I. Project Information*

Project Director	Matthew Bethel
Project Title	A living shoreline design approach that supports the Pointe-au-Chien Indian Tribe's climate change adaptation efforts
Project Location	Pointe-au-Chien, Louisiana
Project Summary	The traditional lands of the Pointe-au-Chien Indian Tribe (“PACIT” or “Tribe”), in Terrebonne and Lafourche Parishes in southeastern Louisiana, include diverse ecological and cultural resources, such as birds, plants, animals, fish, cemeteries, and sacred sites. Historically, Tribe members were fishers, hunters, and farmers. While many Tribal members continue to fish as a livelihood, climate-related hazards threaten their continued existence in the region and ability to thrive. Adaptation measures taken by Tribal members have not been sufficient to withstand increased tropical storm impacts because of the loss of much of their traditional lands to open water, exposing the community to greater storm surge and more frequent flooding. Following Hurricane Ida’s devastating impacts in August 2021, the Tribe is developing a comprehensive community-based strategy to prepare for future storms called the Pointe-au-Chien “Resilient Rebuilding Plan.” Living shorelines are a nature-based solution (NBS) that can support the PACIT in achieving critical aspects of its vision to sustainably rebuild and adapt to increasingly severe climate-related hazards. A deliberate and coordinated approach is necessary to siting such projects so the sum creates enhanced benefit beyond what individual projects may provide. This project presents an opportunity to design a network of coordinated living shoreline structures or “Living Shorelines Network.” This concept is a key strategy for protecting the community from future storm impacts and flooding that honors the Tribe’s cultural heritage and priorities. We expect this process will inform the design of similar measures in other coastal communities most at-risk.

	To pursue our project goal, we engaged in a design process consisting of three objectives: 1. Identify suitable living shoreline types and strategic locations that will protect the PACIT community from increasingly frequent and severe climate-related hazards of coastal erosion, flooding, and storm surge. 2. Engage Tribal partners and subject matter experts in an iterative, participatory process that informs the identification of living shoreline site suitability and design of the Living Shorelines Network by drawing on Tribe member TEK and priorities, partner expertise, and co-benefits to ecosystem services, human health, community capacity, and other related projects. 3. Produce an analysis of relevant legal and regulatory requirements and measures of success that will support the design and implementation of the Living Shorelines Network and similar NBS projects in coastal communities across the region.

II. Executive Summary

To support bridging knowledge to action, the GRP seeks to develop products that are widely accessible and useful to communities, academics, non-governmental organizations, and public and private decision-makers. GRP Executive Summaries are designed to communicate, in clear and non-technical language, what issues GRP has supported, what was done, and what was achieved.

Responses must be written in complete sentences rather than in bullet point.

1. What problem are you addressing, and why does it matter? (up to 100 words) *

Briefly describe the issue your project is tackling. Why is this problem significant to the Gulf region, its communities, ecosystems, or systems of practice?

Coastal Indigenous communities across the Gulf region are facing accelerating land loss, shoreline erosion, flooding, and storm surge driven by sea-level rise, subsidence, and decades of environmental modification. For the Pointe-au-Chien Indian Tribe (PACIT), these impacts threaten homes, cultural sites, livelihoods, and the ability to remain on ancestral lands. Conventional shoreline hardening approaches are often expensive, short-lived, and poorly suited to highly dynamic deltaic systems. This project addressed the urgent need for culturally grounded, place-specific, and implementable nature-based solutions that reduce risk while strengthening ecosystem health and community resilience in the Gulf region.

2. What did you do? (up to 500 words) *

Summarize your key activities and outputs during this period (or planned for the project). Program activities are the actions a program takes (e.g., conducting field research, holding workshops, analyzing data, providing training, building partnerships), while outputs are the direct, tangible products or results of those actions (e.g., number of partnerships established, models created, workshops held, students trained).

This project designed a Living Shorelines Network for the Pointe-au-Chien Indian Tribe through a collaborative, co-production process that integrated Traditional Ecological Knowledge (TEK), scientific modeling, participatory engagement, and applied design. The work focused on identifying where living shorelines are most appropriate, what types of nature-based solutions would be effective under present and future conditions, and how those solutions could realistically move toward implementation.

The project team developed and applied a Living Shoreline Suitability Model (LSSM) customized for PACIT's highly erosional, marsh-dominated coastal landscape. The model synthesized geospatial data on shoreline condition, bathymetry, wave exposure, infrastructure, and land use with TEK-informed priorities identified through workshops, interviews, and field visits. Multiple model iterations were refined using drone imagery, sonar-based bathymetry surveys, and feedback from Tribal knowledge holders and external experts. The final model was deployed as a web-based decision-support tool that is accessible on computers and mobile devices, even in low-connectivity settings.

Community engagement was foundational to the project. The team hosted a project kickoff meeting, multiple in-person workshops, participatory mapping sessions, and one-on-one interviews with Tribal TEK experts. These activities helped identify priority locations for protection, improve the clarity and relevance of model outputs, and ensure that local knowledge directly shaped both modeling and design decisions. Tribal members also guided field data collection and shared observations about erosion patterns, storm impacts, and prior restoration successes and failures.

To translate analysis into action, the design team produced a Living Shorelines Network master plan and five site-specific living shoreline designs for priority locations identified by the Tribe. These designs included plans, cross-sections, construction-ready details, and visual renderings illustrating how oyster reefs, marsh plantings, breakwaters, and hybrid strategies could function under site-specific conditions. Design development was iterative and collaborative, with continuous review by Tribal members, scientists, legal experts, and practitioners to ensure feasibility, cultural relevance, and regulatory compatibility.

In parallel, the legal team assessed permitting and regulatory considerations for living shorelines in Louisiana,

helping align model outputs and design templates with existing approval processes. The project also supported workforce development by training graduate students, undergraduates, and a postdoctoral researcher in community-engaged coastal resilience and interdisciplinary collaboration.

3. What did you achieve? (up to 500 words) *

What were the outcomes or impacts of your work so far? What changed or advanced as a result of your activities—whether in knowledge, people, communities, policies, or systems? Outcomes and impacts are the changes that result from your work—such as increased knowledge, improved decision-making, strengthened community capacity, policy influence, or environmental improvements. For example, your work might lead to new coastal planning practices, or your engagement efforts might help communities better prepare for climate risks. Your education programs might have inspired students to pursue careers focused on Gulf issues or increased their commitment to staying and working in Gulf communities.

This project delivered a community-informed, implementation-ready framework for using nature-based solutions to reduce coastal risk while strengthening cultural and ecological resilience. It advanced both local capacity within the Pointe-au-Chien Indian Tribe and broader practice in Gulf Coast restoration planning.

A primary achievement was the development of a PACIT-specific Living Shoreline Suitability Model that meaningfully includes Traditional Ecological Knowledge with biophysical science. Embedding TEK into the modeling process improved accuracy, relevance, and trust, while producing a tool that supports informed decision-making under current conditions and future sea-level rise scenarios. The accompanying geo-viewer allows Tribal members, practitioners, and partners to explore recommendations in an accessible, transparent way.

The project strengthened community capacity and agency. Through hands-on engagement with mapping tools, workshops, and design visualizations, Tribal members gained practical understanding of living shorelines and how these approaches can protect homes, cultural resources, and fisheries. Many community members expressed renewed confidence that adaptation-in-place is possible and that nature-based solutions align with long-standing relationships to the landscape, especially compared to traditional hard infrastructure that has often failed or degraded over time.

At a systems level, the project demonstrated a replicable model for TEK-informed, participatory coastal planning. Partner organizations reported that the work influenced how they prioritize restoration sites, evaluate project types, and integrate cultural considerations into decision-making. The Living Shorelines Network design and associated tools position the Tribe and its partners to move directly into permitting and construction planning as funding becomes available.

The project also generated lasting professional and educational impacts. Students and early-career researchers gained experience in interdisciplinary teamwork, ethical community engagement, applied modeling, and design translation, helping build a workforce prepared to address Gulf Coast resilience challenges. Project outcomes

contributed to peer-reviewed manuscripts, conference presentations, and outreach products that extend the project's influence beyond the immediate community.

Overall, the work translated knowledge into action by producing tangible tools, designs, and partnerships that support near-term implementation and long-term resilience for PACIT and other Gulf communities facing similar challenges.

4. What's next? (up to 100 words) *

What are your next steps or priorities based on what you've learned? Share any anticipated shifts in direction, upcoming efforts, or recommendations for others working on similar issues.

Next steps focus on implementation, scaling, and sustained learning. Project partners are advancing permitting, landowner coordination, and construction planning for priority living shoreline sites, supported by newly awarded and pending funding through the National Fish & Wildlife Foundation (NFWF). Continued monitoring and periodic updates to the LSSM will help adapt strategies as environmental conditions change. Lessons from this project will be shared with state agencies and other coastal communities to support broader adoption of TEK-informed, nature-based resilience planning across the Gulf region and beyond.

5. Activity Location *

Please fill out the following chart with the relevant locations for your project work using this form.

Progress__Annual_Report_Activity_Location mb.xlsx

Filename: Progress__Annual_Report_Activity_Location mb.xlsx.xlsx **Size:** 11.6 kB

6. Per your approved Data Management Plan, are you expected to submit data? *

Yes

Submit Data Management Project Personnel

Any project members who will be submitting data to GRIIDC must have their own account at GRIIDC that is linked to your current grant project. To facilitate GRIIDC account set-up and ensure you are prepared for the required Dataset Information Form (DIF) submission, the GRP will send the information in the below form to GRIIDC directly.

Key Personnel *

The project's Data Manager and any other key personnel who will be interacting with GRIIDC should be listed in the form below.

	Role of the Project Member	Full Name	Email	Organizational Affiliation
Key Personnel 1	Data Management Coordinator	Alyssa Outhwaite	alyssa.outhwaite@lsu.edu	Louisiana Sea Grant
Key Personnel 2	Project Director	Matthew Bethel	mbethe3@lsu.edu	Louisiana Sea Grant
Key Personnel 3				

Accounts can be requested later for individuals who are not listed in the form, but they will not be able to edit or upload datasets until they have an account.

1. Set up your GRIIDC Account *

1. Each data management project member should first set up their account at this link. https://grp.griidc.org/account
2. Each user should have their own account and accounts should not be shared. If a user already has an account but has forgotten their password, they can reset it here: https://grp.griidc.org/account/reset-password

2. Submit Dataset Information Form (DIF) *

1. All grant projects that will produce data should submit a dataset information form (DIF) within 6 months of the start of funding, even if your data will be archived elsewhere. This assists the GRP with monitoring future submissions.
2. DIF submission can be found at: https://grp.griidc.org/dif
3. Please submit a DIF for every dataset you anticipate will result from your project. They do not have to be exact, as they can be edited or deleted later depending on the actual project results. Additional DIFs can also be submitted later if more or different datasets result from your project.

Review DIF and Data Uploads *

Please confirm that you have added or edited any Dataset Information Forms (DIF) as necessary on the GRIIDC website and/or uploaded any datasets that have been finalized since your last progress report. Datasets must be publicly accessible and linked to GRIIDC by the end date in your full grant Period of Performance.

Yes, I can confirm

III. Progress Report Questions

Please feel free to expand on your answers from the Executive Summary.

1. Please revisit your proposal and review your goals and the outcomes you were seeking to achieve through this grant. How successful were you in meeting your goals? Please assess your success against the criteria you set in your proposal and use any combination of anecdotes, stories, graphs, charts, visuals as well as data to explain your success. Upload supporting files if you choose.*

The project set out to design a Living Shorelines Network to mitigate the impacts of coastal erosion, flooding, and storm surge on the Pointe-au-Chien Indian Tribe (PACIT) community and its traditional lands. The project's success was to be measured by:

1. The identification of suitable living shoreline types and locations;
2. Collaborative, community-driven engagement that integrated Tribal Traditional Ecological Knowledge (TEK); and
3. The analysis of legal, regulatory, and implementation considerations to support the Living Shorelines Network and future nature-based solutions (NBS).

Over the course of the grant period, the project achieved significant progress in all three areas, advancing both the technical and cultural foundations necessary for long-term coastal resilience.

Some of the outputs of this project that demonstrate its success, and are detailed in the answers that follow, include:

- 5 site-specific living shoreline designs completed
- 9 graduate, 5 undergraduate, 1 postdoc trainees
- 14 presentations + 2 manuscripts submitted
- 2 story maps + 1 geo-viewer developed
- 1 Living Shoreline Site Suitability Model developed
- 1 NFWF proposal submitted for continued funding towards design implementation
- 1 relative sea-level rise model developed for future local landscape change scenarios

Knowledge Transfer and Model Integration:

A cornerstone achievement was the development and application of the PACIT Living Shoreline Suitability Model (LSSM), an online decision-support tool that integrates restoration data, local expertise, and geospatial modeling. Our team contributed extensive restoration implementation experience, advising on what was feasible within the area's complex hydrological and ecological conditions. We also provided survey and monitoring data that

enhanced the model's precision and usability.

The collaboration between partners was particularly fruitful. For instance, the Coalition to Restore Coastal Louisiana (CRCL) and a PACIT summer intern cataloged and mapped existing restoration projects across the region. This dataset became a key input for the LSSM, creating valuable synergy between community engagement and technical modeling. The final model, publicly accessible at https://troygeoamtics.maps.arcgis.com/apps/instant/interactivelegend/index.html?appid=72e03d84ce5f40e896db0bb30cd2912a, represents a major step forward in data-driven, community-informed restoration planning.

Adapting the Model to a Unique Landscape:

The LSSM team faced significant challenges due to the unique geography of the area, which required adapting the model to local conditions. While the Virginia Institute of Marine Science (VIMS) model that our LSSM was based on had been used elsewhere in the Gulf, it had to be modified to assess the unique marsh-dominated landscape of coastal Louisiana. For example:

- Instead of categorizing marsh-dense areas as "no action needed," the revised model now provides targeted restoration recommendations that recognize the vulnerability of marsh islands to erosion, saltwater intrusion, subsidence, and sea-level rise.
- The model also accounts for the region's 42-mile terrace systems, recommending the maintenance of existing breakwaters as critical buffers.
- To address the complexity of manual digitization near Tribal lands, the team used Digital Elevation Model (DEM) data to distinguish land from water, scaling up the model without compromising accuracy.
- Drone imagery proved invaluable for ground-truthing the model, enhancing precision, and identifying areas of greatest importance to the community.

These innovations culminated in the identification of five to six primary living shoreline recommendations; each tailored to the local landscape. The LSSM was used for the first time alongside design work, an important milestone for integrated restoration planning.

Technical Challenges and Solutions:

The data preparation phase revealed several technical hurdles, including calibration issues among existing datasets, outdated datasets given the dynamic landscape in the Pointe-au-Chien study area, and incomplete coverage of some datasets for the northern portion of our study area. Through close collaboration and adaptive problem-solving, the team refined data inputs and established streamlined workflows that can inform future applications of the model in other Gulf regions where data availability may be variable or sparse.

Accessibility was also a key focus. By simplifying the model's geometry and reducing the number of vertices, the team successfully made the viewer tool mobile-accessible, enabling usage on phones and tablets. This improvement greatly expands the model's reach and accessibility for community members and project partners.

Another major takeaway from this project is the recognition that maintaining an accurate model in such a dynamic coastal system requires ongoing updates and investment. Drone surveys proved highly effective for keeping data current, and the team is now exploring partnerships (potentially with NOAA) to secure sustained funding and technical support for periodic updates.

Community and Educational Impact:
The project's educational and community outcomes were as strong as its technical achievements. The initiative directly supported nine graduate students, one postdoctoral fellow, and five undergraduates, all of whom gained hands-on experience in community-engaged restoration science and TEK integration. Several of these students have since transitioned into professional roles in environmental science and coastal management, demonstrating the project's success in workforce development.

The Outreach & Engagement (O&E) sub-team also played a crucial role by organizing multiple workshops with the Tribe, which fostered trust, built capacity, and created a lasting method for dialogue about restoration priorities. Integrating TEK into the LSSM and design process resulted in a living shoreline framework that reflects both scientific understanding and cultural values. Our process for co-producting this work was captured and made available through a web-based storymap, accessible here. This product has allowed us to report out the efforts of our project to the greater community and there are plans in place to use this storymap as a communication tool moving forward. For example, we have been co-designing a bookmark about this collaborative work, with links to the storymap printed on one side.

An additional storymap was developed from efforts to characterize relative sea level rise (RSLR) in the PACIT community, a necessary component to understand future land change scenarios to inform resilience planning. The storymap integrates TEK priority considerations while also acknowledging changes in perceived vulnerability under changing RSLR scenarios. These complementary visual communication tools have been helpful in generating dialogue with the community about how to prepare for future scenarios and where best focus limited resources on living shorelines projects and other related restoration and protection activities. The storymap is publicly available and can be found at https://storymaps.arcgis.com/stories/e9f93f043e734422bb22ce2dbad591c5.

Tribal Advisory and Collaborative Outcomes:
The Tribal Advisory Committee affirms that the collaborative process of engagement with Tribal members, knowledge holders, and technical experts fostered an inclusive design approach grounded in cultural heritage and

place-based knowledge. This committee also helped ensure that TEK data and transcripts were managed under Tribal data-sharing agreements consistent with principles that reinforce attention to data provenance and sovereignty.

Deliverables such as the LSSM, the Living Shorelines Network master plan, and the interactive geo-viewer tool stand as tangible outcomes of this co-production process. These tools not only reflect the priorities of the community but also translate them into actionable resilience strategies suited to the PACIT's dynamic environmental context.

Along with these achievements, the project also illuminated areas for continued growth. While the O&E team made strong efforts to maintain engagement, logistical factors such as member proximity and availability sometimes limited deeper, ongoing participation. This insight highlights the importance of investing in community-embedded outreach and sustained relationship-building as core components of resilience planning.

Designs for Living Shorelines:
The landscape architecture team played a central role in translating scientific and community input into tangible, visual design outcomes. Serving as a bridge between technical data and community insight, the design team produced a comprehensive package that included a master plan, design strategy framework, and five site-scale living shoreline concepts representing a range of coastal conditions.

Each site was supported by detailed enlarged plans, cross-sections, perspectives, and AutoCAD-based construction drawings, bringing the LSSM's analytical outputs into physical design form. This iterative, co-creative process enabled TEK experts and community members to visualize how various shoreline strategies (e.g., marsh toes, oyster reefs, gabion curtains) could perform under local conditions. By the conclusion of the grant, all design-related goals had been achieved, providing the Tribe with a complete, community-informed suite of design materials to guide future resilience actions.

Summary Assessment:
The project met and, in many cases, exceeded its goals. It produced a robust, community-informed modeling tool; strengthened technical and cultural partnerships; trained the next generation of restoration practitioners; and laid the groundwork for future coastal resilience initiatives. The PACIT LSSM stands as a model for integrating science, culture, and community in addressing the urgent challenges of coastal change.

Optional File Upload

2. How has your work benefited your organization, professional field, community, or other stakeholders? *

This project has provided far-reaching benefits across multiple dimensions including strengthening organizational practices, advancing the professional field of coastal restoration, and deepening relationships with community partners. Collectively, the work has established a model for holistic, community-based restoration planning that integrates Traditional Ecological Knowledge (TEK), interdisciplinary science, and participatory design.

Empowering Community Resilience:
For the Pointe-au-Chien Indian Tribe (PACIT), the Design project has helped to reaffirm the Tribe's cultural connection to ancestral lands while strengthening capacity to respond to accelerating coastal hazards such as erosion, flooding, and storm surge.

The resulting LSSM design provides a practical and actionable pathway to protect homes, sacred sites, and the community at large. Beyond technical outcomes, the process itself has empowered the community by enhancing understanding of NBS approaches and fostering optimism for adaptation-in-place strategies that align with cultural values. The development of the interactive geo-viewer tool further supports ongoing resilience planning and advocacy, giving Tribal members a visual and accessible platform to guide decision-making well beyond the life of this grant.

Building Capacity Through Outreach and Education:
For the Coalition to Restore Coastal Louisiana (CRCL) and partner organizations, this project has demonstrated a new framework for restoration planning that centers community voices and cultural knowledge. The LSSM and design renderings developed through this effort illustrate how TEK can inform restoration design and site selection in ways that strengthen both ecological and social resilience. The model offers a replicable approach for other Louisiana coastal communities and should serve as a valuable case study for agencies such as the Coastal Protection and Restoration Authority (CPRA) and other state entities seeking to incorporate TEK-based approaches into their planning processes.

The project's findings have already begun to shape internal decision-making at CRCL and among collaborators, informing how future restoration projects are prioritized, designed, and evaluated. Criteria for project type and site selection now more fully reflect not only ecological feasibility but also cultural significance and long-term community resilience.

From an academic perspective, the project has redefined how landscape architecture can function as a bridge between research and community. Faculty and students at LSU gained invaluable hands-on experience working

alongside an Indigenous community, translating data, ethics, and place-based knowledge into spatial design. These experiences have since been integrated into LSU coursework, shaping a new generation of designers versed in community-engaged coastal adaptation.

This work also generated important educational benefits. It directly supported and provided mentoring opportunities for graduate and undergraduate students and a postdoctoral fellow, all of whom gained hands-on experience in community-engaged research methods, qualitative data collection, and interdisciplinary collaboration. These experiences equipped them with valuable professional skills and expanded their capacity to conduct ethical, community-centered environmental work.

Beyond these individual trainees, the project provided a rare opportunity for a team of interdisciplinary scientists to learn from one another's fields, from legal and ecological perspectives to cultural and social science approaches. This exposure fostered mutual respect, broadened understanding of different methodologies, and laid the foundation for ongoing collaborations within and beyond this project.

Collaborative Networks and Knowledge Exchange:
From a legal and technical standpoint, one of the project's greatest benefits was the open exchange of experience and expertise among team members. Each participant contributed prior knowledge from past restoration projects, allowing the team to avoid duplicating efforts and instead focus on advancing innovative methods for living shoreline planning and mapping. This collaborative environment spurred the use of cutting-edge geospatial technologies and novel analytical approaches that have elevated the standard for restoration modeling in the region.

The project also enriched relationships between members of the External Advisory Committee and the Pointe-au-Chien Indian Tribe (PACIT). Each advisor participated in a field visit to potential restoration sites, followed by a shared meal and discussion at the Tribal building. These gatherings fostered meaningful dialogue and mutual learning. Tribel members shared insights from generations of lived experience with the landscape, while advisors contributed technical and scientific expertise. This exchange not only deepened understanding across disciplines and cultures but also built trust and a shared vision for future collaborative work.

Overall Impact:
The project has benefited every stakeholder involved. It has strengthened CRCL's leadership in community-based restoration, contributed to the advancement of TEK-integrated restoration science, trained the next generation of environmental professionals, and fortified partnerships between researchers, practitioners, and Indigenous communities. Most importantly, it has established a living example of how inclusive, interdisciplinary, and culturally grounded approaches can drive innovation and resilience in coastal restoration planning.

3. Are there any other successes related more broadly to this project that you would like to share with us? *

In addition to meeting its stated goals, this project generated several broader successes that have strengthened partnerships, advanced collaboration, and built new foundations for future work in coastal resilience and restoration planning.

One of the most significant outcomes has been the strengthening of partnerships among project collaborators, which has already led to new joint initiatives. Building on the relationships and trust developed through this effort, the team co-developed and submitted a collaborative funding proposal to the National Fish and Wildlife Foundation (NFWF), which was approved for award in December 2025. This project will extend the work begun under the Design project by integrating lessons learned and expanding the reach of community-based restoration approaches. The project also contributed to the success of the Tribal Coastal Resilience Index, an initiative that engaged overlapping Tribal partners. This alignment created opportunities to share data, approaches, and insights, ensuring that Tribal priorities remained central to broader coastal resilience planning efforts.

Operationally, the project spurred meaningful improvements in data management and collaboration practices. The team adopted real-time data sharing and version control through cloud-based platforms such as BOX, greatly improving efficiency, transparency, and interdisciplinary coordination. These practices now serve as a model for how future projects can manage complex datasets and multi-institutional collaboration more effectively.

Another important achievement was the establishment of a foundation for future landscape-change collaborations. By compiling and organizing regional datasets, the project team positioned itself to explore long-term analyses of historical and ongoing land loss patterns; research that could further inform restoration design and planning in the Gulf region.

At the academic level, the project's influence has extended well beyond the immediate team. At Louisiana State University (LSU), the work has already been incorporated into coursework, notably in the LA 7031 Water Systems Design Studio, where students collaborate with peers from the University of Georgia to explore how living shoreline concepts can be integrated into urban settings such as New Orleans. These cross-institutional partnerships introduce students to community-engaged adaptation approaches, extending the project's impact to new regions and future practitioners. The project also elevated the profile of landscape architecture as a critical discipline in the climate resilience space, demonstrating its ability to translate complex environmental data and community narratives into actionable design. This has encouraged greater interdisciplinary collaboration between designers, engineers, coastal scientists, and planners—broadening awareness of how spatial design can advance nature-based solutions and community resilience.

For the Pointe-au-Chien Indian Tribe, the broader impacts of this work are both tangible and deeply personal. Through training, participatory workshops, and hands-on engagement with user-friendly tools like the geo-viewer, the project built internal capacity for resilience planning and advocacy. This empowerment strengthens the Tribe's ability to independently pursue and manage restoration projects, reducing long-term reliance on external technical assistance. Community members have expressed a renewed sense of hope that adaptation can occur without displacement, specifically, that cultural preservation and environmental resilience can progress together. This optimism reflects one of the project's most meaningful outcomes: a strengthened sense of identity and confidence within the PACIT community as it faces ongoing environmental change.

Finally, the external advisory committee reported that their participation was both rewarding and instructive. Field visits and dialogue sessions with the PACIT created meaningful exchanges of ideas, where Tribal members shared restoration priorities and advisors contributed technical insights. The mutual respect and openness of these conversations deepened understanding on both sides and underscored the value of collaborative, cross-cultural approaches to restoration.

Overall, these broader successes highlight the project's lasting impact beyond its initial scope by strengthening partnerships, improving systems for collaboration, and inspiring new directions for research and community engagement in coastal resilience.

4. What did you learn (positive or negative) as a result of this grant? What lessons would you share with other organizations or the field at large? *

This project provided a wealth of lessons, both positive and challenging, that have deepened our understanding of community-based restoration, interdisciplinary collaboration, and the integration of Traditional Ecological Knowledge (TEK) with scientific modeling. Together, these experiences offer valuable insights for our organization, partners, and the broader field of coastal resilience.

Integrating Knowledge and Strengthening Collaboration:
One of the most powerful lessons from this project was the value of integrating TEK with scientific modeling. Community observations complemented and expanded on modeled outcomes, while increasing efficiency and local buy-in. This connection between lived experience and data-driven analysis not only enhanced the model's accuracy but also strengthened trust between scientists and PACIT. One example is how the modeling team adjusted field data collection protocols to focus efforts on areas of highest priority based on the TEK data analyses, as well as what type of field data was collected at those sites to account for shoreline changes identified by the TEK experts. These field data influenced the final LSSM recommendations at those sites and were incorporated into the associated design rendering outputs in visual ways that were relatable to the Tribe. In this way, the project team was able to highlight how the TEK influenced the final design during the final workshop with the Tribe.

The project also reaffirmed the power of collaboration. By bringing together experts from ecology, law, engineering, geospatial science, and community engagement, the team cultivated a dynamic environment for problem-solving and innovation. The diversity of perspectives led to creative solutions that would not have been possible within disciplinary silos.

Technological innovation played a key role as well. The use of drone and remote-sensing technologies significantly improved data accuracy, resolution, and accessibility which allowed the team to verify model outputs, prioritize restoration areas, and communicate findings more effectively to the community.

We also learned that design visualization can bridge disciplines and knowledge systems. Translating hydrodynamic data and TEK narratives into accessible visual formats (e.g. maps, renderings, and diagrams) created a shared language among scientists, designers, and Tribal members. These tools enabled all participants to engage equally in technical discussions and decision-making, transforming complex data into collaborative planning instruments. This approach demonstrates that visual communication is a core strategy for equitable participation in interdisciplinary and community-driven projects.

Challenges and Recommendations:

Working in a highly dynamic coastal system shed light on the difficulty of maintaining accurate, up-to-date data in a landscape that changes rapidly due to erosion, subsidence, and sea-level rise. This work highlights the need for ongoing funding, staffing, and technical capacity to sustain model accuracy over time.

The project's large interdisciplinary team also required strong communication and coordination. Developing a shared vocabulary across disciplines and clearly defining roles and timelines early in the process emerged as key areas for improvement. This experience emphasized the importance of developing tools and communication strategies that make complex information transparent and meaningful to non-technical audiences. Future projects would benefit from establishing structured communication frameworks and periodic check-ins to ensure alignment and accountability.

The External Advisory Committee also reflected on both successes and challenges in fostering dialogue between technical experts and Tribal members. Open, respectful communication proved essential, as did maintaining optimism and momentum when discussions turned to difficult realities such as permitting barriers, logistical constraints, and the high costs of restoration. Sustaining the community's sense of agency and hope in the face of such challenges remains a vital component of long-term success.

Lessons for the Field:

From these experiences, several key lessons emerged for other organizations and the broader restoration community:

- Invest time in building relationships and trust with local partners, this foundation is as critical to success as the technical work itself.
- Leverage existing data and institutional expertise rather than duplicating efforts, freeing resources to focus on innovation and community priorities.
- Use this project as a model for TEK-informed, community-based restoration planning at both state and regional levels, demonstrating how science and cultural knowledge can be meaningfully integrated.
- Prioritize transparent communication both within teams and with communities, to ensure that shared understanding guides every stage of the process.

Overall Reflection:

Ultimately, this project taught us that the most effective restoration efforts are those rooted in collaboration and shared learning. By weaving together technical rigor, Indigenous knowledge, and community trust, we created not only a model for living shoreline planning but also a blueprint for how to approach resilience work in ways that are equitable and enduring.

5. How do you characterize your relationship with the GRP and what suggestions do you have for improvement? *

Our relationship with the GRP has been fundamentally positive and instrumental in supporting the development and implementation of this pioneering project. The GRP's commitment to funding community-driven, culturally relevant resilience initiatives has enabled the PACIT to pursue a Living Shorelines Network design that honors tribal sovereignty and Traditional Ecological Knowledge (TEK), alongside scientific innovations.

The resources and technical support facilitated by the GRP created vital opportunities for collaboration among Tribal members, academic researchers, and practitioners. This cross-sector partnership enriched the planning process and helped ensure the project outputs are both scientifically rigorous and culturally grounded. The GRP's emphasis on equitable participation and community leadership aligns closely with the Tribe's values and empowerment goals.

We appreciated the financial aspects of the support, where grant funds were easily and efficiently distributed as needed. We also recognize that our team was able to retain support consistently throughout the project term, seeing no delays or negative financial impacts during federal leadership changes. Flexibility in the GRP providing a No-Cost Extension (NCE) and the overall structure that allowed the project team to operate effectively was critical to this work as well.

Some areas that might further improve the GRP's support and engagement with Tribal and community partners include more direct communication or involvement with sub awardees. Sub awardees for this work did not have direct communication with GRP, which is understandable for a project of this scale, however, we suggest that GRP might consider adding a technical advisor or monitor role (like NOAA's model) to periodically check in with subaward teams. Another avenue for which this might be made possible is through working with the primary PI to attend periodic team meetings (~1-2/yr). This could help facilitate technical connections, policy alignment, and follow-up for next-phase opportunities.

Another key lesson learned relates to recognition of the benefit of ongoing support in building administrative capacity at the community level, where many essential tasks are undertaken by grassroots participants. Opportunities to continue leveraging grant resources toward program building that supports both current and future efforts would greatly strengthen the overall impact and sustainability of the project and community resilience activities.

Continuing to provide platforms for knowledge exchange between funded projects and sharing lessons learned would also enhance collective progress and innovation within the field.

6. Please provide any other feedback or comments you have for the GRP. *

We are deeply appreciative of GRP's investment in this project and its broader commitment to coastal resilience. The program's flexible funding and interdisciplinary support structure allowed for the fusion of Traditional Ecological Knowledge (TEK) and scientific expertise, which is fundamental for addressing the unique climatic challenges faced by our partnering community. The grant fostered strong partnerships that will extend well beyond the project's timeframe.

In looking to the future, grantees might benefit from:

● A community of practice or post-project convening for knowledge exchange.

● NAS GRP facilitating introductions to agencies or funders that could help continue successful project lines.

● Given the relatively short time-line of the funding cycle an NCE was necessary for this work. We suggest incorporating longer funding timelines for projects that have co-production at their core. This will allow for a critical period of team building and partner negotiations necessary to support community based work.

● Although supporting implementation may be outside of the scope of GRP funding capabilities, we propose a third research phase that supports an aspect of implementation that could further the field of coastal resilience and co-production.

The NAS GRP's support allowed us to complete high-impact, interdisciplinary work that otherwise would not have been possible. We sincerely appreciate the critical role that the Gulf Research Program (GRP) has played in supporting the Pointe-au-Chien Indian Tribe's resilience initiatives through this funding opportunity. The GRP's commitment to fostering equitable, community-driven climate adaptation efforts has enabled us to undertake this culturally grounded and scientifically rigorous project. Hopefully our suggestions and feedback will serve to further enhance the effectiveness and equity of future climate adaptation initiatives across Tribal and frontline communities in the Gulf region and beyond.

7. If applicable, please identify and describe the ways you or your organization leveraged GRP's grant (e.g., other funders, volunteers who worked on the program, in-kind donations etc.) Please specify the value and/or number/hours of volunteers if possible.

The Gulf Research Program (GRP) grant served as a powerful catalyst for expanded partnerships, research outputs, and future funding opportunities. By establishing a strong collaborative foundation among academic, governmental, and non-profit partners, the project achieved its stated goals and generated significant momentum for continued work in community-based coastal resilience and living shoreline design. The deliverables position the PACIT and its partners to move into the permitting and construction planning phase as soon as funding is secured.

The relationships and expertise cultivated through this grant directly contributed to the development of new funding proposals and ongoing collaborations. The project team has submitted follow-up grant applications, including to the National Fish and Wildlife Foundation (NFWF), building on the design and modeling advancements achieved under this award to maintain the momentum of the project team through the permitting process and negotiations with deed holders such as Conoco Philips and others. In addition, ongoing conversations with the Coastal Protection and Restoration Authority (CPRA) have explored opportunities to integrate the Living Shoreline Suitability Model (LSSM) results and nature-based design concepts into project ideas for future iterations of the Louisiana Coastal Master Plan.

These continued collaborations demonstrate the project's lasting impact and confirm that the GRP grant significantly increased the team's competitiveness for future resilience-focused funding opportunities at both the state and national levels.

While no formal volunteer tracking was conducted, the project benefited from substantial in-kind academic and technical collaboration across multiple institutions. This included contributions from: 5 undergraduate students, 8 master's students, 1 Ph.D. candidate, and 1 postdoctoral fellow. These students and researchers provided hundreds of hours of work in data analysis, modeling, visualization, and design development, gaining hands-on experience while advancing the project's scientific and community engagement goals. Their involvement represents an important educational and professional development outcome, cultivating the next generation of practitioners in coastal restoration and community-based resilience design.

The project also leveraged GRP funding to produce a suite of communication and outreach tools that enhance the accessibility and visibility of the work. These include two story maps (https://storymaps.arcgis.com/stories/e9f93f043e734422bb22ce2dbad591c5 and

https://storymaps.arcgis.com/stories/29297a6a5b664520a04ab2c73fc1279f) and an informational bookmark, developed to communicate project goals, methods, and findings to a range of audiences, from community members to policymakers.

The partnerships and data developed through this project also supported the submission of two peer-reviewed manuscripts, contributing new knowledge to the academic and professional literature on community-driven, TEK-informed coastal resilience.

In total, the project team delivered 14 professional presentations during the grant period, spanning conference seminars, poster sessions, and invited lectures. This robust dissemination effort has helped share insights and best practices with regional and national audiences. Looking ahead, an additional series of presentations and panel sessions drawing from this work will be featured at the upcoming Coastal and Estuarine Research Federation (CERF) national conference in Richmond, Virginia this November.

The GRP-funded work also laid the groundwork for continued technical innovation. The project team is currently exploring additional resources to refine and update the LSSM by integrating new LiDAR technologies and automation tools to improve data accuracy and usability. These enhancements will expand the model's long-term applicability and ensure it remains a valuable decision-support tool for the PACIT and other coastal communities facing similar challenges.

Manuscripts Submitted

● San Antonio, K.M., W. Wu, M.B. Bethel (in review, revision requested). Assessing resilience of a coastal wetland to relative sea-level rise for a native American tribe in Louisiana – comparing biophysical prediction and traditional ecological knowledge. Submitted to Estuaries and Coasts 2025.

● Outhwaite A, Santana F, Ferguson G, Matherne C, Dardar D, Bethel M (in review). Woven Through Time: Five Strategies for Enduring Indigenous-Academic Co-Production. Submitted to Estuaries and Coasts September 2025.

Invited Lectures and Presentations Supported by this Grant:

● Living Shorelines and Indigenous Community Resilience for Environmental Sociology, University of Washington, Seattle, WA, 2025 (invited).

● Living Shorelines through the Lens of Indigenous Community Resilience for Landscape Architecture Design Studio, University of Washington, Seattle, WA, 2025 (invited).

● Evolution of Co-production: More than a decade of collaborative efforts between Louisiana Sea Grant and the Pointe-au-Chien Indian Tribe, State of the Coast, New Orleans, LA, 2025 (Oral).

● Co-production of a Living Shoreline Suitability Model using participatory methods through a partnership of academic researchers and an Indigenous community, American Association of Geographers Annual Meeting,

Detroit, MI, 2025 (Oral)

● Bethel, M. 2025. A Living Shoreline Design Approach: Supporting the Pointe-au-Chien Indian Tribe's Climate Adaptation Efforts. State of the Coast Conference. New Orleans, LA, May 20, 2025. (Oral).

● W. Wu, A. Hancock. Coastal Wetlands Under Sea-Level Rise Near The Pointe-Au-Chien Indian Tribe. Final Community Engagement Meeting. Montegut, LA, October 16, 2025. (Poster and Oral).

● W. Wu, K. San Antonio, M. Bethel, J. Holifield. Effects of inundation and soil pore-water salinity on belowground biomass in coastal wetlands adjacent to an Indigenous community. Bays and Bayous Symposium, Biloxi, MS, November 20, 2024. (Oral, contributed).

● K. San Antonio, W. Wu (presenter), M. Bethel, J. Holifield. Assessing resilience of coastal wetlands to sea-level rise near a Louisiana Native Tribe: biophysical prediction and traditional ecological knowledge. Gulf of Mexico Conference, Tampa, FL, February 21, 2024. (Poster, contributed).

● K. San Antonio, W. Wu. Assessing the Resilience of a Coastal Wetland to Sea-Level Rise – Integrating Biophysical Prediction and Traditional Ecological Knowledge. Coastal & Estuarine Research Federation Conference, Portland, OR, November 13, 2023. (Oral, contributed).

● K. San Antonio, M. Bethel, J. Holifield, W. Wu (1st place winner). Assessing the Resilience of a Coastal Wetland to Sea-Level Rise – Integrating Biophysical Prediction and Traditional Ecological Knowledge. Mississippi Geospatial Conference, Long Beach, MS, October 13, 2023. (Poster, contributed).

● Boyd, C. A. 2024. Selected Decision Support Tools to Support Coastal Natural Resource Management. 2024 Enhancing State and Tribal Partnerships Workshop. The Lodge at Gulf State Park, Gulf Shores, AL. November 19-21, 2024. (Invited)

● Boyd, C. A. 2024. Use of Online Decision Support Tools to Support Coastal Natural Resource Management. Troy University Department of Biological and Environmental Sciences Faculty Seminar. Troy University, Troy, AL. 9/27/24.

● Boyd, C. A. and X. Niu. 2024. Living Shoreline Suitability Models at PACIT. PACIT Living Shorelines Workshop # 1 for National Academies of Sciences, Engineering, and Medicine Gulf Research Program; LSU Sea Grant College Program Project. Montegut, LA. June 11, 2024. (Invited)

● Boyd, C. A. and X. Niu. 2024. Development, Availability of Past Living Shorelines Suitability Models (LSSM), and Future Point-au-Chien Indian Tribe LSSM. National Academies of Sciences, Engineering, and Medicine Gulf Research Program; LSU Sea Grant College Program Project "Kick Off" Meeting. Montegut, LA. January 27, 2024. (Invited)