MBRACE Core Research Program 1 Summary Report

MBRACE and Core Research Program 1

The Mississippi Based RESTORE Act Center of Excellence (MBRACE) is Mississippi's Center of Excellence under the RESTORE Act's Center of Excellence Research Grants Program. MBRACE is a consortium of Mississippi's four research universities (Jackson State University (JSU), Mississippi State University (MSU), The University of Mississippi (UM), and The University of Southern Mississippi (USM)), with USM serving as the lead institution. The mission of MBRACE is to seek sound comprehensive science- and technology-based understanding of the chronic and acute stressors, both anthropogenic and natural, on the dynamic and productive waters and ecosystems of the northern Gulf of Mexico, and to facilitate sustainable use of the Gulf's important resources.

In Fall 2017, MBRACE funded its first round of projects under the Core Research Program. Four projects were funded at $625,000 each and examined how ecological conditions relevant to oysters vary over time and between newly restored oyster reefs and adjacent unrestored oyster reefs in Mississippi Sound, Mississippi.

Program Highlights

Through the four projects funded under Core Research Program 1:

- **20** graduate students were supported
- **21** undergraduate students were supported
- **41** presentations were given at professional conferences
- **7** journal articles were submitted or were in preparation at the time of project closeout
- **1** patent application was submitted

During Core Research Program 1, the MBRACE Directorate:

- Co-hosted or co-chaired Center of Excellence Research Grants Program sessions at **3** regional and national conferences
- Gave **5** presentations about the MBRACE program at regional and national conferences
- Participated in **3** Restoration Summit outreach events
- Hosted **2** MBRACE All Hands Meetings

Key Research Findings and Takeaways

During Core Research Program 1, funded researchers:

- Evaluated geologic controls on the location of submarine groundwater discharge (SGD) and resulting modification of water quality parameters proximal to oyster reefs in Mississippi Sound through the collection and synthesis of seismic and isotopic tracer data.
- Synthesized seismic survey data results indicate the presence of a complex network of Pleistocene paleochannels cross-cutting the study area. The paleochannels exhibit relief ranging from 10-15 m as well as widths ranging from 0.3 – 2 km and are infilled with geophysically distinct sediments.
- Designed, built, and lab tested an "Oyster Gape" measurement system to measure and report the opening and closing of an oyster, which was then related to its biological activities.
- Developed an underwater timed release mechanism, allowing for underwater apparatus to be completely submerged and only deploy a float at a user preset time.
- Monitored temporal and spatial variability of abiotic conditions with novel oyster observatories.
- Assessed the impacts of environmental stressors on oyster health *in situ* and under laboratory conditions.
- Showed that oyster larvae densities varied among MS Sound sites and increased throughout the summer of 2018. Early in the spawning season, the supply of oyster larvae appeared to be more limited at nearshore sites than offshore. Abundances of oyster larvae and spat were concordant in 2018. Oyster recruitment did not appear to be limited by larval supply in 2018.
- Generated modeling results that suggest it is possible that MS oyster reefs in western MS Sound are also supplied from non-indigenous sources, originating from LA waters; oyster larvae of good condition are likely supplied to the harvestable oyster reefs in Mississippi waters (in part) from indigenous sources within Biloxi Bay; and East Ship and Horn Islands may represent a choice location for new cultch material to serve as a "relay point" for larvae that originate in Mobile Bay.

Key Management Implications

The funded research directly contributes to an enhanced understanding of oyster reefs and their sustainability by quantitatively measuring (*in situ* and remotely) the spatial and temporal variability of environmental conditions and processes (e.g., water quality parameters, benthic substrate properties) that directly impact oyster survival and growth. Additionally, the funded research further contributed to the Core Research Program topic area by developing adaptive models that enable the observation of these conditions and processes with remote sensing technologies and novel autonomous vehicles, which holds the potential to make their recognition and monitoring more rapid, efficient, and effective. This work will help enable the identification of suitable benthic habitats for reef restoration efforts and yield an improved understanding of the variable environmental stressors on oyster reef habitat quality and quantity. The collection of direct, remote, and autonomous vehicle observations collectively contributes to an expanded scientific understanding of oyster ecosystem resilience and improves the ability of the State of Mississippi to make timely and scientifically informed oyster reef management decisions.

Research Projects

Sustainability and restoration of oyster reef habitat in Mississippi Sound: a larval transport and recruitment approach

The University of Southern Mississippi
PI: Jerry Wiggert
Co-PIs: Ken Barbor, Mustafa Kemal Cambazoglu, Arne Diercks, Anand Hiroji, Stephan Howden, Scott Milroy, Chet Rakocinski

Abstract

The four Mississippi Sound-based project components for this project consisted of: (1) an investigation of oyster recruitment that contrasted viability of wild vs. cultured oyster spat at both restored and control reefs; (2) benthic habitat mapping surveys that characterized sub-bottom structure and resolve seasonal evolution of oyster reef volume; (3) CODAR-observed hourly-resolved surface circulation over oyster beds of interest at 1 km resolution; and (4) application of a suite of interlinked models to investigate interactive impacts of hydrodynamic processes and environmental stressors on transport and recruitment of oyster larvae and the overall productivity of oyster beds.

Project Details

1. The two CODAR stations employed by the project provide a record of surface circulation in the western Mississippi Sound from January 2017 through December 2019 that will provide a baseline for further studies. Through leveraging USGS and MDMR sampling resources, salinity and water level were also available to the project.
2. At shorter time scales, the water level, currents, and salinity vary with the tides and are predominately diurnal. Subtidally, the salinity in western Mississippi Sound is affected by diurnally reversing winds and associated currents. On seasonal to annual time scale the Sound's circulation pattern and salinity distribution are controlled by river discharge.
3. Benthic mapping surveys using multi-beam acoustic instrumentation were employed to comprehensively map the benthic habitat of the oyster beds in western MS Sound. These surveys provide highly resolved characterization of both bathymetry and acoustic backscatter. Through applications of newly developed backscatter processing techniques new insights of substrate and temporal evolution of oyster beds over the growth season were obtained.
4. Collected a benthic mapping baseline condition following the 2019 Bonnet Carré Spillway openings. This will provide a basis from which to assess oyster bed recovery.
5. Larvae densities varied among sites and increased throughout the summer of 2018. Early in the spawning season, the supply of oyster larvae appeared to be more limited at nearshore sites than offshore. Abundances of oyster larvae and spat were concordant in 2018. Oyster recruitment did not appear to be limited by larval supply in 2018.
6. Oyster spat findings show temporal and regional differences. Spat densities, size, and barnacle cover differed between September and August 2018, while spat densities, scar

abundance index, and spat and barnacle cover differed between the two farthest offshore sites and the three nearest inshore sites.

7. Developed a modeling approach that combined highly resolved currents and advective transport pathways realized by a 400 m resolution circulation model with a trophic simulation model to estimate habitat suitability index (HSI). The HSI time series were determined for fixed locations on the oyster reefs targeted by the project's field components as well as along the trajectory of oyster larvae released from oyster beds throughout the Mississippi Sound region, including Mobile Bay and Breton Sound.
8. Modeling results suggest that it is possible that MS oyster reefs in western Mississippi Sound are also supplied from non-indigenous sources, originating from LA waters; oyster larvae of good condition are likely supplied to the harvestable oyster reefs in Mississippi waters (in part) from indigenous sources within Biloxi Bay; and East Ship and Horn Islands may represent a choice location for new cultch material to serve as a "relay point" for larvae that originate in Mobile Bay.

Conclusion

The project's research efforts over the 2-year duration consisted of four main components: (1) CODAR Observations, (2) Benthic Mapping, (3) Oyster Recruitment, and (4) Circulation/HSI Model Approach. These project components directly addressed several research foci identified as critical in the MBRACE Science Plan including: identification of suitable benthic habitats for reef restoration, impact of hydrodynamic and sediment transport processes on oyster population dynamics, and impact of multiple stressors on oyster reef habitat quality, quantity and sustainability. Through integration of our four diverse project components, the project achieved a number of significant advances in understanding and capacity building for future research into the complex physical, ecological and ecosystem services critical to the future vitality of coastal waters.

Biosensors for the measurement of bivalve value movement

Jackson State University
PI: Kamal Ali
Co-PIs: Ali Abu-El Humos, Himangshu Das, Ramzi Kafoury, HuiRu Shih, Francis Tuluri, Sudha Yerramilli

Abstract

The Jackson State University team made use of the advances in electronic and computer technology to develop and build a sensor system that remotely measured and recorded the valve movement of the oyster bivalves. These systems will be used in Mississippi oyster reefs to continuously measure and report the valve gaping of oysters. These data, together with data from the other University partners, will be used, primarily during the spawning season, to better assess the health of oyster reefs.

Project Details

1. Designed, built, and lab tested an "Oyster Gape" measurement system to measure and report the opening and closing of an oyster, which was then related to its biological activities.
2. Data collected using the Oyster Gape measurement system allowed the identification of oyster's spawning cycle, normal versus stressed activities, as well as a mortality event.
3. Developed an underwater timed release mechanism, allowing for underwater apparatus to be completely submerged and only deploy a float at a user preset time. A patent for this device has been applied for.
4. Four visualization platforms were developed to show oyster gaping data in time as well as frequency domains, both in real-time and for post-processed data.

Conclusion

Much information on the health of an oyster and its environment may be obtained by observing the gape activity of the animal. The research team at JSU designed and built a deployable "oyster gape" measurement system. This system consists of small Hall Effect sensors and magnets that are glued to oyster shells and connected to a data logger. The system created in this project is one capable of measuring the gape of an oyster at 10 Hz at an accuracy of 0.01 cm, and both sending that data to the cloud and storing it on an SD card. Visualization platforms were developed for displaying these real time data as live feed videos and the SD card data for post processing and analysis.

Abiotic and biotic influences on current and historic distributions of oyster reefs

The University of Mississippi
PI: Marc Slattery
Co-PIs: Greg Easson, Deborah Gochfeld, Stephanie Showalter-Otts, Kristie Willett

Abstract

The goal of this project was to identify differences in abiotic and biotic stressors at current and historic oyster reef sites, to better understand oyster reef health, and to inform management regarding the best places and practices to improve oyster reef restoration strategies. To address this goal, The University of Mississippi researchers undertook three interdisciplinary objectives: (1) develop and deploy replicate Oyster Sensor Platforms to current and historic oyster reefs; (2) characterize the biochemical and physiological responses of oysters to natural and anthropogenic stressors at these sites; and (3) assess the ecological and environmental impacts of stress on oyster reefs.

Project Details

1. Positioned novel "ocean observing stations" (Oyster Sensor Platforms) carrying temperature, salinity, oxygen, and pH (*i.e.*, important abiotic factors affecting oyster distribution and abundance) sensors, as well as oyster "biosensors", on sites of interest to download temporally and spatially explicit environmental data and to subsample the biosensors.
2. Assessed oyster responses to natural and anthropogenic stressors *in situ*, and under controlled laboratory conditions using molecular, biochemical, and physiological indicators.
3. Quantified ecological differences between current and historic oyster reefs to identify oyster population and oyster reef ecosystem responses to environmental stressors.

Conclusion

Project data identified the upper and lower thresholds for temperature, oxygen, and salinity relative to optimal oyster physiology, with implications for population reproductive potential and individual growth rates. Data also identified sites with high concentrations of anthropogenic and natural stressors that might impact the health of oysters and/or their consumers and inform local resource managers.

Water quality and benthic habitat observations for enhanced understanding and sustainable management of oyster reefs in Mississippi Sound

Mississippi State University
PI: Robert Moorhead
Co-PIs: Padmanava Dash, Adam Skarke

Abstract

This project used field sampling and remote sensing data collected from traditional platforms as well as novel autonomous aerial and marine vehicles to quantify the spatiotemporal variability of water quality and benthic habitat conditions at oyster reef sites in Mississippi Sound. Specifically, the research team: (1) developed robust predictive algorithms to relate *in situ* water quality parameters at oyster reefs in Mississippi Sound to remotely sensed reflectance data collected with satellites and unmanned aerial systems; (2) created benthic habitats maps of seabed sedimentary characteristics proximal to oyster reefs in Mississippi Sound through the collection and synthesis of physical samples and acoustic reflectivity data; and (3) evaluated geologic controls on the location of submarine groundwater discharge and resulting modification of water quality parameters proximal to oyster reefs in Mississippi Sound through the collection and synthesis of seismic and isotopic tracer data.

Project Details

1. Developed robust predictive algorithms to relate *in situ* water quality parameters (phycocyanin, colored dissolved organic matter (CDOM), and suspended particulate matter (SPM)) to remotely sensed reflectance data collected with unmanned aerial systems (UAS). Algorithm estimates for cyanobacteria (via phycocyanin), CDOM, and SPM were consistent with lab measured water samples.
2. Evaluated geologic controls on the location of submarine groundwater discharge (SGD) and resulting modification of water quality parameters proximal to oyster reefs in Mississippi Sound through the collection and synthesis of seismic and isotopic tracer data.
3. Synthesized seismic survey data results indicate the presence of a complex network of Pleistocene paleochannels cross-cutting the study area. The paleochannels exhibit relief ranging from 10-15 m as well as widths ranging from 0.3 – 2 km and are infilled with geophysically distinct sediments.
4. Synthesized an extensive database of archived and newly collected seismic reflection profile data as well as archived core data in order to characterize the structure of the Pleistocene-Holocene unconformity surface under the western Mississippi Sound.
5. Isotopic tracer data indicates that SGD is an active process in the study area but that it is not spatially correlated with paleochannels or oyster habitat. In conclusion: (1) The inverse relationship between SGD concentration and distance from the shoreline is commonly observed and suggests that SGD may be sourced from unconfined coastal aquifers, (2) the shore parallel orientation of the observed paleochannels is not commonly observed and suggest that the eastward prograding St. Bernard lobe of the Mississippi River delta may have exerted a degree of influence on later Holocene surface drainage patterns in the study area, and (3) the morphology of the larger paleochannels suggests

that they evolved from fluvial to estuarine environments as the Holocene transgression submerged and reworked them.

6. Created benthic habitats maps of seabed sedimentary characteristics proximal to oyster reefs in Mississippi Sound through the collection and synthesis of physical samples and acoustic reflectivity data. Variability in backscatter intensity across the surveyed area was associated with substrate classes defined as oyster shell, mud dominated sediment, and sand dominated sediment. High resolution imagery of the bed clearly shows well defined areas of oyster shell, mud dominated sediment, and sand dominated sediment. These interpreted geoacoustical results were ground-truthed with physical samples of sea floor sediment.

Conclusion

The stated goals were achieved through: (1) repeated collection of water samples proximal to oyster reefs for water quality analysis and coincident 8cm GSD multispectral/hyperspectral imagery for the development and validation of predictive remote sensing algorithms; (2) repeated collection of high-frequency (500/1000 kHz) seafloor acoustic reflectivity values and coincident seafloor sediment samples for remote classification of benthic sedimentary substrate near to oyster habitats; and (3) surveys of shallow sub-surface stratigraphy and isotopic tracer activity (radon-222) near oyster reefs to determine potential geologic controls on the location and extent of submarine groundwater discharge and resultant impacts on water quality.

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