Carpenter 1864† were dominant features in many estuaries throughout their native ranges. Many of these estuaries no longer have healthy, productive reefs because of impacts from destructive fishing, sediment accumulation, pollution, and parasites. Once valued primarily as a fishery resource, increasing attention is being focused today on the array of other ecosystem services that oysters and the reefs they form provide in United States coastal bays and estuaries. Since the early 1990s efforts to restore subtidal and intertidal oyster reefs have increased significantly, with particular interest in small-scale community-based projects initiated most

often by nongovernmental organizations (NGOs). To date, such projects have been undertaken in at least 15 US states, for both species of dominant native oysters along the United States coast. Community-based restoration practitioners have used a broad range of nonmutually exclusive approaches, including: (1) oyster gardening of hatchery-produced oysters; (2) deployment of juvenile to adult shellfish ("broodstock") within designated areas for stock enhancement; and (3) substrate enhancement using natural or recycled man-made materials loose or in "bags" designed to enhance local settlement success. Many of these approaches are inspired by fishery-enhancement efforts of the past, though are implemented with different outcomes in mind (ecological services vs. fishery outcomes). This paper was originally presented at the first West Coast Restoration Workshop in 2006 in San Rafael, California and is intended to summarize potential approaches for small-scale restoration projects, including some emerging methods, and highlight the logistical benefits and limitations of these approaches. Because the majority of the past efforts have been with *C. viriginica*, we use those examples initially to highlight efforts with the intent of enlightening current west coast United States efforts with Ostrea lurida. We also discuss site-specific characteristics including "recruitment bottlenecks" and "substrate limitation" as criteria for identifying the most appropriate approaches to use for small-scale restoration projects. Many of the included "lessons-learned" from the smaller-scale restoration projects being implemented today can be used to inform not only large-scale estuary wide efforts to restore *C. virginica*, but also the relatively nascent efforts directed at restoring the United States west coast's native Olympia oyster, *Ostrea lurida*.

Grizzle, R.E., J.K. Greene, and **L.D. Coen**. **2008**. Seston removal by natural and constructed intertidal eastern oyster (*Crassostrea virginica*) reefs: a comparison with previous laboratory studies, and the value of in situ methods. Estuaries and Coasts 31:1208–1220.
An important ecological role ascribed to oysters is the transfer of materials from the water column to the benthos as they feed on suspended particles (seston). This ecosystem service has been often touted as a major reason for many oyster restoration efforts, but empirical characterization and quantification of seston removal rates in the field have been lacking. Changes in chlorophyll a (chl a) concentrations in the water column were measured in May 2005 and June 2006 in South Carolina using in situ fluorometry and laboratory analysis of pumped water samples taken upstream and downstream as water flowed over natural and constructed intertidal oyster reefs. Both methods gave similar results overall, but with wide variability within individual reef datasets. In situ fluorometer data logged at 10 to 30-s intervals for up to 1.3 h over eight different reefs (three natural and five constructed) showed total removal (or uptake) expressed as % removal of chl a ranging from −9.8% to 27.9%, with a mean of 12.9%. Our data indicate that restored shellfish reefs should provide water-quality improvements soon after construction, and the overall impact is probably determined by the size and density of the resident filter feeder populations relative to water flow characteristics over the reef. The measured population-level chl a removal was converted to mean individual clearance rates to allow comparison with previous laboratory studies. Although direct comparisons could not be made due to the small size of oysters on the study reefs (mean shell height, 36.1 mm), our calculated rates (mean, 1.21 L h−1) were similar to published laboratory measured rates for oysters of this size. However, the wide variability in measured removal by the oyster reefs suggests that individual oyster feeding rates in nature may be much more variable than in the laboratory. The proliferation of ecosystem-level models that simulate the impacts of bivalves on water quality based only on laboratory-feeding measurements underscores the importance of further research aimed at determining ecologically realistic feeding rates for oysters in the field. Because in situ methods provide many replicate measurements quickly, they represent a potentially powerful tool for quantifying the effects of oyster reefs, including all suspension-feeding taxa present, on water quality.

Coen, L.D., R.D. Brumbaugh, D. Bushek, R. Grizzle, M.W. Luckenbach, M.H. Posey, S.P. Powers, and G. Tolley. **2007**. AS WE SEE IT. A broader view of ecosystem services related to oyster restoration. Marine Ecology Progress Series 341:303–307.

The importance of restoring filter-feeders, such as the Eastern oyster *Crassostrea virginica*, to mitigate the effects of eutrophication (e.g. in Chesapeake Bay) is currently under debate. The argument that bivalve molluscs alone cannot control phytoplankton blooms and reduce hypoxia oversimplifies a more complex issue, namely that ecosystem engineering species make manifold contributions to ecosystem services. Although further discussion and research leading to a more complete understanding is required, oysters and other molluscs (e.g. mussels) in estuarine ecosystems provide services far beyond the mere top-down control of phytoplankton blooms, such as (1) seston filtration, (2) benthic–pelagic coupling, (3) creation of refugia from predation, (4) creation of feeding habitat for juveniles and adults of mobile species, and for sessile stages of species that attach to molluscan shells, and (5) provision of nesting habitat.

Books, Reports, & Symposia

Thompson, M., and **R. Bartleson 2020.** Second Year Monitoring Update for Constructed Oyster Reefs, Spring Creek Oyster Mitigation Plan. Submitted to Coastal Engineering Consultants Incorporated. March 2020. SCCF Marine Laboratory. Sanibel, FL.

Thompson, M.A., and **R. Bartleson. 2019**. First year monitoring update for the constructed oyster reefs in Estero Bay for the Spring Creek Oyster Mitigation Plan. Submitted to Coastal Engineering Consultants Incorporated by SCCF Marine Laboratory. SCCF Marine Laboratory. Sanibel, FL.

Birch, A., **E.C. Milbrandt**, **M. Thompson**, T. Reis, and K. Radabaugh. **2017**. Southwest Florida Oysters. *In* Oyster Integrated Mapping and Monitoring Program, FWC Publication, 30 pp.

Milbrandt, E.M., **R.D. Bartleson**, and **M.A. Thompson. 2017**. Restoration of oysters and submerged aquatic vegetation in the Caloosahatchee Estuary. Final Report to Florida Dept. of Env. Protection. 121 pp.

Thompson, M.A., **E.C. Milbrandt**, R. Grizzle, **L. Coen**, and **R.D. Bartleson**. **2014**. Long term monitoring of a community-based oyster reef restoration project in Clam Bayou, Southwest Florida. Charlotte Harbor Watershed Summit, March 25–27, 2014, Punta Gorda, FL.

Milbrandt, E.C., and R. Grizzle. **2013**. Benthic Offshore. *In* Integrated Conceptual Ecosystem Model Development for the Southwest Florida Shelf Coastal Marine Ecosystem. W.K. Nuttle and P.J. Fletcher (eds.). NOAA Technical Memorandum, OAR-AOML-102 and NOS-NCCOS-162. Miami, Florida. pp. 79–85.

Thompson, M.A., E. Milbrandt, R.E. Grizzle, **L. Coen**, **R.D. Bartleson**. **2013**. Long Term Monitoring of a Community-Based Oyster Reef Restoration Project in a Recently Modified, Substrate-Limited Southwestern Florida Embayment. 2013 Benthic Ecology Meeting, Savannah GA.

Milbrandt, E.C., **M. Thompson**, **L. Coen**, R.E. Grizzle, K. Ward, and **S. Lartz**. **2012**. Community-based restoration of oyster habitat: a project to evaluate its success, associated effects on water quality and seagrass health in a recently modified, substrate-limited southwestern Florida embayment. Report submitted to The Nature Conservancy and The National Oceanographic and Atmospheric Administration. SCCF Marine Laboratory, Florida Atlantic University, University of New Hampshire.

Volety, A.K., N. Martin, A. Griffith, **R. Bartleson**, and R. Pierce. **2012**. Bioaccumulation and persistence of brevetoxins in oysters *Crassostrea virginica* following a red tide outbreak in southwest Florida, United States. SETAC North America 33rd Meeting, 11/11/2012 Long Beach, CA.

Coen, L.D., B.R. Dumbauld, and M.L. Judge. **2011**. Expanding shellfish aquaculture: a review of the ecological services provided by and impacts of native and cultured bivalves in shellfish-dominated ecosystems. *In* Shellfish Aquaculture and the Environment, S.E. Shumway, Ed., Wiley-Blackwell. 528 pp.

Bartleson, R.D., L. Coen, E. Estevez, V. Kennedy, and J. Leal. **2010**. Die-off of brackish water clams in the Caloosahatchee River, summer 2009: possible contributing factors. Florida United Malacologists Meeting, Sanibel, FL January 2010.

FISH

Publications

Johnson, M., **S. Bortone**, **B. Klement**, and R. Shipp. **2011**. Population changes and location-specific differences for otolith-derived age and growth of recreationally harvested Spotted Seatrout (*Cynoscion nebulosus*) from Alabama in 2007. Gulf of Mexico Science 29:13–24.
Spotted seatrout (*Cynoscion nebulosus*), is a nonmigratory game fish common in the Gulf of Mexico that is important in estuarine ecosystems. Population dynamics of spotted seatrout were examined using otolith-based age-and-growth models derived from observed and back-calculated length-at-age values. These data were used to identify sex-based differences and annular variation. Recent growth was quantified, using marginal increment analysis for comparisons between sexes and the two major bays in Alabama (Mobile Bay and Mississippi Sound). Sex ratios were also compared for these locations. Our results show that females were larger than males and that fish collected in Mobile Bay were larger than those from Mississippi Sound. Combined data from both bays resulted in a sex ratio that approached 1 : 1; however, examination of each bay individually showed that the Mississippi Sound had a female-biased population and that Mobile Bay had a male-biased population. Differences in observed length-at-age measurements became evident between males and females by age 2 with females typically larger than males, whereas the maximum age for males was greater. The oldest females were age 5 and the oldest males were age 8. Compared to previous estimates of trout growth in Alabama, results showed an increase in the modal length of fish and increased growth rates. Results suggest faster growth of the fish in the current population and decreased harvest of larger fish compared to historic estimates. This may be indicative of ecosystem-wide changes in spotted seatrout populations and highlights the need to closely monitor this population.

Bortone, S.A. 2006. A perspective of artificial reef research: the past, present, and future. Bulletin of Marine Science 78:1–8.
In a relatively short time, artificial reef researchers have established a rich and valuable archive of information from which to build future research programs. The personal interactions and dialog essential for the development of "good science" has been established and continues. Ongoing studies have increased in rigor and professionalism while building on ecological theory. Artificial reef research is becoming more sophisticated from a technical perspective, but needs to address the inherent problems in working in a "boundless" environment that often is impacted by human interference. With the incorporation of information from other disciplines, improvements are expected in overall approaches when attempting to answer several fundamental questions. To facilitate this improving trend, adequate funding resources will be essential. Concomitantly, study designs that incorporate large-scale and long-term approaches, when coupled with multi-jurisdictional

cooperation, will eventually allow a full assessment of the potential benefits artificial reefs may have toward achieving fisheries management objectives.

Bortone, S.A., **A.J. Martignette**, and **J.P. Spinelli**. **2006**. Spotted seatrout (Family Sciaenidae) growth as an indicator of estuarine conditions in San Carlos Bay, Florida. Florida Scientist 69(OOS2):127–139.
Life history characters of the spotted seatrout (*Cynoscion nebulosus*) have tremendous potential to discern trends in environmental conditions within and among estuaries. The species is widely distributed (i.e., from North Carolina to Mexico), is both commercially and recreationally important, and rarely leaves its home estuary. Thus, the estuarine conditions to which a population was subjected while growing could affect changes in its life history features such as growth. About 400 spotted seatrout were collected from April through July 2003 from the San Carlos Bay area of the southern portion of Charlotte Harbor in southwest Florida. Otolith sections were examined with enhanced imagery to facilitate recording age and annulus increments from the otolith. There was a significant relationship between otolith radius and fork length that differed between sexes. A comparison of back-calculated size at Age 1 for four year classes (1999–2002) indicated that there were significant differences in growth between year classes. Initial time-series analysis indicated the potential effects of seagrass density and salinity on fish growth. Salinity conditions are artificially manipulated in this estuary and this action may be responsible for the differences in growth rates observed for both males and females among year classes.

WATER QUALITY & MONITORING, ZOOPLANKTON, RED TIDE, AND HARMFUL ALGAL BLOOMS (HABs)

Publications

Chaffin, J.D., S. Mishra, D.D. Kane, D.L. Bade, K. Stanislawczyk, K.N. Slodysko, **K.W. Jones**, E.M. Parker, and E.L. Fox. **2019**. Cyanobacterial blooms in the central basin of Lake Erie: potentials for cyanotoxins and environmental drivers. Journal of Great Lakes Research 45(2):277–289.
Lake Erie western basin (WB) cyanobacterial blooms are a yearly summer occurrence; however, blooms have also been reported in the offshore waters of the central basin (CB), and very little is known about what drives these blooms or their potential for cyanobacterial toxins. Cyanobacteria Index was quantified using MODIS and MERIS data for the CB between 2003 and 2017, and water samples were collected between 2013 and 2017. The goals were to 1) quantify cyanobacteria, 2) determine environmental drivers of CB blooms, and 3) determine the potential for cyanobacterial toxins in the CB. *Dolichospermum* (Anabaena) occurred in the CB during July before the onset of the WB bloom, and then in August and September, the cyanobacteria community shifted towards Microcystis. The largest Dolichospermum blooms (2003, 2012, 2013, and 2015) were associated with reduced water clarity (Secchi disk depth < 4 m), whereas large CB Microcystis blooms (2011 and 2015) were associated with large WB blooms. *Dolichospermum* blooms occurred in high nitrate concentrations (>20 µmol/L) and high nitrogen-to-phosphorus ratios (>100), which indicate nutrient concentrations or ratios did not select for *Dolichospermum*. Additionally, the sxtA gene, but not mcyE or microcystins, were detected in the CB during July 2016 and 2017. The mcyE gene and microcystins were detected in the CB during August 2016 and 2017. The results indicate the CB's potential for cyanotoxins shifts from saxitoxins to microcystins throughout the summer. Continued monitoring of cyanobacteria and multiple cyanobacterial toxins is recommended to ensure safe drinking water for CB coastal communities.

Beckler, J.S., E. Arutunian, T. Moore, R.D. Currier, **E.C. Milbrandt**, and S. Duncan. **2019**. Harmful algae bloom monitoring via a sustainable, sail-powered mobile platform for inland and coastal monitoring. Frontiers in Marine Science. https://doi.org/10.3389/fmars.2019.00587**.**
Harmful algae blooms (HABs) in coastal marine environments are increasing in number and duration, pressuring local resource managers to implement mitigation solutions to protect human and ecosystem health. However, insufficient spatial and temporal observations create uninformed management decisions. In order to better detect and map blooms, as well as the environmental conditions responsible for their formation, long-term, unattended observation platforms are desired. In this article, we describe a new cost-efficient, autonomous, mobile platform capable of accepting several sensors that can be used to monitor HABs in near real time. The Navocean autonomous sail-powered surface vehicle is deployable by a single person from shore, capable of waypoint navigation in shallow and deep waters, and powered completely by renewable energy. We present results from three surveys of the Florida Red Tide HAB (*Karenia brevis*) of 2017–2018. The vessel made significant progress toward waypoints regardless of wind conditions while underway measurements revealed patches of elevated chl. a likely attributable to the K. brevis blooms as based on ancillary measurements. Measurements of colored dissolved organic matter (CDOM) and turbidity provided an environmental context for the blooms. While the autonomous sailboat directly adds to our phytoplankton/HAB monitoring capabilities, the package may also help to ground-truth satellite measurements of HABs if careful validation measurements are performed. Finally, several other pending and future use cases for coastal and inland monitoring are discussed. To our knowledge, this is the first demonstration of a sail-driven vessel used for coastal HAB monitoring.

Ndungu, L.K., J.H. Steele, T.L. Hancock, **R.D. Bartleson**, **E.C. Milbrandt**, M. Parsons, and H. Urakawa. **2019**. Hydrogen peroxide measurements in subtropical aquatic systems and their implications for cyanobacterial blooms. Ecological Engineering 138:444–453.
Hydrogen peroxide is widely recognized as the most stable of the reactive oxygen species (ROS) produced by both biotic and abiotic pathways in natural waters. Its high reactivity in mediating redox transformations may, directly or indirectly, affect aquatic ecosystem functions, including primary productivity. However, environmental interactions between photoautotrophs, particularly cyanobacteria, and hydrogen peroxide are poorly understood. To gain a better understanding of hydrogen peroxide and cyanobacterial interactions, we determined the hydrogen peroxide concentrations in the presence and absence of cyanobacterial blooms in southwest Florida. Hydrogen peroxide concentrations were determined using a fast response amperometric hydrogen peroxide microelectrode. Our measurements ranged from 0 to 5.3 μM in freshwater bodies (ponds, lakes and the Caloosahatchee River) and 0 to 92.9 μM in rainwater. In general, hydrogen peroxide levels were highly associated with cyanobacterial bloom conditions, indicating the potential role of cyanobacteria in hydrogen peroxide production in freshwater. To determine the potential biodegradation of hydrogen peroxide during sample transportation in the dark condition, water samples were passed through 0.2 μm pore size filters immediately after sampling and compared with unfiltered water samples in the laboratory. We found that filtered water samples retained higher concentrations of hydrogen peroxide than unfiltered samples with a mean biodegradation rate of 44 ± 10.6 nmol/h. Out of a total of 26 samples, only one unfiltered sample showed a higher hydrogen peroxide concentration than the filtered samples. Overall, our study found the microelectrode technique could accurately measure hydrogen peroxide concentrations in the samples from various freshwater bodies. This measurement method revealed that hydrogen peroxide concentrations vary with temporal and spatial dynamics of cyanobacterial blooms.

Milbrandt, E.C., **R.D. Bartleson**, **A.J. Martignette**, **J. Siwicke**, and **M. Thompson. 2016**. Evaluating light attenuation and low salinity in the lower estuary with RECON (River, Estuary, and Coastal Observing Network). Florida Scientist 79:109-124.
The southern portion of the Charlotte Harbor region, which includes Pine Island Sound, San Carlos Bay, and the lower Caloosahatchee Estuary, has over 11,700 ha of submerged aquatic vegetation

(SAV). The SAV species in the region have been used as environmental indicators because they are affected by nutrient loading, algae blooms, and freshwater discharges. Management approaches to reduce nutrient loading, phytoplankton concentrations, and high freshwater discharges in the region have also been applied to meet water clarity targets (light attenuation). In an effort to understand the duration and effect of low salinity periods in the lower estuary on water clarity, salinity data at several River, Estuary, and Coastal Observing Network (RECON) sites were analyzed. Optical parameters associated with increased light attenuation (fluorescent dissolved organic matter, chlorophyll, turbidity) were significantly higher during lower salinity periods (less than 25). In addition, discrete light attenuation coefficients, collected as part of RECON monthly maintenance, were analyzed. A synthesis and evaluation of the conditions in the lower Caloosahatchee during the study period (2008-2014) suggest that flow and load reductions would result in increased water clarity.

Martin, N., **L.D. Coen**, **A.J. Martignette**, **E.C. Milbrandt**. **2013**. Testing anti-fouling coatings with special emphasis on coastal observing systems. Florida Scientist 76(2):259–247.
Biological fouling is the accumulation and growth of aquatic organisms on submerged surfaces. Fouling can reduce the operation time and quality of data from aquatic real-time sensors. The SCCF Marine Laboratory currently has seven 'River, Estuary and Coastal Observation Network' (RECON) real-time sensor arrays deployed in the waters throughout southwest Florida. This study's goal was to compare eight commercially available anti-fouling coatings at three RECON stations (Redfish Pass, Gulf of Mexico and Shell Point). At all locations, PVC frames holding six plates (each $\sim$10.2cm^2) with various treatments were deployed. At the RECON sites, plates were deployed for four months and sampled monthly using digital photography. Plate images were analyzed using image analysis software Coral Point Count, for percent cover of organisms such as biofilm and barnacles. Four copper-based coating types were the most effective at preventing fouling, particularly by damaging barnacles and amphipod tubes, especially at high fouling locations. Using the correct coating type at a given RECON site is essential in preventing fouling while also minimizing down-time for redeployment.

Milbrandt, E.C., **R.D. Bartleson**, **L.D. Coen**, **A. Rybak**, **M. Thompson**, P. Stevens. **2012**. Local and regional effects of reopening a tidal inlet on estuarine water quality, seagrass habitat, and fish assemblages. Continental Shelf Research 41:1–16.
Blind Pass is an inlet that separates Sanibel and Captiva Islands in southwest Florida but has historically closed and opened by both anthropogenic and natural processes. In July 2010, a dredging project to open the small inlet between the two barrier islands was completed. The objective of this study was to use and supplement ongoing estuary-monitoring programs to examine the responses of water quality, seagrass habitat metrics, and fish assemblages both in the immediate vicinity of the inlet and at broader scales (up to 40 km2). As far as we are aware, there are no previous studies with this intensity of sampling, both before and after an inlet opening. Significant increases in salinity and turbidity were observed inside Blind Pass, with significant decreases in CDOM and chlorophyll a, however, the effects were not far-reaching and limited to less than 1.7 km from the inlet within Pine Island Sound. Seagrass habitat metrics were expected to respond rapidly after the inlet was opened given the reduced light attenuation. However, there were no changes in shoot densities, species composition, and epiphytic algae within the approximately one-year duration of the study. The reopening of the pass did not substantially change fish assemblage structure, except for those from deeper habitats. Although immediate increases in the abundances of estuarine-dependent species were predicted in shallow habitats post opening, this did not occur. In conclusion, the effects of reopening a relatively small ocean inlet on water quality were apparent in the immediate vicinity of the inlet (within 1.7 km), but far-reaching effects on water quality, seagrass metrics, and fish assemblages were not immediately apparent in this well-flushed estuary. If subtle changes in tidal exchange and circulation affect productivity of seagrasses or its fish assemblages at broad scales, it may take several years to reach a steady state.

Thompson, M.A., **E.C. Milbrandt**, **R.D. Bartleson**, and **A. Rybak**. **2012**. Evaluation of bacteriological and nutrient concerns in nearshore waters of a barrier island in SW Florida. Marine Pollution Bulletin 64:1425–1434.
To determine if local onsite treatment systems affect nearshore water quality, seasonal and rain event monitoring of bacteria and nitrogen was conducted on the Gulf and estuary sides of Captiva Island. Monitoring wells were used to examine the relationship between surface water and groundwater quality.
Nitrates were found to be significantly greater in ground water samples from the areas of Captiva using onsite treatment compared to areas with sewer. However, groundwater enterococci were no greater in areas with onsite treatment. Surface water nitrogen was significantly greater near onsite systems than areas with sewer, linking groundwater and surface water quality. Surface water enterococci increased significantly after rain events. Study results indicated stormwater runoff disperses indicator bacteria from diffuse terrestrial sources into nearshore waters, elevating the concentrations. This study reveals local onsite treatment systems produce elevated surface water nitrogen levels but do not contribute to elevated indicator bacteria concentrations in this system.

Milbrandt, E.C., R. Comny, P. Coble, **A. Martignette**, and **J. Siwicke**. **2010**. Evidence for the production of marine fluorescence dissolved organic matter in coastal environments and a possible mechanism for formation and dispersion. Limnology and Oceanography 55:2037–2051.
A positive linear relationship between salinity and fluorescent dissolved organic matter (FDOM) was observed on several occasions along the West Florida shelf at salinities greater than 36.5. This represents a departure from the typical inverse relationship between FDOM and salinity observed in most coastal regions caused by the mixing of riverine FDOM with clear oceanic water. Three-dimensional excitation-emission matrices showed that the high-salinity, high-FDOM water had blue-shifted spectra characteristic of autochthonous, marine FDOM, with peak M concentrations eight times higher than previously reported for seawater. The blue-shifted fluorescence endmember at high salinity was clearly distinguishable from a photobleached FDOM endmember. A high-resolution time series collected in a shallow embayment with significant Gulf of Mexico influence supplemented cruise data and provided a possible mechanism for the formation of high-salinity, high-FDOM water. During a dry period of spring tides, high-salinity, high-FDOM water was exported at ebb tide and lower-salinity, low-FDOM water was imported during flood tide. During neap tide, FDOM and salinity demonstrated no evidence of either export or dilution from incoming seawater. After a significant rain event, a more typical inverse relationship between salinity and FDOM was observed. Production of FDOM-rich water in shallow embayments has not been observed previously. This is likely an important source of organic matter and dispersion of this material may explain observations of a high-salinity, high-FDOM water in adjacent coastal regions.

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Scientists along the Gulf of Mexico and southeastern United States inevitably are asked to investigate the environmental effects of such extreme natural events as hurricanes. Since the usual post-event sampling strategy is often based upon the application of a pre-event study design that was not originally intended to evaluate disturbance effects, a hurricane evaluation strategy is needed that establishes sampling coverage through a broad network. Coupling this evaluation strategy with the refinement of serval estuarine indicators to assess environmental change will facilitate the evaluation of hurricane effects. Establishing the sampling network and concomitant protocols requires cooperation among scientists and agencies. Fortunately, the number and location of existing laboratories and investigations into establishing estuarine indicators is at hand. Developing a sampling network and protocols will better enable scientists to evaluate the effects of short-term, focused, and intense environmental disruptions.

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