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Selecting indicators to monitor outcomes across projects and multiple restoration programs in the Gulf of Mexico

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ABSTRACT

Tracking the incremental and combined effects of large-scale ecosystem restoration programs is scientifically and socioeconomically challenging; this is especially true for ongoing management and restoration programs in the northern Gulf of Mexico and adjacent areas following the *Deepwater Horizon* oil disaster. When implemented, monitoring programs for large-scale ecosystems typically monitor overall system health and/or the progress toward individual restoration project goals. However, being able to demonstrate successful "individual restoration projects" does not necessarily equate to providing cost-effective benefits at the large-scale ecosystem level, especially when the area and complexity of the system is large. More than $16 billion is available for ecosystem restoration related activities associated with multiple *Deepwater Horizon* settlements (i.e., Gulf Coast Ecosystem Restoration Council, Natural Resource Damage Assessment (NRDA) Trustee Council, and National Fish and Wildlife Foundation). Restoration activities conducted under the NRDA settlement are intended to restore injured resources to conditions that would have existed in the absence of the spill and to compensate the public for lost use of injured resources. Other restoration activities funded by the settlements are designated to restore the Gulf Coast economy, culture and environmental health by addressing a multitude of other ecological and economic injuries in the Gulf ecosystem not directly caused by the spill. Although the collective funding for restoration activities is large, unprecedented, and has the potential to begin making progress toward reducing adverse long-term environmental stressors, it is insufficient to fully address all stressors to restore ecological health in the vast Gulf ecosystem. This creates a unique challenge for restoration program managers who in addition to demonstrating the success of individual projects, need to demonstrate that overall restoration funds were spent wisely and produced significant synergistic benefits to preserve and restore the Gulf ecosystem. This will be especially important as settlement funds are exhausted and resource managers seek public funding to continue restoration and conservation efforts.

We evaluated approaches for integrating the monitoring of individual project outcomes in order to also monitor the combined program progress across all Gulf oil disaster restoration programs based on (1) lessons learned from other large-scale restoration programs; (2) integrated restoration goals and objectives from multiple Gulf restoration programs; (3) common stressors, and potential interactions with varying restoration and conservation target categories and their associated types of projects; and (4) the applicability of monitoring at both the project and program level. We identified a suite of 10 performance metrics or indicators that are applicable to multiple project types and restoration entities in the Gulf using restoration indicators that are highly applicable across restoration categories at both the project and system level. Utilizing a small set of indicators that can be measured across multiple resource and project types creates an opportunity to build a core set of metrics into individual project monitoring plans in a way that is cost-effective, efficient and consistent. Our approach represents one way to track the impacts of restoration activities at a scale larger than the project level in the Gulf, while recognizing the scientific, political and economic challenges associated with restoring the Gulf ecosystem in the wake of the BP *Deepwater Horizon* oil disaster.

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1. Introduction

The BP *Deepwater Horizon* oil disaster injured "the entire ecosystem of the northern Gulf of Mexico" (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). Multiple settlements related to the oil disaster total over $27 billion, of which more than $16 billion is available for ecosystem restoration (Environmental Law Institute, 2016). These dollars will support one of the largest ecosystem restoration efforts ever attempted and are in addition to existing management and restoration activities in the region (e.g., Everglades restoration, Gulf hypoxia reduction, Mississippi River delta restoration, etc.).

The largest restoration-based fund, $8.8 billion, is from settlements related to violations of the Oil Pollution Act and is allocated to the recovery of natural resource damages (NRDA) and the affiliated lost use of the injured resources. The recovery and allocation of settlement funds associated with NRDA is overseen by a group of federal, state and tribal Trustees (Trustee Council) who have developed a programmatic damage assessment and restoration plan (PDARP) (Deepwater Horizon Natural Resource Damage Assessment Trustees, 2016). Restoration funding under NRDA is allocated to 13 restoration categories associated with four overarching restoration goals, as well as categories associated with monitoring, adaptive management and administrative oversight. In addition to the above segregation of restoration funds, the funds are further assigned to numerous additional subcategories and aligned with seven geopolitical entities (one for each of the five Gulf states as well as an open ocean and a regional fund).

The second-largest restoration-based settlement fund is $5.33 billion, allocated to the Gulf Coast Ecosystem Trust Fund and, through the RESTORE Act, to be managed by the Gulf Coast Ecosystem Restoration Council (GCER Council) and the five Gulf states for restoring the Gulf ecosystem, as well as its economies and tourism. The GCER Council developed an Initial Comprehensive Plan in 2013 and an Updated Comprehensive Plan (Gulf Coast Ecosystem Restoration Council, 2016) to guide their restoration program. Thirty-five percent of the Trust Fund is administered by the U.S. Treasury to be allocated equally to the five Gulf states for ecosystem restoration, economic development and promotion of tourism. Thirty percent of the Trust Fund is to be managed by the GCER Council based on the many restoration categories identified in the Comprehensive Management Plan. Another 30 percent of the Trust Fund is allocated to the five Gulf States based on the level of impact from the oil spill for state-led restoration under the Comprehensive Management Plan. The remaining 5 percent of the Trust Fund is divided equally between a NOAA-led science program for monitoring and technology, and the five states to create science-based Centers of Excellence.

Other restoration-based settlement funds included more than $2.5 billion allocated to the National Fish and Wildlife Foundation (NFWF) for creation of the Gulf Environmental Benefit Fund. Louisiana will receive half of this funding for restoring or creating barrier islands and/or implementing river diversion projects in coastal Louisiana. Alabama, Florida, Mississippi and Texas received the remaining funds to support projects that remedy harm to natural resources where there has been injury to, or destruction of, loss of, or loss of use of those resources resulting from the oil spill. Another major restoration-based settlement, the North American Wetlands Conservation Fund (NAWCF), received $100 million for wetlands restoration, conservation and projects benefiting migratory birds. Lastly, $500 million was set aside for the Gulf of Mexico Research Initiative administered by the National Academy of Sciences. The NFWF and NAWCF restoration programs do not have detailed restoration planning documents like those of the NRDA Restoration Plan and the GCER Council's Comprehensive Plan; however, their general goals fall within the overall scope of the goals of these latter programs.

Accounting for money spent for restoration of the northern Gulf of Mexico ecosystem is an important part of reporting to the public and Congress throughout the restoration effort and will span decades. Tracking the outcomes of restoration activities in the Gulf is difficult because both the ecosystem and the governance structures set up to fund projects are large and complex. Each of the major restoration programs has its own decision-making structure, goals, timelines, regulatory requirements and project selection processes. Additionally, when there are no measurable restoration benchmarks for measuring progress it is especially difficult to identify appropriate measures of success (Dale & Beyeler, 2001). The objective of this study is to identify a framework of potential indicators which while related to measuring progress at the individual project level would also be useful for evaluating combined restoration program success in restoring the ecosystem functions of the northern Gulf ecosystem.

All large ecological restoration and management efforts have the difficult task of determining if project goals and objectives are being met (Albemarle-Pamlico National Estuary Partnership, 2012; Degnbol & Jarre, 2004; Doren et al., 2009; Kershner et al., 2011; Niemeijer & Groot, 2008). Thousands of species, habitats, ecological conditions and processes will be directly or indirectly affected by restoration actions in the Gulf and could potentially be monitored to track overall restoration progress. Although monitoring a wide set of species and habitats as indicators across the ecosystem may be considered ideal in some cases (Carignan & Villard, 2002; Dale & Beyeler, 2001), the limits of available funding and political will for monitoring expenditures in the Gulf create the need for a practical approach that takes into account the size of the ecosystem, funding constraints and political complexities.

Ecological indicators act as measures of the overall health of the ecosystem and provide insight on the condition of the environment (Dale & Beyeler, 2001; Doren et al., 2009) and can be monitored to track ecosystem management goals and objectives (Brown et al., 2014; Carignan & Villard, 2002; Dale & Beyeler, 2001; Degnbol & Jarre, 2004; Doren et al., 2009; Great Barrier Reef Marine Park Authority, 2014; Harwell et al., 1999; Kershner et al., 2011; Niemeijer & Groot, 2008; Perry et al., 2010). In a restoration program as extensive as the one underway in the Gulf, we focused specifically on "management or control" indicators over which humans have some influence (Perry et al., 2010) to directly link restoration actions to the indicators of ecosystem effect. This approach allowed us to target those resources and performance metrics which are most likely to be directly affected by restoration actions.

Ecological indicators can be selected using screening criteria to narrow the list of species in the target ecosystem (Albemarle-Pamlico National Estuary Partnership, 2012; Bisland, 2016; Carignan & Villard, 2002; Dale & Beyeler, 2001; Degnbol & Jarre, 2004; Doren et al., 2009; Niemeijer & Groot, 2008; Ottersen et al., 2011; Perry et al., 2010; U.S. Environmental Protection Agency, 2002). Indicator selection should include both management and technical considerations, and be viewed as a tool to solve a specific management problem and less as a way to study resources (Degnbol & Jarre, 2004). In addition to using screening criteria when selecting a group of indicators to monitor, it is also important to focus on how the indicators will work as a set to create a more applicable and effective end product (Niemeijer & Groot, 2008). Our approach seeks to identify a set of monitoring indicators that are highly applicable and relevant (discussed in more detail below) to multiple restoration categories and projects and can be used as a starting point for designing efficient programmatic (larger than project-level) monitoring efforts.

2. Approach

To design our approach, we referred to the literature regarding ecological indicators, large-scale restoration monitoring programs and a few ecosystem-based fisheries management programs that utilized ecological indicators. We adopted components of the general method described in Kershner et al. (2011), such as a hierarchical framework and selection criteria to link indicators to policy goals. The recent