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ABSTRACTS

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Multi-Modal Benthic Habitat Monitoring: A CenSSIS Perspective

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The Center for Subsurface Sensing and Imaging Systems (CenSSIS) is a National Science Foundation Engineering Research Center led by Northeastern University in partnership with UPRM, RPI and Boston University. The centers mission is to revolutionize our capability to sense objects embedded in a distorting media. The applications studied by the Center range from biomedical imaging to environmental monitoring. The Center wants to demonstrate that there are principles in sensing and information extraction that are common to subsurface sensing problems that can be studied to come up with a common framework to deal with these problems that will result in improved understanding of subsurface sensing and imaging across disciplines and will enhance our capability to solve existing and new problems that arise in the field. At UPRM, CenSSIS work has focused primarily in subsurface sensing using hyperspectral imaging and coordinates the efforts in aquatic subsurface sensing of benthic habitats. Hyperspectral remote sensing is one of the technologies applied to this problem showing great promise to monitor estuarine and nearshore benthic habitats. However, since optical remote sensing is limited to depths below 30m for the clearest waters an Autonomous Underwater Vehicle (AUV) has been developed by CenSSIS researchers and used to monitor benthic habitats for depths beyond 30m. This presentation will give an overview of CenSSIS, the research work on benthic habitat mapping using hyperspectral remote sensing and the AUV, as well as the efforts in developing the SeaBED testbed for demonstrating the value of the technology developed by the center.

Development of Rapid Seismic Monitoring Procedures for Incorporation into the Emergent Caribbean Tsunami Warning System (II)

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"Middle America", the geographic area between the continents of North and South America including the Caribbean, has been a site of great plate tectonic activity in the most recent 35 million years. The region continues to be highly geologically active today as the Caribbean tectonic plate advances to the east, sliding past the North American plate and colliding with the South American plate. Type examples of many of the salient features of plate tectonics—subduction zones, deep trenches, transform faults, pull-apart basins, subduction-to-strike-slip transitions, subduction-related volcanics, and volcano-free subduction zones—exist in a relatively small geographical area, In contrast to other places in the world where a similar diversity of features are found and where, not coincidentally, the population at risk of injury due to tectonic-related hazards is huge, dense, and often quite poor. The need to establish a system of rapid notification for tsunami alerting in the Caribbean has been recognized by the emergency managements and the scientific community. In fact, the circum-Caribbean region has a documented history of destructive earthquakes and large damaging tsunamis that have affected coastal areas, including the event of Virgin Island in 1867 and Mona Passage in 1918. These tsunamis have been triggered by large tsunamigenic earthquakes that deformed the ocean floor. Seismic water waves originated in the prominent fault system around the Caribbean are considered to be near-field hazard because they can reach populated coastal areas within few minutes after the earthquake. In the wake of the December 26, 2004 devastating earthquake and tsunami, attention has been focused worldwide to the establishment of local and regional tsunami warning systems. The objective of the seismic/tsunami monitoring, a component of the tsunami warning system, is to detect and inform as rapidly and accurately as possible potential tsunamigenic events and then confirm whether or not a tsunami has been generated. In this research, we examine the application of waveform analysis procedures for the rapid identification of shallow earthquake source parameters in the Caribbean using three-component digital broadband records recorded at local and regional distances. For locally-recorded events, a grid-search method is investigated that uses the entire wave train recorded at multiple stations. A comparative search is conducted between observed and theoretical amplitude spectra at frequencies up to the corner frequency of the recording instrument to identify the best-fitting strike, dip, rake, and focal depth. In the regional procedure, a formal moment-tensor inversion scheme is used with the source depth fixed at 10 km to derive the focal mechanism that best reproduces the waveforms recorded at a single station. The regional analysis provides a timely derivation of the source size and fault geometry that would be useful in the identification of potential tsunamigenic sources in the circum-Caribbean region if the procedure is implemented in an automated manner. The magnitude and mechanism can be obtained within minutes following the occurrence of the earthquake, well within the time period available for tsunami alerting. The local analysis, on the other

hand, is too time-consuming to be useful in the timely derivation of source information for local tsunamigenic earthquakes. The method, however, could be beneficial for checking the accuracy and validity of source parameters derived using the regional procedure.

Population Composition, Geographic Distribution, and Natural Hazards: Vulnerability in the Coastal Regions of Puerto Rico

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Given its geographic location and climatological conditions, Puerto Rico is highly susceptible to natural hazards (e.g., hurricanes, floods, tsunamis, and earthquakes). Coastal or riverine flood areas and steep mountains characterize much of Puerto Rico. Hurricanes San Ciriaco (1899), San Felipe (1928), San Ciprián (1932), Santa Clara (1956), Hugo (1989), and Georges (1998), have had a significant social and economic impact on the Island's population and economy. As a result of changing social and demographic patterns in Puerto Rico, there has been a significant increase in population density, in the proportion of the elderly and physically disabled population, and an increasing concentration of residents in flood and/or landslide prone areas, and especially, along the coastline. According to the Insurance Commissioner's Office, as of June 2003, 160,000 families were living in flood prone areas in Puerto Rico, of which 43,568 (27.2%) did not have flood insurance. These factors have contributed to the increasing vulnerability to natural hazards on the Island. The primary goal of the proposed project is to understand how these and other factors contribute to the vulnerability of the Puerto Rican population living in coastal regions, how they have changed from 1990 to 2000, and how does risk and vulnerability vary according to different social, economic, and demographic variables. This research project is a collaborative and interdisciplinary effort between the Center for Applied Social Research (CISA), the Physical Oceanography Laboratory in the Department of Marine Sciences, both at the University of Puerto Rico-Mayagüez, and the Disaster Research Center at the University of Delaware.

Contamination of Caribbean Coastal Waters by the Antifouling Herbicide Irgarol 1051®

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Water samples were collected targeting potential sites of Irgarol 1051 contamination (a triazine derivative) to assess maximal contamination potential in Puerto Rico and U.S. Virgin Island during 2004. Average values between 20-30 ng Irgarol L^{-1} were found in areas of limited circulation in PR. Slightly higher average concentrations were observed in St. Thomas at Red Hook Bay while orders of magnitude higher concentrations (280-825 ng Irgarol L^{-1}) were found in Benner Bay. Additional work using higher spatial resolution sampling confirmed and better delimited the area of potential Irgarol impact at selected sites (Boqueron, PR, and Benner and Redhook Bay, St. Thomas). Concentration of Irgarol eliciting acute photosynthesis inhibition were observed in a significant portion of Benner Bay while increased concentrations were associated to the entrance of an inland marina at Boqueron. Additional work will be conducted in which coral growth will be assessed under exposure to lower concentrations of Irgarol to investigate potential chronic effects.

Aspergilosis en los Abanicos de Mar: Diversidad de Hongos

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Una enfermedad está afectando a los abanicos de mar (*Gorgonia* spp.) a lo largo del Caribe. Un solo patógeno ha sido identificado en la literatura, *Aspergillus sydowii,* y la enfermedad ha sido identificada como una aspergilosis. Dos fuentes potenciales del inóculo han sido propuestas: nubes de polvo provenientes de África y escorrentía terrestre. Sin embargo, es dificil caracterizar los patógenos y la fuente del inóculo cuando la micoflora típica de los gorgonios sanos y su medioambiente es aún desconocida. En este estudio comparamos las comunidades de hongos aislados de abanicos enfermos, abanicos sanos, y agua de mar. Los hongos fueron identificados a base de morfología y secuenciación de la región ITS del ADN ribosomal nuclear. De los hongo aislados, *Aspergillus flavus* fue mas común en tejido enfermo que en tejido sano. *Penicillium citrinum* fue al revés: más común en tejido sano. *Aspergillus sydowii* (el patógeno reportado) fue aislado de agua de mar pero no de tejido enfermo. Estos resultados sugieren que *A. flavus* pueda tener un vínculo más fuerte con la enfermedad que *A. sydowii*. Una sola colonia de *Gorgonia* puede tener varios hongos a la vez, así que un muestreo extenso es necesario para llegar a conclusiones confiables. Varias cepas de *A. flavus* aislados de *Gorgonia* producen aflatoxinas en cultivo puro; es posible que estas toxinas tengan un papel en la enfermedad.

Restoration of Gorgonian Populations

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A preceding long-term (10 y) monitoring study indicated that recruitment is the bottleneck limiting gorgonian populations. In this study we tested various experimental procedures to determine whether transplants of gorgonian branches can bypass this population bottleneck. Our efforts were partially successful. Annual survival rates of transplanted branches of *Plexaura flexuosa* and *Pseudoplexaura* spp were 91.5% and 55.9% respectively, compared to 91.9% for natural populations in general. A major cause of transplant mortality was breakage of the axial skeleton. This source of mortality may be reduced by future modifications in transplant techniques. Median growth rates of transplanted colonies (*Plexaura*: 1.04 cm/y; *Pseudoplexaura*: 0.28 cm/y) were significantly lower ($p<0.05$) than natural (untransplanted) colonies. This result suggests that sublethal effects represent a more intractable problem for gorgonian transplants.

Endophytic Microbial Diversity in Sea Grass Beds of *Thalassia testudinum* and *Syringodium filiforme* from Cabo Rojo, Lajas and Vieques, Puerto Rico

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Although research on endophytes associated to terrestrial plants have shown these microorganisms can enhance growth of the host plants and deter insect and animal herbivory, studies on endophytic microorganisms associated to healthy tissue in marine plants and algae are scarce. Sea grass beds provide an essential habitat for economically important invertebrate and fish species and threatened endangered species. Although the health and productivity of sea grass beds are critical for coastal area fisheries, no previous study have focused on the role of endophytic microorganisms associated with these plants. The main goal of our research is to determine the endophytic microbial diversity associated to healthy tissue of mature, well establish sea grass beds of *Thalassia testudinum* and *Syringodium filiforme* that has been under different levels of anthropogenic impact. The methods will consists mainly of classical microbiological culturing techniques and environmental genomics. This approach will be useful in assessing both culturable and non-culturable organisms, including bacteria, fungi and possibly archaea. Information obtained from this research will provide answers about the role of this microorganisms in relation to plant health, hence the marine ecosystem it sustain, can be used as subject of study using functional genomics, proteomics and, as sources of molecules with biotechnological potential. Information related to the isolated microorganisms will also become available to the scientific community and general public through an *internet* database. Students participating in this project will be impacted with a competitive interdisciplinary education through research experience with up-to date techniques in molecular microbiology that will allow them to become successful professionals.

Developing a Protocol to Use Remote Sensing as a Cost Effective Tool to Monitor Contamination of Mangrove Wetlands

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The characteristic of vegetation to react to the geochemical conditions of the substrate, has found a use in the remote sensing techniques applied to mineral exploration, where large areas can be efficiently surveyed without expensive field studies. Metal content in the soil changes the leaf reflectance, which is usually expressed as the Normalized Digital Vegetation Index (NDVI), and can be measured using a spectroradiometer in the field and the red and near-infrared bands in satellite images. The proposed study will test the use of remote sensing techniques of mineral exploration to the monitoring of mangrove wetlands for the presence of heavy metal contamination. The low diversity of mangrove vegetation makes them well-suited for this technique. Similar as in mineral exploration, a cost effective technique that does not require costly field studies, will make an excellent tool for government agencies in charge of monitoring the health of wetlands. Five mangrove wetlands will be selected, to test the method, including Joyuda Lagoon (suspected natural Ni-Co contamination), the San José Lagoon (reported Pb, Hg, and Zn contamination), and Guayanilla Lagoon (Hg contamination) and two assumed pristine mangrove forests. Chemical analyses will be carried out of substrate and leaves of the top of the canopy. Reflectance of the leaves will be determined and heavy metal content and NDVI will be correlated and summarized in a Geographical Information System (GIS) showing the location of contaminated areas. A protocol will be written, where on the basis of image analysis, areas of possible heavy metal contamination can discerned and summarized in a GIS. These areas should become high priority areas for field checking for possible pollution. When the method proves to be successful, training sessions and workshops using the remote sensing techniques and the GIS protocol will be organized through the Center for Co-hemispheric cooperation (Co-Hemis).

Mitochondrial DNA Analyses as a Valid Tool for Family and Species Identification of Fish Larvae: Emphasis on Snappers

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Lutjanidae is one of the largest teleostean families and a commercially important one in the Caribbean. Distinguishing lutjanid larvae to the species level is fundamental for appropriate management; however discrimination among each other is difficult despite published larval descriptions. Taxonomic identification of these larvae to the species level represents one of the main bottlenecks in our understanding of their early life cycle. To address this problem, we are in the process of identifying mitochondrial DNA (mtDNA) restriction fragment length polymorphisms (RFLP) and DNA sequence analyses of the 12S rRNA gene, diagnostics to lutjanid species. We consistently found and described larvae from two morphologically distinct types of Lutjanid, designated as type 1 and 2. For type 2 larvae, description to the family level was although unsure due to common morphometrics and meristics with larvae of another perciform family; Serranidae (Groupers). DNA sequence analyses for type 2 larvae showed conserved regions diagnostics to Serranids, resolving their identification as members of the Serranidae family. DNA sequence data from type 1 larvae consistently showed conserved regions characteristics to Lutjanids, as well as variations diagnostics to species as compared to adult sequences. Species identified were: *Lutjanus synagris*, *Lutjanus vivanus*, *Ocyurus chysurus and Rhomboplites aurorubens.* Accurately identification of these larvae will be incorporated to previous dispersal patterns investigations where larvae were only characterized to the family level. Information will be highly valuable to design more detailed research leading to characterize; dispersal, spawning and habitat selection for most of the species for the Lutjanidae family, and perhaps for Serranids. Such information is of vital relevance for the management of coral reef fishes, as the establishment of Marine Protected Areas (MPA's) as an option to restore commercial exploited fish stocks.

Mona Island Reef Fish Community Structure and Function for MPA Design

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One important criterion in the design of marine protected areas (MPA) is the representation of habitats essential for species to complete their life cycles. Some coral reef fishes are dependent on mangrove and seagrass habitats during early life stages therefore habitat connectivity is important in structuring the coral reef fish community. Mona Island MPA in Puerto Rico provides an opportunity to assess habitat connectivity throughout an entire isolated seascape. This remote oceanic island includes a diversity of habitats, lacks submerged mangroves and has a limited distribution of seagrass habitat. The distribution of resident schools of adult grunts and snappers throughout the insular platform is compared to the distribution of juveniles in near shore habitats in order to assess the extent and limitations of the connectivity among habitats through ontogeny. Belt transects in shallow near shore habitats and roving transects in deeper areas around the island were used to quantify and map the most abundant grunt and snapper species. Juveniles were encountered mostly in seagrass and bedrock habitats near shore, although this varied among species. Throughout the shelf, schools of adults were encountered in 20% of the deeper sampling points in coral reef (linear, patch, spur and groove) and colonized bedrock (boulders) habitats, suggesting the use of high relief areas for refuge. The distribution of large schools of adult grunts and snappers varied among species and was dependent upon the distance from habitats where juveniles were observed, as well as the availability and patch size of habitats where adults were observed. Based on this data the challenge to include connected habitats within an MPA is species specific and unique for each location.

KEYWORDS: ontogenetic connectivity, grunts, snappers, Mona Island, Puerto Rico

Comparative Study of the Reproductive Performance of Four Strains of *Artemia* (Branchiopoda: Anostraca)

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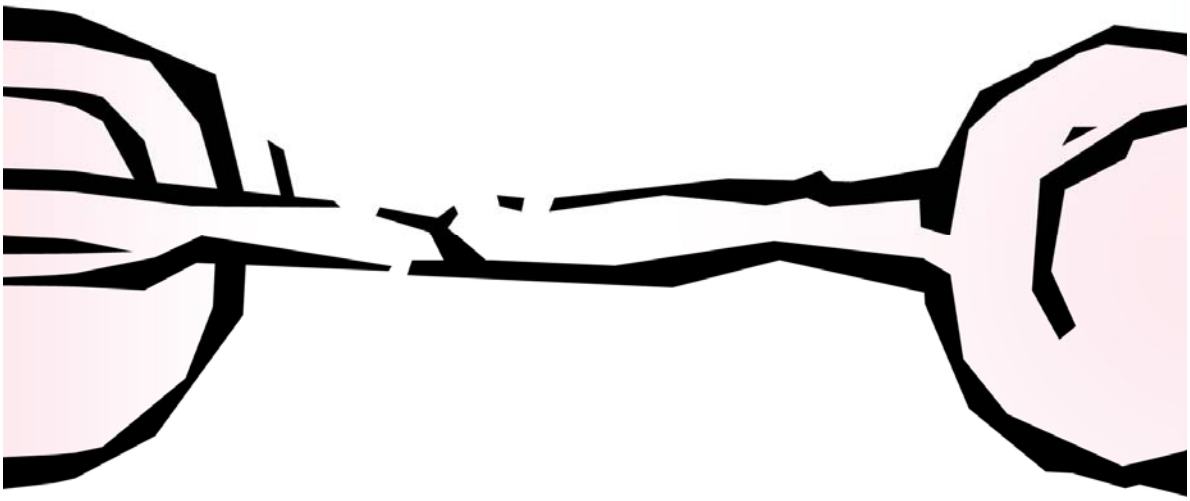
There is an urgent need for the characterization of new populations of *Artemia* due to a worldwide shortage of cysts and an increase in the demand of aquaculturists for this resource. The present study tested the hypothesis that the reproductive performance of individuals would be different among *Artemia parthenogenetica* (APAR), *Artemia* sp. from Lajas, P.R. (LPPR), *Artemia* sp. from Cabo Rojo, Puerto Rico (CRPR) and *Artemia franciscana* from the Great Salt Lake in Utah (GSL). Individual couples of reproductive organisms from the populations studied were cultured at 21˚ C and a salinity of 45 in a recirculation apparatus. The number of offspring produced by individual females was examined every other day for the lifetime of the experimental animals. Reproductive performance estimators and life spans were calculated for each of the populations for the duration of the experiment. Organisms from APAR had the highest reproductive performance and longest life span of all the populations tested while the population from CRPR had the lowest reproductive potential. There was a significantly higher production of cysts than nauplii for all the populations studied. A non significant decline in reproductive performance was observed with an increase in age for all the populations studied. The test hypothesis was supported by the experimental results. The APAR population is the most suitable for the commercial production of *Artemia* biomass in an enclosed system under the conditions studied. The introduction of APAR individuals into local hypersaline environments should be avoided in order to prevent the out competition of local strains by the parthenogenetic animals.



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