Introduction to this dedicated issue

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This dedicated issue of *Shore & Beach* is focused on the response and recovery efforts to restore Gulf of Mexico resources following the Deepwater Horizon (DWH) oil spill of April through July 2010. It contains a collection of scientific papers that reflect efforts on the part of five Gulf states to mitigate injuries caused by the DWH oil spill which happened a decade ago when the DWH platform drilling BP's Macondo well exploded. The horrific accident killed 11 rig workers and started one of the world's worst oil disasters, with almost 160 million gallons of crude oil spewing into the Gulf of Mexico over the course of 87 days.

The 2010 blowout set off a national debate over the safety of offshore drilling as oil leaked uncontrolled from the well 5,000 feet below the surface of the Gulf. After almost three months, during which robot-mounted cameras showed the public video of oil flowing freely at the seabed, the well was temporarily capped on 15 July 2010. A permanent seal was applied two months later. About 40,000 workers and 7,000 vessels were deployed during the response efforts. The parties responsible for the oil spill ultimately agreed to pay $20 billion for damages.

ORGANIZATION OF THIS ISSUE

The *raison d'etre* of this dedicated issue is to assemble scientific papers that discuss and examine the collective processes that help mitigate the coastal environments, geomorphological degradation, and ecological injuries along the coast of Northern Gulf of Mexico (NGoM) during the first post-DWH oil spill decade. The organization of this dedicated issue thus follows a logical sequence with first three papers on topics relevant to all five NGoM states. These are followed by papers related to mitigative efforts after the oil spill by the states of Texas, Louisiana, Mississippi, Alabama, and Florida. Henkel and Dausman's paper is relevant to all the five states of the NGoM and deals with a brief account of funding and its post-Deepwater Horizon distribution; this funding helped collect baseline data which were woefully absent and subsequent coordination of long-term data management in the NGoM (Keating and others); and Gulf-wide data synthesis for restoration planning: utility and limitations (Moss and others). The next group of papers describes how funds were utilized by individual states as enumerated by Sheri Land's paper on ecological benefits of the Bahia Grande Coastal Corridor and the Clear Creek Riparian Corridor acquisitions in Texas. Louisiana has been in front and center of unprecedented wetlands loss that has been the stimulus for many restoration plans since the research projects and scientific reports of the 1980s. Louisiana leads the nation in loss of coastal wetlands and of terrestrial, aquatic, and benthic habitats in and around the coastal systems. The inherent fragility of coastal Louisiana made it extremely vulnerable to the oil spill. The State of Louisiana has implemented several projects as detailed by Khalil *et al.* This loss of wetlands and the concomitant environmental degradation pose serious risks to coastal communities and economic systems that depend on barrier islands and related coastal marine resources. Barrier islands in Louisiana are the first line of defense against storm impacts and these funds helped in large scale restoration of several of these islands as described in three papers by Long *et al.*, Dartez *et al.*, and Thompson *et al.* Coastal erosion increases vulnerability of communities to storm-surge flooding and disruption of community systems, including national oil and gas production — the paper by Hemmerling assesses economic well-being, ecological change and the development of the oil and gas industry in coastal Louisiana. All three oil spill-related funding streams have stressed the importance of adaptive management which has been discussed by Carruthers and others in their paper on adaptive management as it relates to Louisiana. Raynie and others make the case in their paper which discusses Louisiana's System-Wide Assessment and Monitoring Program (SWAMP) and data management as to how the State of Louisiana intends to implement its adaptive management program by collecting baseline data. Implementation of one of the important parameters of SWAMP is discussed by Khalil and others in their paper which details the State of Louisiana's effort to undertake the geophysical data collection on a statewide scale for the first time. Ramseur's paper succinctly describes the restoration efforts in Mississippi by restoring estuarine habitat and structure after the DWH oil spill. Moving further east, Kraft and Hunter help understand the mitigative efforts undertaken in general by the State of Alabama in their overview paper which talks about progress of restoration projects in Alabama with post-DWH funds. Rooney and others talk about success of Alabama Swift Tract Living Shoreline project and subsequent two years of post-construction monitoring results. Last but not the least, Fetherston-Resch discusses results from the first four years of the Florida RESTORE Act Centers of Excellence Research Grants Program.

SUMMARIES OF PAPERS

In their paper *"A short history of funding and accomplishments post-Deepwater Horizon,"* Henkel and Dausman discuss the 2016 "Global" settlement to be paid out by BP over 15 years. This funding was in addition to other investments and settlements in research and restoration in the Gulf. For example, the $500 million that BP voluntarily dedicated to research through the Gulf of Mexico Research Initiative (GOMRI); the $500 million to the National Academy of Sciences, Engineering, and Medicine, Gulf Research Program (NASEM-GRP) resulting from two criminal settlements; as well as other settlements for billions in restoration to the National Fish and Wildlife Foundation's Gulf Environmental Benefit Fund (NFWF-GEBF). With these dollars, they argue that DWH tragedy has given way to an unparalleled opportunity to research, restore, and preserve the ecosystems of the

Gulf of Mexico. According to the Deepwater Horizon Project Tracker Tool (https://dwhprojecttracker.org/), which tracks all reported restoration, conservation, and science funding investments since the DWH oil spill, more than 1,200 projects have been implemented totaling almost $3.4 billion and leveraging over $500 million (DWH Project Tracker 2020). This is a significant investment considering the "Global" settlement was in 2016 and is limited by a 15-year payout from BP (the final payment is scheduled in 2032). By 2032 it is expected that more than $17.5 billion will have been made available for restoration, conservation, and science to the Gulf of Mexico (this number does not include the economic settlements). They assert that much has been accomplished 10 years post-spill, but we are still at the early stages of post-DWH recovery and that continued accomplishments in restoration and science can be expected to be significant over the next decade.

Keating *et al.* present a summary of collaborative work, lessons learned, and suggestions for next steps in coordinating long-term data management in the Gulf of Mexico in the years following the DWH oil spill in *"Coordination of Long-term Data Management in the Gulf of Mexico: Lessons Learned and Recommendations from Two Years of Cross-agency Collaboration*." They discuss how a decade of increased research and monitoring following the DWH has yielded a vast amount of diverse data collected from response and assessment efforts, as well as ongoing restoration efforts. They write that in order to maximize the benefits of these data through proper management and coordination, a cross-agency, cross-organization Long-Term Data Management (LTDM) working group was established in 2017 with sponsorship from NOAA's Office of Response and Restoration (OR&R) and NOAA's National Marine Fisheries Service Restoration Center (NMFS RC) and facilitated by the University of New Hampshire's Coastal Response Research Center. This paper describes the LTDM working group's efforts to foster collaboration, data-sharing, and best data management practices among the many state, federal, academic and non-governmental entities working to restore and improve the coastal environment in the Gulf. The important objectives they discuss are fostering consistency in data standards, discoverability and searchability, and interoperability.

Moss and others discuss that in order to maximize environmental, societal, and financial benefits of these investments, best use of available science is needed to inform project prioritization and planning processes. In their paper, *"Gulf-wide data synthesis for restoration planning: utility and limitations*," they state that synthesizing available data across the NGoM can provide information on potential threats to, and benefits from, projects or suites of projects. To achieve this, subject matter experts from Alabama, Florida, Louisiana, Mississippi, and Texas were identified with recommendations from each of the RESTORE Act Centers of Excellence. These experts provided known sources of Gulf-wide data and recommended metrics that would be most informative, resulting in 40 threat, 19 habitats, and 10 community primary data layers. The data layers were synthesized into combined layers of potential stress, potential ecological benefits, and potential community benefits to support broad-scale prioritization based on likelihood of success and desired outcomes for restoration efforts. These synthesized data can inform the potential for restoration efforts to meet programmatic goals and are discussed in the context of the five goals and four criteria of the RESTORE Council aim of using Best Available Science (BAS) to guide future funding for large and small scale restoration. Overall, it was found that these synthetic data layers, by providing geographically explicit best available science uniformly across a broad geographic area, have potential to inform prioritization of coastal restoration efforts for the NGoM.

Land addresses *"Ecological benefits of the Bahia Grande Coastal Corridor and the Clear Creek Riparian Corridor acquisitions in Texas"*—utilizing $4,865,000 in RESTORE Council Selected Restoration Component funds under Funded Priority List 1 (FPL1). This allowed for the purchase of three tracts of land totalling 2,077 acres and adding to the existing footprint of the Bahia Grande/Laguna Atascosa NWR. Texas coastal stakeholders recognize the challenges of conservation and coastal development. They also recognize that resource protection must be integrated, and conservation of coastal resources must be balanced with increasing development pressure and growing demands on limited water supplies. Success of land acquisition may be measured not only in the number of acres conserved or enhanced through management actions, but also in the diversity and productivity of the habitats represented, their proximity and connectivity (e.g. conservation corridors) to adjacent or nearby conservation lands, and topography that will accommodate anticipated sea-level rise over the coming century. Strategic acquisitions within Gulf coast watersheds, including riparian habitats, have the potential to yield long-term habitat and water quality benefits. Strategic protection of lands also has the potential to enhance community resiliency by reducing development on lands most vulnerable to storm surges and coastal flooding and by mitigating the effects of storm surge and coastal erosion on lands farther inland where development does occur. Conserved, publicly accessible lands can also provide secondary benefits associated with recreation and ecotourism activities such as bird and nature watching, kayaking, canoeing, and fishing that fuel coastal economies and public well-being. Thus, it is argued that coastal restoration generates practical long-term economic benefits. Every dollar spent to preserve wetlands and other natural defenses saves state and local governments an average of $4 in the long run. Land thus suggests that restoration raises property values, increases local tax revenues, improves water quality, reduces erosion, and mitigates storm hazards.

East of Texas, coastal Louisiana is experiencing an "ecocatastrophe" caused by unprecedented land loss as described by Khalil *et al.* in *"Ecosystem restoration in Louisiana – a decade after the Deep Water Horizon oil spill."* The authors, in a high-level assessment of project implementation, make the case that Louisiana could move quickly in the implementation of various restoration plans because robust and comprehensive plans were previously developed and are ready for implementation due to various planning efforts since the 1980s, many which are included in the state-legislated Coastal Master Plan, created after the devastating hurricanes Katrina and Rita in 2005. For the first time, dedicated funding was made available not only for regional programmatic monitoring to implement adaptive management but also for development of the

art and science of restoration. The State of Louisiana was able to efficiently and effectively implement restoration projects funded through recent programs because of the hard work done through previous programs and planning efforts. Decades of progress by a critical mass of experts made up of local, state, and federal natural resource agency staff, academia, political leaders, volunteers, non-governmental agencies, and concerned citizens funded through the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA) program and planning initiatives like the COAST 2050 Plan paved the way for the expedited implementation of recent work. The authors also assert that the results of restoration science and engineering research on the state's coastal landscape will provide a showcase for coastal restoration and management of coastal ecosystems not only for NGoM states, but globally.

Sustaining the land on the coast of Louisiana is vital to our nation's economy as several of the nation's largest ports are located on the Gulf coast in Louisiana. In addition, the ecosystems making up the Louisiana coast are important to sustain some of the largest and most valuable fisheries in the nation. Funded by BP Phase 3 Early Restoration, the goals of the Natural Resource Damage Assessment (NRDA) Outer Coast Restoration Project are to restore beach, dune, and marsh habitats to help compensate spill-related injuries to habitats and species – specifically brown pelicans, terns, skimmers, and gulls. The State of Louisiana has successfully utilized the proceeds from the fines imposed for the Deepwater Horizon incident to significantly jump start barrier island restoration as identified in the Coastal Protection and Restoration Authority (CPRA) of Louisiana Coastal Master Plan (CPRA 2017).

Barrier islands in Louisiana are the first line of defense against storms and provide protection for inland waters and productive estuaries. The goals of the Natural Resource Damage Assessment (NRDA) Outer Coast Restoration Project are to restore beach, dune, and marsh habitats to help compensate spill-related injuries to habitats and species — specifically brown pelicans, terns, skimmers, and gulls. The Shell Island Barrier Restoration and Chenier Ronquille Barrier Island Restoration projects were funded for construction (details by Thompson and others) to provide compensation for habitats observed to be injured during the Deepwater Horizon incident. Beach, dune, and back-barrier marsh habitats were created to provide an ideal environment on which species such as brown pelicans, terns, skimmers, and gulls can thrive. These projects continue to be monitored by CPRA and NMFS to document benefits achieved as a result of the NRDA Outer Coast program.

A model framework to simulate the evolution of a proposed barrier island restoration was developed to aid in management and engineering decisions and to assist with stakeholder expectations for design performance. Long and others discuss a modeling framework to guide restoration decisions for Breton Island developed by an interdisciplinary project team in their paper entitled *"Event and decadal-scale modeling of barrier island restoration concepts for decision support."* This framework relied on combining a process-based model for storm impacts and empirical models of shoreline change and relative sea level rise. Model results were evaluated by the team at multiple checkpoints in order to elicit expert input and adapt the restoration concept. This process eliminated time spent running simulations that provided little value to the decision-making process. The model provided information on the rate of island degradation, the predicted changes across different habitat types (intertidal, supratidal, dune), and the expected performance of the design template through time. Results directly informed engineering design decisions and expedited later project stages including the construction permitting process.

Restoration of several barrier island projects in Louisiana since the early 1990s resulted in depletion of many of the nearshore sand sources and the availability of beach-compatible sediment has become increasingly scarce. Therefore, the offshore sand sources of Ship Shoal (an offshore sandy shoal) and renewable sand sources in the Mississippi River are the closest available sediment sources where sufficient volumes of sediment for beach and dune restoration are available. All the three projects described by Dartez and others in *"Turning a tragedy into large scale barrier island restoration in Louisiana, A three project case study"* utilized these sediment resources. These projects utilized renewable sand resources from the river borrow areas as well as from offshore sources. The Riverine Sand Mining/Scofield Island Restoration (BA-40) project was the first to be implemented through a commitment of remaining funds in the initial emergency protective berms' construction budget formulated into the Berms to Barrier Islands plan. The berm/restoration conversion at Scofield Island was the first to utilize this funding mechanism. The Caminada Headland Beach and Dune Restoration–Increment II (BA-143) project was funded through the National Fish and Wildlife Foundation's (NFWF) Gulf Environmental Benefit Fund, and capitalized on a prior project constructed to the west completing the beach and dune restoration of the entire headland. Lastly, the Caillou Lake Headlands Restoration (TE-100) project was funded through the Natural Resource Damage Assessment (NRDA). The TE-100 project restored the entire degraded beach and dune system backed by a created marsh habitat to complement a prior restoration effort.

Thompson and others discuss that Shell Island and Chenier Ronquille are critical pieces of barrier shoreline within the Barataria Basin in Plaquemines Parish, Louisiana, in their paper entitled *"Restoring barrier habitat in Louisiana to compensate for natural resource injuries: Shell Island and Chenier Ronquille Barrier Restoration Projects."* These large-scale restoration projects were completed in the years following the DWH incident, creating new habitat and reinforcing Louisiana's Gulf of Mexico shoreline. The CPRA completed the construction of the Shell Island NRDA Restoration Project in 2017 which restored two barrier islands in Plaquemines Parish utilizing sand hydraulically dredged from the renewable sand sources of Mississippi River and pumped via pipeline over 20 miles over levees and through towns, marinas, and marshes to the coastline. The NMFS also completed the Plaquemines Parish barrier island restoration at Chenier Ronquille in 2017 utilizing nearshore Gulf of Mexico sediment, restoring wetland, coastal, and nearshore habitat in the Barataria Basin. A design and construction overview is provided in the paper.

Hemmerling and others in their paper *"Double exposure and dynamic vulnerability: Assessing economic well-being, ecological change and the development of the oil and gas industry in coastal Louisiana,"* observe that the oil and gas

industry has been a powerful driver of economic change in coastal Louisiana for the latter half of the twentieth century and into the twenty-first. Yet, the overall impact of the industry on the economic well-being of host communities is varied, both spatially and temporally. While the majority of Louisiana's oil and gas production now occurs offshore, processing the extracted product is an energy intensive undertaking requiring an expansive network of land-based infrastructure. Despite the positive economic aspects of this development, there are also potential negatives posed to coastal ecosystems and to communities located adjacent to oil and gas infrastructure. This research utilizes a double exposure framework to explore the relationship between oil and gas infrastructure development, fish and shellfish habitat, and economic wellbeing in Louisiana's coastal zone from 1950 to 2010. The approach followed four main steps: (1) developing a hazardousness of place model to identify areas of magnified risk due to the combined hazards of multiple potential exposure sites related to the extraction and processing of crude oil and natural gas; (2) developing a model of ecological functioning to measure the ability of aquatic habitat to support key fish and shellfish species; (3) utilizing an integrated community economic wellbeing index to assess change on a decadal timescale; and (4) analyzing selected oil-dependent communities to illustrate how change processes occurring in different energy sectors result in differential outcomes. The results suggest that, for many communities, the dependence on the oil and gas industry has increased economic wellbeing but also increased sensitivity to natural and human-induced changes, including fluctuating economic conditions, environmental stress, coastal habitat destruction, and increasing social and economic pressures.

This influx of funding has greatly increased restoration effort and increased governance complexity associated with project funding, implementation, and reporting. As a result, there is enhanced impetus to formalize and unify adaptive management processes for coastal restoration in Louisiana. Carruthers and others describe "*Strategies to improve implementation of adaptive management practices for restoration in coastal Louisiana*" through synthesis of input from local coastal managers. They summarize historical and current processes for project and programmatic implementation and adaptive management. As detailed in the paper, key gaps and needs to specifically increase implementation of adaptive management within the Louisiana coastal restoration community were identified and developed into eight tangible and specific strategies. These were to: streamline governance through increased coordination amongst implementing entities; develop a discoverable and practical lessons learned and decision database; coordinate ecosystem reporting; identify commonality of restoration goals; develop a common cross agency adaptive management handbook for all personnel; improve communication (both in-reach and outreach); have a common repository and clearing house for numerical models used for restoration planning and assessment; and expand approaches for two way stakeholder engagement throughout the restoration process. A common vision and maximizing synergies between entities can improve adaptive management implementation to maximize ecosystem and community benefits of restoration effort in coastal Louisiana. This work adds to current knowledge by providing specific guidance and recommendations, based upon extensive engagement with several restoration practitioners from multiple state and federal agencies. Addressing these practitioner-identified gaps and needs will improve use of adaptive management in coastal Louisiana, a large geographic area with high restoration implementation within a complex governance framework.

The System-Wide Assessment and Monitoring Program (SWAMP) was developed as an important state-wide monitoring strategy to implement adaptive management. Raynie and others in their paper, "*Statewide monitoring for restoration of coastal Louisiana and data management,*" explain that SWAMP has been developed as a long-term monitoring program to ensure that a comprehensive network of coastal data collection activities is in place to support the planning, development, implementation, and adaptive management of the protection and restoration program and projects within coastal Louisiana. SWAMP includes both natural-system and human-system components. It incorporates the previously-developed Coastwide Reference Monitoring System (CRMS), the Barrier Island Comprehensive Monitoring (BICM) program, and fisheries data collected by the Louisiana Department of Wildlife and Fisheries (LDWF). Other aspects of system dynamics, including offshore and inland water-body boundary conditions, water quality, risk status, and protection performance, which have historically not been the subject of CPRA-coordinated monitoring. This program further facilitates the integration of project-specific data needs into a larger, system-level design framework. Monitoring and operation of restoration and protection projects are being nested within a larger hydrologic basin-wide and coast-wide SWAMP framework and will allow informed decisions to be made with an understanding of system conditions and dynamics at multiple scales. This paper also provides an update on the implementation of various components of SWAMP in coastal Louisiana, which began as a Barataria Basin pilot implementation program in 2015. During 2017, the second phase of SWAMP was initiated in the areas/basins east of the Mississippi River. In 2019, development of SWAMP design was completed for the remaining basins in coastal Louisiana west of Bayou Lafourche. CPRA has re-engineered its data management system to include spatial viewers, tabular download web pages, and a library/document retrieval system along with a suite of public-facing web services providing programmatic access. This system is collectively called the Coastal Information Management System (CIMS; CIMS.coastal.louisiana.gov).

Monitoring of physical terrain is an important parameter of SWAMP. For the first time a systematic approach was adopted to undertake a geophysical (bathymetric, side scan sonar, sub-bottom profile, and magnetometer) survey along more than 6,500 nautical miles (nm) of track-line encompassing almost all of the bays and lakes from Chandeleur Sound in the east to Sabine Lake in the west. This includes approximately 1,600 nautical line miles of recently completed survey from west of Terrebonne Bay to Sabine Lake. This geophysical survey complements the bathymetric survey undertaken under the Barrier Island Comprehensive Monitoring (BICM) Program in the adjacent offshore areas. The paper, entitled *"Overview of statewide geophysical surveys for ecosystem restoration in Louisiana"* by

Khalil and others, describes how a study of this magnitude was conceptualized, planned, and executed along the entire coast of Louisiana for the first time. It is important to note that the initial intent was to collect bathymetric data only for numerical modelling for ecosystem restoration and storm surge prediction. Geophysical data acquisition was added for oyster identification and delineation. In addition, these first-order data help reconstruct the subsurface geological framework essential for sediment exploration to support restoration projects. Analysis and interpretation of the sub-bottom profiler data indicate that the subsurface geology within the SWAMP study area and the surrounding areas are predominately gas/organic mud, paleo-channels, potential paleo-channels, hard-bottom, gas/hard-bottom and mixed sediment. Future work on higher resolution along the closed/tighter survey track-lines (by adding/inserting track-lines between existing survey lines) and collecting ground-truth data including vibracores would support a higher degree of confidence in interpreting and analyzing the geophysical data. The wider line spacing of these surveys does not support eliminating any magnetic anomalies from consideration as potential hazards, pipelines or cultural resources.

Ramseur's paper presents the Mississippi Department of Marine Resources, Office of Coastal Restoration and Resiliency perspective on adaptation and innovation in restoration permitting, collaboration and design that will help the state of Mississippi address future challenges stemming from its ongoing geomorphic evolution, loss of primary landforms and the relationship of these changes to the Deepwater Horizon Oil Spill. The paper, entitled *"Field of dreams: Restoring estuarine habitat and structure in Mississippi after the Deepwater Horizon Oil Spill,"* presents "The Round Island" project in Jackson County, MS to serve as a principal example. Completed through the efforts of four agencies via a Memorandum of Understanding and funded by the NFWF, this project broke a long-standing convention of dumping large quantities of Federal Navigation Channel dredged materials in an Offshore Dredged Material Disposal Site (ODMDS). Not only were 220 acres of new island and marsh habitat created in the Mississippi Sound, Ramseur argues that this project saved millions in federal navigation dollars because it could be more efficiently accessed than the ODMDS site.

Kraft and Hunter's *"An overview of Deepwater Horizon restoration progress in Alabama"* describes how DWH funds are jumpstarting recovery and restoration efforts in Alabama, where over $720 million has been approved for projects to date. The Alabama Department of Conservation and Natural Resources (ADCNR) oversees many aspects of this restoration effort in the state, leveraging existing planning and stakeholder investments to maximize efficiencies and take advantage of local expertise. This paper provides an overview of some of the planning tools utilized by the state of Alabama to support DWH restoration efforts and highlights several of the ongoing restoration projects that will benefit coastal habitats and wildlife. DWH restoration activities will be underway in Alabama for the next several decades. Leveraging existing local expertise and coordinating across different funding sources will be a critical element of maximizing project dollars. Additionally, tracking the progress of restoration at both the project and program scales will be critical for adaptive management of the restoration program over time. Utilizing existing tools and strategic investments in data acquisition and monitoring will support the restoration effort over time.

The Rooney *et al.* paper on *"Alabama Swift Tract Living Shoreline: two years of post-construction monitoring results"* describes how 21 low-crested breakwaters were constructed to function as benthic habitat and reduce shoreline erosion rates as part of Phase III of the Early Restoration Framework Agreement in accordance with the Oil Pollution Act (OPA) following the Deepwater Horizon Oil Spill. NOAA initiated a seven-year post-construction monitoring plan, of which two years have been completed. Post-construction monitoring results so far indicate that the project is currently exceeding biological and shoreline position performance goals. The project partially meets breakwater elevation goals, but the breakwater appears to be functioning as designed. More data are needed to identify any biological trends as a result of the breakwaters. Future monitoring events will continue to provide this needed information. Biological monitoring will be undertaken annually through 2023.

Born of settlements surrounding the Deepwater Horizon oil spill in the Gulf of Mexico, the Florida RESTORE Act Centers of Excellence Program (FLRACEP) is charged with administering approximately $26 million in research grants for Florida over a period of more than 15 years. Centers of Excellence in Florida are selected through a competitive, peer-reviewed process which has thus far awarded $4.3 million in grants to 10 Florida researchers investigating different elements of marine fish and wildlife research and long-term fisheries monitoring. Fetherston-Resch describes the detail in the paper, *"Research results from the first four years of the Florida RESTORE Act Centers of Excellence Research Grants Program."* The initial 11 FLRACEP research grants produced 48 submitted or planned papers and supported 63 students. While these outputs are significant, the FLRACEP Centers of Excellence are tackling important issues in coastal and marine research, resource management, and community resilience. The FLRACEP management team and program staff work to ensure effective program administration and research that is responsive to the needs of the state within the eligible RESTORE Act disciplines. While the program has encountered challenges in its early years, focus remains on the opportunity this funding represents.

PATH FORWARD

Land loss in deltaic plains and erosion along coastal shorelines are global phenomena. Natural processes are impacted to varying degrees by anthropogenic activities so that a long list of interrelated processes work in concert to adversely affect coastal systems in a variety of ways. Similarly, the coastal environments along the NGoM are prone to damages by natural disaster such as hurricanes and susceptible to anthropogenic events such as oil spills. The scale and magnitude of impact varies depending upon several factors including the geographical location. Louisiana was closest in vicinity to the DWH oil spill and incurred significant damage to its barrier islands and interior wetlands in the midst of the state's efforts to restore and protect its fragile coast. Other Gulf states also incurred damages of many kinds.

The DWH oil spill triggered several criminal and civil suits, including the largest environmental settlement in

U.S. history. The majority of restoration funding for the next 15 years will come through one of the DWH mechanisms viz. Natural Resource and Damage Assessment (NRDA), the RESTORE Council, or National Fish and Wildlife Foundation–Gulf Environmental Benefit Fund (NFWF-GEBF). The accomplishments during the last 10 years are significant as several papers in this issue explain. It is expected that in the next 10 years accomplishments in restoration and science will be even more significant as funds are made available, moving the NGoM states towards recovery from the spill. In addition, the lessons learned in restoration and multi-agency coordination through DWH funded activities can provide lasting benefits to other large-scale, multi-agency efforts, restoration or otherwise, in the Gulf region and beyond for decades to come.

The summation of various papers above gives us a snapshot of what has been done by the state and federal partners during the last 10 years. The uneven distribution of numbers of papers from various states is partly reflective of the amount of mitigative programs and projects undertaken by respective states. As stated in papers, one of the important reason for Louisiana to implement so many projects/programs in such a short time was the state's preparedness to implement its Coastal Master Plan which existed prior to the oil spill. Subsequent to the oil spill, other Gulf coast states have developed comprehensive plans for their coasts.

Funding for adaptive management from DWH settlements is not only a very important contribution to the restoration science but a landmark. This has helped much needed monitoring of the projects as well as with baseline data acquisition. Adaptive management will definitely guide our scientific approach to restoration. The need for the next 10 years is that we not only adaptively manage the art and science of our restoration projects and programs but adapt the decision-making process for wise and expeditious distribution of funds to enhance scientific understanding. At the same time while we spent the last decade acquiring much needed data, we should strive for management of these data to support more comprehensive analyses and syntheses to look at the impact of the restoration projects and programs in a more holistic manner. The oil spill settlements are encouraging states to cooperate across political boundaries and think of the entire NGoM holistically to enhance the ecological and economic health of the Gulf.

Several papers in this issue describe the oil spill and the response that followed as unprecedented in scale and in subsequent settlement amounts. Correspondingly, funding for mitigating the impacts of the spill through the NRDA, NFWF, and RESTORE Act programs allowed the states and local municipalities to dedicate substantial resources to the construction of various large-scale ecosystem restoration projects. This significant inflow of funding opened unparalleled restoration opportunities, but at the same time created governance challenges due to multiple responsible parties, various settlements, and several decision-making entities. Understandably these various decision-making entities have different perspectives and different approaches depending upon the mission of their respective member agencies. This is further complicated by the fact that the various funding sources have their own goals and objectives which can overlap or at times be tangential to individual states plans/perspectives. Federal agencies, states, local governments, NGOs, and academia must work together to efficiently and effectively coordinate, cooperate, and collaborate to achieve the goals and objectives to mitigate the impact of the oil spill as envisioned in various oil spill settlements.

The result of interagency and interstate coordination will be a comprehensive portfolio of projects that crosses political boundaries to correspond with the extent of the injuries from the far-reaching impacts of the DWH disaster. It is expected that during the next 10 years, states and federal agencies in the Gulf region would be working on assessing the cumulative effects of restoration projects and how they contribute to the overall health of the Gulf. Continued accomplishments in restoration and science are expected to be significant over the coming 10 years as funds are made available, moving the Gulf of Mexico towards recovery from the spill. In addition, the lessons learned in restoration and multi-agency coordination through DWH funded activities can provide lasting benefits to other large-scale, multi-agency efforts, restoration or otherwise, in the Gulf region and beyond for decades to come.

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The various papers in this issue were written by researchers, consultants, contractors, and partnering agencies who have worked on various aspects of the Deepwater Horizon oil spill. They represent various state agencies across the Gulf states as well as federal agencies and reflect a wide breadth of perspectives, but all share in the same mission: to help the Gulf recover from the largest oil spill in U.S. history. Thanks to all the authors not only for writing these papers, but also for their continued dedication in helping the Gulf recover.

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