THE 2ND JOINT SYMPOSIUM ON THE NATURAL HISTORY AND GEOLOGY OF THE BAHAMAS

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GERACE RESEARCH CENTRE
UNIVERSITY OF THE BAHAMAS
SAN SALVADOR, THE BAHAMAS

PROGRAM CO-CHAIRPERSONS:

Tina M. Niemi

Department of Geosciences
University of Missouri-Kansas City
Kansas City, MO

Kathleen Sullivan Sealey

Department of Biology
University of Miami
Coral Gables, FL

KEYNOTE SPEAKER:

Kam-biu Liu

Department of Oceanography and Coastal Sciences
Louisiana State University
Baton Rouge, LA

ORGANIZER:

Troy A. Dexter

Executive Director
Gerace Research Centre
University of The Bahamas
San Salvador, The Bahamas

DYNAMICS OF PHYSICAL DEPOSITION AND BIOTURBATION OF PLEISTOCENE CARBONATE SUBTIDAL SEDIMENTS, HARRY CAY SITE, LITTLE EXUMA, BAHAMAS

Beckham, Abigail, Smith College, Northampton, MA; **Graveline, Alyssa,** Smith College, Northampton, MA; **Reyna Alvarez, Nathaly,** Smith College, Northampton, MA; **Glumac, Bosiljka ,** Smith College, Northampton, MA; **Curran, H. Allen,** Smith College, Northampton, MA.
Presenter: Bosiljka Glumac, Poster 15

Pleistocene subtidal carbonate deposits of the Cockburn Town Member, Grotto Beach Formation at Harry Cay on Little Exuma Island contain a diverse assemblage of trace fossils, which can be used to assess the impact of burrowing organisms within these sediments. We conducted fieldwork, collected hand samples, and did petrographic analysis of thin sections of individual trace fossils and host rock samples in order to determine how the trace fossils differ from and have modified the host rocks. The stratigraphic section exposed in a large boulder present at Harry Cay Marina exhibited three distinct units and contained individual well-developed *Ophiomorpha*, *Conichnus*, and *Planolites* trace fossils (*Skolithos* also was present, but could not be sampled owing to its small diameter). Unit 1 is 30-50 cm thick and composed of ooid-peloidal grainstone, with some horizontal laminations and an ichnofabric index of 3. Unit 2 is 25-30cm thick and has the same composition as Unit 1, but is extensively bioturbated with a ichnofabric index of 5 (maximum). Unit 3 is 45 cm thick and composed of ooid-skeletal grainstone with well-developed cross bedding and an ichnofabric index of 1. A thick caliche crust tops the unit. Individual trace fossil samples were collected *in situ* from Unit 1 and as loose specimens weathered out from Unit 3 and its equivalents. All units were initially lithified in the marine realm but subsequently were subjected to meteoric diagenesis.

Ophiomorpha burrows, formed by callianassid shrimp, are common at Harry Cay. There are significant compositional differences between the micrite-rich walls of *Ophiomorpha* and the ooid-peloidal grainstone host rock. Like the mature *Ophiomorpha*, the samples of the juvenile *Ophiomorpha puerilis* have much more micrite in the pellets forming the burrow walls relative to the host rocks. This suggests the shrimp are concentrating micrite during their pellet-making and burrow-construction activities, while selectively eliminating coarser sediment grains. A comparative analysis of a subtidal exposure (equivalent to Harry Cay Unit 3) on nearby Great Exuma Island also revealed greater concentration of micrite in *Ophiomorpha* burrow walls relative to their ooid-skeletal packstone/grainstone host rock.

The interiors of *Planolites*, which are burrows filled with sediment that has passed through the gut of ballanoglossid worms, are finer grained than the host rock suggesting that the worms sorted the sediment while ingesting it, with larger grains pushed aside.

The trace fossil *Conichnus conicus*, thought to have formed by the upward movement of burrowing sea anemones, shows a difference in sediment fabric: sand grains appear more closely packed in the host rock compared to *Conichnus* trace fossil, which also seems better lithified relative to the surrounding sediment. This could be explained by the burrowing of the anemone creating a more open, porous fabric that allows for greater concentration of diagenetic fluids and more cement precipitation.

Our results demonstrate that burrowing organisms can modify the composition, texture, and fabric of subtidal carbonate sand-rich sediment through processes of micrite concentration and compaction (*Ophiomorpha*), sand sorting (*Planolites*) and repacking (*Conichnus*), respectively. In conjunction with ichnogenic megaporosity formation associated with open-burrow networks and differential lithification of sediment, these processes can increase heterogeneity of porosity and permeability distribution in carbonate rocks, impacting their aquifer properties.

IMPACT OF OCTOBER 2016 HURRICANE MATTHEW ON SEDIMENT-STARVED SOUTHERN COAST OF LITTLE EXUMA ISLAND, BAHAMAS

Chang , Jessica , Smith College, Northampton, MA; **Eastman, Elsie,** Smith College, Northampton, MA; **Howard, Susannah,** Smith College, Northampton, MA; **Glumac, Bosiljka ,** Smith College, Northampton, MA; **Curran, H. Allen,** Smith College, Northampton, MA; **Savarese, Michael,**
Florida Gulf Coast University, Fort Myers, FL.
Presenter: Bosiljka Glumac, Poster 16

Conch House Beach is a leeward, sediment-starved setting on the south coast of Little Exuma Island, Bahamas that was recently impacted by Hurricane Matthew, a major category 3 hurricane whose eye passed just offshore to the southwest of the study site on October 6, 2016. The goal of our research was to better understand the storm's impact and general depositional patterns along this reach of coast through field and petrographic observations and analysis of historical aerial imagery.

Petrographic analyses of beach sand indicate that it is predominantly composed of heaviliy micritized ooids and lithoclasts derived from weathering of the bedrock (mainly Holocene beachrock and eolian ooid grainstones), with subordinate amounts of skeletal fragments. The unusual brown color of beach sand at this site indicates subaerial weathering in the presence of iron oxides and supports low rates of sediment transport to and deposition in this setting. Historical Google Earth images from 2013 and 2016 also indicate a consistently sand-starved beach environment, with large quantities of dark, weathered bedrock exposed.

The presence of abundant ooids in beach sand and bedrock here supports the interpretation that leeward settings of Bahamian islands are conducive to ooid formation. Our observations suggest that ooids are likely forming in wave-agitated shallow offshore waters <2 m deep. In deeper waters farther offshore, sediment is being stabilized by an organic microbial film. In conjunction with relatively low fair-weather wave energy, this prevents large quantities of sand from being easily transported and deposited on the beach, leading to the general sediment-starved conditions observed here.

Erosion by hurricanes is also a major factor that impacts this coastal setting. Evidence of erosion by Hurricane Matthew, observed in January 2017, included the abundance of freshly exposed, light color bedrock with erosional scars reaching as high as 3.5 m above mean sea level along these steep coastal cliffs. The striking color contrast with dark, weathered bedrock can also be used to examine the formation of new bedrock-derived boulders and their movement and deposition by storm waves. Imbrication direction of recently moved tabular boulders as large as 90 cm in diameter is consistent with their landward transport by storm waves. Boulders encrusted with fresh bivalves were found on the beach more than 10 m from the water's edge, indicating substantial transport by recent storm waves from the shallow offshore subtidal environment. Another major evidence of beach and dune sand erosion and landward transport by Hurricane Matthew was the deposition of a 1 m-thick washover fan into the adjacent mangrove swamp. These observations indicate that storms have a major impact on the style and rate of sedimentation and erosion in this otherwise relatively low-energy coastal setting. This should be taken into account, together with the documented low rates of sediment deposition and high rates of erosion, in any future plans for development along this reach of coast.

CONFIRMATION OF THE OCCURRENCE OF *SYNAPTULA HYDRIFORMIS*, THE "NAKED SEA CUCUMBER", IN OYSTER POND, SAN SALVADOR ISLAND, AND DEMONSTRATION OF INDUCIBLE "LIVE BIRTH" AND SELF-FERTILIZATION

Cole, Eric, S, St. Olaf College, Northfield, MN; **Hahn, Leigh Anne,** St. Olaf College, Northfield, MN; **Thacker, Miranda, C,** St. Olaf College, Northfield, MN; **Choquette, Jessica, M,** St. Olaf College, Northfield, MN.
Presenter: Eric S. Cole, Friday 8:30 AM

We confirm the wide-spread occurrence of the Apodid sea cucumber *Synaptula hydriformis*, in Oyster Pond on San Salvador Island, Bahamas. Three color morphs are described including one that is nearly transparent. Visible inside the colorless morphs, we detect growing juveniles exhibiting "matrophagy" (deriving nourishment from their

mother's tissues). We describe a technique for inducing live birth, and stimulating self-fertilization. Histology reveals an "ovo-testis" capable of simultaneously expressing eggs and sperm. All these observations confirm that this species is capable of simultaneous hermaphroditism, and internal self-fertilization (consistent with its identification). Developmental analysis reveals direct development without a plantkonic larvae, and completion of the adult body form within 24 hours of fertilization. All these traits recommend this holothurian as a "model organism" for the study of invertebrate embryology. The life-history of this organism suggests that it can propagate clonally, making it an ideal colonist of the inland anchialine pond habitats.

EFFECTS OF HURRICANE JOAQUIN ON SILVER THATCH PALMS ON SAN SALVADOR: WIND AND OVERWASH

Cross, Randall, E, Florida Gulf Coast University, Fort Myers, Florida; **Goebel, Anna, M,** Florida Gulf Coast University, Fort Myers, Florida.

Presenter: Randall Cross, Poster 7

Hurricane Joaquin's impact on San Salvador in October of 2015 had dramatically different effects on three populations of silver thatch palm (Coccothrinax argentata). Two populations (Rocky Point and Grotto Beach were part of a long-term study of population structure and dynamics initiated more than a year before the hurricane. Data was collected for the first time at Sandy Hook, on the southern part of the island, in 2016, 8 months after the hurricane. We expected to find extensive mortality of palms across the island. We were surprised to observe very little mortality that could be attributed to the storm in our study populations at Rocky Point and Grotto Beach. However, we found significant mortality at Sandy Hook, but the heavy mortality was confined to a relatively small area. Because the heavily impacted area had a significant overwash event from the storm, we set up study plots in the overwash area and an adjacent unaffected area to quantify the level of mortality of juvenile and adult trees in this area. The level of mortality in the overwash area was > 76% while the level of mortality in the nearby unaffected area was < 0.1%. Since dead adult trees were still standing the likely cause of mortality seemed to be not from direct wind damage or direct wave impact from the storm. We hypothesized that the main cause of mortality in the affected overwash area was indirectly due to storm surge through the inundation of sediments with salt water. We collected soil samples from both of the areas and found that the soil salinity was significantly greater ($p < 0.05$) in the over wash area (872.8 uS/cm versus 207.7 uS/cm). These data demonstrate a significant difference in soil salinity at this site and support the hypothesis that the likely cause of mortality was due to the higher soil salinity levels and mortality from wind and waves was minimal. This study also demonstrated that elevated soil salinity levels can persist for almost 9 months following overwash events.

LATE HOLOCENE HISTORICAL ECOLOGY: THE TIMING OF VERTEBRATE EXTIRPATION ON CROOKED ISLAND, COMMONWEALTH OF THE BAHAMAS

Delancy, Kelly, M, National Museum of The Bahamas, Marsh Harbour, Abaco; **Albury, Nancy, A,** National Museum of The Bahamas, Marsh Harbour, Abaco; **Steadman, David, W,** Florida Museum of Natural History, Gainesville, Florida;
Singleton, Hayley, M, Florida Museum of Natural History, Gainesville, Florida; **Soto-Centeno, J. Angel,** American Museum of Natural History, New York, New York.

Presenter: Kelly Delancy, Friday 9:00 AM

We report eight new accelerator-mass spectrometer (AMS) radiocarbon (14C) dates done directly on individual bones of extirpated species from Crooked Island, The Bahamas. Three dates from the hutia (Geocapromys ingrahami), recovered from a culturally derived bone assemblage in McKay's Bluff Cave (site CR-5), all broadly overlap from AD 1450 to 1620, which encompasses the time of first European contact with the Lucayan on Crooked Island (AD 1492). Marine fish and hutia dominate the bone assemblage at McKay's Bluff Cave, shedding light on vertebrate consumption by the Lucayans just before their demise. A fourth AMS 14C date on a hutia bone, from a non-cultural

surface context in Crossbed Cave (site CR-25), is similar (AD 1465 to 1645) to those from McKay's Bluff Cave. From Pittstown Landing (site CR-14), an open coastal archaeological site, a femur of the Cuban crocodile (*Crocodylus rhombifer*) yielded an AMS 14C date of AD ~1050-1250, which is early in the Lucayan cultural sequence. From a humerus in a non-cultural surface context in 1702 Cave (site CR-26), we document survival of the Cuban crocodile on Crooked Island until AD ~1300-1400, which is several hundred years later than the well documented extinction of Cuban crocodiles on Abaco in the northern Bahamas. We lack a clear explanation of why Cuban crocodiles likely survived longer on Crooked Island than on a larger Bahamian island such as Abaco. One AMS 14C date on Crooked Island's extinct, undescribed species of tortoise (*Chelonoidis sp.*) from 1702 Cave is BC 790 to 540 (2740 to 2490 cal BP), which is ~1500-1700 years prior to human arrival. A second AMS 14C date, on a fibula of this tortoise from McKay's Bluff Cave, is AD 1025 to 1165, thereby demonstrating survival of this extinct species into the period of human occupation.

LIFE AMONG THE WASPS: A REVIEW OF STUDIES ON *CERCERIS WATLINGENSIS* ELLIOTT & SALBERT (HYMENOPTERA: SPHECIDAE) IN THE BAHAMAS

Elliott, Nancy, B, Siena College, Loudenville, NY; **Landry, Carol, L,** The Ohio State University, Mansfield, OH.
Presenter: Nancy Elliott, Friday 9:30 AM

In November 1975, the first Hartwick College class on Bahamian arthropods was conducted on San Salvador. Experts at the U.S. National Museum determined that one of the collected wasps was a new species, which Elliott later described. The wasp was named *Cerceris watlingensis*; the species has since been collected on other southern islands of the Bahamas archipelago. Over the years, we conducted a number of field studies on the behavior of *C. watlingensis* on San Salvador, including several aspects of nesting behavior. Females preyed on weevils, primarily an *Artipus* species that was carried to the nest in flight but was not paralyzed. In contrast, most sphecids paralyze prey before carrying them to the nest. Nest excavations showed numerous nest cell chambers below the end of a main entrance channel; the oldest cells were as deep as 60 cm below the soil surface. Since females spent little time within the nest between foraging flights, we assumed that prey were initially deposited in the main channel and later moved to cells deeper in the nest. At first, most nests appeared to contain a solitary female, but we found one nest that contained at least two. In subsequent studies, wasps were labeled with unique patterns of paint that allowed us to identify each individual. These studies demonstrated that nest sharing was more common than previously thought, and is the result of two different aspects of behavior: young females remained within the parental nest for several days after emergence, or switched into a pre-existing nest some distance from the natal nest. In either case, nest sharing did not result in obvious aggressive behavior. We also observed individually-marked males on *Croton linearis* at a nesting site near the north end of San Salvador. There was a significant linear relationship between male visits to the plants and the number of days that nearby nests were active. This behavior might increase the probability that males find and mate with virgin females as they emerge from their nests. Since that time, we have observed wasps making floral visits to at least seven additional plant species.

HURRICANE JOAQUIN IMPACTS ON OYSTER POND, SAN SALAVADOR, BAHAMAS

Ford, Dawn, M, The University of Tennessee at Chattanooga, Chattanooga, TN; **Abernathy, Jalana,** The University of Tennessee at Chattanooga, Chattanooga, TN; **Mitchell, Ashton,** The University of Tennessee at Chattanooga, Chattanooga, TN;
Black, Luke, The University of Tennessee at Chattanooga, Chattanooga, TN; **Schwartz, Alex,** The University of Tennessee at Chattanooga, Chattanooga, TN; **Novak, Sabrina ,** University of Tennessee at Chattanooga, Chattanooga, TN.
Presenter: Dawn Ford, Friday 7:30 PM

Over the past 4 years, studies of interior pond biota have been conducted by UTC on San

Salvador, Bahamas. In 2015, Hurricane Joaquin directly impacted the island and disturbed the mangrove vegetation, pond biota, and sediment of many of the interior ponds, including Oyster Pond. Oyster Pond is a fully marine pond lined by red mangroves (*Rhizophora mangle*) and has a number of conduits connecting the pond to the ocean and perhaps other ponds. The post-hurricane recovery of pond biota, specifically those living on biotic outcroppings and mangrove prop roots, is currently being investigated with a focus on macroalgae and invertebrates. Comparisons with pre-hurricane data reveal that in general green macroalgal species have recovered, while several red and brown macroalgal species have not successfully reestablished. In comparing the western side of the pond to the less impacted eastern side of the pond, the data suggest that the more impacted mangroves can support fewer algal and invertebrate species and in less abundances than healthy mangroves. This finding might be explained by the detrital nature of mangrove systems.

THE LONG-TERM IMPACTS OF A BAHAMAS FIELD EXPERIENCE ON STUDENT PARTICIPANTS

Ford, Dawn, M, The University of Tennessee at Chattanooga, Chattanooga, TN; **Eshbaugh, Hardy,** Miami University, Oxford, OH; **Branson, R. Christopher,** Jane and Terry Semel Research Institute for Neuroscience and Human Behavior at UCLA, Los Angeles, CA.
Presenter: Dawn Ford, Poster 9

For many years, Bahamian field courses have been taught by faculty at Miami University and the University of Tennessee at Chattanooga (UTC). While it is assumed that these experiences are very impactful on students, little is documented about the long-term effects of such experiences on students' personal and professional development. The purpose of this study was to assess the perceived impacts of these courses on former students' development using a 25-question instrument. In November 2015-January 2016, the online survey was administered to former students of Bahamas field courses offered by these institutions between 1977 and 2014. Of the 450 former students contacted, 156 responded to the survey. Survey results showed that a high proportion of respondents "agreed" that the experience had a high impact on their personal development, professional development, and international perspective. Additional analyses indicated no statistically significant differences between groups or within groups, suggesting that perceived impacts are the same for both institutions, males and females, and all age groups. The top benefits of Bahamian field courses reported by the respondents included exposure to Bahamian culture, establishing relationships with faculty and peers, and participating in hands-on experiences. There were overwhelmingly positive comments made by respondents and many cited the course as life-changing. These findings support the continued offering of such experiences.

STORM-DEPOSITED BOULDER RIDGES ALONG ROCKY SHORELINES OF SAN SALVADOR ISLAND, BAHAMAS: LONG-TERM MONITORING AND SIGNIFICANCE

Glumac, Bosiljka , Smith College, Northampton, MA; **Curran, H. Allen,** Smith College, Northampton, MA.
Presenter: Bosiljka Glumac, Friday 8:00 PM

Monitoring changes in morphology and distribution of coastal boulder ridges and the direction and amount of movement of individual large boulders can provide useful information about the intensity and effects of storms that impact Bahamian island coasts. We have ongoing monitoring projects for two boulder ridges on San Salvador: one along the reef- and lagoon-protected northern coast around Singer Bar Point (SBP, length ~790 m) and the other on the high-energy southern coast west of The Gulf (TG, length ~460 m).

Our initial work in January 2012 described the SBP ridge as wide (up to 14 m) and with a low crest (~1.5 m above mean sea level), whereas the TG ridge was generally narrower, with a sharp crest located on a cliff-bench 3-5 m above mean sea level. The largest boulders from each site were photographed, located with GPS coordinates, measured (length, width, thickness), and characterized by composition (subtidal calcarenite, coral

rubblestone, eolianite, lithified paleosol), shape (tabular or irregular), and degree of roundness.

Largest boulders at SBP are generally smaller (15 total; ~150-4000 kg; with most <1500 kg) and more rounded than those at TG (12 total; ~700-4500 kg; with all but one >1000 kg). Boulders are eroded from the seaward rocky coast, transported and deposited by high-energy storm waves. Smaller size and better rounding of clasts are more common at SBP than TG, indicating multiple events of milling in the surf prior to deposition along this low-profile coast as compared to the high cliff-profile TG coast. The presence of larger boulders and fossil coral rubblestone boulders at TG indicates that stronger storm waves were required to erode and transport them.

Our monitoring from January 2013, 2016, and 2017, after Hurricanes Sandy (October 2012), Joaquin (October 2015), and Matthew (October 2016), respectively, resulted in only modest modifications to the SBP ridge along the protected northern shore. In contrast, the TG area along the high-energy southern shore was drastically modified: we were not able to relocate 2 boulders post-Sandy, and only 5 of the remaining boulders were relocated with certainty after Joaquin. Two of those, weighing ~2 tons each, were transported as much as 20 m and 26 m inland to the NNW. The southern edge of the boulder ridge moved landward by 4-5 m exposing an underlying Pleistocene/Holocene boundary *terra rossa* paleosol, which stands out in aerial images and can be used to map the extent of storm erosion. Joaquin modified the formerly sharp-crested, narrow boulder ridge into a larger, broad boulder field stripped of vegetation. Boulders of various sizes covered sections of the island's main coastal road (cleared and back in service as of spring 2017). Post-Hurricane Matthew, which passed too far from the coast of San Salvador to have any major impact, 10 new boulders and high-resolution drone aerial imagery were added to our monitoring program at TG. Information on the distribution and morphology of boulder ridges and the dynamics of their modification are long-term indicators of storm patterns and activity and should be used to inform coastal development on San Salvador and elsewhere in the Bahamas.

PLANT-SEDIMENT INTERACTIONS IN TERRESTRIAL AND SHALLOW MARINE ENVIRONMENTS OF THE BAHAMAS: EXAMPLES AND IMPLICATIONS

Glumac, Bosiljka , Smith College, Northampton, MA; **Curran, H. Allen,** Smith College, Northampton, MA.
Presenter: Bosiljka Glumac, Poster 14

Quaternary deposits in the Bahamas reveal multiple examples of substrate modification by terrestrial and marine plants that constitute important evidence of past vegetation and can be used as paleoclimate indicators of temperature and precipitation regimes. Modification of sediment by plants can also produce significant amounts of post-lithification porosity and permeability, which can increase reservoir quality of the host rocks. Various modes of plant root preservation in the form of rhizoliths are the most common evidence of such plant-sediment interactions in the Bahamas. Another well-known example includes the role of red mangrove (*Rhizophora mangle*) root systems in trapping sediment and preventing coastal erosion. Here we discuss other less well documented examples of plant interactions with carbonate sediment from Bahamian coastal and shallow subtidal settings to demonstrate their highly variable nature and products. These examples include: 1) eolian deposits with impressions of silver thatch palm fronds (*Coccothrinax argentata*); 2) impressions of terrestrial plant roots (sea grape = *Coccoloba uvifera*), prostrate stems (bay geranium = *Ambrosia hispida*), runners (railroad vine = *Ipomoea pes-caprae*), and blades (sea oats = *Uniola paniculata*) in eolian and back-beach deposits; 3) large vertical pipes present in Holocene eolianite and possibly representing buried palm tree trunks and/or roots, which may also exploit pre-existing paths created by dissolution or other mechanisms; 4) highly porous "spongiform" texture of Holocene eolianite, which likely forms by sand trapping and lithification around dense roots, stems and organic litter of grass and shrub vegetation, including various microbial, fungal and insect communities, as well as

accumulation and burial of marine algae (e.g., *Sargassum*) and seagrasses in beach sediment; and 5) extensive modern seagrass (*Thalassia testudinum*) root systems that trap sediment in shallow marine subtidal settings and have potential to leave traces in the geological record, but have not commonly been documented from ancient strata. Similarly, large and extensive palm tree roots do not seem to be easily preserved and recognized in carbonate grainstones, but they may be partially responsible for producing the commonly observed spongiform texture of Holocene non-marine deposits in the Bahamas.

DISTRIBUTION AND NATURE OF MICROBIALITES IN THE COCKBURN TOWN FOSSIL REEF (PLEISTOCENE, GROTTO BEACH FORMATION), SAN SALVADOR ISLAND, BAHAMAS: PRELIMINARY RESULTS

Griffing, David, H., Hartwick College, Oneonta, NY; **Kortright, Skylar,** Hartwick College, Oneonta, NY; **Glumac, Bosiljka,** Smith College, Northampton, MA; **Curran, H. Allen,** Smith College, Northampton, MA.
Presenter: David Griffing, Poster 17

The Sangamonian (MIS 5e) Cockburn Town reef (Grotto Beach Fm.) on San Salvador Island, Bahamas, is an important source of data for the debate regarding rapid sea-level changes during the last interglacial highstand. Although Cockburn Town reef microbialites have been previously identified, details of their distribution remained unexplored. Preliminary re-examination of these deposits reveals a complex distribution of microbialites in relation to major and minor discontinuities within the reef deposit. A widespread erosional hardground surface separates Reef I and II developmental phases. Exposures of coral floatstone and framestone well below this hardground surface exhibit pristine coral material as well as fragments with 1-5 mm-thick skeletal encrustations typical of normal post-mortem colonization in modern Bahamian reefs. Higher Reef I strata exhibit branching corals and fragments with discrete upward-thickening coatings of laminated micrite-skeletal silt that cover early skeletal crusts. SEM examination of broken laminar surfaces reveals small tubular casts resembling microbial filaments, supporting a microbial origin for these coatings. Microbial coatings increase in abundance and in thickness upward, from a few thin coatings that comprise 2-5% of the rock, to 30-80mm thick coatings on most branches. Immediately below the Reef I-II boundary hardground, both laminated and clotted microbialite forms microbial-skeletal boundstone that coalesces between coral branches to comprise 40-50% of the rock (and locally > 80%). In one area, thin drapes of skeletal-ooidal grainstone form shingled partitions within the dense microbial-skeletal boundstone and indicate episodes of lateral accretion. In contrast to Reef I deposits, most of the corals and coral fragments in overlying (Reef II) deposits examined lack microbialite coatings, and display little or no skeletal encrustation, abrasion or corrosion. Still, Reef II strata are truncated by two hardgrounds (one mid unit and one capping the reef deposit that is part of the major regression leading into the last glacial). Assuming the reef coral to microbialite transition developed in response to environmental changes associated with sea-level drop, then the Cockburn Town reef microbialites and hardgrounds support previous interpretations that at least one (and perhaps more) short-term sea-level fluctuation occurred during the last interglacial highstand.

LIFE HISTORY AND SEXUAL HISTOLOGY OF *SYNAPTULA HYDRIFORMIS*

Hahn, Leigh, A, St. Olaf College, Northfield, MN; **Cole, Eric, S,** St. Olaf College, Northfield, MN.
Presenter: Leigh Anne Hahn, Poster 6

Synaptula hydriformis (Lesueur, 1824) is a hermaphroditic self-fertilizing sea cucumber. A unique feature of this species is their ovo-testis and viviparous abilities. Through histology done in January 2016, this organ was found to contain both sperm and eggs. The ovo-testis's existence has been verified by past researchers who studied the species, although there was debate over whether or not an individual could self-fertilize. Its viviparity is fairly unique among other synapula who tend to release gametes into the water instead. *S.*

hyrdriformis was first found in the Bahamas in 1886, but little research has been done on specimens from the area. The species has been found everywhere from Bermuda to Brazil, but the coloration of local species appears to be different than most places. Specimens are mostly commonly observed as either red or green, but individuals from Oyster Pond come in clear, brown, and striped varieties.

TROPICAL ANCIENT DNA REVEALS RELATIONSHIPS OF THE EXTINCT BAHAMIAN GIANT TORTOISE *CHELONOIDIS ALBURYORUM*

Kehlmaier, Christian, Museum of Zoology, Senckenberg Dresden, Germany; **Albury, Nancy, A,** National Museum of The Bahamas, Abaco, The Bahamas; **Barlow, Axel,** University of Potsdam, Potsdam, Germany; **Hastings, Alexander, K,** Virginia Museum of Natural History, Martinsville, Virginia; **Steadman, David, W,** Florida Museum of Natural History, Gainesville, Florida.
Presenter: Nancy Albury, Poster 1

Ancient DNA of extinct species from the Pleistocene and Holocene has provided valuable evolutionary insights. However, these are largely restricted to mammals and high latitudes because DNA preservation in warm climates is typically poor. In the tropics and subtropics, non-avian reptiles constitute a significant part of the fauna and little is known about the genetics of the many extinct reptiles from tropical islands. We have reconstructed the near-complete mitochondrial genome of an extinct giant tortoise from the Bahamas (*Chelonoidis alburyorum*) using an approximately 1000-year-old humerus from a water-filled sinkhole (blue hole) on Great Abaco Island. Phylogenetic and molecular clock analyses place this extinct species as closely related to Galapagos (*C. niger* complex) and Chaco tortoises (*C. chilensis*), and provide evidence for repeated overseas dispersal in this tortoise group. The ancestors of extant *Chelonoidis* species arrived in South America from Africa only after the opening of the Atlantic Ocean and dispersed from there to the Caribbean and the Galapagos Islands. Our results also suggest that the anoxic, thermally buffered environment of blue holes may enhance DNA preservation, and thus are opening a window for better understanding evolution and population history of extinct tropical species, which would likely still exist without human impact.

TEMPORAL STABILITY OF *ORBICELLA ANNULARIS* SYMBIOSES: A BAHAMIAN CASE STUDY

Kennedy, Emma, V, University of Exeter, Exeter, UK; **Stevens, Jamie, R,** University of Exeter, Exeter, UK.
Presenter: Jamie Stevens, Friday 10:30 AM

Orbicella annularis is unusual among Caribbean corals in being flexible in terms of the symbiont taxa it can associate with. Recent papers have explored the extent of this flexibility across a large spatial scale (almost the entire species range), describing symbioses with 22 endosymbiont clades and exploring a variety of environmental gradients, geographic distance and host genetic diversity. However, the *Symbiodinium* communities of *O. annularis* have also been shown to fluctuate on a temporal scale, both in terms of density (e.g., seasonal fluctuations in abundance), and in response to environmental stressors (sporadic changes in abundance and in community composition). Some corals, such as *Acropora millepora*, demonstrate very variable symbiont communities from year to year. In order to explore the robustness of observed spatial patterns, it is necessary to investigate the temporal stability of symbiont communities. In this paper we describe a small-scale study in which we used denaturing gel gradient electrophoresis (DGGE) and ITS2 ribosomal DNA sequence profiles to assess the stability of symbiont communities in *O. annularis* at four sites in the Bahamas, across a period of six years.

THE IMPACT OF HABITAT TYPE ON COMPETITIVE INTERACTIONS BETWEEN ALIEN FIRE ANTS AND ANT SPECIES ASSEMBLAGES ON SAN SALVADOR ISLAND, THE BAHAMAS

Kjar, Daniel, Elmira College, Elmira, NY; **Park, Zachory,** Georgetown University, Washington, DC.
Presenter: Daniel Kjar, Poster 2

On San Salvador Island, The Bahamas, Solenopsis invicta (Red Imported Fire Ant) is an invasive species that was believed to be introduced into the Caribbean around 1890. The purpose of this study was to determine if habitat type affects the competitive interactions between the alien fire ant, S. invicta, and native ant species assemblages on the island. Extensive ant sampling and observation were conducted in three distinct habitat types on San Salvador Island; palmetto, blackland (coppice), and plantations during 2014 and 2015. Here we create an index (PK index) which ranks ant species based on their effectiveness as competitors across all habitats based on how often they come to baits in a particular habitat, how quickly they arrive, and how quickly they recruit to the bait compared to the average of other ants in the study. Our data show that interactions and foraging behavior among ant species change substantially among habitats. Solenopsis invicta and other invasive species appear to have a competitive advantage in terms of arrival and recruitment to baits in the once heavily disturbed plantation habitat and the continuously disturbed palmetto habitat. However, S. invicta had the highest PK index in only the plantation habitat. This suggests that some set of factors present in the plantation habitat are contributing to the success of the species in that habitat and are not present in the other habitats in this study.

GENETIC DIVERSITY AT 6 MICROSATELLITE MARKERS IN THE LONG HORNED CRAZY ANT OF SAN SALVADOR ISLAND, THE BAHAMAS, AND ITS ASSOCIATION WITH HABITAT DOMINANCE.

Kjar, Daniel, Elmira College, Elmira, NY; **Yaw, Bridget,** Elmira College, Elmira, NY; **Miller, Ashley,** Elmira College, Elmira, NY.
Presenter: Ashley Miller, Poster 3

During the field summers of 2014 and 2015 field observations of ant interactions at baits on San Salvador Island, The Bahamas, showed that *Paratrechina longicornis*, an introduced invasive ant species, appeared to have two distinct behaviors. In some locations *P. longicornis* rapidly recruited massive numbers of foragers to baits and in other locations had very poor competitive abilities with other species (regardless of apparent nest density or local abundance). In order to further examine these outcomes we collected *Paratrechina* from as many locations as possible, along with behavioral data, and we will look at the genetic diversity among these populations using 6 microsatellite markers. Due to the nature of species introductions (often a single queen or nest), populations of introduced ant species often have little genetic variability leading to increased cooperation among nests and release from conspecific competition. We believe that there may be two distinct genotypes on the island and areas where competitive abilities are low may be a different population from those where *Paratrechina longicornis* has dominated the local ant community.

DORYMYRMEX ANTILLANA, RED IMPORTED FIRE ANTS, AND THE LONG HORNED CRAZY ANT: A LOOK AT WHAT I HAVE LEARNED ABOUT THE ANT COMMUNITY ON SAN SALVADOR

Kjar, Daniel, Elmira College, Elmira, NY.
Presenter: Daniel Kjar, Friday 11:00 AM

On San Salvador Island, The Bahamas, ants are a dominant member of the animal community. No matter where you go, and sit, you will encounter ants and often more than just one. Over the last 9 years I have been examining several aspects of this community. Habitat plays a very important role in determining the ant community and the competitive interactions among species. Along with habitat, genetics may play a role in these interactions and I will discuss the genetics and habitat of one of the world's most invasive species, the Long Horned Crazy Ant, present all over the island but not always in dense populations. Lastly, I will describe our recent work on an interesting ant species, *Dorymyrmex antillana*. A common native species on San Salvador and throughout the Bahamas, but one that has a only recently been recognized as its own species.

SPATIAL VARIATION IN MOLLUSK COMMUNITIES AROUND SAN SALVADOR ISLAND, BAHAMAS

Kowalewski, Michal, Florida Museum of Natural History, University of Florida, Gainesville, FL; **Casebolt, Sahale,** Florida Museum of Natural History, University of Florida, Gainesville, FL.
Presenter: Michal Kowalewski, Friday 11:30 AM

Surficial accumulations of mollusk shells may provide minimally invasive, quantitative data potentially suitable for assessing spatial organization of local benthic ecosystems. We collected 61 bulk samples along 12 transects to evaluate distribution and ecological characteristics of mollusk-dominated benthic communities around San Salvador Island, Bahamas. The samples yielded a total of 20,608 specimens, which represented a minimum of 181 mollusk species. Indirect multivariate ordinations (NMDS) separated samples by locality (even in the case of transects sampling different parts of the same bay) indicating that shell assemblages faithfully archive local differences in mollusk communities. At the regional scale, a clear faunal separation is observed between windward and leeward sides of the island, suggesting that water energy represents an overriding regional driver controlling local community composition. Within each energy regime, the faunal composition of mollusk assemblages is primarily controlled by seagrass vegetation. The results indicate that San Salvador benthic communities are characterized by a predictable spatial organization controlled primarily by physical and, secondarily, biological (seagrass vegetation) processes. That these patterns can be discerned so clearly by sampling shell assemblages suggests that studies centered on dead mollusks provide a viable and largely non-invasive strategy for examining processes that drive spatial structuring of marine communities locally and regionally.

TRENDS IN FLOWERING PHENOLOGY AND FLOWERING INTENSITY FOLLOWING THREE HURRICANES

Landry, Carol, L, The Ohio State University, Mansfield OH; **Elliott, Nancy, B,** Siena College, Greenlawn NY.
Presenter: Carol Landry, Friday 7:00 PM

The purpose of this study was three-fold: to describe trends in the flowering phenology and flowering intensity of plants in coastal communities following hurricanes, to compare these characteristics in years with and without hurricanes, and to determine if plants that produced flowers received visits from insect pollinators at the same rate in years with and without hurricanes. The study is part of a larger research program investigating the role of plant-insect interactions in the maintenance of biodiversity in Bahamian coastal plant communities, which experience frequent, sometimes catastrophic, hurricanes. Data were collected on San Salvador Island, The Bahamas, during the first half of December in years 2010-2016, and in October 2011. Three hurricanes impacted San Salvador during this timeframe: Irene (Category 3, August 2011), Sandy (Category 2, October 2012), and Joaquin (Category 4, October 2015). Data were collected over 6-12 days at the same site locations on the island. In years following hurricanes, we recorded vegetative damage within 200 m of the coast; in all years, we recorded the floral condition of all coastal plant species, estimated flowering intensity, and recorded floral visitors observed incidently or during 10-15 minute watch intervals. Depending on the year, we spent 40-90 person hours recording observations of floral visitors between 0900 hours and 1630 hours. Damage to plants increased with storm intensity and duration, distance from the coast, and local topography. The type of damage sustained by the plants ranged from stripped leaves, flowers and fruits, to broken branches, to broken trunks and/or uprooted plants. Preliminary analysis demonstrates that plant species varied in their response to hurricanes in terms of phenology, and that pollinator visitation rates to most plant species were lower in years with hurricanes versus years without hurricanes. Pollinator diversity also declined with hurricane strength, but this does not appear to be correlated with the phenology of specific plant species.

FLANK MARGIN CAVE COLLAPSE IN THE BAHAMAS: PREDICTIVE METHODS

Lawrence, Orry, P, Mississippi State University, Mississippi State, MS; **Mylroie, John, E,** Mississippi State University, Mississippi State, MS.
Presenter: John Mylroie, Poster 18

The risk of sinkhole collapse in The Bahamas is almost entirely caused by failure of cave roofs; cover-collapse sinkholes, common elsewhere and caused by catastrophic sediment flow into underground voids, is almost non-existent because soil cover is thin. On the large banks of The Bahamas, conduit flow at depth leads to large collapse features that under current sea-level conditions become blue holes. Predicting this collapse is difficult. On large and small banks, flank margin caves, formed in the distal margin of the fresh-water lens at a past sea-level highstand, are common, as is a subset of that cave type, the banana hole. Flank margin caves have three entrance types: dissolution pit, side breach, or ceiling collapse. The latter two are the result of mass erosional forces; pits form by focused vadose dissolution. Banana holes typically result in roof collapse due to their location in Pleistocene strand plains which cause them to form with thin roofs predisposed to failure. It was suggested that slope could be used as a proxy for controlling factors in Bahamian flank margin cave collapse. This study demonstrated that 7.5 minute topographic maps cannot resolve slopes in enough detail to predict potential collapse locations. Field surveys with 1 m contours allowed for a more concise slope range in which each entrance type preferentially occurred; collapse breaches and pits were common on gentle slopes and side breaches on steep slopes. Flank margin caves and banana holes are easy to localize in a general sense, but the specific position of these voids within those localities eludes easy analysis. Further investigation into the location of subsurface voids and the collapse risk associated with such voids can be performed using various geophysical methods including GPR and gravity surveys, although these methods are labor intensive and time consuming.

THE EFFECTS OF HURRICANE JOAQUIN ON THE ONSHORE-OFFSHORE ZONATION OF ENCRUSTING FORAMINIFERA AT SAN SALVADOR, BAHAMAS

Lewis, Ronald , Auburn University, Auburn, Alabama; **Asher, Sarah,** Auburn University, Auburn, Alabama; **Speetjens, Sara,** Auburn University, Auburn, Alabama; **Sundbeck, Sally,** Auburn University, Auburn, Alabama.
Presenter: Ronald Lewis, Poster 8

Benthic foraminifera that are firmly attached to hard substrates (encrusting foraminifera) have been studied as part of the reef ecosystem and in actualistic studies to aid in paleoenvironmental reconstructions of shallow-water carbonates. A common research technique is to investigate their distribution by collecting cobble-sized pieces of reef rubble and other clasts from a range of environments. One benefit of focusing on encrusting foraminifera is that they are less likely to be transported out of their habitats than are free foraminifera. However, even large clasts can be transported great distances during high-energy storm events, an issue that has caused some concern for researchers. The small Bahamian island of San Salvador provides a good test case as its encrusting foraminifera are well known, and the island was impacted directly by a major hurricane. Hurricane Joaquin, a category 4 hurricane with sustained winds of 130 mph, which moved very slowly (5-6 mph), impacted San Salvador in early October 2015. We visited the island March 13-18, 2016 (5.5 months after the event). Cobbles were examined in situ, and five or more clasts were collected from the following, previously studied sites: Telephone Pole Reef, Dump Reef, and Salt Pond 1 (near-shore); Snapshot Reef and Salt Pond 2 (patch reefs); Gaulin's Reef (bank barrier reef); and Vicki's Reef (platform margin). Previous studies on San Salvador have shown that near-shore assemblages are dominated by well-preserved *Homotrema rubrum*; lagoonal patch reefs are varied but typically have prominent *Planorbulina* spp.; bank barrier reefs are dominated by *Homotrema rubrum* but with some *Gypsina plana*; and shelf-margin assemblages are dominated by large *Gypsina plana*.

None of the reefs examined in this study showed effects of recent storm damage, and only one cobble was clearly upside down. The high proportion of *Planorbulina* on cobbles found at Dump Reef may indicate transport shoreward from the lagoon. This was also found on the south end of the island, however even cobbles with encrusting foraminifera found on land at The Gulf did not seem to have been moved large distances based on the foraminiferal assemblages. Overall, the pattern of distribution observed previously was still intact.

STATISTICAL EVALUATION OF FORAMINIFERAL DEATH ASSEMBLAGES IN BEACH SANDS OF SAN SALVADOR ISLAND, BAHAMAS

Mattheus, Christopher, R, Lake Superior State University, Michigan; **Diggins, Thomas, P,** Youngstown State University, Ohio; **Stockmaster, Brittany, A,** Coastal Carolina University, South Carolina; **Klein, Veronica, J,** Lake Superior State University, Michigan.
Presenter: Thomas Diggins, Poster 11

Coastal paleoenvironmental investigations benefit from microfossil analyses of sedimentary deposits, particularly when aiming to distinguish washover from ambient sedimentation in lagoonal settings or evaluating strandplain deposits from a provenance perspective. Coastal reconstructive work subsequently benefits from an inventory of species assemblages along the shore, the proximal source of overwash and aeolian materials. Sediment grab samples were collected, as part of a class project, from thirteen separate beaches along the isolated Bahamian platform of San Salvador Island in an effort to inventory and evaluate potential influences of varying coastal geologic framework, offshore reef occurrence, sedimentology, and inferred nearshore hydrodynamics on foraminiferal death assemblages along the shoreline. Analogous foreshore, backshore, and dune sedimentary subenvironments were sampled and a sediment splitter was used to generate unbiased sub-samples for particle-size analysis and micropaleontological assessment, respectively. The foraminifera identified from these samples encompass shallow-water benthic varieties of the calcareous Miliolina and Rotaliina as well as the agglutinated Textulariina suborders. Their relative abundances vary from beach to beach and among individual beach subenvironments. The Miliolina dominate the overall fossil assemblage, comprising over 75% of all specimens sampled. However, this percentage ranges spatially from 29% to 100%. The Rotaliina are the second-most abundant suborder in the overall assemblage while only one Textulariina specimen was sampled. Differences in assemblage composition are suggested to relate, in part, to varying dispersal patterns along the coast of San Salvador Island and the differential weathering and erosion of tests. The latter is showcased by comparing highest-energy to lowest-energy beach samples. Sandy Point, the beach with the coarsest shoreline materials, is dominated exclusively by specimens of *Archaias angulatus*. Prior studies show this species of the Miliolina suborder to represent the most erosion-resistant of sampled species. More heavily sheltered/lower-energy beaches, characterized by smaller grain sizes, are subsequently associated with higher relative abundances of the less robust Rotaliina species. Accordingly, PCA analyses integrating grain-size and foraminiferal species data resolve a distinction between low- and high-energy beach settings. Additional work may provide insights into the effects of patchy habitat distribution, irregular coastal geologic framework, and complex nearshore hydrodynamics on coastal foraminiferal dispersal patterns.

GEOMORPHOLOGY OF THE LATE HOLOCENE SANDY HOOK STRANDPLAIN, SAN SALVADOR ISLAND, BAHAMAS

Mattheus, Christopher, R, Lake Superior State University, Sault Sainte Marie, MI; **Farhan, Salam, A,** Youngstown State University, Youngstown, OH; **Fowler, Joshua, K,** Youngstown State University, Youngstown, OH.
Presenter: Christopher R. Mattheus, Poster 12

The landform succession and stratigraphic architecture of Sandy Hook, a late Holocene strandplain on the isolated Bahamian carbonate platform of San Salvador Island, are evaluated from ground-penetrating radar data, sedimentary analyses, and a GIS-based assessment of beach-

ridge orientation and spacing. The integrative dataset establishes a conceptual evolutionary model for Sandy Hook, which covers around 1.75 kmý of the island's southeastern coast. Late Holocene sea-level rise, storm climate, and sediment supply are investigated as potential geomorphic forcing mechanisms. Four distinct en-echelon beach-ridge sets, each characterized by distinct ridge orientations and spacing, are delineated across Sandy Hook from aerial photographs. The most shore-distal ridges are spaced an average 50 m apart while the youngest and most shore-proximal set is characterized by an average spacing of around 30 m. Beach-ridge sets are bound by topographically prominent ridges that truncate paleoshorelines, are demarked by changes in vegetation type and/or density, and mark a transition to new ridge spacings. Subsurface geophysical data, collected perpendicular to coastal strike using a 200 MHz GPR setup, resolve shoreward-prograding clinoform geometries at 1-4 m in depth. Shoreward-inclined radar surfaces, characterized by slopes around 0.2, represent paleo-foreshore environments and document the progradational history of the strand. The internal architecture of Sandy Hook is generally defined by conformable sedimentary successions, recognized as parallel-inclined stratal surfaces of uniform geometry bound by unconformities. These bounding surfaces truncate underlying, older stratal units and are characterized by onlap of overlying, younger ones. This subsurface framework is suggestive of a pattern of strandplain growth that is punctuated by episodic ravinement. The general compartmentalization of the Sandy Hook strand implies changing environmental conditions. Studies of similar strandplain environments have related such landform juxtapositions to variances in storm climate and/or sediment supply. The continued reduction in shallow shelf area fronting the prograding beach system at Sandy Hook likely affected strand evolution by progressively altering nearshore hydrology and sediment supply. The intrinsic influence of accommodation-space loss across the shallow shelf is reflected in seaward-decreasing ooid contents across beach-ridge sets and strongly implied by the accompanied reduction in ridge spacing.

SUPERSTORMS: THE BAHAMIAN EVIDENCE FOR THE LAST INTERGLACIAL (MIS 5E)

Mylroie, John, E, Mississippi State University, Mississippi State, MS.

Presenter: John Mylroie, Sunday 7:30 PM

Sea level during the last interglacial (MIS 5e) was ~6m above present, and has been interpreted to represent a warmer climate than today's current interglacial. It has been speculated that such warmer temperatures could have increased storm intensity and storm frequency. Recently, two hypotheses have been advanced that purport to demonstrate an increase in storm intensity during MIS 5e. The first hypothesis considers fenestrae at elevations up to 43 m in The Bahamas to be evidence of superstorm washover. Additional observations include rip-up clasts and loss of bedforms and root structures as a result of wave scour. Such an event should produce a tempstite with a wide-ranging footprint, but none exists. The fenestrea can be explained as rainfall slurries, the rip-up clasts are weathering products of calcarenite protocol development, and the bedforms and root structure absence or presence is a difference in transgressive versus regressive eolian formation, respectively. Eleuthera Island contains chevron ridges proposed to be large washover structures, and boulders assumed to have beenflung up onto the land by superstorm waves. The chevron contain climbing wind ripples and are eolian; tempestites are not present. The boulders are karrentisch and rest on pedestals,. To emplace them would require extreme energies, but other interpretations such a fossil tower karst and boulders rolling down slope remain viable. The boulder area has an extremely small footprint, extending a few kilometers on the northeast shore of Eleuthera, and such a small footprint is more than an order of magnitude smaller than that for Sandy or Katrina, recent large storms. Hurricane Joaquin, the largest category 4 hurricane in the Bahamas since 1866, produced no boulder or chevron structures of the magnitude described for MIS 5e superstorms.

VEGEMORPHS AS A MEANS TO DIFFERENTIATE TRANSGRESSIVE-PHASE FROM REGRESSIVE-PHASE QUATERNARY EOLIAN CALCARENITES, SAN SALVADOR ISLAND, BAHAMAS

Mylroie, John, E, Mississippi State University, Mississippi State, MS; **Birmingham, Andrew, N,** Mississippi State University, Mississippi State, MS; **Mylroie, Joan, R,** Mississippi State University, Mississippi State, MS.
Presenter: John Mylroie, Sunday 8:30 AM

During the start of Quaternary interglacial conditions, sea-level rise floods the top of the steep-sided carbonate platforms of The Bahamas, and carbonate sediment production is significant. This carbonate sediment is rapidly produced in large volumes within relatively small lagoons, and eolian calcarenites immediately develop on the remaining dry ground adjacent to their source beaches. As these dunes form as sea level is rising, they are referred to as transgressive-phase eolianites. Continued reef growth to wave base as the highstand stabilizes diminishes lagoon wave energy, and further dune production is modest until the end of the interglacial, when sea level begins to fall and surf zone processes pass through the platform lagoons, where stored carbonate sediments are remobilized into beaches and a second episode of dune production occurs. The resulting dunes are regressive-phase eolianites. These two eolianite packages bracket the leading and trailing portions of individual sea-level highstands. Various criteria have been developed to identify transgressive-phase and regressive-phase eolianites; however, the one with the most potential is based on plant trace fossils, variously called rhizomorphs, rhizocretions, or vegemorphs (vegemorphs is used herein as it refers to any plant structures, not just roots). Extensive field work has demonstrated quantitatively that vegemorphs are found preferentially in regressive-phase eolianites, and that the presence of vegemorphs disrupts the fine-scale eolian bedding. Transgressive-phase eolianites have notably fewer vegemorphs, and as a consequence, exhibit undisturbed fine-scale laminations. Vegemorph absence or presence is readily observable on vertical faces, and so paleodunes exposed at sea cliffs, in quarries or road cuts, or in caves can be easily categorized as transgressive-phase or regressive-phase deposits, respectively.

KARST DENUDATION IMPACT ON QUATERNARY GLACIOEUSTASY DETERMINATIONS

Mylroie, John, E, Mississippi State University, Mississippi State, MS; **Mylroie, Joan, R,** Mississippi State University, Mississippi State, MS.
Presenter: Joan Mylroie, Sunday 11:00 AM

Fossil coral reefs and related subtidal deposits have been used as indicators of Quaternary glacioeustasy, traditionally by examination of fossil coral reef terraces on carbonate islands and coasts that have been tectonically uplifted. These studies do not account for dissolutional denudation, which lowers the terrace surface; the terrace surface has been assumed to be the depositional surface. Denudation is cumulative over time, making higher and therefore older terrace placement far below their actual depositional elevation. Examination of karst pedestals (karrentische) on Guam reveals the denudation to be ~50 mm/ka); this value correlates with theoretical denudation models corrected for eogenetic carbonates in tropical settings. Flank margin caves, which form in the distal margin of the fresh-water lens within a carbonate island, are excellent sea-level indicators. Analysis of flank margin cave elevations throughout the Bahamian Archipelago indicates that the archipelago has had past sea-level highstands greater than 6 m, perhaps up to 15 m or more, for which no fossil coral data exists. Denudational removal of these older corals has biased the record to younger events. Older fossil corals may exist in settings in which they were entombed by eolian calcarenites and protected from denudation. Only flank margin caves commonly remain as viable terrestrial signatures of these older sea-level highstands.

HIGH-RESOLUTION UAV MAPPING OF COASTAL EROSION AND BOULDER MOVEMENT PRODUCED BY THE 2015 HURRICANE JOAQUIN ON SAN SALVADOR, THE BAHAMAS

Niemi, Tina, M, UMKC, Kansas City MO; **Preisberga, Anniya,** UMKC, Kansas City MO; **Rucker, John, D,** UMKC, Kansas City MO; **Nolan, Joseph, A ,** UMKC, Kansas City MO; **Rose, Tori, L,** UMKC, Kansas City MO.
Presenter: Tina M. Niemi, Sunday 8:00 PM

The Bahamian island of San Salvador was directly affected by Hurricane Joaquin over a two-day period in Oct. 2015 when the storm travelled SW from Bermuda, passed SE of the island then turned, intensified to a Category 4 hurricane, and then passed across the island from the S-SW. To map the hurricane related changes in the coastal environment, we utilized a DJI Quadcopter 3 mounted with 12 Megapixel, 4K video camera to collect aerial data at four locations. We preprogrammed flight paths designed to acquire 70% image overlap using a smartphone app designed by Pix4D. The data were processed using Agisoft PhotoScan to render both a high-resolution digital orthomosaic, as well as a georeferenced digital elevation model (DEM). These datasets were then compared to our pre-hurricane aerial photography collected with a kite in March and June 2014 and to satellite imagery from Google Earth. These before and after images allow us to determine how the coastline changed. Our field research in March (2015, 2016, 2017) and June (2015, 2016) provide ground-based photographic and orientation data on boulder location, imbrication, and beach conditions. The high-resolution, low-altitude imagery allowed us to map the boulder field, measure the evidence of storm surge height by flotsam lines surrounding the boulder field, and calculate boulder movement by matching erosion scars to boulder position, and boulder size to position. We also noted where road construction debris provided boulders that had moved. It is clear that boulders that are exposed along the wave-cut platform at low tide of the Pleistocene Cockburn Town Reef have been transported up the cliff and inland in this storm event based on boulder identification. We have previously noted that coastal reentrants are the location of coves where wave action is focused and thus increase lift. Coastline retreat where cliffs collapse downward are located along these coves and provide large boulders which are available for transport upward. These coves become the staging ground for boulders to be elevated in extreme storm events. Our data show that the coves are locations of wave focusing and greater storm surge and landward transport of boulders. Our aerial UAV imagery from Green Cay along Grahams Harbour on the northwest side of the island show that large boulders previously noted there did not move in this hurricane.

WHAT MAKES THE HOLE? TOOL AND ORNAMENT CONSTRUCTION OF *CODAKIA ORBICULARIS* AND ITS ROLE IN RECYCLING OF THE ARCHAEOLOGICAL RECORD BY THE BLUE CRAB *CARDISOMA GUANHUMI*, SAN SALVADOR ISLAND, BAHAMAS

Park Boush, Lisa, E, University of Connecticut , Storrs, CT; **Buynevich, Ilya, V,** Temple University, Philadelphia, PA; **Curran, H, A,** Smith College, Northampton, MA; **Gnivecki, Perry, L,** Miami University, Oxford, OH; **Berman, Mary Jane,** Miami University, Oxford, OH; **Kopcznski, Karen,** Temple University, Philadelphia, PA; **Shkembi, Bruno,** University of Connecticut, Storrs, CT .
Presenter: Lisa Park Boush, Poster 13

The bivalve *Codakia orbicularis* (Linnaeus, 1758), Family Lucinidae and common name tiger lucine, is found throughout the Caribbean and Florida. *C. orbicularis* shells are found typically in Lucayan middens, with Lucayans being the indigenous inhabitants of the Caribbean. Of significance is the fact that the blue land crab, *Cardisoma guanhumi*, commonly recycles shells in the process of burrowing, thereby exporting *C. orbicularis* to the surface. Some of these shells are abraded in various areas, including the ventral, anterior and posterior margins, as well as in the umbo region. We measured 174 *C. orbicularis* shells from surface collections (N=29), the 18 cm depth interval (N=17) from Pigeon Creek Dune 1 site, the 30-40 cm interval (N=14) at SSP82-16 and the 0-20 cm depth interval (N=126) at SSP82-5, San Salvador, Bahamas, examining the amount of abrasion in these four regions of the valve. Of the surface-collected materials that were recycled by *C. guanhumi*, 7% were abraded on the anterior margin, 17% on the

posterior, 24% along the ventral margin and 10% within the umbo region. Ventral margin abrasion was most likely caused by Lucayans using shells as scrapers. Umbo abrasion was likely due to working the shell for bead or adornment purposes, or to use the shells as fishing net weights. In our sample, only 33% of the shells that were abraded in this way culminated in a complete hole. Of the other two, one was a failed attempt and broken and the other did not penetrate the valve. There was no correlation between valve size and abrasion area or frequency. Similarly, there was no difference in abrasion in shells of variable sizes collected from the surface and those found within the archaeological record. The fact that abraded shells occurred on the surface in areas adjacent to *C. guanhumi* burrows indicates significant recycling of shell material to the surface by these powerful burrowers. Thus, "crabturbation" has had a significant role in preservation of these archaeological sites, and other sites presently within the habitat of blue land crabs are vulnerable to similar disruption.

A 6000 YEAR MULTI-PROXY PALEOCLIMATE RECORD FROM TWO LAKES ON ELEUTHERA, BAHAMAS

Park Boush, Lisa, E, University of Connecticut, Storrs, CT; **Myrbo, Amy,** University of Minnesota, Twin Cities, MN; **Yakabowskas, Dana,** University of Connecticut, Storrs, CT; **Berman, Mary Jane,** Miami University, Oxford, OH; **Gnivecki, Perry, L,** Miami University, Oxford, OH; **Brown, Erik, T,** University of Minnesota, Duluth, MN.
Presenter: Lisa Park Boush, Sunday 9:30 AM

High resolution paleoclimate records for the past 6,000 years have been recovered from two lakes of differing types-a coastal lagoon and a blue hole-on the island of Eleuthera, Bahamas. Multi-proxy records were analyzed on sediment cores from three sites (254, 114 and 104 cm in length) taken along shore-normal transects in Shad Pond (SHAD), a hypersaline coastal lagoon, and three sites (170, 155 and 151 cm in length) from Duck Pond Blue Hole (DPBH). Sediment composition and granulometry, loss on ignition (LOI), X-ray fluorescence (XRF) measurements, as well as oxygen isotope and trace element measurements on ostracods provide the basis for our reconstruction of the paleoclimate history from these two basins. High resolution XRF scans of Ca, Br, Fe and Sr as well as loss on ignition show a marked change around 3700 cal BP that correlates with the top of a peat layer in Shad Pond and potential rapid sea level rise. This is followed by a period of high variability from 3700 cal BP until approximately 2000 cal BP possibly representing wet/dry cycles, corroborated by the .18O record recovered from ostracod shells as well as their trace element Mg:Ca and Sr:Ca ratios. The .18O records show an overall depletion from +1.47 ppm to -2.04 ppm (VPDB) throughout the 6000-year record, with highest variability between the 4000-3000 cal BP period. Trace element analyses reveal a Mg:Ca and Sr:Ca record that positively co-varies and trends with the .18O record. Evidence for a meteoric lens collapse at 1.6-1.8 ka as sea-level rise breached a local sill and altered coastal circulation in Shad Pond is also apparent. Despite the differences in lake type (i.e. coastal lagoon vs. blue hole), the records from these two lakes record climate-driven changes in the Late Holocene. These multi-proxy records correspond to other patterns seen regionally in the Caribbean, as well as globally.

SPELEOTHEM DEPOSITION IN EOGENETIC CARBONATES: THE CONSEQUENCES FOR STRONTIUM

Ridlen, Nicole, M, Mississippi State University, Mississippi State, MS; **Mylroie, John, E,** Mississippi State University, Mississippi State, MS; **Polk, Jason, S,** Western Kentucky University, Bowling Green, KY; **Mylroie, Joan, R,** Mississippi State University, Mississippi State, MS.
Presenter: John Mylroie, Poster 19

Eogenetic carbonate rocks develop from allochems precipitated primarily as aragonite (e.g. green algae, mollusks, corals) and high-Mg calcite. (e.g. echinoderms, red algae). Relative to calcite, Strontium (Sr) preferentially enters the orthorhombic aragonite crystal lattice, giving eogenetic carbonate rocks a higher Sr background than older teleogenetic rocks, in which the aragonite has inverted to calcite. Vadose speleothems (stalagmites) forming in caves in eogenetic carbonate rock

should show a high Sr content. The Sr levels in the speleothems should decrease with rock age as the aragonite inverts and the Sr is lost. Strontium levels in speleothems have been used as a paleoclimate indicator, but the influence of eogenetic Sr has been under appreciated. This issue has become more important as oceanic island caves and speleothems hosted in eogenetic carbonates have recently been utilized as mid-ocean paleoclimate indicators. Curacao, in the southern Caribbean, contains a series of tectonically uplifted terraces of eogenetic carbonate rock. These carbonate rocks contain flank margin caves in which speleothem growth is active. Samples from caves in each terrace show a progressive loss of Sr in each higher, and therefore older, terrace. The ?Higher Terrace?, older mid-Pleistocene age host rock, was calcitic with 0.44 ppm Sr; one speleothem from a cave in this rock contained 0.25 ppm Sr. The "Middle Terrace", younger mid-Pleistocene host rock, was also calcitic, with 1.43 ppm Sr; two cave speleothems had Sr values of 0.30 and 0.31 ppm. The "Lower Terrace", late Pleistocene in age, was 40% aragonite and 60% calcite, with a Sr value of 6.89 ppm; two cave speleothems had Sr values of 8.68 and 8.28 ppm. Utilizing caves from a single location removes any climatic differences in calcite inversion and speleothem deposition, leaving rock age as the major factor in the Sr variation in these speleothems.

DAMAGE FROM HURRICANE MATTHEW TO THE CLIFTON HERITAGE PARK ON NEW PROVIDENCE ISLAND IN THE BAHAMAS

Rucker, John, D, UMKC, Kansas City MO; **Niemi, Tina, M,** UMKC, Kansas City MO; **Nolan, Joseph, A,** UMKC, Kansas City MO; **Rose, Tori , L ,** UMKC, Kansas City MO.

Presenter: John Rucker, Sunday 10:30 AM

Hurricane Matthew passed from SE to NW over New Providence Island on October 6, 2016 as a category 4 Hurricane on the Saffir-Simpson scale. Clifton Heritage Park, located on the western coast of the island, and containing the ruins of the Loyalist period Clifton plantation, was severely impacted by Hurricane Matthew. In addition to damage to park facilities, the shoreline was heavily affected by the scouring of soil, movement of large boulders, and movement and deposition of large flotsam and jetsam. We mapped and documented the hurricane-related changes at two locations using a DJI Quadcopter 3 mounted with a 12 Megapixel, 4K video camera to collect aerial data. The data were processed using Agisoft PhotoScan to render both a high-resolution digital orthomosaic, and a georeferenced digital elevation model (DEM). We also documented these areas with ground based photography as well as measurement of size and orientation of boulders. At Flipper Beach, there is a distinct line of boulders near the shoreline, and another distinct line of more buoyant flotsam along the line of a Loyalist period field wall approximately 80 m from the shoreline. Between these two locations, the soil has been scoured away in some areas down to bedrock. It is likely that this location was particularly affected due to the focusing effect of the cove in which Flipper Beach lies, as well as the previous anthropogenic clearing of vegetation in the area. Farther south, at the historic period "Pirate Stairs", the large stone that originally covered the archway over the stairs has been moved roughly 2 m to the north. At this location, approximately 6 m above sea level, there is clear evidence of overwash, including the movement of large boulders, scouring of soil, and deposition of fan corals and marine plant fragments. Taken together, this evidence allows a reconstruction of the energy of the hurricane, as well as the height of its storm surge - which was significant.

A VULNERABILITY ANALYSIS OF HURRICANE JOAQUIN'S EFFECTS ALONG THE PERIMETER OF SAN SALVADOR ISLAND, BAHAMAS

Savarese, Michael, Florida Gulf Coast University, Ft. Myers, FL; **Buynevich, Ilya,** Temple University, Philadelphia, PA; **Glumac, Bosiljka,** Smith College, Northampton, MA; **Curran, H. Allen,** Smith College, Northampton, MA; **Park Boush, Lisa, E,** University of Connecticut, Storrs, CT; **Caris, Jon,** Smith College, Northampton, MA; **Kopcznski, Karen,** Temple University, Philadelphia,

PA.
Presenter: Lisa Park Boush, Sunday 7:00 PM

Effects of Hurricane Joaquin (Sept/Oct 2015) were highly variable on the perimeter of the small, exposed Bahamian island of San Salvador. Following the USGS storm impact scale method, the geological effects of Joaquin were assessed relative to foredune elevation and swash height. Damage was categorized, in order of increasing severity, as: swash, collision, overwash, and inundation damage. Assessment of 9 representative regions was undertaken in Jan 2016 using orthophotos and digital elevation models generated from drone flights, georadar, and ground surveys. Storm surge was not a critical factor for most of the island, and persistent flooding and breaching of coastal barriers was not common. Consequently, minimal overwash and inundation damage occurred. The south shore was an exception, where wave action was extreme. Here, 5-m-high cliffs were overtopped, causing erosion at the leading edge and extensive landward movement of boulders within a 6.3 ha area. New boulders, as large as 3 m in diameter, were generated, and older blocks from prior storms, estimated to weigh 1-3 tons, moved up to 26 m inland. The principal road was damaged and inundated by debris. Along the east (windward) and west coasts, hurricane impact caused substantial dune scarping and some overwash, though no dune systems were breached. Overtopping into the backdune occurred at numerous locations along both coasts, onto the circum-island Queen's Highway, and into several swale lakes. Scarped dunes lost as much as half their volume with retreat as far as the dune crest. Some dune scarps at the time of assessment had already shown signs of eolian repair. These scarps will remain as recognizable subsurface features in future geophysical images. A rejuvenated tidal channel was scoured along the southeastern coast, establishing an ephemeral connection to Pigeon Creek, and a massive overwash fan of approximately 1 ha now blocks the mouth of this channel. Overall, no significant, irreparable coastal change occurred as a consequence of Joaquin. Although the storm imposed economic hardship, much of its geomorphologic legacy has already being modified by fair-weather processes. Because of the potential consequence of future storm activity, we recommend that a comprehensive assessment of storm vulnerability be undertaken throughout the archipelago.

HURRICANE MATTHEW PROJECT: DOCUMENTING THE COASTAL ECOSYSTEM COSTS OF HURRICANES ON NEW PROVIDENCE, BAHAMAS WITH COMMUNITY PARTNERS

Sullivan Sealey, Kathleen, University of Miami, Coral Gables, FL; **Shiel-Rolle, Nikita,** Young Marine Explorers, Nassau, Bahamas.
Presenter: Kathleen Sullivan Sealey, Thursday 8:00 PM

The Hurricane Matthew Project (HMP) was initiated to document the damage to coastal resources from the historical Category 4 hurricane that impacted four major islands in The Bahamas. A team of scientists and students started with an assessment of the damage done by Hurricane Matthew on the most populous island of New Providence. Coastal neighborhoods and citizen scientists participated to develop a rapid impact assessment protocol to document damage to the coastal environment, looking specifically at developed and protected coastal environments (including two national parks). The assessment evaluated building damage, vegetation damage, flooding, solid waste as well as coastal erosion to produce GIS maps to visualize the severity of damage. The HMP has evaluated the cost of coastal erosion as well as degradation of coastal water quality and decline of biological diversity to identify high priority areas for coastal restoration. The role of coastal protected areas in preventing and minimizing damage to nearby human communities was considered. The final outcome was a community-based rapid ecological assessment protocol. The severity of this hurricane damage is unprecedented and offers an opportunity to re-develop to mitigate damage from future storms.

PALEOSOL AND CAVE MINERALOGY FROM ELEUTHERA, THE BAHAMAS

Sumrall, Jonathan, B, Fort Hays State University, Hays, KS; **Sumrall, Jeanne, L,** Fort Hays State University, Hays, KS; **Gauvey, Kaitlyn, L,** Fort Hays State University, Hays, KS; **Sides, Kristin, E,** Sam Houston State University, Huntsville, TX; **Larson, Erik, B,** Shawnee State University, Portsmouth, OH.
Presenter: Jeanne Sumrall, Poster 20

Paleosols on Eleuthera, The Bahamas were sampled to determine the clay mineralogy from outcrops and from within Hatchet Bay Cave. In addition, cave mineral samples were collected from additional flank margin and littoral sea caves. Paleosol samples were processed to remove carbonates and organics before fractionating by size. Treatments (K-saturation, Mg-Saturation, Heating, and Gylcolnation) were used to determine the specific clay mineralogy of each sample. Petrographic thin sections were also prepared to determine characteristics of each type of paleosol (porosity, cementation, allochems, iron oxide content). Cave mineral samples were powdered and analyzed using powdered X-ray Diffraction (XRD). The dominant clay mineral present in the paleosols on Eleuthera was Fe-rich chlorite ((Fe+2,Mg,Al,Fe+3)6(Si,Al)4O10(OH,O) 8) and Illite (K0.6(H3O)0.4Al1.3Mg0.3Fe+20.1Si 3.5O10(OH)2ú(H2O)) based on 14 and 10 peaks. The larger [002] 7 peak compared to the [001] 14 peak indicates a Fe-rich chlorite. In addition, a small peak shift from 14 to 6.1 in several samples may suggest the presence of Boehmite (AlO(OH)). Non-clay materials include low-Mg calcite and quartz. Cave minerals included carbonates (calcite and aragonite), sulfates (gypsum), phosphates (hydroxyapatite, fluorapatite, chlorapatite, and woodhouseite), and Mn-oxides. All minerals except woodhouseite have previously been reported from Bahamian caves. Woodhouseite (CaAl3(SO4)(PO4)(OH)6) is part of the Alunite supergroup and has been previously reported as the product of bat guano in cave environments. Woodhouseite samples came from Hatchet Bay Cave, specifically from small crusts found on the exposed paleosol within the cave. The presence of woodhouseite was confirmed in three samples from various locations within the cave. Woodhouseite presence in this instance likely represents phosphate-rich leachate derived from the combination of seawater and guano interacting with the various aluminum-rich phases found within the clay fraction of the paleosol. Previous Bahamian cave mineral studies did not have access to exposed paleosols within caves, making this an interesting addition to the diverse cave mineral inventory of The Bahamas.

DENUDATION ANALYSIS OF CEMENTED CARBONATE DUNE COMPLEXES ON ELEUTHERA, THE BAHAMAS

Sumrall, Jeanne, L, Fort Hays State University, Hays, KS; **Jordan, Miranda, M,** Sam Houston State University, Huntsville, TX; **Larson, Erik, B,** Shawnee State University, Portsmouth, OH.
Presenter: Jeanne Sumrall, Sunday 9:00 AM

The denudation rates of three cemented eolian carbonate dunes on Eleuthera, The Bahamas, one at the North Twin Coves (NTC) complex, and two at South Point (SP1 and SP2), were calculated using geometric field analysis, carbon dating, and laboratory analysis. Five samples were collected from the truncated dunes. Carbon dating of whole rock samples confirmed that the upper and lower dunes are Holocene. Radiocarbon dates from the dunes suggests an 88-59 year (+/- 30yrs) difference in ages from the lower truncated surface to the upper truncated surfaces for NTC and SP1 dune complexes. An approximate denudation of 2 meters from apex of the dune to truncation surface was established for SP2 using the geometry of the dune bedding planes and estimated initial dune height. A sample was collected from the lateral bedding planes used to establish initial dune height on the lower outer edge of the dune. The analysis of this sample provided a maximum dune age of 6,602 cal yrs BP (+/- 30yrs). If the mechanical and chemical denudation is the approximated 2 meters for the SP2 dune, it is possible that the dune was exposed and denuded at a relatively constant minimum rate of 30.3cm/1000yrs. This rate is well below the maximum denudation rate of 107.1cm/1000yrs,

based off of maximum theoretical dissolution calculations. Carbon dates of TC and SP1 suggest either an unrealistic total denudation between 0.88-3.6cm or an unrealistic denudation rate. It is possible that the carbon dates do not show the correct gap in time between the upper and lower dune surfaces because they likely came from the same offshore source material that blew onshore over time. Similar allochems found in all of the dunes, and porosity differences associated with higher cementation rates in the lower dunes when compared to the upper dunes provide evidence for this idea. However, if the carbon dates are accurate, it is possible that a catastrophic event, such as a storm, mechanically weathered and truncated the poorly cemented lower dune. More substantial sampling and analysis of dune complexes needs to take place to better determine the actual rate of denudation.

LABORATORY CULTURE AND LIFE HISTORY CHARACTERSTICS OF THE APODID SEA CUCUMBER, SYNAPTULA HYDRIFORMIS FOUND ON SAN SALVADOR ISLAND, BAHAMAS.

Thacker, Miranda, St. Olaf College, Northfield, MN; **Cole, Eric, S.,** St. Olaf College, Northfield, MN.
Presenter: Miranda Thacker, Poster 5

We investigated natural history characteristics of an abundant Apodid sea cucumber collected from Oyster Pond on San Salvador Island in the Bahamas. Three color morphs were identified for Synaptula hydriformis, (brown, striped and pale green), as well as another genus and species, possibly Chiridota rotifera. We developed a method for inducing both spawning and birthing. This is achieved through a cold-shock treatment administered to the adult sea cucumbers. Larvae are born within 24 hrs of a 10-minute cold shock. This same treatment may also induce internal spawning. We confirm details of a simultaneous hermaphroditic lifestyle, self-fertilization, internal brooding of the larvae, and a pattern of direct embryonic development that bypasses the planktonic auricularia larval form. A successful technique for culturing juvenile sea cucumbers was established. This initially involved culturing the floc found at the bottom of their home habitat and eventually progressed to feeding them on cultured dinoflagellates. The transparent adult body, and the ease with which embryonic development can be induced and observed recommend Synaptula as an alternative model organism for exploring problems of echinoderm embryology. It is also intriguing to speculate on their ability to establish genetic clones during colonization of new habitat.

HIDDEN HISTORY ON SAN SALVADOR ISLAND

Winter, John, Molloy College, Rockville Centre, New York.
Presenter: John Winter, Sunday 11:30 AM

After Hurricane Joaquin passed over San Salvador Island in October 2015, Google Earth provided satellite images of the island for October 10, 12, and 16, 2015. These images revealed the extensive coastal damage that was done to the island. In addition, these images revealed the ruins of buildings that had been hidden under the vegetation over the years. One set of buildings was located 1900 feet west from the Queens Highway by the old Fortune Hill settlement, which lies north of the Kerr Mount ruins. These eight buildings lie at the base of the western slope of the second lithified dune ridge from the Queens Highway. The buildings are arranged in a row style. Each of the buildings has a built in fireplace, which has two wooden beams over the opening. The chimneys collapsed over the years. These buildings had two facing doors on the east and west sides, but lacked windows. The style of these buildings is similar to slave homes from the plantation era. These buildings might be related to the early days of the Kerr Mount plantation or a larger building up the hill to the east. More modern buildings were observed in the area from the 1900's with a diversity of architectural design.

IF A TREE FALLS IN THE FOREST . . .

Winter, John, Molloy College, Rockville Centre, New York.
Presenter: John Winter, Poster 10

When high speed winds hit San Salvador Island, many people are interested in searching for coastal impacts. Yet there is evidence of high speed winds affecting the island's interior. Fallen and uprooted trees that survive these winds can be observed within the island's interior. Some of these uprooted trees die, while others develop new vertical growth. No specific time frame has been assigned to these disasters.