Session III-Room A1

THE REPORT CARD CHAMPION PROGRAM: CULTIVATING AWARENESS TO ACTION THROUGH A LEADERSHIP LENS

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As the human population continues to rise, we can also expect the magnitude of environmental issues to increase. Through various programs and outreach, organizations are working diligently to communicate at the local and global level, the importance of sustainable behavior change in efforts to preserve our natural world. Connecting residents to the environment is often a challenging task, but through community-based education and leadership, we can begin to navigate a sustainable pathway together.

The Galveston Bay Report Card is a citizen-driven, scientific analysis of the health of Galveston Bay. This project is a collaborative effort between Houston Advanced Research Center and Galveston Bay Foundation, funded through Houston Endowment. A practical response to the effects of climate change on the Bay, the report card examines, among other things, loss or degradation of coastal habitats, freshwater inflows, and water and sediment quality. Since 2015, the report card has annually featured 22 indicators across six categories to grade the Bay's ecosystem. The overall health of Galveston Bay has been a "C" since the project launched in 2015. Over the past four years, Galveston Bay Foundation's advocacy staff have informed nearly 10,000 adults and children through public presentations and programs, and the web site has counted over 2.5 million visitors to view the report card.

The Report Card Champion Program is an advocacy program that branches off the Galveston Bay Report Card. It gives students and community groups, the skills and knowledge needed to cultivate action for Galveston Bay. Also, it creates an "awareness to action" approach with the current and next generation of conservationists. It seeks to empower the community in the Houston-Galveston area to advocate and preserve Galveston Bay. In its first year, the program has reached over 300 students. The program consists of a workshop, followed by a project or campaign implemented to conserve or protect Galveston Bay. It can be tailored to elementary through high school or adult groups, and includes a comprehensive introduction to conservation leadership, specifically focusing on Galveston Bay issues, are provided to all participants. Next, an overview of professional development skills is presented; this includes the importance of building partnerships, team collaboration, and project development. Lastly, hands-on activities to promote communication skills and deepen understanding of complex issues present in Galveston Bay.

This program not only empowers residents with knowledge and skills, but it also fosters the growth of true community-based conservation. Thus, passing down knowledge and skills that are imperative for future conservation progress. In efforts to cultivate a community conservation ethic, it is important to connect conservation with diverse audiences. Conservation can no longer be a "one pronged" approach. It will take addressing different angles, issues, and audiences in various ways. In this case, the infusion of leadership begins the process of cultivating the communities that are connected to Galveston Bay. By focusing efforts through a leadership lens using these programs, we can support the path that leads to a straight "A" Bay.

Session III-Room A1

BREAKING DOWN BARRIERS IN ENVIRONMENTAL EDUCATION

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Megan Imme, Education Coordinator, Galveston Bay Foundation, Houston, Texas

"I learned that mud isn't scary!" Galveston Bay Foundation's education programs have a long history of engaging urban and low-economic youth. Participant surveys have resulted in detailed information regarding the barriers that students face when it comes to experiencing nature, and how the programs have helped them overcome these barriers.

Many of the 3000-4000 K-12th grade students that participate in Galveston Bay Foundation's education programs each year experienced both physical and psychological trauma resulting from the flooding disaster during Hurricane Harvey in 2017 that extended throughout the greater Houston region. "As we were coming out of the issues of Hurricane Ike, Hurricane Harvey Hit. We have students that are still trying to build their homes. Because of this program, students have become more involved in their community, have been exposed to new careers, and have developed a sense of pride about the bay. This program has helped some of my lowest achieving students gain self-confidence in ways I couldn't have ever imagined." – 2018 participating teacher. On average, 76% of education participants are of an underrepresented ethnicity; 57% of participants are low-income; and 51% of participants are female. For many students, their participation in one of Galveston Bay Foundation's environmental STEM education programs is their first experience with nature. After Hurricane Harvey, these first experiences are incredibly important. Students having positive experiences in nature are crucial for the future of our region and Galveston Bay. Galveston Bay Foundation's goal is to create a safe and positive learning environment for all students. Once students feel safe, they can open themselves up to new experiences and truly engage in hands-on learning. With multiple positive experiences, students will be more apt to become life-long environmental advocates and stewards of Galveston Bay. You can grasp the long-term impact the programs have on participants by reading the following responses received in the 2017 former student survey that we distributed to teachers to send to their former students:

- "I volunteer more now than I ever have in my life because I know a small amount of time I give towards a cause can make a huge impact." – 2013 participant
- "I have a dislike and fear of bugs. I hate them honestly. But by being outside surrounded by positive influences and in a fun environment I got into the mud and muck just like everyone else. I also had a knee injury at the time and getting out and about and being mobile really helped me." – 2012 participant

During the presentation, we will describe results gathered from years of program participant surveys, teacher evaluations, and surveys of former participants. From these surveys, we are able to understand the various barriers that students have when it comes to experiencing nature, allowing us to address these challenges head-on and create environmental education programs that are inclusive and relevant to all students. Session participants will learn about survey creation, view data regarding student barriers, how educators address these barriers during field experiences, and the resulting short and long-term behavioral changes.

Session III-Room A2

PREDATOR AND SALINITY EFFECTS ON INVERTEBRATE COMMUNITIES IN GALVESTON BAY MARINAS

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Communities of marine invertebrates, comprised of both native and non-native species, develop on hard surfaces in estuaries, including shell beds, docks, and marinas. These communities include oysters and mussels, sea squirts, barnacles, and worms that perform key functions in estuary ecology, filtering the water to extract plankton, creating complex habitats, and providing critical food resources for crabs and fishes. They also include non-native species that have been introduced through hull-fouling and ballast water discharge—and are often more prevalent in estuaries with active ports, such as the Houston Ship Channel. Such non-native organisms may remain relatively benign, or they may become problematic invaders with severe economic impacts. Understanding the factors that shape the composition of these communities is therefore extremely important for Galveston Bay's ecology and economy.

To date, relatively little is known about how Galveston Bay's wide salinity range and related variation in predators influences how these communities develop and the extent to which non-native species are found within them. In some regions, such as Pacific Panama near the entrance to the Panama Canal, fish predation has been shown to control an economically devastating sea squirt. In other locations, such as San Francisco Bay, local predators do little to control invaders. Moreover, strong salinity variation across Galveston Bay is likely to affect invertebrate communities directly, but may also indirectly shape them by determining which predators are present.

To address these questions, we conducted an experiment restricting predator access to invertebrate communities as they developed, in five Galveston Bay marinas located along a salinity gradient (in Baytown, La Porte, Seabrook, Pelican Island, and West Galveston Island). Our research team deployed small PVC settlement panels for three months beginning in May 2019, with a portion in predator-exclusion cages and the other portion open to predators. We conducted live analysis of species present at the end of August 2019, and report here how predators influenced community characteristics. We also report the presence of non-native taxa, and differences across the five sites. Our findings provide new information about factors influencing invertebrate community development and the presence of non-native species around the Bay. This research also represents the first bay-wide survey of fouling invertebrates in Galveston Bay marinas in over a decade. Results highlight the importance of increased monitoring, which can help us understand how environmental changes affect invertebrate community composition, and also enable earlier detection of potentially problematic invasive species.

Session III-Room A2

UNDERSTANDING THE ECOLOGY OF ATLANTIC RANGIA IN GALVESTON BAY: DECIPHERING THE ROLE OF FRESHWATER INFLOWS

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Jenny Oakley – Environmental Institute of Houston, University of Houston- Clear Lake, Houston, Texas

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Atlantic Rangia, *Rangia cuneata*, is an oligohaline clam found in abundance along the northern Gulf of Mexico. *Rangia cuneata* has been used as one of a suite of indicator species for establishing freshwater inflow regimes in Texas estuaries including Galveston Bay. The Galveston Bay estuary represents the largest estuary in Texas and supports the largest shellfish and finfish fisheries. During 2011 through 2013, the Galveston Bay watershed was exposed to a severe drought of record that reduced freshwater inflows significantly while increasing salinity. Recent distributional studies (2011-2014) conducted by multiple investigators found that the Trinity River delta, which received the highest freshwater inflow and exhibited the lowest salinities supported the largest specimens (highest mean shell length and meat index: MI = % soft tissue weight/total weight and caloric content) compared to other areas of Galveston Bay which received less freshwater inflow. During 2015-16 freshwater inflows had increased to long-term average levels within Galveston Bay. In 2016, we resurveyed Trinity Bay at 50 sites for *R. cuneata* to reevaluate the distribution and growth of this species. During 2016 the average MI was 30.3 ± 0.5% in contrast to 12.5 ± 0.5% recorded during the previous 2011-2014 studies. This increase in average MI was contributed to increased freshwater inflow and reduced salinity compared to the drought years 2011-2014. In our current study, high frequency time series of water temperature and salinity were collected from February 2018 to August 2019 at 10 sites in Trinity River Delta. *R. cuneate* were also sampled seasonally for density and size range. These data when combined with published historical data were compared to freshwater inflow to develop a predictive inflow model relating freshwater inflow, salinity levels, and *R. cuneata* population density and somatic growth. The importance of exposure regime (intensity and duration) is discussed.

Session III-Room A2

MONITORING THE MOVEMENTS AND HABITAT USE PATTERNS OF COASTAL FISHES IN GALVESTON BAY, TX USING ACOUSTIC TELEMETRY

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Coastal and estuarine fishes are often at the forefront of anthropogenic stressors including fishery exploitation and habitat degradation. Characterizing movement patterns and the habitats that are most critical to supporting their populations can aid in building effective ecosystem-based management strategies. Acoustic telemetry is currently being used to monitor small- and large-scale movements of an assemblage of coastal and estuarine fishes in Galveston Bay, Texas including Southern Flounder, Black Drum, Spotted Seatrout, Atlantic Tarpon, Alligator Gar, Bull Sharks, and Blacktip Sharks. This species assemblage represents the variability in life history strategies of coastal and estuarine predatory fishes in the Gulf of Mexico. Each species exhibits different feeding strategies and varying degrees of estuarine-dependence, freshwater tolerance, and scale of movements. Transmitter tags, which emit an acoustic signal with a known frequency and pattern, are being implanted into 40-50 individuals of each species, and an array of 50 acoustic receivers are positioned throughout Galveston Bay to record acoustic signals from tagged fish. The data produced by this acoustic telemetry system will be used to determine the distance and frequency of movement of individuals, patterns of ingress and egress at passes that connect the estuary to the sea, and the habitats and regions that are used most frequently by each species. Additionally, spatiotemporal overlap patterns among species will be examined, which can provide insight into their ecological interactions. The ultimate goal of this acoustic telemetry project is to enhance our understanding of the structure and function of Galveston Bay by characterizing the habitat use of an assemblage of ecologically- and socioeconomically-important fishes.

Session III-Room A2

THE SEAWATER CARBONATE CHEMISTRY OF GALVESTON BAY, TEXAS AND IMPLICATIONS FOR OYSTER REEF HEALTH

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The carbonate chemistry system controls the acidification levels of seawater and estuarine waters and thus affects calcifying organisms' ability to produce calcium carbonate ($CaCO_3$) shells and skeletons. The carbonate chemistry of an ecosystem can be described by several parameters, we focus on pH, partial pressure of CO_2 (pCO_2), and the $CaCO_3$ saturation state (Ω). The Ω refers to the stability of $CaCO_3$ in seawater, with $\Omega>1$ favoring $CaCO_3$ formation and $\Omega<1$ favoring dissolution. Human activities, including burning fossil fuels, deforestation, and altering freshwater inputs to estuaries can increase acidification levels of seawater, which increases CO_2 and decreases pH and Ω. Calcifying marine organisms, like oysters and corals, are particularly sensitive to this acidification because it slows $CaCO_3$ production and increases dissolution. Galveston Bay is an estuarine ecosystem on the Texas coast with oyster reefs that provide critical ecosystem services, including water filtration, shoreline protection, and habitat for several valuable fisheries. Therefore, characterizing the carbonate chemistry is an important part of assessing the health of the Galveston Bay ecosystem. Here we describe the carbonate chemistry of Galveston Bay at seven time points from June 2017 through November 2018, including assessing the impact of Hurricane Harvey. Spatially, Ω follows the salinity gradient, with higher Ω where salinity is high near the mouth of the bay and Ω decreasing towards the freshwater sources in the upper bay. However, pCO_2 and pH do not follow salinity and are higher and lower, respectively, close to the coast. Waters near the coast may have higher turbidity that limits light for photosynthesis and enhances net respiration, which increases CO_2 levels and decreases pH. Seasonally, Ω fluctuates in response to wet and dry conditions, where increased river discharge (March 2018) correlates with decreased Ω and dry periods (June 2018) with increased Ω. In contrast, temporal changes in pCO_2 and pH are driven by seasonal changes in temperature, with lower pCO_2 and higher pH in November 2017 and March 2018 as cooler waters limit gas dissolution. Following Hurricane Harvey in August 2017, the excessive rainfall and runoff lead to significant and prolonged acidification and decreases in Ω which may negatively affect oyster growth and formation of $CaCO_3$ shells. In addition, the entire bay was flushed with freshwater for up to 2 weeks, causing a large oyster freshwater die-off. While the carbonate chemistry appears to have recovered from Harvey by March 2018, recovery of the oyster reefs requires recruitment and growth of new larval oysters that are particularly sensitive to Ω levels. Therefore, continued monitoring of the carbonate chemistry of Galveston Bay is critical for assessing whether or not conditions are conducive to the recovery of these oyster reefs.

Session III-Room A4

GIS RESOURCES FOR THE MAPPILY CHALLENGED: TOOLS, PROGRAMS AND FIELD DATA COLLECTION APPS FOR BEGINNERS

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The field of Geographic Information Systems (GIS) has evolved at an incredibly fast rate and multiple user-friendly products are now available that were unknown just a few years ago. Formerly, all major GIS work was conducted using ESRI products (ArcMap, ArcDesktop, etc.) that were costly and difficult to master. New technologies have enabled users to utilize smart phones and tablets, offering high quality field data collection. This presentation will cover new tools, apps and data available for free or low cost to managers and researchers.

Many local nonprofits, federal, state and local agencies use ESRI products. In the last few years, a new GIS alternative had become more widespread. QGIS is a user friendly open source Geographic Information System (GIS) licensed under the GNU General Public License. QGIS is an official project of the Open Source Geospatial Foundation (OSGeo). It runs on Linux, Unix, Mac OSX, Windows and Android and supports numerous vector, raster, and database formats and functionalities. We will introduce QGIS and provide links and resources for learning the program.

Data collection in the field formerly required expensive all in one GPS units that were difficult to use and became obsolete quickly. We will cover several options of new Bluetooth GPS units (in multiple price ranges and accuracy levels) that can link to any smart phone or tablet. These external GPS units provide higher accuracy than normal phone GPS systems and can be used in areas with no cell service.

With the increase in handheld consumer products, a multitude of apps have been developed for data collection. We will cover several iOS and Android apps that range from free to several hundred dollars for use. Demonstrations will be provided of Mapit GIS and ArcCollector.

Lastly, we will touch on favorite, user-friendly sites to find Galveston Bay focused data (aerial orthophotos, Digital Elevation Models, recent Post Harvey images, etc.).

Higher quality spatial data is vital for ongoing research in the Galveston Bay area. By sharing new resources we hope to keep partners engaged and current on the latest tools at their disposal.

Session III-Room A4

A New Approach to Functionally Assess Estuarine Fish Communities in Response to Hydrologic Change

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Abstract
Decreasing freshwater inflows and extreme weather events can alter physical and ecological characteristics of estuarine ecosystems. Functional assessment approaches may identify indicators of environmental change and ecological response. This study used a 24-year coastal fisheries trawl dataset (1993-2016), corresponding environmental data and functional assessment techniques to evaluate changes in the fish assemblage of Galveston Bay, Texas (USA) in response to freshwater inflows, environmental parameters, drought and flood. Using a multi-method approach, 107 fish species were analyzed across eleven functional groups. Nonmetric multidimensional scaling (nMDS), distance based linear models and graphing techniques using annual departures from period averages were used to determine relationships between functional group abundance, inflows and environmental parameters. Estuarine resident carnivore, estuarine resident omnivore, marine migrant carnivore and marine straggler carnivore functional groups exhibited highest species richness and abundance. The relationship between inflows, salinity and functional group abundance was greatest in Trinity Bay, diminishing with increasing distance from major freshwater sources. The drought of 2011-2014 saw declines in abundance of all functional groups with rebounds in 2015-2016. Patterns of functional abundance in West Bay were decoupled from inflows and correlated salinity changes. Freshwater migrant carnivores (e.g. blue catfish) were identified as a potential bioindicator for Trinity Bay, while estuarine resident and marine functional groups were limited in their potential to serve as bioindicators. Functional methodologies provide insight into effects of environmental change on complex, estuarine ecosystems. Further study is needed to determine if functional methodologies can be applied in other estuaries to identify bioindicators of changing environmental condition.

Session III-Room A4

ECOSYSTEM HEALTH ASSESSMENT FOR THE COASTAL GULF OF MEXICO: OPPORTUNITIES FOR DOWNSCALING TO GALVESTON BAY

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Efforts to manage complex coastal ecosystems using ecosystem-based management require reproducible quantitative metrics to evaluate overall ecosystem function and health. A Coastal Health Index (CHI) was developed in 2019 as the first integrated assessment of the health of the coast for the Northern Gulf of Mexico (GOM), and nine regions along the coast. The CHI is an ecosystem-based approach to measuring coastal ecosystem health using standardized, reproducible, and globally accepted methods. The CHI synthesizes ten variables, including: food provisioning (commercial fisheries and aquaculture), artisanal fishing opportunity, natural products, carbon storage, coastal protection, tourism and recreation, coastal livelihoods and economies, sense of place (iconic species and lasting special places), clean waters, and biodiversity (habitats and species). Each of the ten variables represents a measurable outcome of ecosystem health and are combined to assess overall ecosystem health as a score out of 100. The CHI for the Northern Gulf of Mexico is 70, indicating that populations could gain more benefits from coastal ecosystem services if efforts were made to improve management strategies. Index scores varied greatly by both variable and region.

The variable that scored the lowest for the Gulf overall was Carbon Storage (34). The sub-variables with the highest scores were coastal livelihoods (93) and economies (94). The two lowest scoring regions of the GOM were the two Texas regions (F7b Lower Texas Barrier Island System = 65, F7a Upper Texas Barrier Island System = 58). Region F7a extends from Corpus Christi Bay to Galveston Bay and has the highest percentage (26%) of developed land (including cultivated crops) compared to the other regions in the Gulf Coast. It is also the region with the lowest overall CHI score, as well as the Lasting Special Places sub-variable. Impacts from the loss of natural coastal habitats includes: increased flooding, increased vulnerability to tropical storms, reduction in biodiversity, reduction in carbon storage potential, and large-scale shifts in cultural connections to the natural world. This region also exhibited the second lowest score in the Tourism and Recreation variable, which has also shown a consistent declining trend. The preference for economic development in this region has created a landscape that may discourage tourism and recreation centric to the natural environment. While this region is known for its industry and strong economy, F7a comes in 6th out of the nine regions for both the Coastal Livelihoods and Economies sub-variables when it comes to the coastal sectors of the economy. This is likely in-part due to the lost opportunity for a healthy Tourism and Recreation market.

Opportunities exist for future sub-regionalization or estuary-specific CHI(s), which can be calculated using the same framework, which may be able to utilize more fine-scale data for smaller spatial scale refinement of the index. CHI allows for quick communication of large quantities of information to both resource managers and the general public using an easy to understand scoring system. The composite nature of the CHI is helpful to provide guidance on many potential avenues for improving coastal management. Continued calculation of the CHI as more recent data becomes available will provide a helpful measure of changing coastal health conditions and can help resource managers measure response to management actions.

Session III-Room A4

ECO-LOGICAL: LINKING ENVIRONMENTAL RESOURCES AND TRANSPORTATION PLANNING FOR SUSTAINABLE DEVELOPMENT

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The Houston-Galveston region is one of the largest and fastest growing metropolitan areas in the United States and home to a diverse array of environmental resources such as forests, grasslands, wetland and prairies. These critical ecological resources are being lost as a result of rapid and sustained urban growth. The Houston-Galveston Area Council (H-GAC) developed an Eco-Logical Tool for the 8-County region (Harris and surrounding Counties) to identify and safeguard these valuable ecosystems from future development. The tool allows to measure the impacts associated with future transportation projects in the early stages of planning process. Thus, helps in preserving the critical ecological resources that are necessary for maintaining and improving the quality of life in the region.

The Eco-Logical tool was developed under the guidance of H-GAC's Ecological Advisory Committee. The tool is developed in two phases. Phase one involves developing a basemap of ecotype features and phase two includes developing an interactive geospatial web application that enables to conduct spatial analysis and summarizations.

The Ecotype basemap was developed using various GIS and Remote Sensing techniques. Image classification for LandSat 8 Satellite Data, Normalized Difference Vegetation Index (NDVI) analysis for Color Infrared Aerial Imageries, and infusion of FEMA Flood Zones were some of the main operations applied in the data development. In addition, Texas Parks and Wildlife Department's (TPWD) ecological data was also embedded in the final dataset. The complete spatial coverage of the ecological data consists of 14 land classifications that includes 7 ecological land types and 7 non-ecological land types. Upland Forest, Bottomland Forest, Prairies, Tidal Prairies, Wetlands, Tidal Wetlands, Grasslands are the ecological land types. While Developed (4 categories), Row Crops, Barren Lands, and Open Water are the non-ecological land types.

The new dataset along with various other critical environmental and socioeconomic data are presented in the web-based interactive geospatial tool that is easy to use and has the capability of conducting spatial analysis, summarizing data, and generating reports. Additionally, the tool is designed to have functions for "Red Flag Investigation". A Red Flag Investigation (RFI) is a quantitative analysis of Infrastructure, Mining/Mineral Exploration, Hazardous Material Concerns, Water Resources, Historical Resources, and other data within a defined buffer of a proposed project area. The information and results generated from this

data and interactive application can be incorporated into project planning, design, and construction with the goal of minimizing impacts to local ecological resources.