Socio-economic monitoring recommendations for Beezley Reef restoration project in Galveston Bay, Texas

submitted to

The Nature Conservancy

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Introduction

In the Gulf of Mexico, natural and anthropogenic disasters, both acute and chronic as well as small and large-scale, compounded over time, have impacted Gulf environments and economies. Oil spills, hurricanes, chronic flooding, freshwater inflows, coastal erosion, subsidence, and factors related to climate change continue to drive habitat and biodiversity loss, affecting environmental and human well-being. Natural resource programs and policies have identified ecological restoration as a means to achieve environmental and socio-economic goals. Socio-economic goals can include supporting community resilience, economic prosperity, social and community values, public health, risk reduction and hazard mitigation, and other aspects of human well-being.

The Nature Conservancy employs oyster reef restoration as a direct approach toward slowing and reversing coastal erosion and sustaining healthy coastal habitats. Their long-term objective is to manage the Gulf's oyster resources collaboratively using a coordinated approach that delivers the ecosystem functions and services needed to sustain healthy reef habitats and economically sustainable oyster fisheries. In collaboration with local, state, and regional partners, The Nature Conservancy has set oyster restoration goals for specific bays and estuaries throughout the Gulf of Mexico based on the desired levels of oyster production and ecosystem services for those locations. These services increase the resilience of coastal communities, including protecting adjacent shorelines; providing forage and refuge habitat for commercially, recreationally, and ecologically important species of fish, shrimp, crabs, and other reef-associated estuarine species; improving/maintaining water quality via the filtration that takes place when oysters feed; acting to slow currents between reefs and shorelines to allow sediment to drop out of suspension and diminish; limiting or minimizing erosion; and providing larval oysters to adjacent commercial and public harvest areas to stock these areas (Bendick et al., 2018).

The long-term success of these oyster reef restoration projects depends on whether reefs are built in environments that can continue to support the natural growth and reproduction of oysters, on the engineering design of the reefs, and the management of oyster harvest and other surrounding environmental and human impacts. Long-term and holistic monitoring of restored reefs is essential to evaluate the successes and failures of restoration efforts and identify opportunities for improvement. Holistic monitoring should include the measurement of ecological changes attributed to the restoration project, as well as the ecosystem service and social and economic impacts. While biological and ecological monitoring (e.g., number of oysters, the physical growth of the reef, fish and wildlife populations, water quality, etc.) is the standard for most oyster reef restoration projects, socio-economic monitoring of restoration is not consistently implemented in the Gulf of Mexico. This makes the evaluation of restoration success difficult. A few examples exist, such as the collaborative study by The Nature Conservancy and the Texas Sea Grant College Program. In 2014, The Nature Conservancy managed the restoration of Half Moon Reef in Matagorda Bay, Texas. In the two years post-construction, the reef exhibited extraordinary productivity and growth of live oysters, which led to a substantial increase in marine biodiversity and productivity. The restoration was an ecological success, but its impact on human well-being was not evaluated. A series of surveys and economic analyses found a positive economic impact on recreational fishing communities due to the successful restoration effort (Carlton et al., 2016). Studies like these provide a baseline for developing critically important socio-economic monitoring plans associated with habitat restoration investments taking place across the Gulf of Mexico and beyond.

Overall purpose and approach

The following describes the framework the contracted project team (the Community Resilience Group at Harte Research Institute for Gulf of Mexico Studies) used to develop a socio-economic monitoring plan for the Calcasieu Lake oyster reef restoration site and a human dimensions analysis. This work aims to provide The Nature Conservancy and its partners with a pilot socio-economic monitoring plan that can be implemented for monitoring the Beezley Reef (Galveston-Trinty Bay) oyster reef restoration site and adjacent human communities. This pilot plan is envisioned to serve as recommendations for holistic monitoring of oyster reef restoration projects and as a model for other practitioners, funders, and planners interested in evaluating the multiple benefits of restoration activities.

The socio-economic outcomes, metrics, and measurement protocols proposed in this pilot socio-economic monitoring plan are grounded in the foundational work of the Gulf of Mexico Ecosystem Service Logic Models and Socio-economic Indicators (GEMS) project (Olander et al., 2020). The GEMS project emerged after the National Academy of Sciences called for measurement of the social and economic impacts of the large-scale investments in restoring the Gulf of Mexico following the Deepwater Horizon Oil Spill. While billions of dollars continue to be spent on restoring the Gulf's environment and economy, there has been little to no monitoring or reporting on how restoration is or is not contributing to economic and social recovery in the Gulf. Funded by the Gulf Research Program of the National Academies, the GEMS project was a collaboration of the Nicholas Institute at Duke University, the Harte Research Institute at Texas A&M - Corpus Christi, The Nature Conservancy, and The Bridge Collaborative. The GEMS project enabled practitioners, funders, researchers, and stakeholders across the Gulf to co-create science-based ecosystem service logic models that illustrate pathways linking different coastal restoration project types to human well-being. These models capture the impacts of restoration as they cascade through the biophysical system to result in social and economic outcomes (Figure 1). The model components include the intervention (e.g., restoration project), biophysical changes, human activity changes, socio-economic outcomes, and potential metrics for monitoring. Metrics for monitoring each of these outcomes were identified by experts, as were measurement protocols to determine how much social and economic outcomes change over time and who is likely to be affected by those changes. The GEMS products and resources are housed on a web-based tool that can help inform the planning and monitoring of restoration projects (https://nicholasinstitute.duke.edu/project/gems). Managers, practitioners, funders, and researchers can use GEMS resources to plan for social and economic impacts from the beginning of new restoration programs and projects, add social and economic outcomes to existing programs, choose relevant and practical metrics, and monitor chosen metrics.

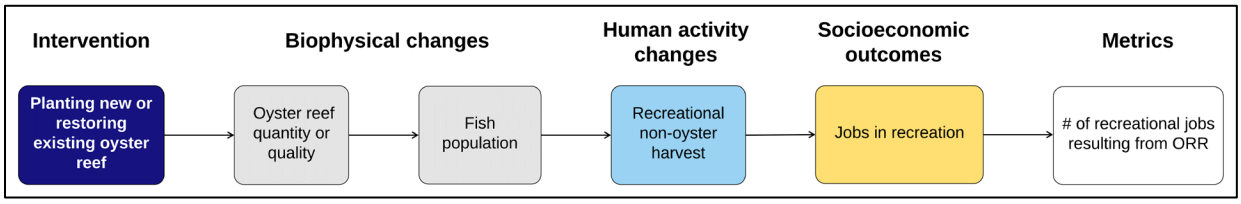

Figure 1. The base components for a GEMS ecosystem service logic model. Using this model as a starting framework, experts across the Gulf of Mexico created more complex models demonstrating the multiple pathways between restoration activities (e.g., oyster reef restoration) and socio-economic outcomes (e.g., jobs in recreation). (Olander et al. 2020)

Site description: Beezley Reef, Galveston Bay

The Beezley reef restoration site is located within the Galveston-Trinity Bay complex, along the mid coast of Texas. Funding for the restoration effort was initially provided by the National Fish and Wildlife Foundation through the Gulf Environmental Benefit Fund. Additional funds were provided by Cummins Foundation, Inc. and CenterPoint Energy Foundation. This project has been managed in partnership between The Nature Conservancy, Galveston Bay Foundation, and Texas Parks and Wildlife Department. Texas Water Development Board provided additional support for this project.

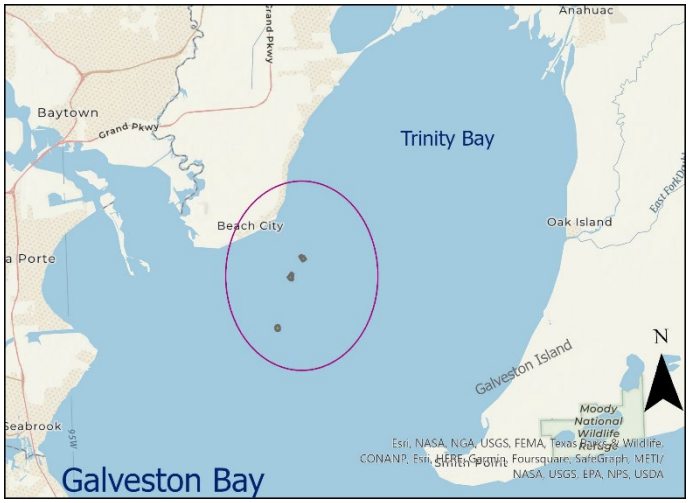

Figure 2. The oyster reef restoration site known as Beezley Reef in Galveston-Trinity Bay complex in coastal Texas.

Figure 3. Figure 3. Oysters and other reef-forming organisms adhere to the limestone rock used to restore the reef. The oysters will continue to grow over time, contributing to the restored reef and surrounding ecosystem. Photo courtesy of The Nature Conservancy.

This oyster reef restoration project was constructed in 2021 by The Nature Conservancy and is envisioned as part sanctuary and harvestable reef. At around 40 acres in size, 25 are open for commercial oyster harvest, with 15 acres to be preserved (not harvestable) as a broodstock sanctuary reef. This design allows for a sustainable approach to commercial oyster harvest. The sanctuary reef is expected to provide a nearby source of larvae to the harvestable areas. Additionally, the new oyster reefs in this site will help filter coastal waters, enhance water quality, and provide food and shelter for different fish species, shrimp, crabs, and other invertebrates.

Monitoring of oyster reefs in Galveston Bay is primarily conducted by Texas Parks and Wildlife, playing a key role in overseeing the health and sustainability of these vital ecosystems. The Harte Research Institute for Gulf of Mexico Studies contributes to the effort by conducting ecological studies that provide valuable insights into the broader Gulf of Mexico region. Additionally, project-specific measurements and data may be collected by engineering firms engaged in restoration initiatives, contributing to a comprehensive understanding of the conditions and performance of the oyster reefs.

Ecosystem Service Logic Model (ESLM) for Oyster Reef Restoration

http://bit.ly/NI-GEMS

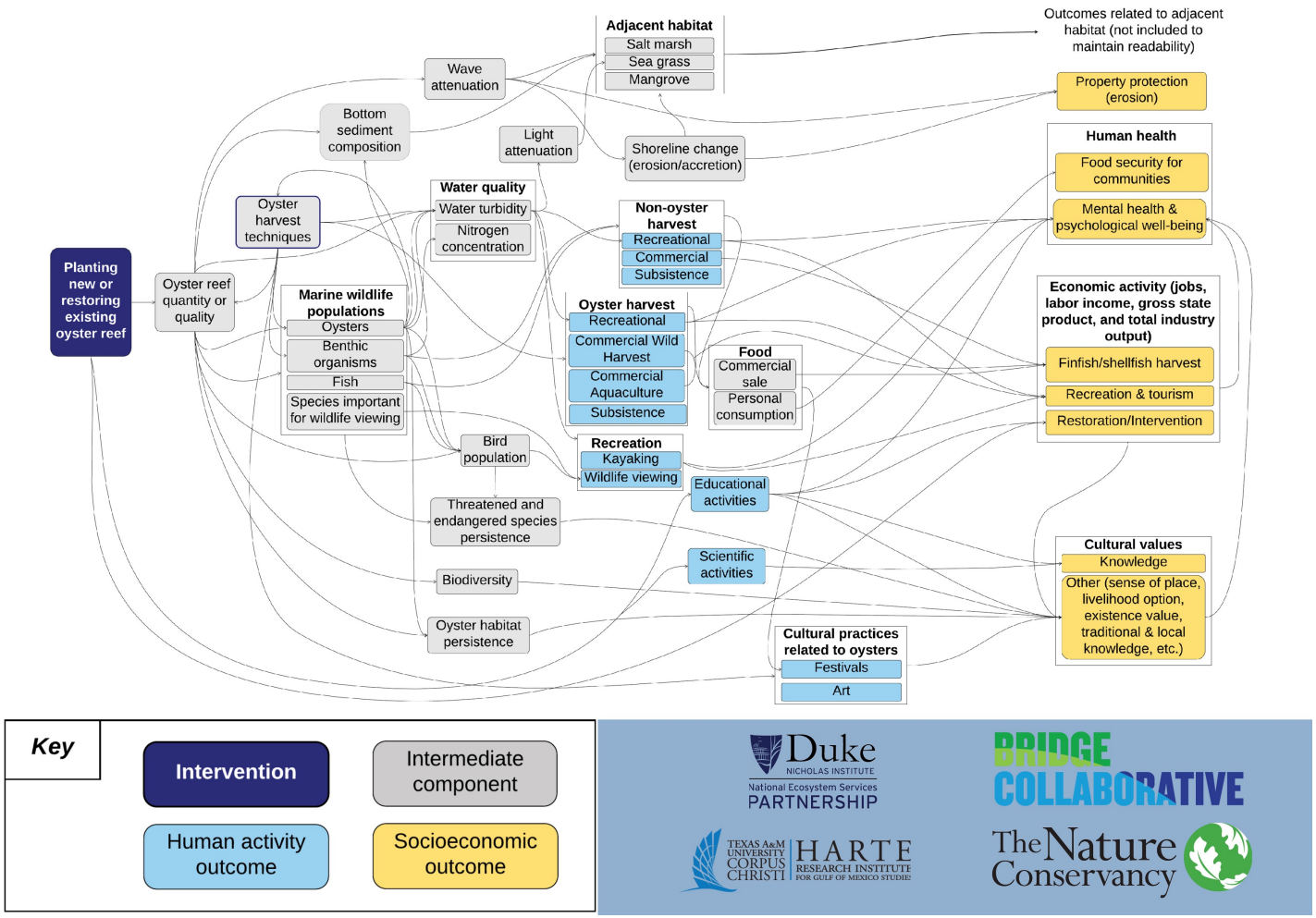

Figure 4. This ecosystem service logic model, entitled, "General Oyster Reef Restoration," was used as a reference for creating and validating the socio-economic monitoring plan for The Nature Conservancy's oyster reef restoration site at Beezley Reef in Galveston Bay, Texas. (Olander et al., 2020; https://nicholasinstitute.duke.edu/project/gems)

Monitoring plan development methods

Based on GEMS models, socio-economic outcomes likely to result from this restoration could include diverse and interrelated social, cultural, physical health, mental health, and economic outcomes. For the purposes of this socio-economic monitoring plan, the GEMS "General oyster reef restoration" ecosystem service logic model was selected as a framework (Figure 4) because it can be applied to any type of oyster reef restoration design (i.e., subtidal, intertidal, harvested, non-harvested, protected, etc.). As described above, the Beezley Reef site is designed to include portions that are protected/non-harvested as well as harvested, thus increasing the types of socio-economic outcomes likely to result from the restoration effort. In this model, socio-economic outcomes (yellow boxes in Figure 4) most likely to result from oyster reef restoration include Property Protection from erosion; Human Health related to food security as well as to mental and psychological well-being; Economic activity related to finfish/shellfish harvest, recreation and tourism, and to the restoration activity itself; Cultural Values including knowledge, and other values such as sense of place, livelihood option, existence value, traditional & local knowledge, etc.

While this GEMS model and its associated outcomes and metrics were validated by peer review and expert input, it is necessary to evaluate each potential outcome and recommended metric to determine relevance and feasibility at a local level. In doing so, socio-economic monitoring of the Beezley Reef restoration site is more likely to be effective and efficient in considering the local capacity to carry out such a plan. To evaluate the GEMS outcomes and metrics for feasibility and relevance to the Beezley Reef site, the research team conducted two components of work that informed the socio-economic monitoring recommendations in this plan. These work components include 1) subject matter expert interviews and 2) a human dimensions analysis of adjacent communities. Below is a brief overview of each component; however, a more comprehensive description of those methods and results can be found in (Del Angel, Lozada, and Hale, 2023).

1. Subject Matter Expert Interviews

This phase of work included the preparation and submission of Institutional Review Board (IRB) application materials for conducting ethical human subject research. The purpose of the subject matter expert interviews was to access local and regional knowledge regarding oyster reef restoration goals; to gather site-specific details that could inform the development of this plan; request data and identify data gaps; and discuss the partnerships and data needed to carry out socio-economic monitoring of the Beezley Reef site. This required co-developing a list of local or regional experts with The Nature Conservancy partners involved in this project. An initial list of experts was created, and using the snowball sampling method, additional names of experts to request interviews with were added to the list based on the interviewee's recommendation. All expert interviews took place during July and August of 2023. Experts with local knowledge regarding the restoration project itself or of the community in the surrounding geographic area, provided verbal input through discussion in meetings with the project team. All input was documented, sorted into "segments," and then organized into themes ("codes") relating to the GEMS socio-economic outcome categories. Analysis was conducted in MAXQDA©, a qualitative and quantitative analysis software. For example, after analyzing the interview transcriptions, subject matter experts discussed socio-economic outcome categories, including Cultural Values (n=3) and Economic Activities (n=5) relevant to the Beezley Reef restoration project. Some experts mentioned that as a cultural value, the reef design is expected to enhance the ecosystem's resilience and ecosystem

services. Others suggested that the restoration project may generate some economic activity through its construction and possibly by enhancing oyster and non-oyster harvests in the future. This can promote economic activity in the areas of recreational and commercial fishing. Feedback like this was used to select and recommend socio-economic metrics that are locally relevant and potentially feasible. The full list of interview questions, description of methods, and summarized results is available in (Del Angel, Lozada, and Hale, 2023).

2. Human Dimensions Analysis

The human dimensions analysis was designed to characterize the values currently held by people that live nearby or visit the restoration site or nearby area, thus further validating the relevance of the GEMS model for the Beezley Reef site. It is important to know what types of human perceptions, values, and activities take place in a restoration area so that socio-economic monitoring plans are relevant, feasible, and effective for the location. This analysis was also conducted to establish a baseline understanding of human values and perceptions so that if monitoring is implemented and continued, changes in human values and perceptions attributed to the restoration project or program can be tracked and compared over time. This phase of work also included the preparation and submission of Institutional Review Board (IRB) application materials for conducting ethical human subject research. We designed a human dimensions survey and distributed it online. Two team members distributed survey flyers in communities adjacent to the Beezley Reef site (Galveston Bay area); locations for surveys were selected after consultation with The Nature Conservancy project partners and subject matter experts. The survey identifies how people utilize natural resources and assets in the restoration area, what their perceptions are related to natural assets, and the knowledge and awareness levels regarding the specific restoration site. Survey response analysis was conducted in MAXQDA©, a qualitative and quantitative analysis software. The human dimensions survey questions and summarized results are available in (Del Angel, Lozada, and Hale, 2023).

Survey responses yielded valuable insights into various socio-economic outcomes potentially linked to oyster reefs in the Galveston Bay-Trinity Bay area. The reported behaviors, activities, concerns, and impacts provide a nuanced understanding of the complex relationship between the community and oyster reef restoration. For example, activities like boating and recreational fishing emerge as potentially influenced by these restoration efforts. Participant comments revealed a range of perspectives, highlighting concerns about the negative impact on sailing and boating activities. However, positive outcomes were also observed, with oyster restoration being associated with support for other popular activities such as fishing, birding, and wildlife viewing.

To validate the local-level relevance of the GEMS model outcomes and associated metrics for the restoration site, we cross-referenced the results of the subject matter expert and the human dimensions analysis interviews (all of the coded segments) with the socio-economic outcomes indicated in the GEMS model (Figure 4). If the socio-economic outcomes and human activities were mentioned or discussed in either the interviews or surveys, this provides some "Evidence of Local Relevance" as seen in Table 1. We use this evidence to support our recommendations for metrics in the following section.

Table 1. Evidence of Local Relevance analysis for Beezley Reef: General Oyster Reef Restoration Outcomes and Metrics (adapted from GEMS/ Olander et al., 2020). Socio-economic outcomes from the GEMS model were cross-referenced with the results of the Subject Matter Expert Interviews and Human Dimensions Analysis (public survey). If the socio-economic outcomes were mentioned in either the interviews or surveys, it received a Yes in this analysis (n = number of coded segments), which provided some evidence of local relevance; the associated metrics were then included in our recommendations for monitoring.

Socio-economic Outcome	**Was the outcome or metric mentioned by Subject Matter Experts? Yes/No**	**Was the outcome or metric mentioned by Public Survey Respondents? Yes/No**	**Potential Monitoring Metric**
Cultural Values: Knowledge	No	Yes n=15	Number of people with additional knowledge of habitat restoration effects and other project outcomes based on project site
Cultural Values: Education-related Knowledge	Yes n=2	Yes n=70	Number of people with additional knowledge of habitat restoration effects and other project outcomes
Cultural Values: Awareness-related Knowledge	Yes n=2	Yes n=24	Number of people with additional knowledge of habitat restoration effects and other project outcomes on broader scale
Cultural Values: Other	Yes n=2	No	Change in project or program identified cultural value
Economic Activity - Finfish/Shellfish Harvest	No	No	Number of aquaculture jobs supported by project
Economic Activity - Finfish/Shellfish Harvest	No	No	Change in economic activity from project associated commercial aquaculture harvest
Economic Activity - Finfish/Shellfish Harvest	No	Yes n=2	Change in economic activity from project associated commercial fish harvest
Economic Activity - Recreation & Tourism	Yes n=2	Yes n=54	Change in recreational activity expenditures associated with project site visitation
Economic Activity - Recreation & Tourism	Yes n=2	Yes n=54	Change in recreational fishing expenditures associated with project site visitation
Economic Activity - Recreation & Tourism	Yes n=2	Yes n=54	Number of jobs supported through recreational fishing at project site

Economic Activity - Recreation & Tourism	Yes n=2	Yes n=54	Change in economic activity from recreational fishing
Economic Activity - Restoration/Intervention	Yes n=2	Yes n=7	Number of restoration jobs supported by project
Economic Activity - Restoration/Intervention	Yes n=2	Yes n=7	Total restoration expenditures by project
Economic Activity - Restoration/Intervention	Yes n=2	Yes n=7	Change in economic activity from restoration spending
Human Health - Food Security for Communities	No	Yes =7	Proportion of surveyed harvesters who say that food caught/harvested at the site is important for feeding their household
Human Health - Food Security for Communities	No	No	Proportion of protein or nutrition from food harvested at restoration site
Human Health - Mental Health & Psychological Well-being	No	No	Change in cognitive function
Human Health - Mental Health & Psychological Well-being	No	Yes n=16	Change in subjective well-being
Property Protection & Value - Property Protection from Erosion	No	Yes n=54	Number of properties or length of infrastructure adjacent to shoreline with reduced erosion after project

Socio-economic Monitoring Recommendations for Beezley Reef oyster reef restoration

1. Monitor Cultural Values

To determine how the restoration project has or has not affected local cultural values, the awareness, education, and knowledge related to the restoration project can be measured over the short and long term. These three metrics can be measured separately or as part of a combined measurement tool or instrument. It is important to note that whenever humans are involved in research, an expert with experience in human subject research should be consulted, and best practices should be adhered to. Depending on the types of questions included in the measurement instrument, a review from an Institutional Review Board (IRB) may be required to carry out an analysis. An IRB is an administrative group associated with an institute organization charged with reviewing all research involving human participants before the start of the research. The IRB is primarily concerned with protecting the welfare, rights, and privacy of human subjects.

a. ***Recommended Metric: Awareness: Number of people with additional knowledge of habitat restoration effects and other project outcomes on a broad scale***

Measuring awareness of the Beezley Reef oyster reef restoration project and its outcomes enables understanding of how much community members are aware of the restoration project itself and its effects. Awareness can come from disseminating information about the project through local news stories, information passed on by community members, driving by the restoration site, seeing construction or project signage, and social media platforms. Awareness can be assessed using surveys, interviews, or focus groups. Specifically, this metric determines the number of people with additional awareness of the effects of the Beezley Reef oyster reef restoration project due to living or working in proximity to the restoration project site. For more details on this type of measurement, visit https://nicholasinstitute.duke.edu/sites/default/files/gems/protocols/knowledge-awareness-overview.pdf.

b. Recommended Metric: Knowledge: Number of people with additional knowledge of habitat restoration effects and other project outcomes based on project site

This metric is similar to the awareness metric, but it goes beyond awareness to understand the number of people with additional knowledge of oyster reef restoration habitat effects and other restoration outcomes specific to the Beezley Reef site. Surveys, interviews, and focus groups can be used to determine how many people have additional knowledge attributable to the site, what kind of knowledge they have, and even how they obtained that knowledge. This metric can also be combined with the Awareness metric above or the Education-related knowledge metric described below.

c. Recommended Metric: Education-related knowledge: number of people with additional knowledge of habitat effects and other project outcomes

Education activities associated with the Beezley Reef oyster reef restoration effort, including formal educational programs (e.g., classroom lessons, coursework) and informal learning opportunities (e.g., volunteering at the restoration site), can affect an individual's and a community's awareness, knowledge, attitudes, values, behavior, environmental practices, and participation in additional activities related to the environment. Evaluating the impacts of education related to or in association with the Beezley Reef restoration project can help to improve the project's outcomes, contribute to local learning, and demonstrate the restoration project's impacts to funders and the wider community. Specifically, this metric would track the number of people with additional knowledge of oyster reef restoration effects and other project outcomes attributed to local educational outreach or programming. This can be assessed using surveys, interviews or focus groups, and as mentioned above, IRB experts should be consulted when humans are involved in research, before beginning educational assessments. Subject matter experts that we interviewed suggested potential local partners for monitoring education-related knowledge including Galveston Bay Foundation, Baytown Nature Center, Texas Master Naturalists, and Texas Sea Grant. For more information and examples for how to conduct education-related knowledge assessment visit https://nicholasinstitute.duke.edu/sites/default/files/gems/protocols/knowledge-education-overview.pdf.

d. Recommended metric: Cultural Value: Change in project or program identified cultural value

Cultural values can include cultural diversity, spiritual and religious value, education value, aesthetic value, sense of place, sense of security, indigenous knowledge, existence value, among others. To determine Cultural Value outcomes captured in the subcategory of "Other" in the GEMS model, an in-

depth study may be required. These cultural value outcomes of restoration are often referred to as Cultural Ecosystem Services, or CES, and understanding these Cultural Ecosystem Services is important for continued management of the Beezley Reef oyster reef restoration project now and into the future. Through subject matter expert interviews and as seen through the results of the human dimensions analysis, communities in this area are intimately connected to Beezley Reef. The human dimensions survey and analysis conducted as part of this socio-economic monitoring plan is a good example of how to capture some aspects of CES for the restoration site (Del Angel, Lozada, and Hale, 2023). A University partner or other expert institution with access to mixed methodologies and social science expertise may be required to conduct a CES evaluation for this site. For more information about measuring cultural value, see https://nicholasinstitute.duke.edu/sites/default/files/gems/protocols/project-identified-cultural-value-overview.pdf.

2. Monitor Economic Activity

a. Recommended Metric: Number of restoration jobs supported by restoration project

In the GEMS model (Figure 4), Economic Activity related to the restoration project itself is indicated as a likely outcome of oyster reef restoration projects. Restoration jobs include engineers, construction workers, practitioners, education coordinators, and other staff that are partially or fully employed because of project implementation or funding. For example, The Nature Conservancy, as managers of the Beezley Reef oyster reef restoration project, can use the project budgets, reports, and contracts information to determine the number of full time or part time employees that were hired from project inception and throughout the life of the project. Further, demographic information can be collected to get a sense of who had access to employment opportunities, so that local vs. non-local employment information related to economic activity attribute to the project site can be tracked over time. For more details on this metric and associated protocols, see https://nicholasinstitute.duke.edu/sites/default/files/gems/protocols/restoration-jobs-overview.pdf.

b. Recommended Metric: Change in economic activity from restoration spending

This metric requires that jobs, labor income, gross state product, and total industry output be modeled based on project expenditures and would likely be combined with additional Economic Activity metrics related to the Restoration/Intervention category, such as the below *Total restoration expenditures by restoration project.* This metric would be most appropriate for monitoring broad-scale or program-wide outcomes of one or more oyster reef restoration projects over time, and will likely require partnership with economic modeling experts. If there are multiple restoration projects taking place in the Galveston-Trinity Bay area, project managers of each individual site may want to consider partnering to evaluate total restoration spending in the area as a combined effort.

c. Recommended metric: Total restoration expenditures by restoration project

The restoration project managers for Beezley Reef likely track the total amount of money spent on the restoration project as reported in the project budget, at a given time interval, such as an annually. Expenditures could include equipment, engineering, construction, maintenance, employment, monitoring, and more. Expenditure data, tracked over time, can reveal Economic Activity as a direct

outcome of the Beezley Reef restoration project.
https://nicholasinstitute.duke.edu/sites/default/files/gems/protocols/restoration-expenditures-overview.pdf

d. Recommended metric: Change in economic activity from recreational fishing

Establishing a baseline understanding of economic activity relevant to recreational fishing now would be useful for comparison later as the reef changes over time. Similar to the effect Half Moon Reef had in Matagorda Bay, Texas (Carlton et al., 2016), it may be worth modeling the jobs, labor income, and total industry output associated with recreational fishers visiting the restored Beezley reef area. In our human dimensions survey results for this location, there was interest in understanding how the newly constructed oyster reefs may support fish assemblage, and thereby increased recreational fishing activity in the area. Protocols related to this metric can be found at https://nicholasinstitute.duke.edu/sites/default/files/gems/protocols/Rec_Fish_Overview.pdf

e. Recommended Metric: Number of jobs supported through recreational fishing at project site

Recreational fishing jobs include paid full-time or part-time positions that support recreational fishery operations. These positions include for hire fishing guides, private boat rentals, shore-based fishing support, and the sale and maintenance of durable goods such as rods, boats, and vehicles. While a survey may seem like an approach to getting a direct count of how many recreational fishing jobs are supported by a restoration site, it is difficult to identify every person in the project area whose job is affected by the site. So, a more common approach is to estimate the total number of recreational fishing jobs resulting from recreational fishing expenditures associated with a restoration project. This requires that you first estimate recreational fishing expenditures associated with the site and involves using a multiplier that is available through the National Marine Fisheries Service. Recreational fishing expenditures are typically calculated by multiplying the number of recreational fishing trips to the project site (estimated from random sampling counts as part of structured monitoring) by the average trip expenditure. This method helps to estimate and identify trends related to recreational fishing activity and expenditures following project implementation. Refer to the Recreational Fishing Expenditures Protocol documents for more information, such as:
https://nicholasinstitute.duke.edu/sites/default/files/gems/protocols/recreational-fishing-jobs-overview.pdf and
https://nicholasinstitute.duke.edu/sites/default/files/gems/protocols/Rec_Fish_Overview.pdf

f. Change in recreational fishing expenditures associated with project site visitation

Recreational fishing expenditures can be calculated by multiplying the number of recreational fishing trips to the project site (estimated from random sampling counts as part of structured monitoring) by the average trip expenditure. This method helps practitioners identify trends related to recreational fishing activity and expenditures after the restoration project has been implemented. It cannot estimate the economic impact or contribution of the site to local economies or easily account for surplus or redistribution of fishers into the area. It is the estimate of total recreational fishing expenditures due to the project compared to a baseline of recreational fishing expenditures in the

region. For more details visit https://nicholasinstitute.duke.edu/sites/default/files/gems/protocols/Rec_Fish_Overview.pdf

a. Recommended Metric: Change in recreational activity expenditures associated with project site visitation

Like the above metric, this metric helps restoration project managers estimate trends related to recreational activity and expenditures after a restoration project has been implemented. Recreational activity expenditures are usually calculated by multiplying the number of recreational activity trips or number of visitors to the project site (most likely people would visit the Beezley Reef site by boat), by the average trip or individual expenditure. The number of trips or number of visitors can be estimated from random sampling counts as part of a planned and structured monitoring protocol. If data on expenditures is not available, it can also be estimated from random sampling surveys or the individual travel-cost method. For more information about this metric and protocol visit: https://nicholasinstitute.duke.edu/sites/default/files/gems/protocols/recreational-activity-and-expenditures-overview.pdf

b. Recommended Metric: Change in economic activity from project associated commercial fish harvest

To understand how commercial fish and shellfish harvest patterns may have changed in response to the Beezley Reef restoration project, managers can report harvest volume and revenue; this data is available through the NOAA commercial harvest data (NOAA Commercial Fisheries Landings Data). Restoration project managers may also want to model commercial harvest jobs, labor income, gross state product, and total industry output annually using federal and state harvest/landings data and state data for oysters. It is important to note that change in economic activity from commercial harvest could be due to changes in species regulations changes or areas might be closed to harvest due to water quality issues. This metric may require partnering with an expert familiar with fisheries data and economic modeling.

3. Monitor Human Health

a. Recommended Metric: Food Security: Proportion of surveyed harvesters who say that food caught/harvested at the site is important for feeding their household

For this metric, the project manager would ideally use a survey to collect baseline data on subsistence harvest and food security before the project is implemented and would continue to monitor this outcome over time. Subsistence data is scarce, so establishing this baseline sooner than later is important to enable a stronger assessment of how the oyster reef restoration project might contribute to changes in food security for induvial families or households. Intercept surveys, perception surveys, and focus groups are common methods to determine the relevant importance of food security for individuals and communities near the restoration site. For more explanation see: https://nicholasinstitute.duke.edu/sites/default/files/gems/protocols/food-security-overview.pdf

b. Recommended Metric: Change in subjective well-being

Restoration projects can affect the health and well-being of an individual or group. Thus, this metric captures any changes individuals or communities may be experiencing in terms of their mental health and well-being as a result of the Beezley Reef oyster reef restoration project. This would involve

determining a person's happiness as they define it for themselves, and usually requires a survey. This metric would likely require partnership with an organization that has an Institutional Review Board for ethical conduct of human subject research. For more information on how to measure subjective well-being see: https://nicholasinstitute.duke.edu/sites/default/files/gems/protocols/mental-health-subjective-wellbeing-overview.pdf

4. Monitor Property Protection & Value

a. *Recommended Metric: Number of properties or length of infrastructure adjacent to shoreline with reduced erosion after project*

The suggested metric, with the caveat that shoreline erosion is not a primary goal of The TNC Beezley Reef Restoration Project based on project objectives and expert interviews, recognizes the public's high concern about this environmental issue. To address this, future restoration projects iwhtin Galveston Bay may consider including it as a metric. The proposed metric involves measuring property acreage, the number of properties, or the area of infrastructure adjacent to the restoration area with reduced erosion since the installation of oyster reefs, to be reported annually. Long-term monitoring, utilizing the Bureau of Economic Geology's data on bay shoreline changes, is recommended see: https://www.beg.utexas.edu/research/programs/coastal/the-texas-shoreline-change-project). For short-term assessments, a combination of digital spatial analysis techniques, on-the-ground assessments using photographic monitoring, drones, and elevation profile monitoring can be employed to evaluate changes in shoreline characteristics. Stakeholder assessments, coupled with the cultural values section, can identify those impacted by erosion or interested in protection within the project service area. More information and suggested methods for the property protection metric can be found at https://nicholasinstitute.duke.edu/sites/default/files/gems/protocols/property-protection-erosion-overview.pdf.

Conclusion

This study employed an Ecosystem Service Logic Model to identify potential socio-economic metrics for monitoring the outcomes of oyster reef restoration in Galveston Bay. The local relevance of these potential socio-economic outcomes and metrics was rigorously analyzed using data from expert interviews and an online public survey. The resulting plan delineates 15 proposed metrics categorized under cultural values, economic activity, human health, and property protection and value.

It is important to note that all the outcomes and associated metrics in the original GEMS model are worthy of consideration for developing a socio-economic monitoring plan. However, what works for one community may not be effective for another. Thus, the a need for evaluating local relevance and selecting the metrics that have the most potential for capturing the benefits of oyster reef restoration at this site. Effective monitoring requires local and regional partnerships, open data exchange, and consistent funding and support. The recommendations herein will require testing and, through trial and error, can be adapted to meet the needs of the restoration managers, funders, community members, and anyone interested in understanding the multiple benefits of restoration. This plan is intended to be collaborative, adaptive, and regularly updated as the socio-economic monitoring efforts evolve parallel to the changing environment and community.

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