Galveston Bay Estuary Program
FY 2025 M&R Project Proposal

Please complete the proposal form and submit to the appropriate Subcommittee Coordinator (end of form) by August 4, 2023. No late submittals will be considered for funding.

SECTION ONE: GENERAL INFORMATION

Subcommittee:

Monitoring & Research

Project Name:

Monitoring to assess long-term restoration success in Galveston Bay wetlands

Project Previously Funded by GBEP? Yes ☐ No ☒

Lead Implementer:

Texas A&M University at Galveston

☐ Federal, State, or Local Government ☐ Council of Government ☒ Public ISDs or Universities
☐ Nonprofit ☐ Other*

* If lead implementer not listed above, the proposing party will need to partner with an interlocal/interagency entity to be selected for funding. Please reach out to GBEP staff with any questions.

Contact Information:

Project Representative Name	Anna Armitage
Project Representative Phone	409-740-4842
Project Representative Email	armitage@tamu.edu

Amount Requested:

$151,161

Is the project scalable? ☒

Amount Requested per year (if applicable):

FY 2025 (09/01/2024-08/31/2025)	$50,227
FY 2026 (09/01/2025-08/31/2026)	$53,681
FY 2027 (09/01/2026-05/31/2027)	$47,253
Total	$151,161

Total Project Cost:

$151,161

Is this an estimate? ☐

Project Duration (beginning no earlier than September 1, 2024 – 2.5 year maximum project length):

9/1/24 – 2/28/27

Project Urgency:

Funding during this cycle will generate data that can be applied to improve upcoming restoration projects, thus maximizing the efficient use of taxpayer dollars to support wetland restoration. In addition, funding in the current cycle will enable the PI to leverage existing funding from Ducks Unlimited to support additional personnel. (see below)

Leveraging (in-kind and/or cash):

This project will leverage findings from previous work supported by the GBEP (Jurgens & Armitage, FY 2022). Specifically, that project quantified substantial spatial heterogeneity in restoration success, but the mechanisms driving that variation in success are not yet clear. Success may be partially linked to the presence (or failure) of erosion control structures such as geotubes, as well as to the degree of subsidence in older restored sites in mound configurations. The proposed work will build on that previous work by increasing the number and type of sites, and will provide a more robust assessment of structural features that are linked to restoration success.

This project will also leverage current funding to PI Armitage from Ducks Unlimited. This project (funded through June 2025) seeks to determine if the provision of ecosystem services (e.g., carbon sequestration potential, trophic support) improves or declines over time in older restoration sites. The Ducks Unlimited funding will support additional personnel (one technician and one student), thus allowing us to sample more sites when combined with GBEP funding.

In addition, this project will leverage existing research equipment and computing resources at TAMUG, including PI Armitage's fully equipped field ecology laboratory and a fleet of vehicles and vessels at TAMUG to support site access.

Partners and Their Roles:

Project partners will include the Texas Parks & Wildlife Department (TPWD) for permitting and site access. Additional project partners will include numerous end users that will benefit from information to support science-based decision-making, including restoration practitioners, decision makers, and non-profit agencies. PI Armitage has already established a network of natural resource partners, including contacts from the TPWD, the Texas General Land Office (TGLO), the U.S. Fish & Wildlife Service, the Galveston Bay Foundation, the Gulf Coast Joint Venture, and a variety of industry partners. These contacts (e.g., Woody Woodrow/US FWS; Tara Whittle/TGLO; Philip Smith & Vanessa Mintzer/GBF) will serve as liaisons to community stakeholder groups to ensure that a broad range of perspectives and inputs are considered in the application of project outputs. In addition, these contacts will serve as primary lines of communication to convey the project's scientific outputs to restoration decision makers in agencies such as TPWD and TGLO, ensuring that the results will be considered in future restoration project design.

SECTION TWO: *GALVESTON BAY PLAN, 2ND EDITION* IMPLEMENTATION

Galveston Bay Plan, 2nd Edition References
https://gbep.texas.gov/ensure-safe-human-and-aquatic-life-use/
https://gbep.texas.gov/protect-and-sustain-living-resources/
https://gbep.texas.gov/engage-communities/
https://gbep.texas.gov/inform-science-based-decision-making/

The 2021 Galveston Bay Report Card indicates that wetlands in Galveston Bay are experiencing multiple stressors, including habitat loss, pollution, and sea level rise. Wetland restoration is an increasingly important part of effective and forward-looking coastal management strategies to compensate for these stressors. However, the long-term (10+ years) resilience of these restored areas and the sustained provision of ecosystem services are rarely quantified. Furthermore, there are likely to be substantial differences in long-term ecosystem service provision in sites with different soil configurations, such as mounds vs. beneficial uses tidal flats. By conducting research to fill a critical information gap in evaluating the provision of ecosystem services in older wetland restoration sites, this project will address both of the *Inform Science-Based Decision Making Action Plans* described in the Galveston Bay Plan:

Action Plan 1: Collaborate with Research Institutions to Support Focus Area Applied Research and Monitoring (RES). TAMUG and PI Armitage have a long record of conducting rigorous, peer-reviewed scientific research that supports actionable wetland restoration decisions.

Action Plan 2: Increase Access to Galveston Bay Ecosystem Information (ACS). Active dissemination of research findings to project partners, management decision makers, and stakeholders (e.g., through presentations to the GBEP M&R committee) will ensure that the information collected as part of this project will be widely accessible to end users.

Galveston Bay Plan Priority Area Actions Addressed:

Plan Priority 4: Inform Science-based Decision Making

RES-1 ☐	RES-2 ☐	RES-3 ☐	RES-4 ☐
RES-5 ☐	RES-6 ☐	RES-7 ☒	RES-8 ☒
ACS-1 ☐	ACS-2 ☒	ACS-3 ☐	

Plan Priority Area Actions Detail:

Action Plan 1:
This project will directly support RES-7 (Evaluate Ecosystem Services) and RES-8 (Complete Coastal Resiliency and Acclimation Studies) by assessing ecosystem service provision in older (10+ year) restoration sites in mound and beneficial uses tidal flat configurations. These plans address a priority issue where a "*lack of available applied research and monitoring data can prevent understanding of Galveston Bay ecosystem components.*" The proposed research will facilitate the improved implementation of "*estuary preservation initiatives*" such as wetland restoration. Outputs supported by this project will include open access datasets and management guidance recommendations shared though open access websites and technical publications.

Action Plan 2:
The project will also implement ACS-2 (Provide Access to Monitoring and Research Data). Outputs supported by this project will include published datasets and journal articles, and the dissemination of information to GBEP stakeholders, decision makers, Galveston Bay user groups, and the public. Outcomes will be shared through presentations at the State of the Bay symposium and to GBEP Stakeholders through quarterly GBEP meetings. In addition, a press release of findings in lay terms will be distributed to local community media outlets through the TAMUG media office.

Does the project implement any other Galveston Bay Plan Priority Area Actions, or the other Subcommittee priorities?

☐ WSQ (Ensure Safe Human and Aquatic Life Use)
☒ NRU (Protect and Sustain Living Resources)
☐ PPE (Engage Communities)

Other Subcommittee Detail:

Natural Resources Uses Subcommittee:
One of the NRU subcommittee priorities is to *enhance existing or ongoing restoration/conservation efforts*, with a particular focus on projects addressing *failing geotubes across West Galveston Bay*. The central goal of the proposed project is to identify structural features (e.g., elevation profile, erosion control structures) that are linked to the sustenance of ecosystem services in restoration wetlands. One actionable recommendation will be to identify areas where amendments or other topographical modifications to existing restoration projects would boost ecosystem service provision, thus *enhancing existing restoration efforts.*

In addition, the proposed project will address the NRU-identified issue of *failing geotubes* by building on previous work supported by the GBEP (Jurgens & Armitage, FY 2022). Specifically, outcomes from that project identified heterogeneity in restoration success, which may have been at least partially due to the presence (or failure) of erosion control structures such as geotubes. Funding in the upcoming cycle will increase the number of sites across a wider range of soil configurations, and will provide a more robust assessment of structural features that are linked to restoration success. Findings from this study will provide scientific support for prioritizing the maintenance and repair of geotubes in West Galveston Bay.

Galveston Bay Plan:
This project also addresses Action Plan HC-2 (Habitat Restoration) of the Galveston Bay Plan through direct study of ecosystem functions and services in restored wetlands. By filling knowledge gaps about the resilience of restoration wetland functions over time, this project will improve science-based management of these critical coastal habitats.

Other Plans Implemented:

The proposed project supports multiple local and regional conservation and management plans that prioritize wetland restoration and monitoring. For example:
The *Texas Coastal Management Plan* specifies the need to "Monitor the success of enhancement/restoration projects."
The *Texas Wetland Conservation Plan* states that "The overall purpose of State Wetlands Conservation Plans is to improve the efficacy and efficiency of governmental and private sector efforts to protect, restore and create wetlands in a state or on tribal lands."
The *Gulf Coast Joint Venture Conservation Plans* focus on wetland restoration and monitoring, as described in their mission statement: "…to advance the conservation of important bird habitats within the GCJV region through biological planning and design, implementation of habitat conservation actions, and focused monitoring and evaluation of the planning and implementation process"

SECTION THREE: SUBCOMMITTEE PRIORITIES

M&R Subcommittee Identified Priorities
Proposals must address one or more of the following actions:

☒ Meaningful and effective monitoring of existing and new projects (NRU/WSQ/PPE support)
☐ Exposure and response to emerging contaminants across trophic levels
☐ Reestablishing dermo monitoring programs (Ex. Oyster Sentinel)
☐ Project Component: Results translated to plain language/practical knowledge

Subcommittee Priority Detail:

The fundamental goal of habitat restoration is to increase the amount of a target habitat and improve the associated ecological functions and services. However, the full recovery of ecosystem functions and services – including the development of food webs and carbon sequestration – occurs on a decadal time scale, often spanning ten years or more. However, most restoration monitoring and assessment occurs on a relatively short time scale, over a period of a few years. As such, the long-term sustenance of ecosystem service provision is often assumed but seldom verified. This project will fill a critical information gap by *monitoring existing projects* to evaluate the provision of ecosystem services in older restoration sites. Furthermore, there are likely to be substantial differences in long-term ecosystem service provision in sites with different soil configurations, such as mounds vs. tidal flats created with beneficial uses material. The study will focus on restored mounds in Jumbile Cove, Dalehite/Starvation Cove, and Bird Island Cove/McAllis Point (Galveston, TX; see **Project Map**). Portions of these areas were restored in 2004-2005, and other portions were restored more recently (between 2011 and 2015). Restored sites in each of these areas will be compared to nearby reference wetlands. At full scale, this project will also include sites with expansive tidal flats created through beneficial uses (BU) material placement, paired with reference areas on Bolivar Flats; these BU sites can be removed and integrated into future project proposals if it is required to scale the current project down.

This project will leverage previous work funded by Ducks Unlimited; this previous work highlighted the critical need to monitor and assess existing projects. In that project, we determined that the older restored sites had distinctly less elevation heterogeneity than the middle-aged site (see **Supplemental Photos**). On the older (20-year-old) mounds, the highest elevation points were dominated by mid-marsh species such as the succulents *Batis maritima* and *Salicornia* spp. In contrast, younger (10-year-old) mounds had a higher midpoint elevation that included salt pan habitat and upland and high marsh species such as *Tamarix* (salt cedar), *Phragmites*, and *Spartina spartinae*. This difference in elevation profile is unlikely to be an artifact of construction technique, since salt marsh restoration in the region typically targets a narrow elevation range (~0.5 m above mean lower low water) in order to promote *S. alterniflora* establishment. Rather, these elevation differences are likely due to subsidence and relative sea level rise in the time since construction. A review of historical aerial imagery indicates that the reference areas also experienced subsidence during this time period (since 2000), and that adjacent upland habitat transitioned into tidal marsh habitat. This difference between older and newer sites suggests that restored mounds are prone to substantial subsidence within 20 years of construction. Without a higher elevation refuge, this will likely result in a degradation of the quality and extent of vegetated habitat over time. Future sampling efforts will build on this previous work by (a) increasing replication to ensure that this is not a site-specific outcome, and (b) quantitatively characterizing differences in plant communities at the whole-site level in order to account for the full range of elevation zones present. This previous work highlights the need to monitor existing projects to identify potential shortcomings in existing restoration projects, and will thus provide rigorous scientific support to improve the design of future restoration projects.

Does the Project work with new, smaller communities/partnerships?
☐ Yes
☒ No

n/a

SECTION FOUR: PROPOSAL DETAILS

Project Summary:

The goal of this project is to fill a needed information gap in evaluating the provision of ecosystem services in older wetland restoration sites across a range of soil configurations. This study will conduct research to understand the links between coastal wetland restoration design and the successful long-term provision of ecosystem services, thus providing rigorous scientific support for future restoration projects.

Full Project Description (1,000 words or less):

As wetland restoration becomes an increasingly important part of effective and forward-looking coastal management strategies, it is vital that the best available science is used to boost near-term and long-term restoration success. Restoration projects vary widely in terms of size, soil configuration (e.g., mounds vs. continuous fill), and the inclusion of erosion control structures such as sills or geotubes. These designs often boost emergent plant cover over near-term (5-year) scales, but links to improved ecosystem service provision over a longer time period are largely unquantified. Furthermore, some erosion control structures in Galveston Bay have subsided over time, thus exposing restored areas to more fetch and wave action, potentially leading to degradation of restored sites. Thus, the overarching goal of this project is to assess the relationships between standard success metrics (plant cover), key restoration project design features, and ecosystem service provision in older (10+ year) restoration sites. One of the key outcomes of this project is a robust assessment of site design features that yield successful restoration of key ecosystem services, including carbon sequestration and food web support. This outcome will generate rigorous scientific support for the design of future restoration projects and will ensure appropriate and efficient use of regional resources in ecosystem management.

The overarching goal of this project is to assess the relationships between standard success metrics, key restoration project design features, and ecosystem service provision in older (10+ year) restoration sites across a range of soil configurations. To achieve this goal, the project team will conduct field studies to test the following hypotheses:

H1: Carbon sequestration potential will be (a) positively related to site size and areal cover of emergent vegetation, and (b) higher at sites reinforced by erosion control structures such as breakwaters or berms.

H2: Trophic support for coastal food webs will be positively related to the area of nonvegetated tidal mudflats.

Site selection

Several study areas in Galveston Bay have been identified based on site age and accessibility (see **Project Map**). Each study area includes restored marshes that vary in age, ranging from 17+ years (restored in 2005) to 7 years old (restored in 2015). Restored portions of the study areas are comprised of either mound formations or tidal flats (beneficial uses) (see **Project Map** and **Supplemental Photos**). Each study area also includes expanses of unmanaged (reference) marsh. A minimum of three sampling stations will be established in each of three restored and reference areas. Each sampling station will include areas of high elevation salt marsh, low elevation salt marsh, and tidal flat (3-5 replicate stations x 3 elevations x 3 ages x 2 soil configurations = 54-90 samples; can be scaled if needed).

Field measures

Field measures will be stratified across habitat elevation zones (e.g., tidal flat, low marsh, high marsh), with randomly located (based on pre-determined GPS coordinates) replicate (3-5) sampling stations

within each elevation zone at each site. Field sampling will occur in early fall of project years, corresponding with peak biomass at the end of the growing season. A comprehensive suite of abiotic features (e.g., soil and water characteristics, mound size and shape, elevation profile, presence of erosion control structures) will be measured at each site. Response metrics will focus on characteristics that are closely linked to the ecosystem services identified in the study hypotheses, including:

Carbon sequestration potential. Carbon sequestration potential, often estimated as carbon pools in plant and soil fractions, is closely linked to plant biomass and productivity. Therefore, relevant indicators for the ecosystem service of carbon sequestration include aboveground plant cover and productivity, species identity, and belowground biomass. Therefore, the team will sample the following metrics: (1) Aboveground plant cover (total and by species) will be visually estimated in 10 1-m^2 quadrats along 100-m transects at each sampling station. Productivity of common species will be measured with a SPAD-502 portable leaf meter (Konica Minolta Corporation). (2) Relative belowground biomass will be assessed by extracting a core (5 cm diameter, 30 cm deep). Cores will be sectioned into 2-cm segments and washed through a 2-mm sieve to remove sediment. Roots will be dried and weighed to determine biomass.

Faunal communities and trophic support. Coastal wetland restoration is often intended to boost habitat value for charismatic vertebrates with commercial or recreational value (e.g., fishery species or birds). The value of restored wetlands for these targeted fish or bird species is closely linked to food availability. Therefore, relevant indicators for the ecosystem service of supporting faunal communities include measures of basal trophic sources: (1) Benthic microalgal biomass (total and fractions of diatoms, cyanobacteria, and green algae) will be measured in situ with a Benthotorch (bbe Moldaenke), which returns total biomass and algal composition data, calculated from measured fluorescence from the substrate. (2) Biofilms are the thin surficial layer of diatoms, cyanobacteria, and other bacteria and microorganisms, enveloped in a coating of extracellular mucus on the sediment surface, and are important food sources for many small-bodied shorebirds. Chlorophyll a (the common proxy for biofilm biomass) and total organic matter will be measured in samples from the top 1-mm of sediment to assess biofilm quantity and quality. (3) For infaunal communities, replicate cores (10 cm diameter, 30 cm deep) will be collected and rinsed through a 0.5-mm sieve. Samples will be sorted to the lowest practical taxonomic level, enumerated, and then dried to determine biomass.

Analysis and expected outcomes

Biotic and abiotic data will be analyzed with univariate and multivariate approaches to identify site characteristics that are linked to successful and persistent restoration of target ecosystem services. The outputs will provide rigorous scientific evidence to support future decisions about restoration projects that intend to provide carbon sequestration and trophic support for ten or more years after restoration.

Latitude/Longitude (Optional):

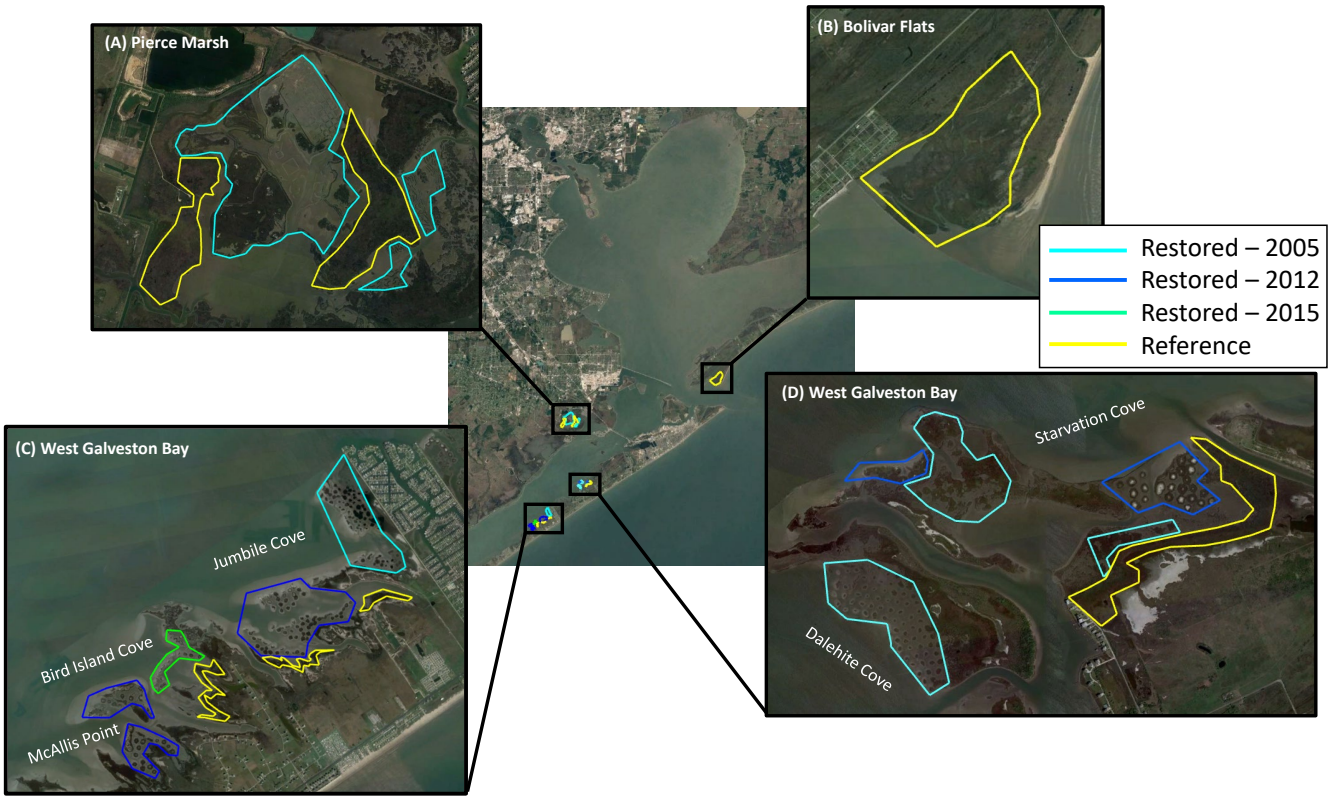
Tentative site locations (see **Project Map**):

Site name	Coordinates
Dalehite/Starvation Coves	N 29.225720˚, W 94.943898˚
Jumbile Cove	N 29.192890˚, W 94.990611˚
Bird Island Cove/McAllis Point	N 29.180917˚, W 95.008082˚
Pierce Marsh	N 29.316737˚, W 94.967956˚
Bolivar Flats	N 29.369174˚, W 94.742337˚

Location:

West Bay, Segment ID 2424, Hydrologic Code Unit 12040204
Lower Galveston Bay, Segment ID 2439, Hydrologic Code Unit 12040204

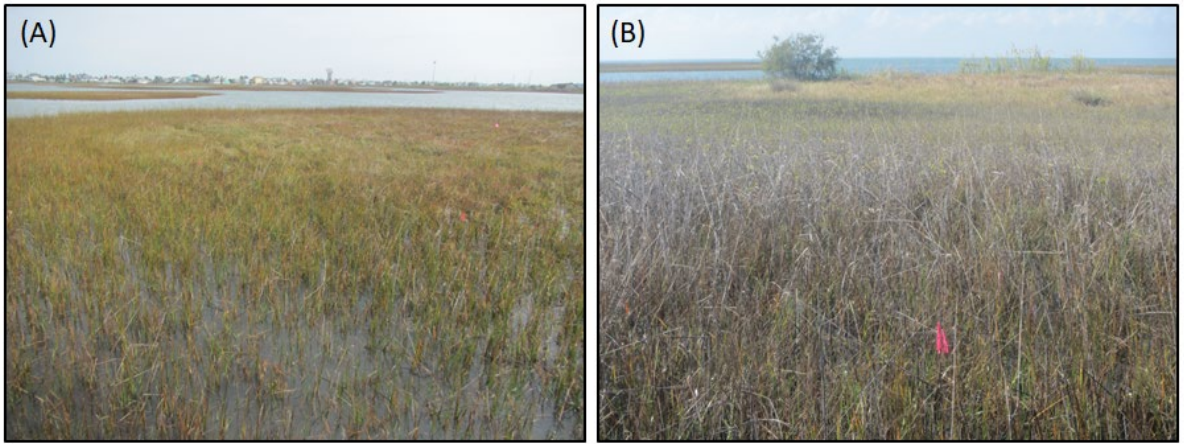
Project Map



Project map depicting potential restored and reference study sites in Galveston Bay. (A) Pierce Marsh contains a combination of beneficial uses and mound configurations. (B) Bolivar Flats is a reference area that has not undergone active sediment placement. (C) and (D) Restoration sites in mound configurations in West Galveston Bay. Polygon colors indicate the year that restoration was completed.

Supplemental Photos/Graphics (Optional):

Representative site photo showing circular mounds of restored marsh vegetation in Jumbile Cove, West Galveston Bay.



Images of the highest point of (A) older (20 year old) and (B) younger (10 year old) restoration sites, illustrating higher elevation and increased plant diversity at the younger site.

SECTION FIVE: BUDGET DETAILS

BUDGET CATEGORIES:		Budget
a.	Personnel/Salary	56090
b.	Fringe Benefits	10512
c.	Travel	6000
d.	Supplies	5800
e.	Equipment	0
f.	Contractual	0
g.	Construction	0
h.	Other*	23867
i.	Total Direct Costs (Sum a - h)	102269
j.	Indirect Costs	48892
k.	Total (Sum of i & j)	151161

*Other: If Budget Category "Other" is greater than $25,000 or more than 10% of budget total, identify the main constituents:

Other expenses include airboat charters ($6,400), truck and boat fuel during field work ($2,000), graduate student tuition ($10,867), publication costs ($3,000), and conference registration fees ($1,600).

Indirect Cost Agreement

Indirect Cost Reimbursable Rate: The reimbursable rate for this Contract is 52.5 (year 1); 54% (years 2 &3) of (check one):

☐ salary and fringe benefits
☒ modified total direct costs
☐ other direct costs base
If other direct cost base, identify:

This rate is less than or equal to (check one):
☒ Predetermined Rate—an audited rate that is not subject to adjustment.
☐ Negotiated Predetermined Rate—an experienced-based predetermined rate agreed to by Performing Party and TCEQ. This rate is not subject to adjustment.
☐ Default rate—a standard rate of ten percent of salary/wages may be used in lieu of determining the actual indirect costs of the service.

Indirect Cost Rate Agreement dated 9/2/2022 is attached as Appendix A.
Cognizant Federal Agency: Department of Health & Human Services, Denise Shirlee, (214) 767-3261

Please Submit Project Proposals (Microsoft Word Only – No PDFs) by August 4, 2023 to:

WSQ Subcommittee
Christian.Rines@tceq.texas.gov

NRU Subcommittee
Lindsey.Lippert@tceq.texas.gov

PPE Subcommittee
Kari.Howard@tceq.texas.gov

M&R Subcommittee
Cassandra.Taylor@tceq.texas.gov

Galveston Bay Estuary Program
FY 2025 M&R Project Proposal

Please complete the proposal form and submit to the appropriate Subcommittee Coordinator (end of form) by August 4, 2023. No late submittals will be considered for funding.

SECTION ONE: GENERAL INFORMATION

Subcommittee:

Primary subcommittee for submission: M&R

If funds through the M&R subcommittee are limited or the following proposal is deemed better suited for another subcommittee, we would like to be considered for one of the other subcommittee(s).

Project Name:

Microplastic and per-/polyfluoroalkyl (PFAS) substance bioaccumulation in Diamondback Terrapin (*Malaclemys terrapin*) from Galveston Bay

Project Previously Funded by GBEP? Yes ☐ No ☒

Lead Implementer:

University of Houston-Clear Lake; Environmental Institute of Houston

☐ Federal, State, or Local Government ☐ Council of Government ☒ Public ISDs or Universities
☐ Nonprofit ☐ Other*

* If lead implementer not listed above, the proposing party will need to partner with an interlocal/interagency entity to be selected for funding. Please reach out to GBEP staff with any questions.

Contact Information:

Project Representative Name	Mandi Gordon
Project Representative Phone	281-283-3794
Project Representative Email	gordon@uhcl.edu

Amount Requested:

$178,200.92

Is the project scalable? ☒

Amount Requested per year (if applicable):

FY 2025 (09/01/2024-08/31/2025)	$ 89,019.08
FY 2026 (09/01/2025-08/31/2026)	$ 97,181.84
FY 2027 (09/01/2026-05/31/2027)	$ 0.00
Total	$ 178,200.92

Total Project Cost:

Requested Project Costs:	$ 178,200.92
Estimated Leverage/In-Kind Funds:	$ 93,000.00
Potential Additional In-Kind Funds:	$ 21,000.00
Total Project Cost:	$ 292,200.92

(see Leveraging section for estimates of additional costs through other sources/in-kind)

Is this an estimate? ☒

Project Duration (beginning no earlier than September 1, 2024 – 2.5 year maximum project length):

24 months (2 years), beginning September 1, 2024 and ending August 31, 2026

Project Urgency:

The proposed study will serve as an expansion of two inter-agency studies being conducted during the same period (September 1, 2024 through August 31, 2026). It will also serve to expand existing terrapin outreach and education programs previously established by Galveston Bay Foundation and for which funds expired at the end of June 2023.

The first concurrent study is an evaluation of microplastic contaminant bioaccumulation in Texas Diamondback Terrapin (*Malaclemys terrapin littoralis*; herein referred to as "terrapin") from Matagorda and San Antonio Bays which is part of a larger project being conducted by the University of Houston-Clear Lake (UHCL) that is funded by the Matagorda Bay Mitigation Trust (MBMT) through August 31, 2026 (total funds = $499,999.91). Funds provided by the Galveston Bay and Estuary Program (GBEP) will be used to expand the evaluation of microplastic bioaccumulation in terrapin to the upper Texas coast by allowing us to sample populations in the Galveston Bay complex.

The second concurrent study is a range-wide assessment of per- and polyfluoroalkyl (PFAS) contaminant accumulation in terrapin from the Atlantic coast. This work is being led by the U.S. Geological Survey (USGS). Samples collected by UHCL from terrapin in Galveston Bay were originally being provided to the USGS on an opportunistic and *pro bono* basis, as UHCL does not currently have support for terrapin monitoring in Galveston Bay. Additionally, UHCL has already coordinated with the USGS to provide samples from Matagorda and San Antonio Bay terrapin in conjunction with the project funded by the MBMT. Funds provided by GBEP will allow for expansion of sample collection into the upper Texas coast by allowing us to collect samples from terrapin populations in Galveston Bay in a dedicated capacity.

Funds provided by GBEP will also be used to conduct a microcosm study evaluating trophic bioaccumulation, and potentially bioamplification, of PFAS and microplastic contaminants in primary prey sources (periwinkle snails, *Littorina* sp., and *Spartina alterniflora* grasses) from Diamondback Terrapin in Galveston Bay. This component is a crucial step to understanding how these contaminants are incorporated into terrapin populations but is not currently funded by either of the concurrent studies described above.

Leveraging (in-kind and/or cash):

Leverage/In-Kind funds were calculated using the estimated costs for: 1) salary (based on estimated time) supported by state or other, concurrent project funds for key personnel supporting the proposed study; 2) sample processing costs supported by other ongoing, concurrent projects; and 3) estimated costs for outreach materials or programs already in place to support the proposed study. Below is a breakdown by each participating agency of contributed costs used to calculate these leverage funds. Please note: no time will be tracked or reported as part of the proposed study; all estimated costs detailed below are anticipated should the proposed study be selected for funding at the requested amount.

Leverage/In-Kind funds provided by UHCL:	$ 43,000.00
Leverage/In-Kind funds provided by USGS:	$ 30,000.00
Leverage/In-Kind funds provided by GBF:	$ 8,000.00
Leverage/In-Kind funds provided by TAMU:	$ 12,000.00

Total Leverage/In-Kind funds included in calculation of Total Project Cost: $ 93,000.00

In addition to the Leverage/In-Kind funds noted above, the USGS may support expenses for per- and polyfluoroalkyl (PFAS) sample analyses at a cost of $350 per sample. The final amount for sample analyses will vary depending on the total number of samples collected through the proposed study, but should we be successful in collecting the number of samples anticipated in the study (~60), additional funds from this type of Leverage/In-Kind work could increase the total project amount by an additional $21,000 (or more) from the total noted above.

Partners and Their Roles:

Project Lead:

Mandi Gordon (gordon@uhcl.edu), Environmental Institute of Houston, Senior Biologist – Mandi will serve as the principal investigator on the project. She will also serve as a committee member for an M.S. graduate student funded through the project and will be responsible for coordination between all internal and external project partners, completion of contract deliverables, and communications with GBEP project management.

External Project Partners:

David Haskins (dhaskins@usgs.gov), U.S. Geological Survey's Eastern Ecological Science Center, Biologist/Post-doctoral Research Associate – Dr. Haskins is the acting study lead on the concurrent USGS study evaluating PFAS contamination in Diamondback Terrapin populations along the Atlantic coast of the United States. His role will be to facilitate sample analyses and data integration between the proposed study and the ongoing USGS assessment. Dr. Haskins may also serve as an outside committee member for a M.S. graduate student funded through this project and provide expert training to project personnel conducting fieldwork.

Natalie Karouna (nkarouna@usgs.gov), U.S. Geological Survey's Eastern Ecological Science Center, Research Ecologist – Dr. Karouna is the acting lead principal investigator on the concurrent USGS study evaluating PFAS contamination in Diamondback Terrapin populations along the Atlantic coast of the United States. Her role will be to facilitate data integration and sharing between the proposed study and ongoing USGS assessment. Dr. Karouna may also serve as an outside committee member for a M.S. graduate student funded through this project.

Lisa Scobel (lscobel@galvbay.org), Galveston Bay Foundation, Marine Debris Programs Coordinator – Lisa currently coordinates terrapin outreach and the marine debris program at the Galveston Bay Foundation, including efforts for microplastic and Nurdle Patrol surveys. Her role will be to expand education and outreach of marine debris and contaminants as they relate to accumulation and magnification in higher order vertebrates.

Natasha Zarnstorff (nzarnstoff@galvbay.org), Galveston Bay Foundation, Water Quality Programs Coordinator – Natasha currently coordinates the water quality program at the Galveston Bay Foundation, including volunteer and citizen science-based monitoring. Her role will be to assist with field activities, coordinate with Galveston Bay Foundation's expansive volunteer base, and support education and outreach efforts as needed.

Cindy Wilems (cwilems@galvbay.org), Galveston Bay Foundation, Director of Education – Cindy currently manages the education programs at Galveston Bay Foundation. Her role will be to oversee implementation of K-12 educational curricula and programming focused on Diamondback Terrapins.

Michelle Lawing (anna.lawing@ag.tamu.edu), Texas A&M University, Associate Professor – Dr. Lawing is currently an assistant professor of spatial sciences in the Department of Ecosystem Science and Management. Her role will be to serve as expert counsel and provide support to the proposed study through spatial analyses.

Internal Project Partners:

George Guillen (guillen@uhcl.edu); Environmental Institute of Houston, Executive Director; College of Science and Engineering, Professor – Dr. Guillen will be serving as a topical expert and graduate committee member/advisor for a M.S. graduate student funded through this project.

Cindy Howard (howard@uhcl.edu); Environmental Science, Department Chair; College of Science and Engineering, Professor – Dr. Howard will be serving as a topical expert and graduate committee member/advisor for a M.S. graduate student funded through this project.

TBD, College of Science and Engineering, M.S. Graduate Student – funds provided through this opportunity will support one graduate student in the M.S. in Environmental Science program through the UHCL College of Science and Engineering.

SECTION TWO: *GALVESTON BAY PLAN, 2ND EDITION* IMPLEMENTATION

Galveston Bay Plan, 2nd Edition References
https://gbep.texas.gov/ensure-safe-human-and-aquatic-life-use/
https://gbep.texas.gov/protect-and-sustain-living-resources/
https://gbep.texas.gov/engage-communities/
https://gbep.texas.gov/inform-science-based-decision-making/

The proposed study supports or supplements multiple components of the Galveston Bay Plan. Specific to Priority Four (Inform Science-Based Decision Making) Actions, we propose a collaborative study between multiple institutions for applied research and monitoring by evaluating the effects of biological stressors (RES-1), geochemical stressors (RES-2), and physical stressors (RES-3) on terrapin and their associated prey items. Additionally, we propose to increase access to Galveston Bay ecosystem information (ACS) through data-sharing and interagency collaboration (ACS-1) and dissemination of monitoring and research results to a range of audiences (ACS-2).

In addition to Plan Priority Four Actions, below we note additional Actions addressed by the proposed study and include which primary objective (outlined in the Project Summary section of this document) addresses these topics. Additionally, we reference currently funded GBEP projects with goals or objectives analogous to the proposed study (found on the Current Projects page of the GBEP website). While these analogous studies document presence or integration of microplastic and/or PFAS contaminants, to our knowledge, they do not address these contaminants in relation to conservation or management strategies for a Species of Greatest Conservation Need, such as the Texas Diamondback Terrapin.

Finally, according to the Completed Projects Portion of the GBEP website, no project focused on the terrapin has been funded by GBEP to date. The proposed study offers a unique opportunity for GBEP to support research related to a coastal, estuarine-dwelling Species of Greatest Conservation Need as well as a species which represents the "next-step" in contaminant bioaccumulation analyses for shoreline-dependent species. Terrapin serve as a sentinel species for accumulation of contaminants in larger and longer-lived vertebrates than those species previously studied through GBEP funds (Bangma et al. 2019).

Plan Priority One: Ensure Safe Human and Aquatic Life Use
The proposed study addresses the following priorities for ensuring safe human and aquatic life use:
- Support nonpoint source education and outreach campaigns (NPS-2; proposed study objective 2)
- Improve regional contact recreation risk awareness (PHA-2; proposed study objective 2)

Plan Priority Two: Protect and Sustain Living Resources
While the proposed study does not directly address current Plan priorities for protection and sustainability of living resources, we provide the opportunity to examine contaminant effects to a species currently ignored by the Galveston Bay Plan's Species Conservation (SC) action items (supplemental to SC-1). We also provide the opportunity to evaluate contaminant effects on a group of organisms (herpetofauna) historically underrepresented in ecotoxicology research (Grillitsch and Schiesari 2010, USGS 2021). Evaluation of contaminants in terrapin allows for baseline data compilation which can be related to living resources by examining the effects of persistent contaminants in terrapin and how they accumulate in organisms residing in their essential habitat (*Spartina* dominated saltmarshes).

Plan Priority Three: Engage Communities
The proposed study addresses the following priorities for engaging communities:
- Develop new and support existing stewardship programs and volunteer opportunities for stakeholders (SPO-1; proposed study objective 2)
- Develop new and support existing programs in Galveston Bay to engage the public in a dialogue about key issues (PEA-1; proposed study objective 2)
- Develop new and support existing programs in Galveston Bay that change behaviors and attitudes in Galveston Bay with a focus on adult education (PEA-2; proposed study objective 2)
- Develop new and support existing K-12 Galveston Bay estuary-related curricular materials for regional use (PEA-3; proposed study objective 2)

*****Section continues on next page*****

Currently funded GBEP projects with analogous objectives or goals related to the proposed study

- *Long-term Monitoring of Living Shorelines*, Lee College (in partnership with the University of Houston-Clear Lake)
- *The Distribution, Fate, and Transport of Emerging Contaminants in Galveston Bay*, Texas A&M University
- *Galveston Bay Oyster Microplastics: Baselines and Impacts*, Texas A&M University at Galveston
- *The Effect of Microplastic on the Base of Marine Food Webs*, Texas A&M University at Galveston
- *The Fate of Emerging Per- and Polyfluoroalkylated Substances (PFAS) Pollutants in Shellfish and Fish of Galveston Bay*, Texas A&M University at Galveston
- *Microplastics in the Galveston Bay Watershed: The Big Impacts of Tiny Pollution*, University of Houston-Clear Lake
- *Baseline Assessment of Microplastics in Galveston Bay*, U.S. Geological Survey
- *Occurrence of Microplastics in Tributaries to Galveston Bay*, U.S. Geological Survey

*** Please note, a full list of literature cited is included in Appendix A, submitted as a supplemental file with this proposal document. ***

Galveston Bay Plan Priority Area Actions Addressed:

Plan Priority 4: Inform Science-based Decision Making

RES-1 ☒	RES-2 ☒	RES-3 ☒	RES-4 ☐
RES-5 ☐	RES-6 ☐	RES-7 ☐	RES-8 ☐
ACS-1 ☒	ACS-2 ☒	ACS-3 ☐	

Plan Priority Area Actions Detail:

RES-1: Conduct biological stressor monitoring and research

We address concerns about biological stressors by evaluating the overall effects of contaminants on health of individual terrapin. By evaluating contaminant levels in prey sources (*Littorina* snails and *Spartina* grasses), we aim to better understand the implications of contaminant loading on organisms consumed by terrapin. Through the proposed study, we plan to assist GBEP with addressing all four activities and outputs noted under RES-1. Results will be presented at the State of the Bay Symposia. Data will be shared for inclusion on the GBEP website and the UHCL website and other locations, as applicable. Public dissemination of the data will be done through development of a technical report that will be made publicly available, presentation at in- or out-of-state professional conferences, development of a white paper (if applicable and valid), and other avenues as opportunities arise. Finally, we plan to coordinate with GBEP to develop ways in which data collected through the proposed study will be incorporated into the State of the Bay Report, as needed.

RES-2: Conduct geochemical stressor monitoring and research

We address concerns about geochemical stressors by evaluating the trophic bioaccumulation and potential biomagnification of contaminants in terrapin from Galveston Bay. Similar to RES-1, we plan to assist GBEP with addressing all four activities and outputs noted under RES-2, through the methods outlined above.

RES-3: Conduct physical stressor monitoring and research

We address concerns about physical stressors by evaluating the level of and potential effects of microplastic bioaccumulation in terrapin from Galveston Bay. By determining the amount of microplastic accumulation observed in terrapin, we will compile baseline information important to our understanding of the overarching effects of these particles and the compounds they may adsorb (such as PFAS) to higher-order vertebrates. Similar to RES-1 and RES-2, we plan to assist GBEP with addressing all four activities and outputs as outlined above.

ACS-1: Tracking ecosystem health indicators

We aim to aid in tracking ecosystem health indicators by providing data related to contaminant bioaccumulation and trophic interactions to the Galveston Bay Regional Monitoring Database and by supporting regional monitoring and data reporting efforts. We plan to coordinate with GBEP to develop ways in which data collected through the proposed study will be used in this capacity, as needed.

ACS-2: Access to monitoring and research data

We aim to support activities from ACS-2 by providing information and data relevant to the State of the Bay Symposia, the Galveston Bay Regional Monitoring Database, and the State of the Bay Report. We plan to coordinate with GBEP to develop ways in which data collected through the proposed study will be used in this capacity, as needed.

Does the project implement any other Galveston Bay Plan Priority Area Actions, or the other Subcommittee priorities?

☒ WSQ (Ensure Safe Human and Aquatic Life Use)
☒ NRU (Protect and Sustain Living Resources)
☒ PPE (Engage Communities)

Other Subcommittee Detail:

If funds through the M&R subcommittee are limited or the following proposal is deemed better suited for another subcommittee, we would like to be considered for one of the other subcommittee(s).

Water and Sediment Quality (WSQ) Subcommittee

NPS-2: Support non-point source education and outreach campaigns
We aim to supplement this Action by supporting continued outreach and education efforts to a wide range of audiences. Efforts will be focused on terrapin in Galveston Bay, though data related to contaminant analyses resulting from the study will be incorporated into existing programs to increase awareness about non-point sources of contaminants.

PHA-2: Improve regional contact recreation risk awareness
Should the opportunity arise, we can supplement this Action by supporting continued outreach and education efforts related to persistent contaminant accumulation in coastal habitats and the organisms residing within these living shorelines. While terrapin are no longer a primary source of food for humans (though they once were), education about how contaminants accumulate and potentially biomagnify in higher order vertebrates may serve to increase public awareness.

Natural Resource Uses (NRU) Subcommittee

SC-1: Native species management
While terrapin are not specifically addressed in the Galveston Bay Plan, they are recognized by the Texas Parks and Wildlife Department (TPWD) as a species of Greatest Conservation Need (TPWD 2020). Additionally, the International Union for the Conservation of Nature classifies terrapin as "Vulnerable" with observed population declines range-wide (https://www.iucnredlist.org/species/12695/507698). Data collected will be provided to TPWD to support native species management in Texas.

Public Participation and Education (PPE) Subcommittee

SPO-1: Stewardship programs and volunteer opportunities
Utilizing volunteer programs coordinated by partners included in the proposed study, we aim to support existing programs by providing opportunities to assist with field work and data collection. While this is not a primary objective of the proposed study, volunteers will be allowed to participate in field activities and assist with education and outreach events, as needed.

PEA-1: Key issue engagement
Accumulation and dispersion of long-term, persistent compounds, such as microplastics and PFAS, is an evolving issue for many communities in the Galveston Bay area. Through the proposed study, we aim to support ongoing awareness and education programs or campaigns in the region.

PEA-2: Adult education
Through volunteer programs, Master Naturalist groups, university programs, and other potential outreach groups, we aim to support ongoing adult education efforts in communities surrounding Galveston Bay. As opportunities arise, we intend to disseminate information about terrapin and contaminant analyses resulting from the proposed study.

PEA-3: Kindergarten to 12th grade (K-12) education efforts
Through Galveston Bay Foundation's Education Department, we plan to support ongoing K-12 education efforts through the implementation and expansion of existing programs teaching topics such as trophic interactions, animal adaptations, and conservation efforts.

Other Plans Implemented:

In addition to Actions addressed in the Galveston Bay Plan, the proposed study also addresses aspects of other state and gulf-wide plans and strategies.

Concerns and data deficiencies outlined in the Gulf of Mexico Diamondback Terrapin Conservation Action Plan developed by The Nature Conservancy and partnering Gulf states (including members from the proposed project team [M. Gordon and G. Guillen]). Specifically, pollution and marine debris were listed as some of the highest-ranking threats Gulf-wide (Mohrman 2022).

As part of the Texas Conservation Action Plan, terrapin are recognized as a Species of Greatest Conservation Need and resulting data from the proposed study will be provided to the Texas Parks and Wildlife Department for inclusion in their species status reviews and ongoing monitoring database (the Texas Natural Diversity Database).

Goals of the Wildlife and Fisheries Team outlined in the Gulf of Mexico Alliance's Governor's Action Plan include multiple actions related to interagency collaborative efforts to prioritize research on threats to species of conservation need, with multiple studies focused on impacts to terrapin already funded Gulf-wide through different incentive programs.

SECTION THREE: SUBCOMMITTEE PRIORITIES

M&R Subcommittee Identified Priorities
Proposals must address one or more of the following actions:

☒ Meaningful and effective monitoring of existing and new projects (NRU/WSQ/PPE support)
☒ Exposure and response to emerging contaminants across trophic levels
☐ Reestablishing dermo monitoring programs (Ex. Oyster Sentinel)
☒ Project Component: Results translated to plain language/practical knowledge

Subcommittee Priority Detail:

Meaningful and effective monitoring of existing and new projects
As described in the Urgency section of this document, the proposed study aims to take advantage of two ongoing studies being conducted by UHCL and USGS. Additionally, funds from the proposed study will aid in supporting UHCL Texas Diamondback Terrapin Monitoring Program (TDTMP), the longest-running program for terrapin in the state. As of the writing of this proposal, the UHCL TDTMP is not supported by any external funding sources. Funds provided by GBEP are crucial for tying together components of all three monitoring programs/studies to provide baseline data for a holistic assessment of the effects of microplastic and PFAS contaminants in terrapin from Galveston Bay.

Exposure and response to emerging contaminants across trophic levels
The proposed study aims to address this priority by conducting a first-of-its-kind assessment of PFAS trophic accumulation in terrapin and their primary prey sources from Galveston Bay. Additionally, the proposed study will evaluate baseline levels and effects of microplastics on terrapin from Galveston Bay, a globally emerging contaminant of concern.

Results translated to plain language/practical knowledge
Through the proposed study, many opportunities will be provided for data dissemination to a wide range of audiences through volunteer activities, education and outreach programs, integration of data into the Galveston Bay Report Card (as needed), presentation at the State of the Bay Symposia, and development of a technical report and potential white paper (as applicable). Additionally, information will be provided to GBEP for inclusion on the program's website and the University of Houston-Clear Lake website.

Does the Project work with new, smaller communities/partnerships?
☐ Yes
☒ No

While the proposed study does not initially involve work with new or smaller communities and partnerships, the Galveston Bay Foundation Education Team continually assesses the need to facilitate new partnerships and offer K-12 curriculum throughout the Greater Houston-Galveston area. Should an opportunity arise during this project period to facilitate existing terrapin educational programming to new schools/programs, Galveston Bay Foundation staff will work to foster these partnerships for future expansion of terrapin education and outreach.

SECTION FOUR: PROPOSAL DETAILS

Project Summary:

This project aims to evaluate and inform researchers, conservation managers, and the general public about contaminant build-up in a sentinel species (the Texas Diamondback Terrapin, *Malaclemys terrapin littoralis*) in Galveston Bay. Our primary objective is to evaluate trophic bioaccumulation of contaminants (specifically microplastics and PFAS compounds) in terrapin and their primary prey sources (periwinkle snails, *Littorina* sp., and *Spartina alterniflora* grasses). A secondary objective is to expand ongoing education and outreach efforts about this Species of Greatest Conservation, including details about how these compounds accumulate across tropic levels.

Full Project Description (1,000 words or less):

While inshore and nearshore coastal habitats face a myriad of issues globally, accumulation of anthropogenic contaminants is an ongoing concern. For example, large (or "macro") plastic debris > 5 mm in diameter persisting within the environment can be worn into smaller pieces through physical and chemical processes and through exposure to ultraviolet light (Derraik 2002, Weinstein et al. 2016). These smaller particulates, called "microplastics" (defined as plastic particulate < 5mm in diameter) ultimately accumulate within shoreline habitats and affect the wildlife which are dependent on these habitats to survive, either through habitat degradation or ingestion of particulates. Additionally, accumulation of per- and polyfluoroalkyl substances (PFAS; also known as "forever chemicals") in shoreline habitats may lead to detrimental health effects in a wide range of species (Hedgespeth et al. 2023).

Microplastics are a known vector for adhesion of persistent organic pollutants (POPs) and hydrophobic organic chemicals (HOCs) (Scott et al. 2021, Cheng et al. 2021). Microplastic particles have been shown to store POPs and HOCs at concentrations greater than the surrounding environment, though the adsorption of PFASs in microplastics is not as well understood (Liu et al. 2015). A recent study showed that, in freshwater environments, microplastic particles of all types tested adsorbed PFAS contaminants at factors ranging from 24 to 259 times the background lake concentration (Scott et al. 2021). Another recent study in an estuarine delta in China suggested that microplastics serve as a route for bioaccumulation of PFASs through trophic biomagnification (or bioamplification) in the food chain (Cheng et al. 2021).

Use of shoreline-dependent sentinel wildlife species can aid humans in understanding the potential effects of accumulation and biomagnification of microplastic and PFAS compounds in areas where humans recreate and live. To date, most aquatic studies on microplastic bioaccumulation and toxicity have focused on species primarily found in open water environments (e.g., fish, shellfish, oysters) or migrant species (e.g., birds). Additionally, though direct impacts of PFAS compounds are better known in birds, mammals, and fish, herpetofauna have been historically underrepresented in PFAS and microplastics research (Grillitsch and Schiesari 2010). The Texas Diamondback Terrapin (*Malaclemys terrapin littoralis*, "terrapin") is a semi-aquatic estuarine turtle which serves as an ideal candidate for a sentinel species in evaluating microplastics and PFAS bioaccumulation in shoreline habitats. Terrapin represent a transitional species between fully-aquatic and fully-terrestrial organisms, are generally longer lived than previously studied species, reside in low-lying wetland habitats that serve as primary filtration areas for terrestrial contaminants, and are consumers of organisms which may harbor contaminants (e.g., *Littorina* snails and *Spartina* grasses) (Brennessel 2006, Alleman and Guillen 2017, Pulster et al. 2022).

Trophic assessments of PFAS bioaccumulation and biomagnification have shown that accumulation rates vary between species groups and that invertebrates may store PFAS in higher concentrations than vertebrates, though accumulation is poorly understood in macroinvertebrates (Lewis et al. 2022, Munoz et al. 2022, Hedgespeth et al. 2023). A recent study of terrapin in South Carolina documented a sex-dependent effect on PFAS concentrations but did not see a relationship with body mass nor examine PFAS amplification through trophic mechanisms (Bangma et al. 2019). Alternatively, halophytes (such as *Spartina* grasses) have been shown to be useful in phytoremediation of heavy metals and POPs, though their ability to remediate PFAS contaminants is unknown (Roe and MacFarlane 2022). Should Spartina grasses have the ability to absorb PFAS, this could be useful for remediation efforts but detrimental to terrapin as they are known to ingest this plant (either directly or indirectly) (Alleman and Guillen 2017).

The proposed project aims to fill knowledge gaps related to contaminant bioaccumulation and biomagnification through a multi-faceted, interdisciplinary approach. Our primary goal is to evaluate microplastic and PFAS contaminant concentrations in terrapin populations from Galveston Bay. Addressing this goal will serve to expand ongoing studies in two ways: 1) a direct expansion of microplastic contaminant and health analyses already funded in Matagorda and San Antonio Bays and 2) a direct expansion of PFAS

contaminant and health analyses being conducted as a collaborative effort between UHCL and the U.S. Geological Survey (USGS). The proposed study aims to merge the contaminant and health analyses components of these ongoing assessments to create a more holistic evaluation of the effects of contaminants on a sentinel species, also recognized as a Species of Greatest Conservation Need (TPWD 2020). A secondary goal of the proposed project is to support ongoing efforts by the Galveston Bay Foundation for terrapin outreach and education, expanding existing programs to cover contaminants and their effect on terrapin and shoreline habitats. An important component of disseminating results of scientific research involves public education and outreach. Sharing information across a wide range of individuals can lead to increased participation and interest by local citizens, recreational enthusiasts, students, and public educators. Data resulting from this study will be made publicly available through multiple sources and may be used by students, educators, and professionals for future assessments of contaminants in Galveston Bay.

*** Please note, a full list of literature cited is included in Appendix A, submitted as a supplemental file with this proposal document. ***

Latitude/Longitude (Optional):

See Location section below for general coordinates of survey areas. A map of proposed survey areas is also included in the Projects Map section.

Location:

As part of our long-term Texas Diamondback Terrapin Monitoring Program, the University of Houston-Clear Lake has identified four priority (e.g., "primary") locations of known Texas Diamondback Terrapin populations in West Galveston Bay:

- Green's Lake: N29° 16' 13.4538", W94° 59' 23.8236" (WGS84)
- South Deer Island: N29° 16' 21.5256", W94° 54' 42.2778" (WGS84)
- Sportsman's Marsh: N29° 15' 21.0990", W94° 56' 25.5084" (WGS84)
- Sweetwater Preserve: N29° 16' 3.9144", W94° 53' 22.5486" (WGS84)

In addition to these long-term monitoring locations, samples may be collected from terrapin in other (e.g., "secondary") regions of Galveston Bay, including but not limited to:

- Mud Island: N29° 4' 56.5680", W95° 8' 51.885" (WGS84)
- Halls Lake: N29° 11' 23.7690", W95° 6' 23.0538" (WGS84)
- Shell Island: N29° 27' 3.4740", W94° 55' 40.6740" (WGS84)
- Goat Island Complex: N29° 28' 8.0904", W94° 38' 47.4612" and N29° 30' 57.603", W94° 32' 21.1884" (WGS84)

See Figure 1 in Projects Map section below for distribution of potential survey areas.

Projects Map

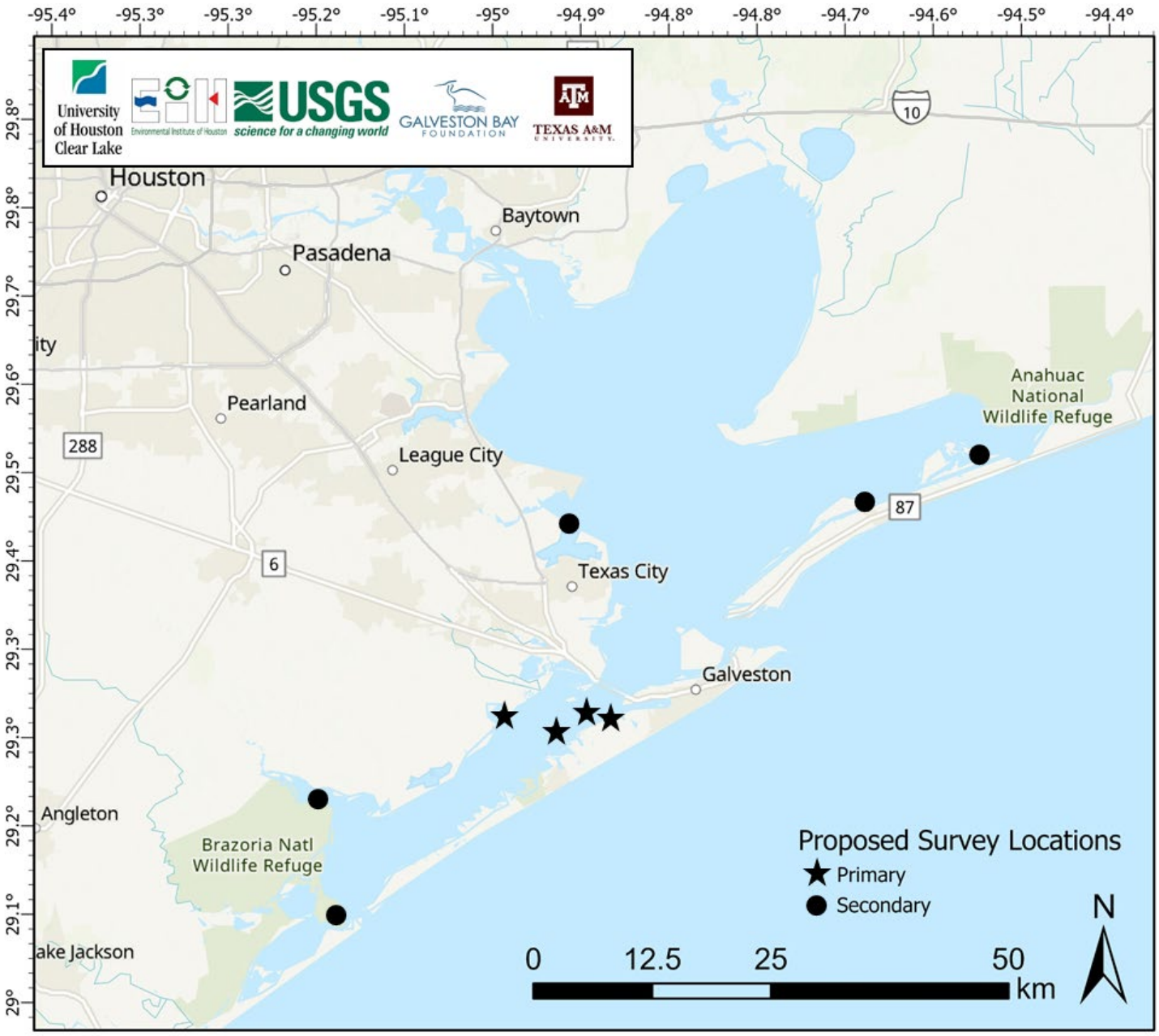


Figure 1 Map of Galveston Bay with primary and secondary proposed terrapin survey locations noted. Samples will be collected from portions of the Lower Galveston Bay Watershed, representative of the Implementation Location for all Action items to be addressed by the proposed study.

Supplemental Photos/Graphics (Optional):

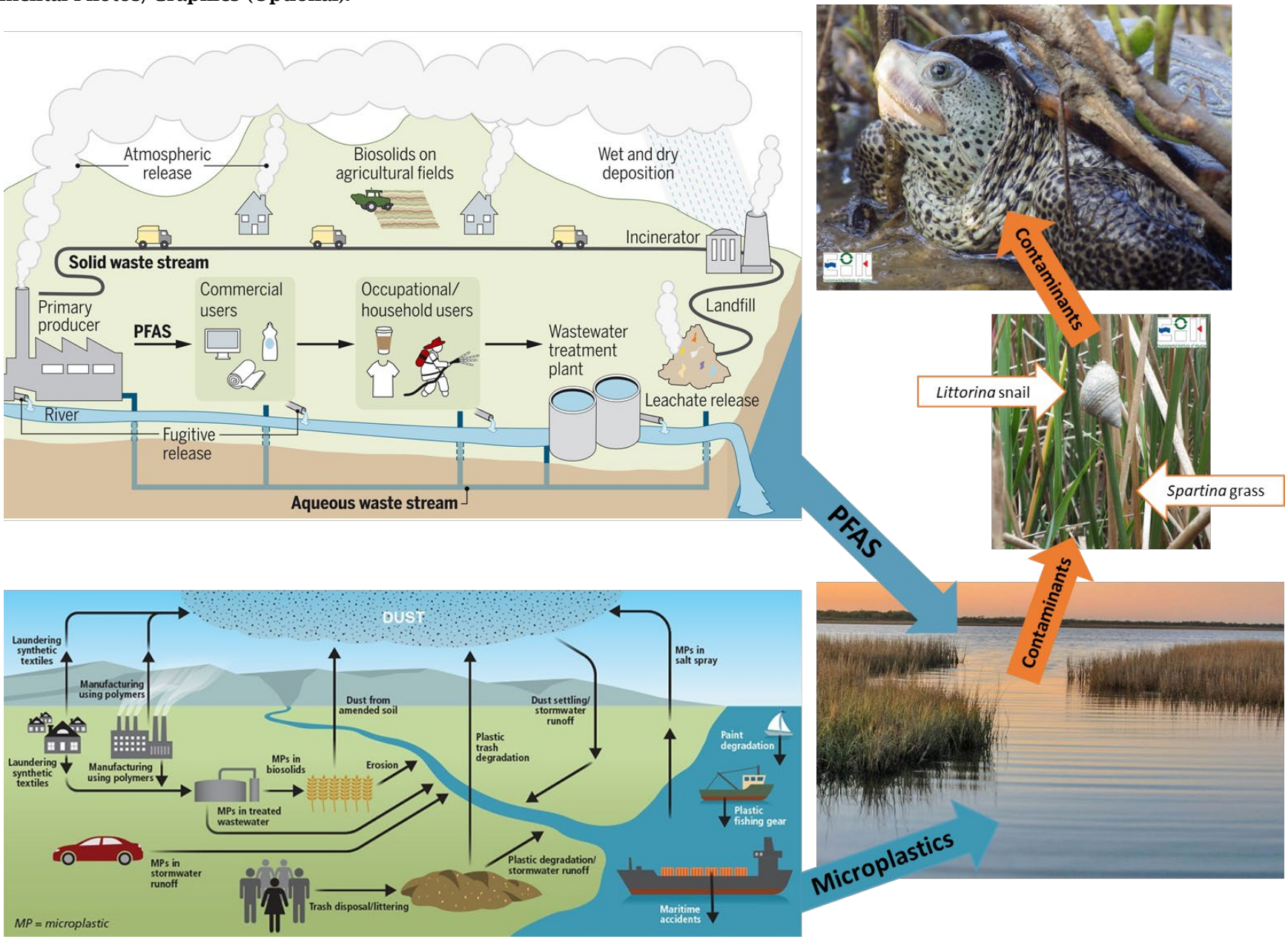


Figure 2 Examples of pathways for contaminant bioaccumulation in higher order vertebrates. Adapted from Yirka (2022; https://phys.org/news/2022-02-impact-pfas-containing-products-environment.html), Peters et al. (2021; https://www.haleyaldrich.com/resources/articles/microplastics-legislation-is-imminent-why-should-you-care/), and The Nature Conservancy (https://www.nature.org/en-us/get-involved/how-to-help/places-we-protect/clive-runnells-family-mad-island-marsh-preserve/).

SECTION FIVE: BUDGET DETAILS

BUDGET CATEGORIES:		Budget
a.	Personnel/Salary	$ 64,437.69
b.	Fringe Benefits	$ 10,049.15
c.	Travel	$ 8,990.00
d.	Supplies	$ 35,150.00
e.	Equipment	$ 0.00
f.	Contractual	$ 17,832.69
g.	Construction	$ 0.00
h.	Other*	$ 11,049.42
i.	Total Direct Costs (Sum a - h)	$ 147,508.95
j.	Indirect Costs**	$ 30,691.97
k.	Total (Sum of i & j)	$ 178,200.92

*Other: If Budget Category "Other" is greater than $25,000 or more than 10% of budget total, identify the main constituents:
**Indirect costs do not include charges for student stipend ($8,000 total), per university guidelines

Indirect Cost Agreement

Indirect Cost Reimbursable Rate: The reimbursable rate for this Contract is 22% of (check one):

☐ salary and fringe benefits
☒ modified total direct costs
☐ other direct costs base
If other direct cost base, identify:

This rate is less than or equal to (check one):
☒ Predetermined Rate—an audited rate that is not subject to adjustment.
☐ Negotiated Predetermined Rate—an experienced-based predetermined rate agreed to by Performing Party and TCEQ. This rate is not subject to adjustment.
☐ Default rate—a standard rate of ten percent of salary/wages may be used in lieu of determining the actual indirect costs of the service.

Note: A copy of the UHCL federally negotiated indirect cost agreement is included in Appendix A (submitted as a supplemental file with this proposal document).

Please Submit Project Proposals (Microsoft Word Only – No PDFs) by August 4, 2023 to:

WSQ Subcommittee
Christian.Rines@tceq.texas.gov

NRU Subcommittee
Lindsey.Lippert@tceq.texas.gov

PPE Subcommittee
Kari.Howard@tceq.texas.gov

M&R Subcommittee
Cassandra.Taylor@tceq.texas.gov

Galveston Bay Estuary Program
FY 2025 M&R Project Proposal

Please complete the proposal form and submit to the appropriate Subcommittee Coordinator (end of form) by August 4, 2023. No late submittals will be considered for funding.

SECTION ONE: GENERAL INFORMATION

Subcommittee:

Monitoring and Research (*note: also addresses priorities within NRU – Protect and Sustain Living Resources*)

Project Name:

Establishment of an Oyster Sentinel Program for Tracking *Perkinsus marinus* (Dermo) in Oysters of Galveston Bay.

Project Previously Funded by GBEP? Yes ☐ No ☒

Lead Implementer:

Environmental Institute of Houston – University of Houston Clear Lake

☐ Federal, State, or Local Government ☐ Council of Government ☒ Public ISDs or Universities
☐ Nonprofit ☐ Other*

* If lead implementer not listed above, the proposing party will need to partner with an interlocal/interagency entity to be selected for funding. Please reach out to GBEP staff with any questions.

Contact Information:

Project Representative Name	George Guillen
Project Representative Phone	281-283-3950
Project Representative Email	guillen@uhcl.edu

Amount Requested:

$297,404

Is the project scalable? ☒

Amount Requested per year (if applicable):

FY 2025 (09/01/2024-08/31/2025)	$153,977.97
FY 2026 (09/01/2025-08/31/2026)	$143,426.37
FY 2027 (09/01/2026-05/31/2027)	
Total	$297,404.33

Total Project Cost:

$297,404

Is this an estimate? ☐

Project Duration (beginning no earlier than September 1, 2024 – 2.5 year maximum project length):

2.0-2.5 years (currently budgeted for 2 years, but could be extended to 2.5 years).

Project Urgency:

The majority of bay bottom in Texas estuaries consists of flat soft sediment with the exception of oyster reefs. The Eastern Oyster, *Crassostrea virginica* is considered to be an ecosystem engineer and keystone species providing limited hard-bottom habitat and numerous ecosystem services (e.g. wave protection, water filtration, fisheries, complex habitat, and hard bottom substrate). It is estimated that oyster reefs have 50 times the surface area of an equally sized flat bottom (TGLO 2023). Oysters are considered a reliable bioindicator of estuarine ecosystem health which integrates the effects of freshwater inflow, pollutants, climate variability, and habitat destruction (e.g. dredging, overharvest, and shell mining) and extreme weather (droughts, floods, storms) impacts (Thomas et al 2018). The Texas oyster fisheries alone are valued at approximately $33.4 million annually and supports commercial fishermen along the coast (Ruben, Z. 2023). Oysters suffer from numerous biological and anthropogenic sources of stress and mortality. Many competitors, parasites, predators, diseases, and pollutants have been identified, and the manner in which they infect or kill oysters has been described (VanderKooy 2012). In the Gulf, the pathogenic protozoan, *Perkinsus marinus* or 'Dermo', is widely distributed throughout the oyster-producing waters of the Gulf, and the prevalence of the parasite is high among oyster populations. Intensive Dermo infections have been associated with massive mortalities throughout the Gulf, especially during the summer, when high water temperatures and salinities exacerbate disease conditions (VanderKooy 2012). Consequently it is important to understand the influence of various stressors on this critical resource.

In 2007 the Texas Legislature passed Senate Bill 3 (SB3) which established a process for developing environmental flow standards for all of the major river basins and bay systems in Texas. Senate Bill 3 established a new regulatory system for protecting environmental flows; consensus-based regional approach involving an expert team and a balanced representation of stakeholders. This involved the development of environmental flow standards for each estuary based on various "indicator species" or "bioindicators" representing a "sound ecological environment that maintains the productivity, extent, and persistence of key aquatic habitats in and along the affected water bodies". The Trinity and San Jacinto and Galveston Bay Basin and Bay Expert Science Team (Trinity-San Jacinto BBEST) developed recommended freshwater inflow standards based largely on an analysis of various bioindicator responses to freshwater inflow (Trinity-San Jacinto BBEST 2009). This information was used to develop seasonal inflow standards for Galveston Bay (TCEQ 2011).

One recommended bioindicator for Galveston Bay was the oyster disease Dermo, which is a disease in oysters caused by the parasite *Perkinsus marinus* (formerly *Dermocystidium marinum*). Dermo has caused high mortality in eastern oysters. For Galveston Bay, the Trinity-San Jacinto BBEST (TSJ-BBEST) found that the frequency of juveniles infected with Dermo significantly correlated to increasing salinity and decreasing total surface water inflow and increasing Trinity River discharge. In Upper Galveston Bay, the TSJ-BBEST found that increasing temperature and declining dissolved oxygen were significantly related to the increase in the number of juvenile and commercial sized oysters infected with Dermo. While in the lower Galveston Bay, there was a significant increase in the number of commercial sized oysters infected with decreasing San Jacinto River discharge. Overall the highest number of oysters infected (both juvenile and commercial sized) were collected in lower Galveston Bay where they saw higher salinities. While the oysters themselves did not prove to be a useful bioindicator, their predators and occurrence of disease appeared to be (Trinity-San Jacinto BBEST 2009; Quigg and Steichen 2015). In order to continue to evaluate the influence of freshwater inflow on Galveston Bay ecosystems monitoring of freshwater inflow, salinity, temperature and Dermo should be adopted to evaluate implementation of SB3 rules and collect additional data to develop and refine recommended future environmental flow standards (TSJ BBASC & TSJ-BBEST 2012).

The adoption of a monitoring program for Dermo in oysters is urgently needed. Dermo data has not been collected since 2015 even though environmental flow standards were adopted in 2012 (Silvy et al 2020; Oyster Sentinel 2023). Since Dermo monitoring has not occurred, timely evaluation and adaptive management of TCEQ environmental flow standards is impossible.

Leveraging (in-kind and/or cash):

Oyster collection will be conducted by EIH using previously purchased gear (boat and oyster dredge, oyster tongs) and by hand at a targeted 5 index sites (1/bay) to capture the natural salinity gradient and maximize detection of temporal trends. Furthermore, oysters will be collected by project partners, TPWD and Prestige. The five index sites will likely be established at sites historically monitored by previous investigators.

EIH contacted Christine Jensen, who is the Galveston Bay Ecosystem Leader, to request assistance in oyster collection to maximize our effort under a variety of sea conditions. As a result we have partnered with TPWD Coastal Fisheries who have committed to provide specimens for this study during their routine oyster monitoring program. TPWD has agreed to retain a subsample of oysters for this study. Field sample collection will be facilitated by in-kind labor and equipment supplied by TPWD. This includes the labor of at least 2 technicians and their associated vessel and dredge to collect 10 oysters/collection at 5 bays X 1-2 reefs per bay over 7 quarters across 2 years. Based on information provided by Ms. Jensen we estimate that this can cost at least a total of 70-140 man-days (5 x 7 x 2 X 2 or 1) over 2 years of the project. We are working with TPWD to see if this can be translated to equivalent dollar amounts.

Joel Anderson, is the Facility Manager at the Perry R. Bass Marine Facility, in Palacios. He and selected staff will provide laboratory support for genetic analysis of Dermo using protocol previously developed with qPCR technology (Culbertson et al 2012).

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Lastly we have also contacted and obtained cooperation from Prestige Seafood (Lisa Halili - owner), who has agreed to provide oysters harvested from Lease and Public reefs during their harvest operations, and potentially at a new restoration reef site over time (Retts Reef).

We will also contact the Galveston Bay Foundation to obtain access to their restoration sites and sponsored oyster gardens. The exact dollar amounts for the development and maintenance of these sites is difficult to estimate at this time.

Partners and Their Roles:

Principal Investigator: George Guillen, Ph.D. – Guillen@uhcl.edu; Environmental Institute of Houston
Co-Principal Investigator: Jenny Oakley, Ph.D. – Oakley@uhcl.edu; Environmental Institute of Houston

Project Collaborator**:** Christine Jensen -christine.jensen@tpwd.texas.gov; TPWD Galveston Bay Ecosystem Leader – Dickinson Lab. Ms. Jensen will be assisting the project by providing staff and gear to collect oysters for use in Dermo monitoring while conducting scheduled oyster surveys using TPWD standard methodology. TPWD will share field data with the project team. He has also been invited to serve as co-author or project review team and on the thesis advisory committee of graduate students

Project Collaborator: Joel Anderson- joel.anderson@tpwd.texas.gov; TPWD Facility Manager: Perry R. Bass Marine Fisheries Research Center; Palacios. Mr. Anderson and some of this staff will assist with validation of Dermo readings by using qPCR methods. Comparison of the methods will be conducted.as on of the goals of the project. He has also been invited to serve as co-author or on the project review team and on the thesis advisory committee of graduate students.

Project Collaborator: Ms. Lisa Halili owner of Prestige Oysters, a commercial oysterman. She has agreed to provide harvested oysters collected from public reefs and leases by their vessels. This may also provide access to oysters from a restoration reef “Retts Reef”.

SECTION TWO: *GALVESTON BAY PLAN, 2ND EDITION* IMPLEMENTATION

Galveston Bay Plan, 2nd Edition References
https://gbep.texas.gov/ensure-safe-human-and-aquatic-life-use/
https://gbep.texas.gov/protect-and-sustain-living-resources/
https://gbep.texas.gov/engage-communities/
https://gbep.texas.gov/inform-science-based-decision-making/

Eastern oysters are an estuarine keystone species and an "ecosystem engineer" that creates limited hard-bottom habitat and ecosystem services (e.g. wave protection, water filtration, supporting fisheries, complex vertical relief structure). Oysters are considered a reliable bioindicator of estuarine ecosystem health which integrates the effects of freshwater inflow, pollutants and habitat destruction (e.g. dredging) and extreme weather (droughts, floods, storms). Consequently it is important to understand the influence of various stressors on this critical resource.

The proposed study directly supports specific actions recommended by the Galveston Bay Estuary Program and described in The Galveston Bay Plan. This study directly supports **Plan Priority 4 – *Inform Science-based decision making* and the associated** Action Plan ***Applied Research and Monitoring through collaboration with Research Institutions (RES*).** The study directly supports the **RES-1** Goal of *increasing the understanding of the Galveston Bay ecosystem by Developing new and support existing efforts to conduct biological stressor*s (e.g. Dermo or *Perkinsus marinus*) monitoring and research.

The study also supports **Plan Priority 2: *Protecting and sustaining habitat and living resources*.** Understanding the role of pathogens on oysters, a keystone species, is the focus of this study. Oysters are considered excellent bioindicators of estuarine health and freshwater inflow. **Under Priority 2, this study will directly support Action Plan 3 – sustaining freshwater inflows (FWI);** specifically **FWI-3 Freshwater inflows research.** This research also supports BBEST monitoring recommendations for TCEQ adopted environmental flow standards, specifically the adoption and further evaluation of Dermo as a bioindicator.

Galveston Bay Plan Priority Area Actions Addressed:

Plan Priority 4: Inform Science-based Decision Making

RES-1 ☒	RES-2 ☐	RES-3 ☐	RES-4 ☐
RES-5 ☐	RES-6 ☐	RES-7 ☐	RES-8 ☐
ACS-1 ☒	ACS-2 ☒	ACS-3 ☐	

Plan Priority Area Actions Detail:

[[Please state the action and output addressed and how the project contributes to implementing the output.]

This study directly supports **Plan Priority 4 – Inform Science-based decision making and the associated Action Plan Applied Research and Monitoring through collaboration with Research Institutions (RES**). The study directly supports the **RES-1 Goal of increasing the understanding of the Galveston Bay ecosystem** by developing new and support existing efforts to conduct monitoring and research on biological stressors (e.g. Dermo or *Perkinsus marinus*).

The ACS Action Plan includes three Actions to increase understanding of and access to monitoring and research information in Galveston Bay. This project will provide data and information from ongoing data collection to the Oyster Sentinel database which will be available to GBEP and their contractors to be incorporated into **GBEP's Regional Monitoring Database in collaboration with local research institutions and organizations (ACS-1)**.

Dermo **monitoring and research results will be widely distributed using a variety of outreach tools tailored to each audience, including Oyster Sentinel (ACS-2).**

Does the project implement any other Galveston Bay Plan Priority Area Actions, or the other Subcommittee priorities?

☒ WSQ (Ensure Safe Human and Aquatic Life Use)
☒ NRU (Protect and Sustain Living Resources)
☐ PPE (Engage Communities)

Other Subcommittee Detail:

[Please explain in detail how project addresses other Galveston Bay Plan Priority Area Actions (be specific; NPS-1, SPO-3, etc.) or subcommittee priorities.]

This project directly supports the following tasks:

- Provides meaningful and effective monitoring of existing and new projects (NRU/WSQ/PPE support) i.e. Implementation monitoring of SB3 environmental flow regimes for Galveston Bay.
- Reestablishes a Dermo monitoring program (Ex. Oyster Sentinel)
- Project Component: Results translated to plain language/practical knowledge

The study also supports **Plan Priority 2: Protecting and sustaining habitat and living resources. Understanding the role of pathogens on oysters, a keystone species, is the focus of this study**. Oysters are considered excellent bioindicators of estuarine health and freshwater inflow... T **Under Priority 2, this study will directly support Action Plan 3 – sustaining freshwater inflows (FWI); specifically FWI-3 Freshwater inflows research.**

We plan to provide online educational material for downloading and a web link describing the important role of Dermo in oyster reef ecology and its relationship to freshwater inflow. Along with this outlet this information will be provided to citizens through non-profit organizations like the Galveston Bay Foundation. Additional information will be provided on how to log into the Oyster Sentinel web site, download data, and generate simple summary charts.

Other Plans Implemented:

[Texas Coastal Management Plan, Texas Coastal Resiliency Master Plan, Texas Wetland Conservation Plan, GCJV Conservation Plans, etc.] .

The proposed project aligns with the following state and gulf-wide plans and strategies.
The project supports SB3 Implementation, Work Plan for Galveston Bay

The Texas Coastal Resiliency Master Plan: The project aligns with the key "Ecological Resiliency Strategies", specifically R1-45: Galveston Bay Oyster Reef Planning & Restoration.

The Gulf of Mexico Alliance's Governor's Action Plan: Aligns with two priority issue items: Habitat Resources & Wildlife and Fisheries which focus on assessing status and trends, threats, and needs of priority wildlife species, including Oysters.

The Gulf States Marine Fisheries Commission's The Oyster Fishery of the Gulf of Mexico, United States: A Regional Management Plan – 2012 Revision. Publication No. 202 (VanderKooy 2012). This interjurisdictional stock management plan, identified multiple research and data needs for state stocks of oysters including 13.1 "developing a greater understanding of oyster population dynamics, reproduction, recruitment, growth, natural mortality, connectivity between populations" One of the specific actions listed was "determining factors contributing to MSX and Dermo infection". The proposed research will provide critical information on environmental factors contributing to Dermo infection and oyster mortality.

SECTION THREE: SUBCOMMITTEE PRIORITIES

M&R Subcommittee Identified Priorities
Proposals must address one or more of the following actions:

☐ Meaningful and effective monitoring of existing and new projects (NRU/WSQ/PPE support)
☐ Exposure and response to emerging contaminants across trophic levels
☒ Reestablishing Dermo monitoring programs (Ex. Oyster Sentinel)
☒ Project Component: Results translated to plain language/practical knowledge

Subcommittee Priority Detail:

[Please explain in detail how project addresses priorities selected. Attachments may be submitted via email in conjunction with this application.]

This project addresses several M&R and NRU Committee priorities listed below:

- It provides meaningful and effective monitoring of existing and new projects that include oyster restoration and conservation (NRU support)
- It reestablishes Dermo monitoring programs (Ex. Oyster Sentinel)
- It includes a mechanism to disseminate results in plain language/practical knowledge to a wide audience though the Galveston Bay data portal and the Oyster Sentinel program.
- The PI will also develop an educational PSA handout regarding the pathogen that will be made available online.

The proposed project specifically aims to establish a Dermo monitoring program and will actively participate in the Oyster Sentinel program, which also provides a web distribution program for reporting and viewing and downloading current Dermo data across the Gulf of Mexico and Galveston Bay.

This program is well recognized. Data will be archived on the Oyster Sentinel web database. And could be posted on GBEP web sites and can be accessed from the Oyster Sentinel for updating the State of the Bay and Status and Trends reports. The project will also produce a public information (web and pdf downloadable) pamphlet discussing Dermo diseases, oyster health, oyster fisheries, bay ecology, and freshwater inflow and salinity effects. It will also include information on programs and contacts of existing state and federal programs and activities.

This will also address **PPE priority: Adult engagement in science literacy focused on the Galveston Bay estuary** and watershed through dissemination of the pamphlets and distribution through Oyster Sentinel.

Finally this project will provide critical information that can address **NRU priorities**: Project provides benefit to Native Fish and Wildlife, including Federal and State Listed Species, Species of Greatest Conservation Need, or Nongame Wildlife with special emphasis on projects addressing seagrasses, intertidal reef/shell hash, and benthic organisms. **Oysters provide a unique living hard bottom habitat for a unique assemblage of benthic organisms** that also support important sportfish species including Sheepshead and obligate community of species such as Skilletfish and gobies.

The study specifically supports **Plan Priority 2: Protecting and sustaining habitat and living resources. Understanding the role of pathogens on oysters, a keystone species, is the focus of this study. Oysters are considered excellent bioindicators of estuarine health and freshwater inflow. Under Priority 2, this study will directly support Action Plan 3 – sustaining freshwater inflows (FWI); specifically FWI-3 Freshwater inflows research**.

Does the Project work with new, smaller communities/partnerships?
☐ Yes
☒ No

[TBD.]

SECTION FOUR: PROPOSAL DETAILS

Project Summary:

This project will establish an Oyster Sentinel Program for tracking *Perkinsus marinus* (Dermo) in Oysters within Galveston Bay. Dermo presence, prevalence and intensity will be monitored along with estimates of freshwater inflow, salinity, water temperature, and auxiliary variables to evaluate how Dermo responds to freshwater inflow in comparison to projected TCEQ environmental flow standards for adaptive management use.

Full Project Description (1,000 words or less):

In 2007 the Texas Legislature established the Senate Bill 3 (SB3) external stakeholder process for development of environmental flow standards. Environmental flow standards were adopted for Galveston Bay (TCEQ 2011). An Implementation Work Plan included recommendations for ongoing refinement of bioindicators (TSJ BASC & BBEST 2012). In order to address this research need and data gap we propose to reestablish the Oyster Sentinel Program for tracking *Perkinsus marinus* (Dermo) in Galveston Bay.

The primary objectives of this study are:

1) To establish a monitoring network for evaluating Dermo levels in Galveston Bay oysters

2) To compare and contrast Dermo presence, prevalence and severity in oysters using RMTF and qPCR methods in Galveston Bay by sub-bay, reef, season, temperature, freshwater inflow and salinity

5) Submit pertinent data to the Oyster Sentinel online network

6) Characterize potential relationships of Dermo with environmental variables (e.g. season, various flow metrics (e.g. instantaneous, cumulative time steps), salinity, and temperature.

7) Prepare report on study findings along with recommendations for long-term adoption and support.

Field Collection

In order to increase the probability of detecting a response of Dermo to salinity exposure we will try and deploy sites across known spatial gradients in salinity (e.g. lower and upper bay). We will also attempt to establish up to 5 “index sites” in Galveston Bay, with at least one within each major bay at historical Oyster Sentinel sites (Oyster Sentinel 2023) (Figure 1). These fixed sites may also overlap with random sites generated and selected by TPWD. These index sites may also include both intertidal and/or wadeable areas and will be monitored by EIH using boat deployed oyster dredges, oyster tongs, or by hand. Sampling will consist of a combination of randomly selected sites that TPWD samples, opportunistic samples collected by commercial fishermen at public reefs and leases and from UHCL samples obtained from index sites established within each open bay waterbody segment as defined by TCEQ (TCEQ Surface Water Quality Viewer Accessed 2023). The majority of oysters will be collected through the TPWD dredge collections (Martinez-Andrade 2018). Samples collected by TPWD will come exclusively from subtidal reefs (Figure 2). The TPWD collects oysters at reefs using a spatially randomized site selection protocol from a specified grid (Figure 3).

The methodology used to collect and process oyster samples is described in their Coastal Fisheries operations manual (Martinez-Andrade 2018). Sampling for oysters occurs year round. They take 30 random samples every month from a sample grid that overlaps with mapped oyster reef. That results in a total of 360 samples per year.

At each site an oyster dredge is pulled for 30 seconds at 3 mph. Oysters larger than 25 mm (1 in) are counted and measured. Dead oysters and fragments greater than 25 mm (1 in) and oyster spat in the range of 5-25 mm (0.2 – 1 in) are counted. TPWD also collects information on oyster density, size and % recently dead (box oysters) and environmental data (e.g. latitude, longitude, date, time, depth, bottom temperature, dissolved oxygen, salinity, and turbidity). A subsample of up to 10 oysters, which can be taken from the 19 measured, and placed on ice These samples will be transferred to EIH within 24 hours.

Ray’s Fluid Thioglycollate Medium (RFTM) assays

In the lab oyster tissue samples will be excised and processed according to “Ray’s Fluid Thioglycollate Medium (RFTM)” assays (Mackin 1962; Ray 1966; Craig et al. 1989; Dungan and Bushek 2015). Once processed and following approximately one week of incubation the tissue is compressed on a slide and stained with Lugols solution. The Dermo spores are then stained. The slide is examined and a Dermo

infection intensity will be assessed using a numerical score (Mackin 1962 as modified by Craig et al. 1989) (Figure 4). In addition, a digital image is taken with the microscope camera for archival purposes.

Genetic Lab Methods – Perry R. Bass Marine Fisheries Station

Genetic methods are increasingly being employed in diagnostic assays for parasite detection in marine invertebrates. In this study the results of RFTM testing will be compared to newer qPCR genetic methods comparable to comparisons made by Culbertson et al. (2012). Multiple quantitative polymerase chain reaction ("qPCR") assays have been developed to detect common parasites of Eastern Oysters that cause morbidity across the range of the species, including *Haplosporidium nelsoni* ("MSX") (Day et al. 2000, Wilbur et al. 2012), and Dermo (Audemard et al. 2004, De Faveri et al. 2009, Gauthier et al. 2006, Marquis et al. 2020).

Tissue samples collected from oysters will be sub-sampled for DNA analysis. Approximately 20 mg of mantle tissue will be excised and preserved in 95% ethanol, and used for extraction of whole genomic DNA from each oyster using Qiagen DNeasy blood and tissue kits to isolate DNA from Eastern Oysters. The qPCR method of Gauthier (2006, "PMAR" assay) is species-specific, in that the PCR fragment being amplified is targeted by primers and probes specifically designed in the presence of a sequence alignment of *Perkinsus marinus*. The DNA isolation and qPCR steps will be carried out on an Applied Biosystems Quant Studio 3 quantitative thermal cycler. Our lab has used this technology to quantify parasite infections in several shrimp species (Swinford and Anderson 2021, 2023; Swinford et al. 2021).

Data Management and Analysis

All data collected will also be submitted to the Oyster Sentinel Website for dissemination to the public and use by GBEP while preparing status and trends reports. Oyster Sentinel is a web-based community which uses the health condition of Eastern oyster to assess the environmental health of northern GOM estuaries. The site displays prevalence and intensity of infection of oysters for Dermo.

Report Preparation.

A final report will be produced that summarizes the distribution of Dermo levels in oysters. Potential correlations between environmental causal and response variables such as Dermo levels will be analyzed and presented. A priori models will be constructed and run to identify the most parsimonious and best fitting model that explains the greatest amount of variation in Mackin scores and candidate causal variables.

Latitude/Longitude (Optional):

[degrees, minutes, and seconds format] –see Figure 1-3.

Location:

Oyster reefs found within Galveston Bay including TCEQ waterbody segments: Trinity Bay, Upper Galveston Bay, Lower Galveston Bay, East Bay, West Bay and Christmas Bay (Figures 1-2).

Study Map (Figures 1 - 3).

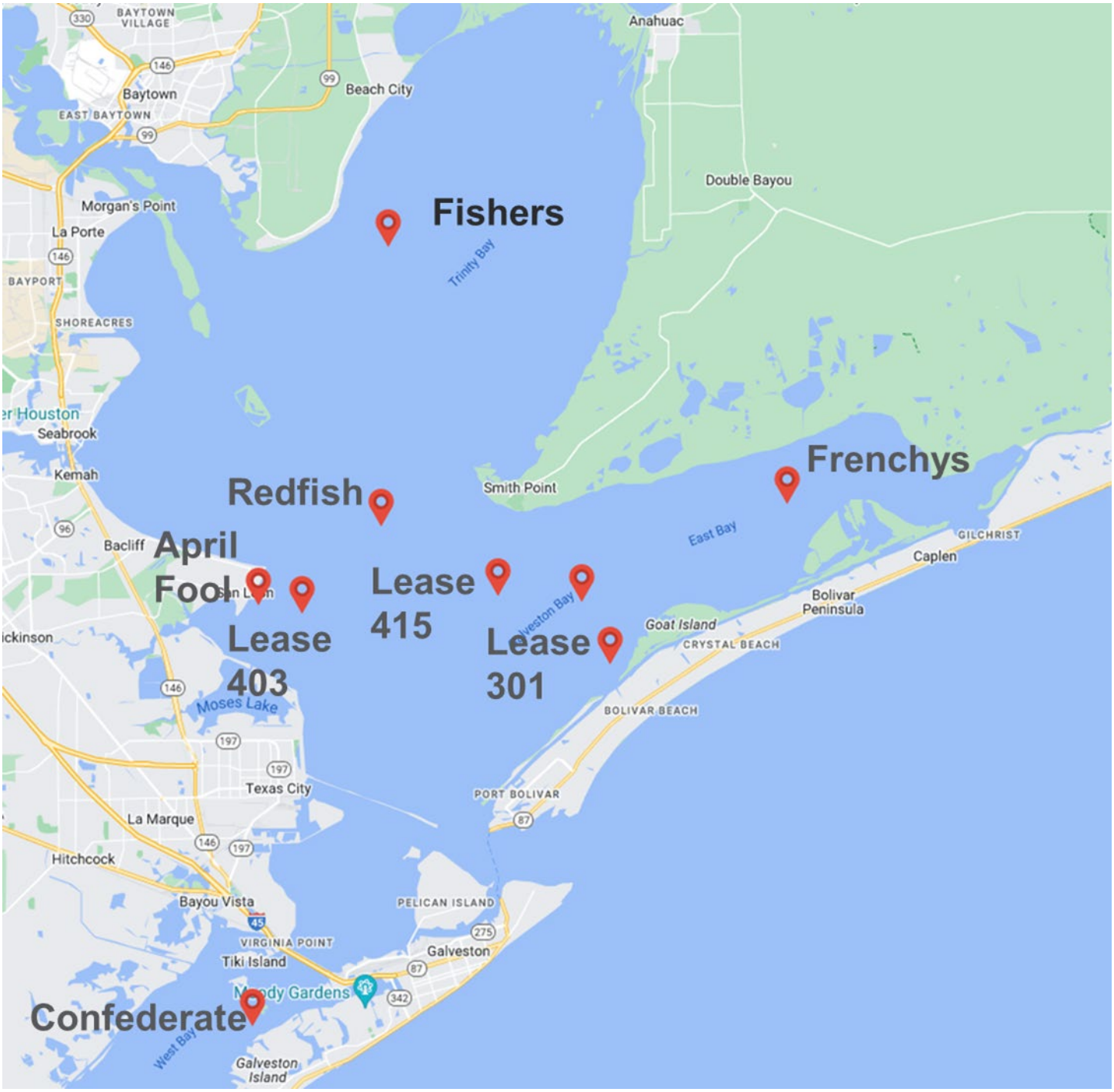


Figure 1.Potential index sites at public and lease reefs where historical Dermo monitoring has occurred (Source: Accessed 8/4/23) https://data.oystersentinel.cs.uno.edu /organizations/uno/divisions/gulfscei/dermo/regions/galveston-bay.

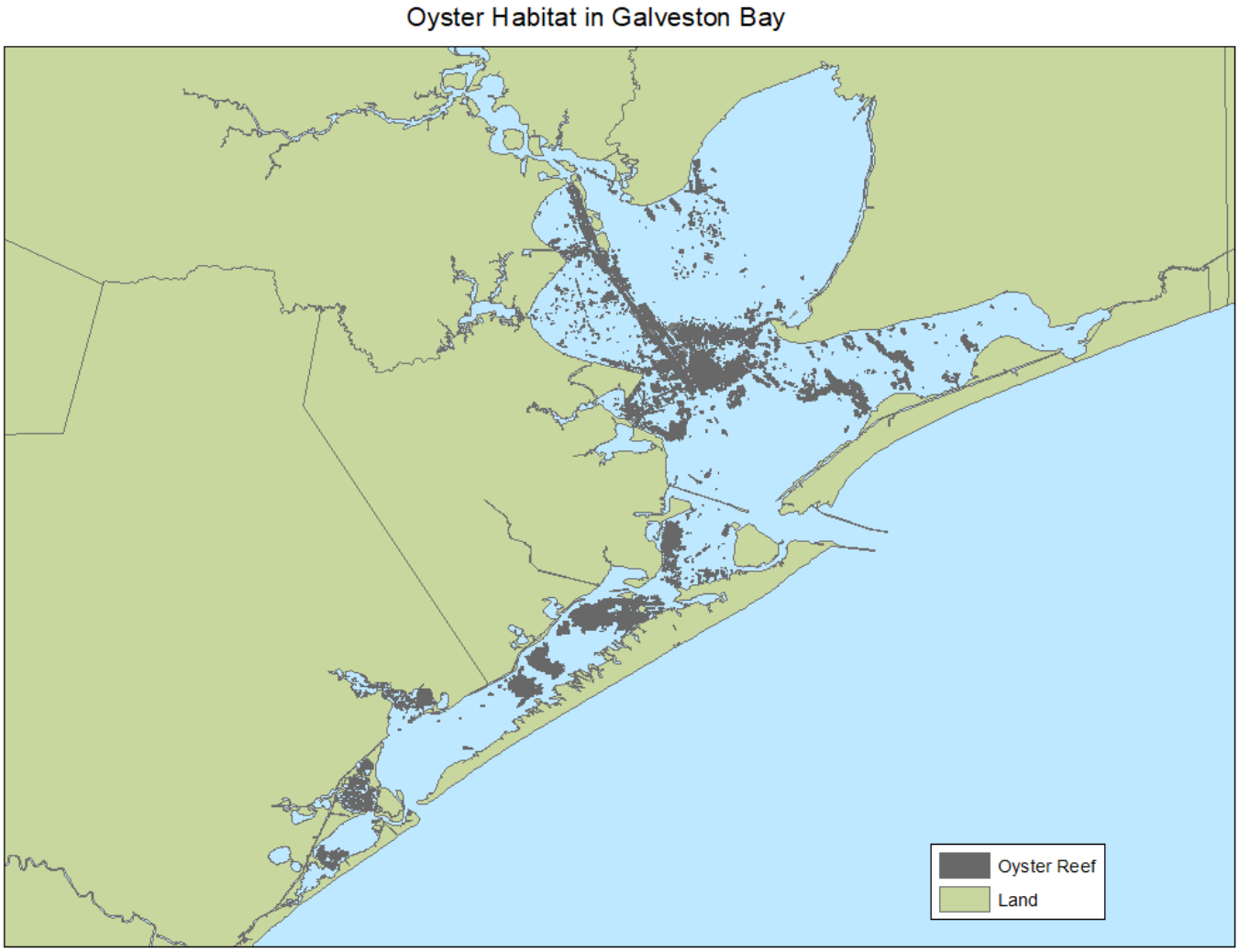


Figure 2. Oyster reefs within the Galveston Bay system based on surveys conducted during 1991 and 2008-2013 (Provided by Christine Jensen TPWD).

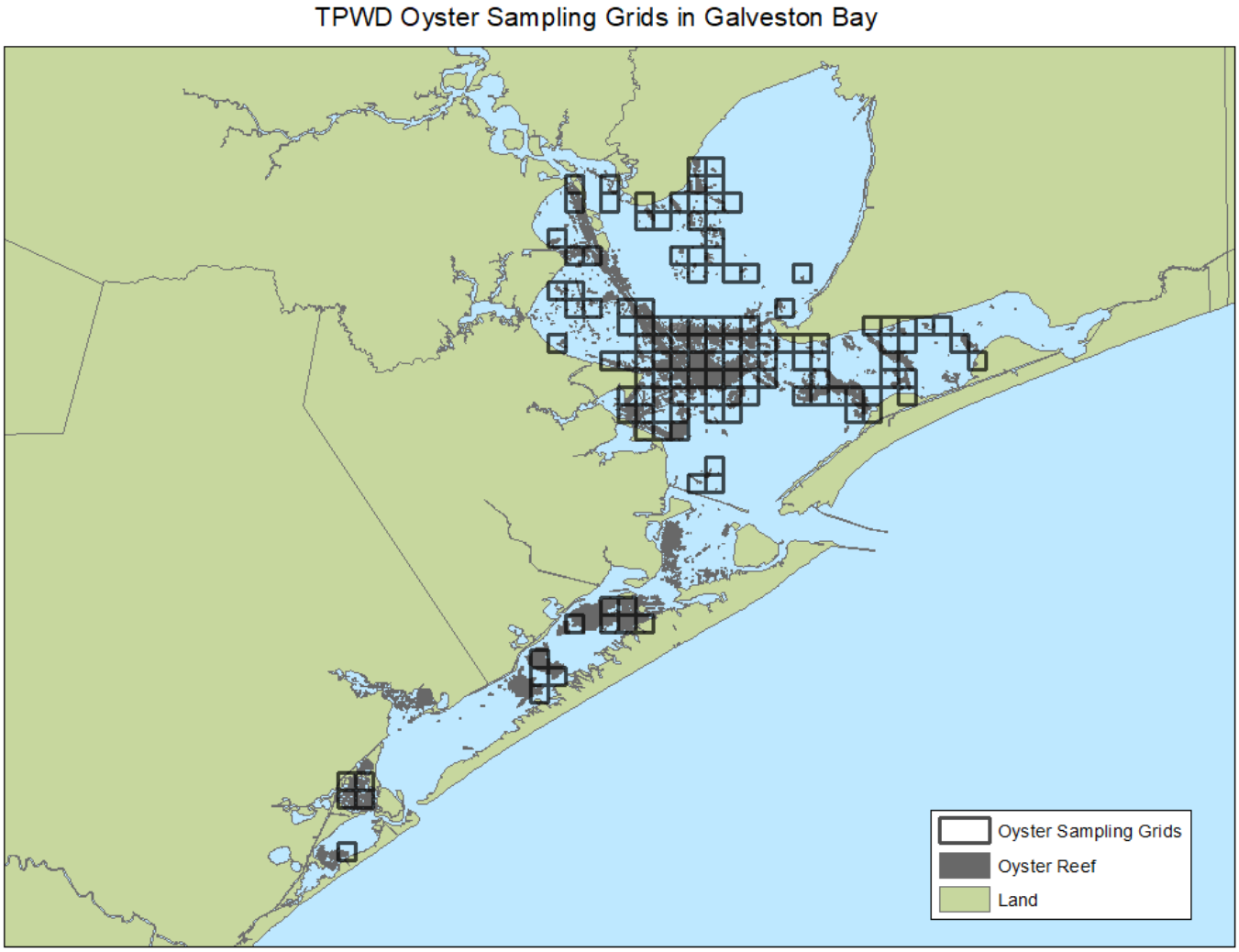


Figure 3. Sampling grid used by TPWD to select oyster reefs within the Galveston Bay system. Data depicted is from 2019.

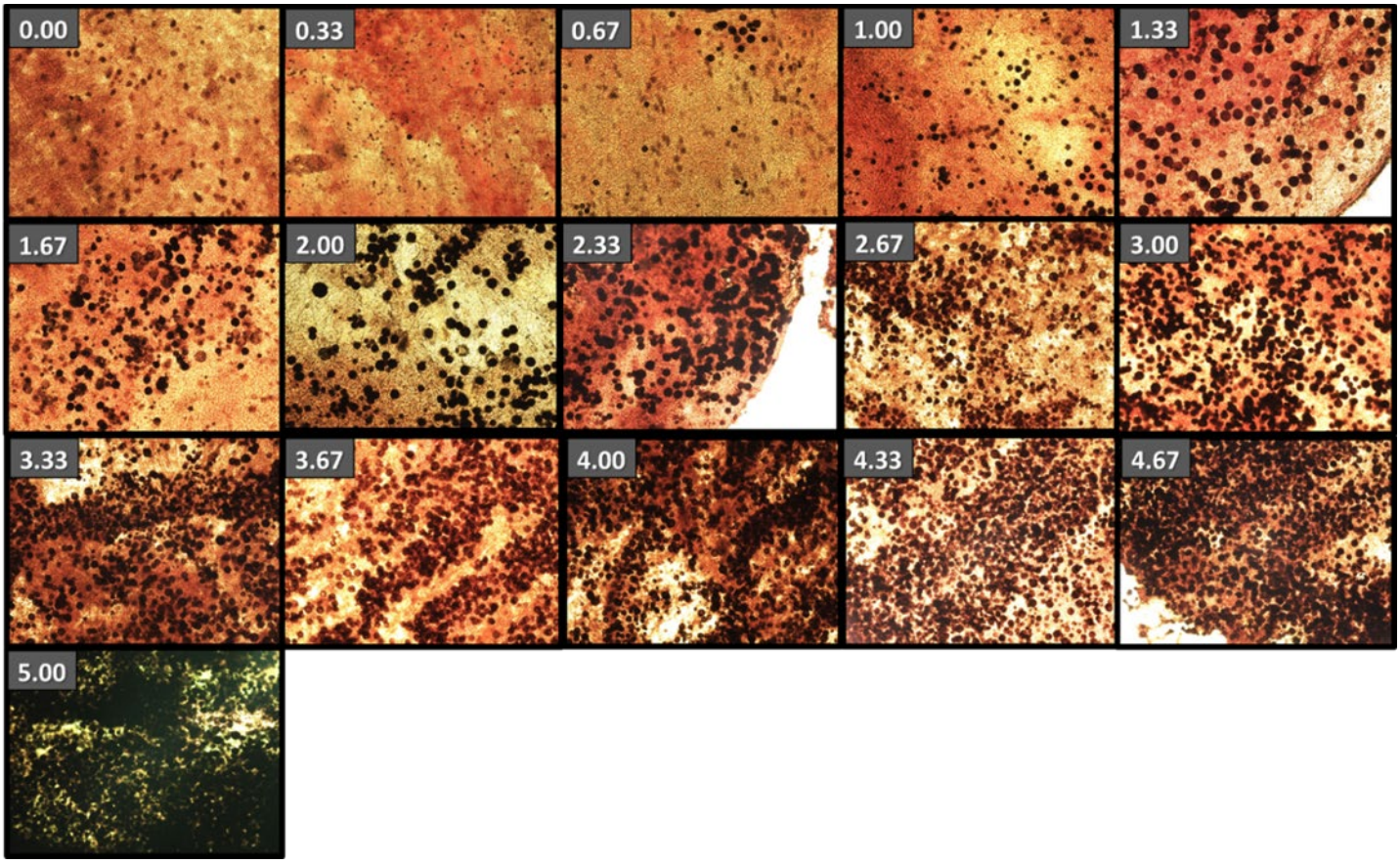


Figure 4. Examples of tissue pathology slides showing the range of Dermo intensity rating using Ray's Fluid Thioglycollate Method (RFTM) and Mackin (1962) 0-5 scale as modified by Craig et al. (1989).

SECTION FIVE: BUDGET DETAILS

BUDGET CATEGORIES:		Budget
a.	Personnel/Salary: (2 graduate students 100%; 1 senior staff 63-75%; PI 4-8%)	$ 161,338.01
b.	Fringe Benefits: (PI and senior staff32%; grad students – 9%)	$33,688.16
c.	Travel: 1 in-state conf; 1 out of state	$4,335.50
d.	Supplies: reagents, small salinity meters; oyster tong & dredge	$19,918.00
e.	Equipment (none requested)	0
f.	Contractual	0
g.	Construction	0
h.	Other* Vessel day rates, field mileage rate, grad student stipend, conference registration	$900.00
i.	Total Direct Costs (Sum a - h)	$245,216.67
j.	Indirect Costs Off Campus (Basis: 22% MTDC)	$52,187.67
k.	Total (Sum of i & j)	$297,404.33

*Other: If Budget Category "Other" is greater than $25,000 or more than 10% of budget total, identify the main constituents:

Indirect Cost Agreement

Indirect Cost Reimbursable Rate: The reimbursable rate for this Contract is 22% of (check one):

☐ salary and fringe benefits
☒ modified total direct costs
☐ other direct costs base
If other direct cost base, identify:

This rate is less than or equal to (check one):
☒ Predetermined Rate—an audited rate that is not subject to adjustment.
☐ Negotiated Predetermined Rate—an experienced-based predetermined rate agreed to by Performing Party and TCEQ. This rate is not subject to adjustment.
☐ Default rate—a standard rate of ten percent of salary/wages may be used in lieu of determining the actual indirect costs of the service.

Please see attached "Appendix 1- 2020 UHCL IDC Agreement" for the federally negotiated indirect cost agreement for the University of Houston-Clear Lake which is 22% of the modified total direct costs (which excludes equipment over $5,000 in value) for all "off campus" grants or contracts.

Please Submit Project Proposals (Microsoft Word Only – No PDFs) by August 4, 2023 to:

M&R Subcommittee
Cassandra.Taylor@tceq.texas.gov

Galveston Bay Estuary Program
FY 2025 M&R Project Proposal

Please complete the proposal form and submit to the appropriate Subcommittee Coordinator (end of form) by August 4, 2023. No late submittals will be considered for funding.

SECTION ONE: GENERAL INFORMATION

Subcommittee:

M&R

Project Name:

Ecological distribution and associated biomarkers of toxicity of microplastics exposure in Galveston Bay

Project Previously Funded by GBEP? Yes ☐ No ☒

Lead Implementer:

Texas A&M University at Galveston (Public University)

☐ Federal, State, or Local Government ☐ Council of Government ☒ Public ISDs or Universities
☐ Nonprofit ☐ Other*

* If lead implementer not listed above, the proposing party will need to partner with an interlocal/interagency entity to be selected for funding. Please reach out to GBEP staff with any questions.

Contact Information:

Project Representative Name	Dr. David Hala
Project Representative Phone	409-795-8072
Project Representative Email	halad@tamug.edu

Amount Requested:

$118,306

Is the project scalable? ☐

Amount Requested per year (if applicable):

FY 2025 (09/01/2024-08/31/2025)	$56,259
FY 2026 (09/01/2025-08/31/2026)	$62,047
FY 2027 (09/01/2026-05/31/2027)	$0.00
Total	$118,306

Total Project Cost:

$118,306

Is this an estimate? ☐

Project Duration (beginning no earlier than September 1, 2024 – 2.5 year maximum project length):

September 1, 2024 – August 31, 2026 (2 years)

Project Urgency:

This project will use novel and highly sensitive mass spectrometry (Pyrolysis – GCMS) to measure microplastics levels in the surface waters and biota (oysters, fish) of Galveston Bay. Stress biomarker enzyme activities in biota will also be measured for risk assessment analysis of adverse health effects.

Leveraging (in-kind and/or cash):

None declared at this time.

Partners and Their Roles:

Ms. Christine Jensen, Coastal Fisheries Division, Texas Parks and Wildlife Department

SECTION TWO: *GALVESTON BAY PLAN, 2ND EDITION* IMPLEMENTATION

Galveston Bay Plan, 2nd Edition References
https://gbep.texas.gov/ensure-safe-human-and-aquatic-life-use/
https://gbep.texas.gov/protect-and-sustain-living-resources/
https://gbep.texas.gov/engage-communities/
https://gbep.texas.gov/inform-science-based-decision-making/

Action Plan: Collaborate with Research Institutions to Support Focus Area Applied Research and Monitoring (RES)

The proposed project aligns with GBEP's **RES-1** priority area as it will study the extent to which resident biota species (oysters, fish) in Galveston Bay are exposed to micro- and nanoplastics particles, and determine whether the microplastics body-burdens are likely to cause adverse health effects.

Action plan: The plan for the proposed project is to assess the extent of micro- and nanoplastics presence in the surface waters of Galveston Bay and their bioaccumulation in biota spanning various tropic levels in Galveston Bay (oysters, fish). In addition, commonly used enzyme biomarkers of oxidative stress will be used to determine whether micro- and nanoplastics exposure is likely causing adverse health effects (i.e., excessive redox stress which can cause inflammation, cell membrane, or DNA damage). The focus will be on oysters and fish as they play an important economic and ecological role in the bay. Biota samples will be obtained through long standing collaboration with TPWD at the Dickinson Marine Labs.

Action: Preliminary studies performed by the co-PI, Kaiser, have shown highly variable microplastics levels in the surface waters of Galveston Bay (**Fig. 1 (a)**), and with recent numeric modeling showing more localized clustering of heavier microplastics/plastics particles ($\geq$ 5 mm) vs. microplastics particles only in size range (1 µm – 5 mm) (**Fig. 1 (b)**). Overall, there is a lack of data on the bioaccumulation of micro- and nanoplastics particles (size range $\leq$ 1 µm) in the tissues (liver, muscle) of biota (oysters, fish) from the bay. The preliminary data on microplastics levels in Galveston Bay surface waters indicates a much broader distribution of 'smaller' microplastics particles (i.e., 5 µm – 5 mm) vs. 'larger' particles ($\geq$ 5 mm). Therefore, we expect more widespread bioaccumulation of micro- and nanoplastics particles in the biota of the bay.

Finally, preliminary studies performed by P.I.'s Hala, Kaiser, and Quigg have shown the preferential bioaccumulation of three major classes of micro- and nanoplastics particles in oysters and select fish species from Galveston Bay (**Fig. 2**). Namely, these are polyethylene, polypropylene, and nylon-66. The levels of all three microplastics particles were detected at $\leq$ 3 µg/gram tissue (muscle for fish, gill/mantle for oysters). In addition, the PI (Hala) also has prior experience with the measurement of stress enzyme biomarker analysis in fish collected from Galveston Bay and the northwestern Gulf of Mexico (Cullen et al., 2019).

Galveston Bay Plan Priority Area Actions Addressed:
Plan Priority 4: Inform Science-based Decision Making

RES-1 ☒	RES-2 ☐	RES-3 ☐	RES-4 ☐
RES-5 ☒	RES-6 ☐	RES-7 ☐	RES-8 ☐
ACS-1 ☐	ACS-2 ☐	ACS-3 ☐	

Plan Priority Area Actions Detail:

This project aims to increase the current understanding of the ecological distribution of micro- and nanoplastics particles in Galveston Bay. The project will use highly sensitive and selective mass spectrometry (Pyrolysis – GCMS) to quantify the levels of up to 12 micro- and nanoplastics polymers in the surface waters and biota (oysters, fish) from Galveston Bay. In addition, the physiological effects of micro- and nanoplastics body-burdens in the resident biota will be determined by quantifying the activities of stress enzyme biomarkers. The specific priority area actions addressed are as follows:

RES-1: Conduct Biological Stressor Monitoring and Research

Problem addressed: The surface waters of Galveston Bay have been shown to be polluted with microplastics. However, there is a lack of knowledge on micro- and nanoplastics body-burdens in the exposed biota, and assessment of whether micro- and nanoplastics exposure is causing adverse health effects in the biota.

Relevance: The proposed study complements existing GBEP funded research projects (as performed by other research teams) that are studying the extent of microplastics pollution in the surface waters and sediments of Galveston Bay. The proposed project complements existing GBEP funded studies as it focusses attention on quantifying micro- and nanoplastics particles ($\leq$ 1 μm size range) that are not easily detectable or quantifiable using existing analysis methods, such as microscopy or Fourier Transformed Infrared (FTIR) spectroscopy. In addition, there is a lack of studies examining whether elevated micro- and nanoplastics body-burdens can induce adverse biomarker responses (and likely cause adverse health effects). As a result, this study will measure hepatic tissue levels of oxidative stress enzyme activities as biomarkers of exposure and adverse effects.

Action: We will determine microplastics levels and stress enzyme biomarker activity in biota (oysters, fish) sampled from Galveston Bay.

Outcome/goal: The results of this project can assist risk assessment efforts to associate microplastics exposures (or bioaccumulated body-burdens) with adverse health effects of oysters and fish in Galveston Bay.

RES-5: Conduct Monitoring and Research to Address Limits to Seafood Consumption

Problem addressed: The Galveston Bay watershed receives discharges from major industrial, agricultural, and municipal effluents and has intense shipping traffic. These various inputs into the bay are sources of legacy (PAHs, PCBs, Dioxins) and emerging (pharmaceuticals, microplastics) pollutants. Currently funded studies by GBEP have shown the widespread presence of microplastics particles in the surface waters of Galveston Bay (typical size range from 1 μm - 5 mm). While these studies highlight the likely exposure of aquatic biota to microplastics, there is a lack of information on the body-burdens of microplastics in the biota (oysters, fish) from the bay.

Relevance: Preliminary studies by P.I.'s Hala, Kaiser, and Quigg have shown microplastics particles in the size range of $\leq$ 1 μm to readily bioaccumulate in the tissues of oysters (gill/mantle) and fish (muscle, liver). The most prominent particles measured included polyethylene, polypropylene, and nylon-66. The levels of all three were detected at $\leq$ 3 μg/gram tissue (muscle for fish, gill/mantle for oysters) (**Fig. 2**).

Action/Outcome: This project will quantify the extent to which there is microplastics exposure and bioaccumulation in biota from Galveston Bay. In relevance to the RES-5 priority a dietary risk assessment will also be undertaken to estimate likely human exposure from the consumption of microplastics-tainted seafood (oysters, fish muscle),

Does the project implement any other Galveston Bay Plan Priority Area Actions, or the other Subcommittee priorities?

☒ WSQ (Ensure Safe Human and Aquatic Life Use)
☐ NRU (Protect and Sustain Living Resources)
☐ PPE (Engage Communities)

Other Subcommittee Detail:

The results of this project will be of relevance to the WSQ Subcommittee as it will quantify the extent to which microplastics bioaccumulate in biota from Galveston Bay. This knowledge will enable a dietary risk assessment to be performed to estimate likely human exposure from the consumption of microplastics-tainted seafood (oysters, fish muscle).

Other Plans Implemented:

None currently.

SECTION THREE: SUBCOMMITTEE PRIORITIES

M&R Subcommittee Identified Priorities
Proposals must address one or more of the following actions:

☒ Meaningful and effective monitoring of existing and new projects (NRU/WSQ/PPE support)
☒ Exposure and response to emerging contaminants across trophic levels
☐ Reestablishing dermo monitoring programs (Ex. Oyster Sentinel)
☐ Project Component: Results translated to plain language/practical knowledge

Subcommittee Priority Detail:

The proposed project addresses the M&R Subcommittee's identified priorities as follows:

1) Meaningful and effective monitoring:

- The project will use highly sensitive and selective mass spectrometry (Pyrolysis – GCMS) to quantify the levels of up to 12 microplastics polymers in the surface waters and biota (oysters, fish) from Galveston Bay.
- The proposed project complements existing GBEP funded studies as it focuses attention on quantifying microplastics particles ($\leq$ 1 µm size range) that are not easily detectable or quantifiable using currently applied analysis methods, such as microscopy or Fourier Transformed Infrared (FTIR) spectroscopy.

2) Exposure response across trophic levels:

- The project will use enzyme biomarkers of oxidative stress to determine whether microplastics exposure and bioaccumulation in biota is causing adverse health effects (i.e., excessive redox stress which can cause inflammation, cell membrane, or DNA damage).
- The knowledge of microplastics body-burdens in biota will enable a dietary risk assessment to be performed to estimate likely human exposure from the consumption of microplastics-tainted seafood (oysters, fish muscle).

Does the Project work with new, smaller communities/partnerships?

☐ Yes
☐ No

To be determined.

SECTION FOUR: PROPOSAL DETAILS

Project Summary:

This project will assess the extent of microplastics pollution in the surface waters of Galveston Bay and their bioaccumulation in resident biota (oysters, fish). In addition, stress enzyme biomarker activity in biota will also be measured to assess whether there are adverse health effects related to microplastics exposure.

Full Project Description (1,000 words or less):

The major goal of this project is to quantify micro- and nanoplastics (≤ 1 µm size range) levels in the surface waters of Galveston Bay and those bioaccumulated in the tissues of biota (oysters, fish). In addition, the activities of oxidative stress enzymes will also be measured in the tissues of biota to determine adverse health effects.

Rationale: Plastics were first invented in the 1940s and are widely used in various domestic and industrial products due to their flexible, lightweight, durable, and low thermo-conductive properties (Andrady, 2011). The global production of plastics has increased from 15 million tons to 335 million tons in the last 70 years (Dawson et al., 2018; Gall & Thompson, 2015). Plastics are made of synthetic polymers such as lipophilic polyethylene, polypropylene, polystyrene, polyolefin, polyethylene terephthalate, polyvinyl chloride. They are introduced into the environment from industrial or domestic sources. Examples include pellets, fibers, films, microbeads etc. that can be made into consumer or industrial products. Over time, these products can degrade to form microplastics of various shapes such as disks, fragments, fibers, and particles. A size range of 8-10 µm is typically found in the gills and digestive tract of aquatic biota. While large plastics particles (>5 mm) can physically block the intestine of organism, causing death through starvation, smaller particles (i.e., ≤ 1 µm to 5 mm) can penetrate various tissue and affect enzymatic activity and cell metabolism. Some health hazards of micro- and nanoplastics include induction of oxidative stress, genotoxicity (i.e., DNA damage), and changes in cellular physiology (LeMoine et al., 2018). The biomagnification of micro- and nanoplastics across food webs can ultimately pose a hazard to human health through the consumption of tainted sea food.

Significance and Dissemination of Research: The proposed study complements existing GBEP funded research studying microplastics pollution in the surface waters and sediments of Galveston Bay. The proposed project complements these studies as it focusses attention on quantifying micro- and nanoplastics levels (≤ 1 µm size range) that are not easily detectable or quantifiable using existing analysis methods, such as microscopy or Fourier Transformed Infrared (FTIR) spectroscopy. In addition, there is a lack of studies examining whether elevated microplastics body-burdens can cause adverse biomarker responses. As a result, this study will also measure hepatic tissue levels of oxidative stress enzyme activities as biomarkers of exposure and adverse effects.

Hypothesis/Objectives:

Overall objective: To determine micro- and nanopplastics levels surface waters and biota of Galveston Bay, and measure stress enzyme biomarker activities in biota (oysters, fish) to assess adverse health effects.
Central hypothesis: Elevated micro- and nanoplastics exposure and bioaccumulation will positively correlate with increased activities of stress enzymes, indicating the adverse effects of exposure.
Specific Objective 1: Quantify micro- and nanoplastics levels in surface waters and tissues of biota sampled from Galveston Bay (gill/mantle of oysters; and muscle, liver in fish).
Specific Objective 2: Quantify oxidative stress enzyme biomarkers in tissues of biota.

Experimental Design and Methods: Surface water samples will be sampled from various dock-side sampling locations for micro- and nanoplastics analysis. Furthermore, previously archived (sampled in 2021) tissue samples from Eastern oysters and fish (i.e., red drum, spotted seatrout, and gafftopsail catfish) will be analyzed for micro- and nanoplastics body-burdens. More recently sampled fish (obtained in collaboration

with TPWD) will also be processed for micro- and nanoplastics and stress enzyme biomarker analysis. Micro- and nanoplastics levels will be measured using a Frontier Laboratories Auto-shot sampler pyrolizer in conjunction with an Agilent 8890 GC System coupled with Agilent 7010B Triple Quadrupole GC/MS. Whereas enzyme activities will be quantified using existing methods and a Cytation 5 spectrophotometer.

Preliminary Data: The levels of up to 12 microplastics polymers have been quantified in the surface waters of Galveston Bay (**Fig. 1**). The microplastics measured included: Polyethylene (PE), polypropylene (PP), polystyrene (PS), styrene butadiene rubber (SBR), polyvinyl chloride (PVC), polyamide N-6 (PA), nylon-66 (N66), polycarbonate (PC), polyurethane (PUR), poly(methyl methacrylate) (PMMA), polyethylene terephthalate (PET) and Acrylonitrile butadiene styrene (ABS). Overall, higher surface levels of microplastics particles (≥20 µg/L sum total) are evident closer to highly urbanized areas such as Clear Creek and Dickinson Bayou (relative to the less industrialized areas of Trinity Bay and Smith Point) (**Fig. 1 (a)**).

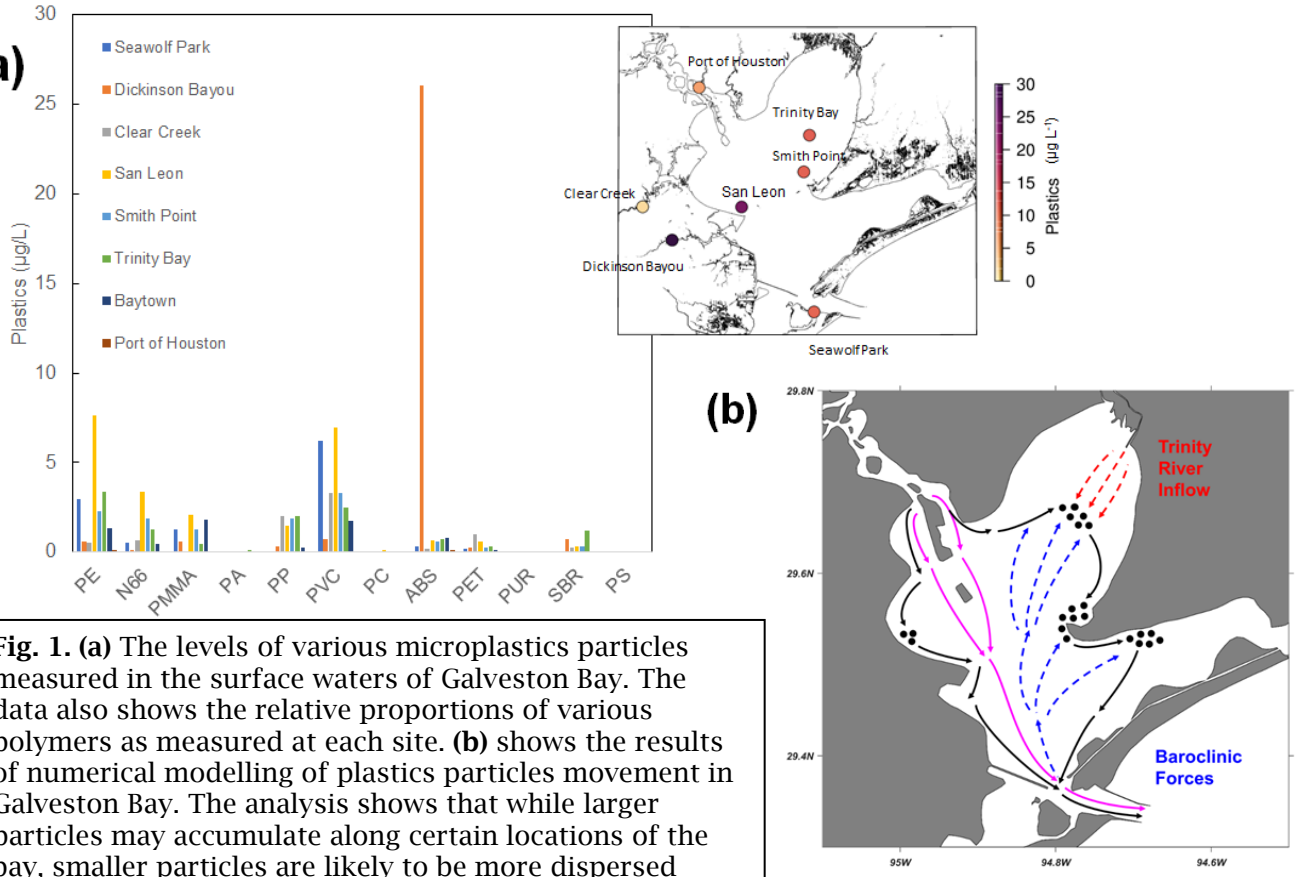


Fig. 1. (a) The levels of various microplastics particles measured in the surface waters of Galveston Bay. The data also shows the relative proportions of various polymers as measured at each site. **(b)** shows the results of numerical modelling of plastics particles movement in Galveston Bay. The analysis shows that while larger particles may accumulate along certain locations of the bay, smaller particles are likely to be more dispersed throughout the bay, and therefore likely to be more bioavailable to resident biota (Summers et al., in press).

Numerical simulations were used to model the transport of microplastic particles in Galveston Bay when released from Buffalo Bayou (**Fig. 1 (b)**). Black and pink arrows indicate likely pathways of negatively and neutrally buoyant particles, respectively. The blue arrows indicate baroclinic forcing in the lower layer, and high frequency clustering areas of relatively heavy particles are indicated with black dots.

Finally, the preliminary analysis of micro- and nanoplastics bioaccumulation in biota from Galveston Bay showed the prominent plastics in fish and oysters to be N66 (Nylon), PE (Polyethylene) and PP (Polypropylene) (**Fig. 2**). Traces of PMMA (Poly(methyl methacrylate) was found in Red drum and Seatrout; PVC (Polyvinyl chloride) was found in Seatrout and Rubber (SBR) in oysters. Our results show that oyster seemed to have the highest concentration of N66, PE and PP. There seems to be a trend with oyster showing the highest concentrations of plastics followed by Catfish and Seatrout. Red drums had the lowest concentration. Overall, the highest levels detected in biota are in range of up to ~3000 µg/g of tissue.

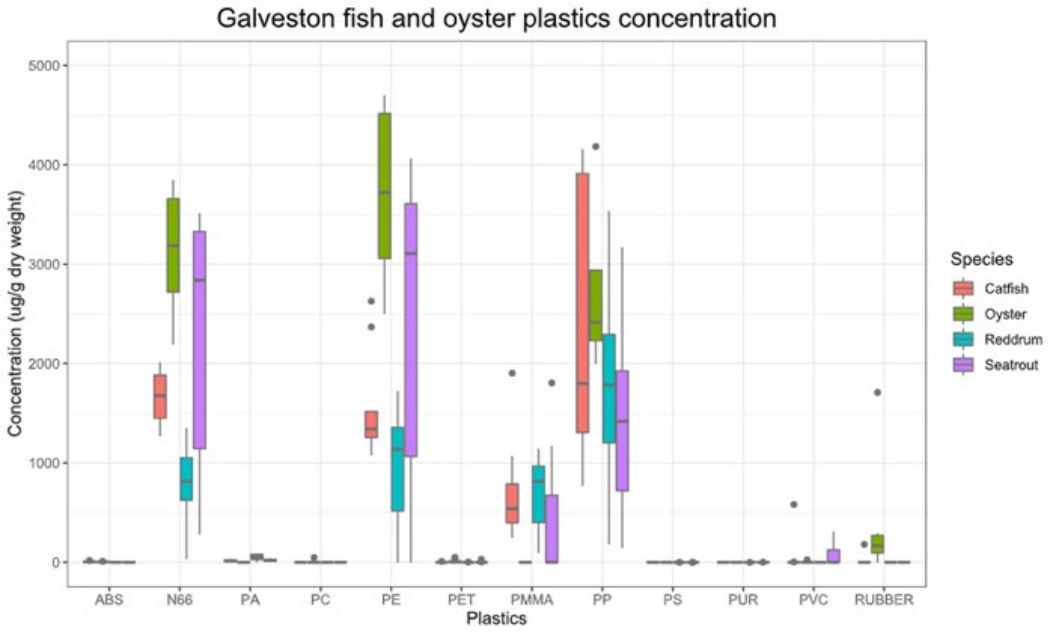


Fig. 2. Micro- and nanoplastics concentrations of fish (Catfish, Red drum, Seatrout) and oyster collected from Galveston Bay, reported in µg/g dry weight.

Potential Impact and Project Outcomes: The data generated will allow for correlation of micro- and nanoplastics levels with physiological effects (i.e., induced biomarker responses) and provide a framework for the risk assessment of exposure and adverse effects in aquatic biota, and by extension, likely human exposure through the consumption of tainted seafood.

References cited:

Andrady, A. L. (2011). Marine pollution bulletin, 62(8), 1596-1605.
Cullen, J. A., et al., (2019). Science of The Total Environment, 650, 1158-1172.
Dawson, A., et al., (2018). Environmental science & technology, 52(5), 3195-3201.
Gall, S. C., & Thompson, R. C. (2015). Marine pollution bulletin, 92(1-2), 170-179.
LeMoine, et al., (2018). Environmental pollution, 243, 591-600.
Summers et al., in press. Science of the Total Environment.

Latitude/Longitude (Optional):

N/A

Location:

Field sampling in Galveston Bay will comprise randomized sampling for biota (as performed by TPWD), and dockside sampling for surface water samples at sites including (but not limited to): Port of Houston, Trinity Bay, Smith Point, Clear Creek, San Leon, Dickinson Bayou, and Seawolf Parkway. Laboratory analysis will be performed at the research facilities of Texas A&M University at Galveston (TAMUG).

Projects Map

Not Applicable

Supplemental Photos/Graphics (Optional):

Not Applicable

SECTION FIVE: BUDGET DETAILS

BUDGET CATEGORIES:		Budget
a.	Personnel/Salary	$38,489
b.	Fringe Benefits	$9,243
c.	Travel	$2,000
d.	Supplies	$14,000
e.	Equipment	Not requested
f.	Contractual	Not requested
g.	Construction	Not requested
h.	Other*	$17,630
i.	Total Direct Costs (Sum a - h)	$81,362
j.	Indirect Costs	$36,944
k.	Total (Sum of i & j)	$118,306

*Other: If Budget Category "Other" is greater than $25,000 or more than 10% of budget total, identify the main constituents:

-$5,000: Maintenance service costs for analytical instruments
-$600: Conference registration
-$12,030: Graduate student tuition & fees

Indirect Cost Agreement

Indirect Cost Reimbursable Rate: The reimbursable rate for this Contract is 52.5% (Year 1) and 54.0% (Year 2) of (check one):

☐ salary and fringe benefits
☒ modified total direct costs
☐ other direct costs base
If other direct cost base, identify:

This rate is less than or equal to (check one):
☒ Predetermined Rate—an audited rate that is not subject to adjustment.
☐ Negotiated Predetermined Rate—an experienced-based predetermined rate agreed to by Performing Party and TCEQ. This rate is not subject to adjustment.
☐ Default rate—a standard rate of ten percent of salary/wages may be used in lieu of determining the actual indirect costs of the service.

Indirect Cost Rate Agreement dated 9/2/2022 is attached as an Appendix.
Cognizant Federal Agency: Department of Health & Human Services, Denise Shirlee, (214) 767-3261

Please Submit Project Proposals (Microsoft Word Only – No PDFs) by August 4, 2023 to:

WSQ Subcommittee
Christian.Rines@tceq.texas.gov

NRU Subcommittee
Lindsey.Lippert@tceq.texas.gov

PPE Subcommittee
Kari.Howard@tceq.texas.gov

M&R Subcommittee
Cassandra.Taylor@tceq.texas.gov

Galveston Bay Estuary Program
FY 2025 M&R Project Proposal

Please complete the proposal form and submit to the appropriate Subcommittee Coordinator (end of form) by August 4, 2023. No late submittals will be considered for funding.

SECTION ONE: GENERAL INFORMATION

Subcommittee:

M&R

Project Name:

Ecological distribution and associated biomarkers of toxicity of microplastics exposure in Galveston Bay

Project Previously Funded by GBEP? Yes ☐ No ☒

Lead Implementer:

Texas A&M University at Galveston (Public University)

☐ Federal, State, or Local Government ☐ Council of Government ☒ Public ISDs or Universities
☐ Nonprofit ☐ Other*

* If lead implementer not listed above, the proposing party will need to partner with an interlocal/interagency entity to be selected for funding. Please reach out to GBEP staff with any questions.

Contact Information:

Project Representative Name	Dr. David Hala
Project Representative Phone	409-795-8072
Project Representative Email	halad@tamug.edu

Amount Requested:

$118,306

Is the project scalable? ☐

Amount Requested per year (if applicable):

FY 2025 (09/01/2024-08/31/2025)	$56,259
FY 2026 (09/01/2025-08/31/2026)	$62,047
FY 2027 (09/01/2026-05/31/2027)	$0.00
Total	$118,306

Total Project Cost:

$118,306

Is this an estimate? ☐

Project Duration (beginning no earlier than September 1, 2024 – 2.5 year maximum project length):

September 1, 2024 – August 31, 2026 (2 years)

Project Urgency:

This project will use novel and highly sensitive mass spectrometry (Pyrolysis – GCMS) to measure microplastics levels in the surface waters and biota (oysters, fish) of Galveston Bay. Stress biomarker enzyme activities in biota will also be measured for risk assessment analysis of adverse health effects.

Leveraging (in-kind and/or cash):

None declared at this time.

Partners and Their Roles:

Ms. Christine Jensen, Coastal Fisheries Division, Texas Parks and Wildlife Department

SECTION TWO: *GALVESTON BAY PLAN, 2ND EDITION* IMPLEMENTATION

Galveston Bay Plan, 2nd Edition References
https://gbep.texas.gov/ensure-safe-human-and-aquatic-life-use/
https://gbep.texas.gov/protect-and-sustain-living-resources/
https://gbep.texas.gov/engage-communities/
https://gbep.texas.gov/inform-science-based-decision-making/

Action Plan: Collaborate with Research Institutions to Support Focus Area Applied Research and Monitoring (RES)

The proposed project aligns with GBEP's **RES-1** priority area as it will study the extent to which resident biota species (oysters, fish) in Galveston Bay are exposed to micro- and nanoplastics particles, and determine whether the microplastics body-burdens are likely to cause adverse health effects.

Action plan: The plan for the proposed project is to assess the extent of micro- and nanoplastics presence in the surface waters of Galveston Bay and their bioaccumulation in biota spanning various tropic levels in Galveston Bay (oysters, fish). In addition, commonly used enzyme biomarkers of oxidative stress will be used to determine whether micro- and nanoplastics exposure is likely causing adverse health effects (i.e., excessive redox stress which can cause inflammation, cell membrane, or DNA damage). The focus will be on oysters and fish as they play an important economic and ecological role in the bay. Biota samples will be obtained through long standing collaboration with TPWD at the Dickinson Marine Labs.

Action: Preliminary studies performed by the co-PI, Kaiser, have shown highly variable microplastics levels in the surface waters of Galveston Bay (**Fig. 1 (a)**), and with recent numeric modeling showing more localized clustering of heavier microplastics/plastics particles ($\geq$ 5 mm) vs. microplastics particles only in size range (1 µm – 5 mm) (**Fig. 1 (b)**). Overall, there is a lack of data on the bioaccumulation of micro- and nanoplastics particles (size range $\leq$ 1 µm) in the tissues (liver, muscle) of biota (oysters, fish) from the bay. The preliminary data on microplastics levels in Galveston Bay surface waters indicates a much broader distribution of 'smaller' microplastics particles (i.e., 5 µm – 5 mm) vs. 'larger' particles ($\geq$ 5 mm). Therefore, we expect more widespread bioaccumulation of micro- and nanoplastics particles in the biota of the bay.

Finally, preliminary studies performed by P.I.'s Hala, Kaiser, and Quigg have shown the preferential bioaccumulation of three major classes of micro- and nanoplastics particles in oysters and select fish species from Galveston Bay (**Fig. 2**). Namely, these are polyethylene, polypropylene, and nylon-66. The levels of all three microplastics particles were detected at $\leq$ 3 µg/gram tissue (muscle for fish, gill/mantle for oysters). In addition, the PI (Hala) also has prior experience with the measurement of stress enzyme biomarker analysis in fish collected from Galveston Bay and the northwestern Gulf of Mexico (Cullen et al., 2019).

Galveston Bay Plan Priority Area Actions Addressed:
Plan Priority 4: Inform Science-based Decision Making

RES-1 ☒	RES-2 ☐	RES-3 ☐	RES-4 ☐
RES-5 ☒	RES-6 ☐	RES-7 ☐	RES-8 ☐
ACS-1 ☐	ACS-2 ☐	ACS-3 ☐	

Plan Priority Area Actions Detail:

This project aims to increase the current understanding of the ecological distribution of micro- and nanoplastics particles in Galveston Bay. The project will use highly sensitive and selective mass spectrometry (Pyrolysis – GCMS) to quantify the levels of up to 12 micro- and nanoplastics polymers in the surface waters and biota (oysters, fish) from Galveston Bay. In addition, the physiological effects of micro- and nanoplastics body-burdens in the resident biota will be determined by quantifying the activities of stress enzyme biomarkers. The specific priority area actions addressed are as follows:

RES-1: Conduct Biological Stressor Monitoring and Research

Problem addressed: The surface waters of Galveston Bay have been shown to be polluted with microplastics. However, there is a lack of knowledge on micro- and nanoplastics body-burdens in the exposed biota, and assessment of whether micro- and nanoplastics exposure is causing adverse health effects in the biota.

Relevance: The proposed study complements existing GBEP funded research projects (as performed by other research teams) that are studying the extent of microplastics pollution in the surface waters and sediments of Galveston Bay. The proposed project complements existing GBEP funded studies as it focusses attention on quantifying micro- and nanoplastics particles ($\leq$ 1 μm size range) that are not easily detectable or quantifiable using existing analysis methods, such as microscopy or Fourier Transformed Infrared (FTIR) spectroscopy. In addition, there is a lack of studies examining whether elevated micro- and nanoplastics body-burdens can induce adverse biomarker responses (and likely cause adverse health effects). As a result, this study will measure hepatic tissue levels of oxidative stress enzyme activities as biomarkers of exposure and adverse effects.

Action: We will determine microplastics levels and stress enzyme biomarker activity in biota (oysters, fish) sampled from Galveston Bay.

Outcome/goal: The results of this project can assist risk assessment efforts to associate microplastics exposures (or bioaccumulated body-burdens) with adverse health effects of oysters and fish in Galveston Bay.

RES-5: Conduct Monitoring and Research to Address Limits to Seafood Consumption

Problem addressed: The Galveston Bay watershed receives discharges from major industrial, agricultural, and municipal effluents and has intense shipping traffic. These various inputs into the bay are sources of legacy (PAHs, PCBs, Dioxins) and emerging (pharmaceuticals, microplastics) pollutants. Currently funded studies by GBEP have shown the widespread presence of microplastics particles in the surface waters of Galveston Bay (typical size range from 1 μm - 5 mm). While these studies highlight the likely exposure of aquatic biota to microplastics, there is a lack of information on the body-burdens of microplastics in the biota (oysters, fish) from the bay.

Relevance: Preliminary studies by P.I.'s Hala, Kaiser, and Quigg have shown microplastics particles in the size range of $\leq$ 1 μm to readily bioaccumulate in the tissues of oysters (gill/mantle) and fish (muscle, liver). The most prominent particles measured included polyethylene, polypropylene, and nylon-66. The levels of all three were detected at $\leq$ 3 μg/gram tissue (muscle for fish, gill/mantle for oysters) (**Fig. 2**).

Action/Outcome: This project will quantify the extent to which there is microplastics exposure and bioaccumulation in biota from Galveston Bay. In relevance to the RES-5 priority a dietary risk assessment will also be undertaken to estimate likely human exposure from the consumption of microplastics-tainted seafood (oysters, fish muscle),

Does the project implement any other Galveston Bay Plan Priority Area Actions, or the other Subcommittee priorities?

☒ WSQ (Ensure Safe Human and Aquatic Life Use)
☐ NRU (Protect and Sustain Living Resources)
☐ PPE (Engage Communities)

Other Subcommittee Detail:

The results of this project will be of relevance to the WSQ Subcommittee as it will quantify the extent to which microplastics bioaccumulate in biota from Galveston Bay. This knowledge will enable a dietary risk assessment to be performed to estimate likely human exposure from the consumption of microplastics-tainted seafood (oysters, fish muscle).

Other Plans Implemented:

None currently.

SECTION THREE: SUBCOMMITTEE PRIORITIES

M&R Subcommittee Identified Priorities
Proposals must address one or more of the following actions:

☒ Meaningful and effective monitoring of existing and new projects (NRU/WSQ/PPE support)
☒ Exposure and response to emerging contaminants across trophic levels
☐ Reestablishing dermo monitoring programs (Ex. Oyster Sentinel)
☐ Project Component: Results translated to plain language/practical knowledge

Subcommittee Priority Detail:

The proposed project addresses the M&R Subcommittee's identified priorities as follows:

1) Meaningful and effective monitoring:

- The project will use highly sensitive and selective mass spectrometry (Pyrolysis – GCMS) to quantify the levels of up to 12 microplastics polymers in the surface waters and biota (oysters, fish) from Galveston Bay.
- The proposed project complements existing GBEP funded studies as it focuses attention on quantifying microplastics particles ($\leq$ 1 µm size range) that are not easily detectable or quantifiable using currently applied analysis methods, such as microscopy or Fourier Transformed Infrared (FTIR) spectroscopy.

2) Exposure response across trophic levels:

- The project will use enzyme biomarkers of oxidative stress to determine whether microplastics exposure and bioaccumulation in biota is causing adverse health effects (i.e., excessive redox stress which can cause inflammation, cell membrane, or DNA damage).
- The knowledge of microplastics body-burdens in biota will enable a dietary risk assessment to be performed to estimate likely human exposure from the consumption of microplastics-tainted seafood (oysters, fish muscle).

Does the Project work with new, smaller communities/partnerships?

☐ Yes
☐ No

To be determined.

SECTION FOUR: PROPOSAL DETAILS

Project Summary:

This project will assess the extent of microplastics pollution in the surface waters of Galveston Bay and their bioaccumulation in resident biota (oysters, fish). In addition, stress enzyme biomarker activity in biota will also be measured to assess whether there are adverse health effects related to microplastics exposure.

Full Project Description (1,000 words or less):

The major goal of this project is to quantify micro- and nanoplastics (≤ 1 µm size range) levels in the surface waters of Galveston Bay and those bioaccumulated in the tissues of biota (oysters, fish). In addition, the activities of oxidative stress enzymes will also be measured in the tissues of biota to determine adverse health effects.

Rationale: Plastics were first invented in the 1940s and are widely used in various domestic and industrial products due to their flexible, lightweight, durable, and low thermo-conductive properties (Andrady, 2011). The global production of plastics has increased from 15 million tons to 335 million tons in the last 70 years (Dawson et al., 2018; Gall & Thompson, 2015). Plastics are made of synthetic polymers such as lipophilic polyethylene, polypropylene, polystyrene, polyolefin, polyethylene terephthalate, polyvinyl chloride. They are introduced into the environment from industrial or domestic sources. Examples include pellets, fibers, films, microbeads etc. that can be made into consumer or industrial products. Over time, these products can degrade to form microplastics of various shapes such as disks, fragments, fibers, and particles. A size range of 8-10 µm is typically found in the gills and digestive tract of aquatic biota. While large plastics particles (>5 mm) can physically block the intestine of organism, causing death through starvation, smaller particles (i.e., ≤ 1 µm to 5 mm) can penetrate various tissue and affect enzymatic activity and cell metabolism. Some health hazards of micro- and nanoplastics include induction of oxidative stress, genotoxicity (i.e., DNA damage), and changes in cellular physiology (LeMoine et al., 2018). The biomagnification of micro- and nanoplastics across food webs can ultimately pose a hazard to human health through the consumption of tainted sea food.

Significance and Dissemination of Research: The proposed study complements existing GBEP funded research studying microplastics pollution in the surface waters and sediments of Galveston Bay. The proposed project complements these studies as it focusses attention on quantifying micro- and nanoplastics levels (≤ 1 µm size range) that are not easily detectable or quantifiable using existing analysis methods, such as microscopy or Fourier Transformed Infrared (FTIR) spectroscopy. In addition, there is a lack of studies examining whether elevated microplastics body-burdens can cause adverse biomarker responses. As a result, this study will also measure hepatic tissue levels of oxidative stress enzyme activities as biomarkers of exposure and adverse effects.

Hypothesis/Objectives:

Overall objective: To determine micro- and nanopplastics levels surface waters and biota of Galveston Bay, and measure stress enzyme biomarker activities in biota (oysters, fish) to assess adverse health effects.
Central hypothesis: Elevated micro- and nanoplastics exposure and bioaccumulation will positively correlate with increased activities of stress enzymes, indicating the adverse effects of exposure.
Specific Objective 1: Quantify micro- and nanoplastics levels in surface waters and tissues of biota sampled from Galveston Bay (gill/mantle of oysters; and muscle, liver in fish).
Specific Objective 2: Quantify oxidative stress enzyme biomarkers in tissues of biota.

Experimental Design and Methods: Surface water samples will be sampled from various dock-side sampling locations for micro- and nanoplastics analysis. Furthermore, previously archived (sampled in 2021) tissue samples from Eastern oysters and fish (i.e., red drum, spotted seatrout, and gafftopsail catfish) will be analyzed for micro- and nanoplastics body-burdens. More recently sampled fish (obtained in collaboration

with TPWD) will also be processed for micro- and nanoplastics and stress enzyme biomarker analysis. Micro- and nanoplastics levels will be measured using a Frontier Laboratories Auto-shot sampler pyrolizer in conjunction with an Agilent 8890 GC System coupled with Agilent 7010B Triple Quadrupole GC/MS. Whereas enzyme activities will be quantified using existing methods and a Cytation 5 spectrophotometer.

Preliminary Data: The levels of up to 12 microplastics polymers have been quantified in the surface waters of Galveston Bay (**Fig. 1**). The microplastics measured included: Polyethylene (PE), polypropylene (PP), polystyrene (PS), styrene butadiene rubber (SBR), polyvinyl chloride (PVC), polyamide N-6 (PA), nylon-66 (N66), polycarbonate (PC), polyurethane (PUR), poly(methyl methacrylate) (PMMA), polyethylene terephthalate (PET) and Acrylonitrile butadiene styrene (ABS). Overall, higher surface levels of microplastics particles (≥20 µg/L sum total) are evident closer to highly urbanized areas such as Clear Creek and Dickinson Bayou (relative to the less industrialized areas of Trinity Bay and Smith Point) (**Fig. 1 (a)**).

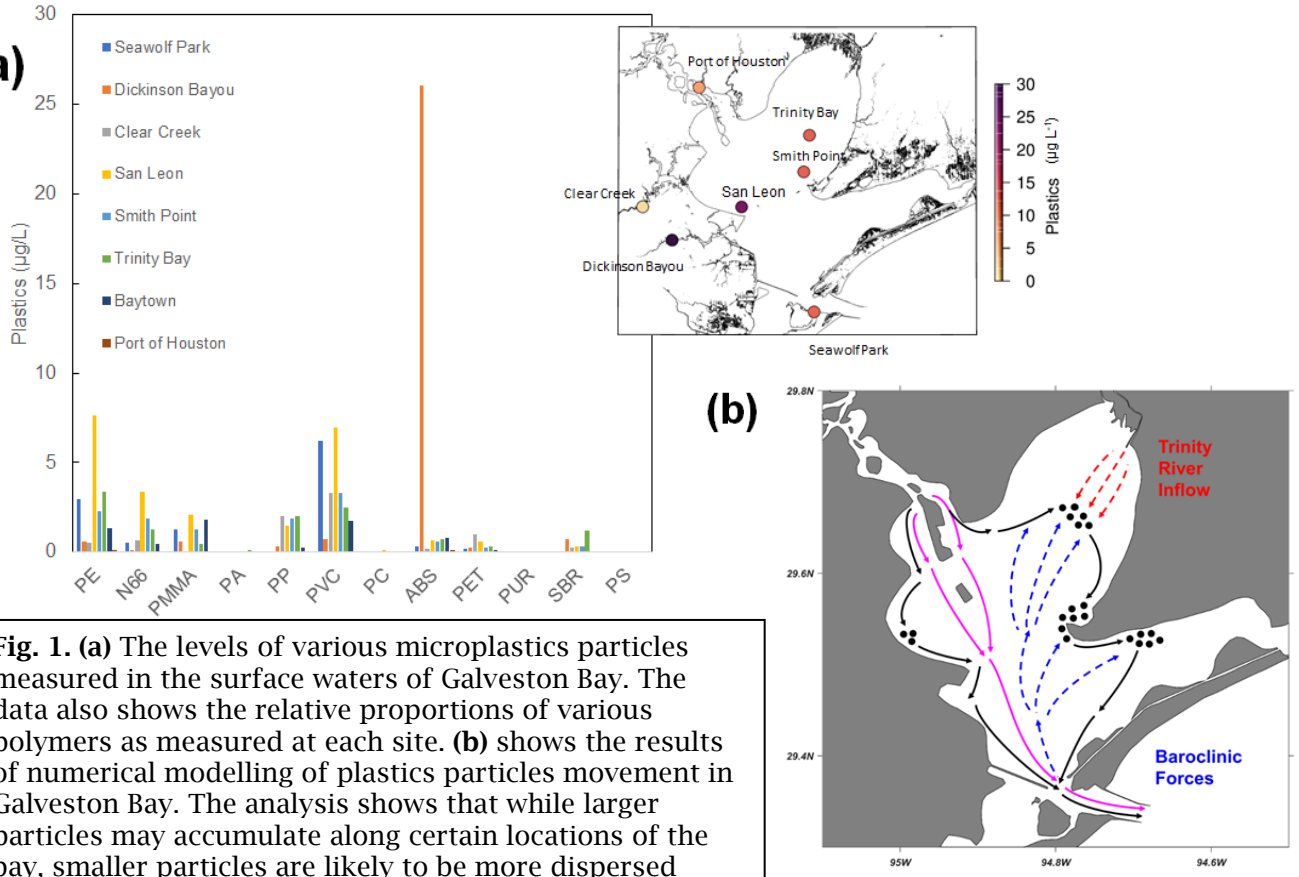


Fig. 1. (a) The levels of various microplastics particles measured in the surface waters of Galveston Bay. The data also shows the relative proportions of various polymers as measured at each site. **(b)** shows the results of numerical modelling of plastics particles movement in Galveston Bay. The analysis shows that while larger particles may accumulate along certain locations of the bay, smaller particles are likely to be more dispersed throughout the bay, and therefore likely to be more bioavailable to resident biota (Summers et al., in press).

Numerical simulations were used to model the transport of microplastic particles in Galveston Bay when released from Buffalo Bayou (**Fig. 1 (b)**). Black and pink arrows indicate likely pathways of negatively and neutrally buoyant particles, respectively. The blue arrows indicate baroclinic forcing in the lower layer, and high frequency clustering areas of relatively heavy particles are indicated with black dots.

Finally, the preliminary analysis of micro- and nanoplastics bioaccumulation in biota from Galveston Bay showed the prominent plastics in fish and oysters to be N66 (Nylon), PE (Polyethylene) and PP (Polypropylene) (**Fig. 2**). Traces of PMMA (Poly(methyl methacrylate) was found in Red drum and Seatrout; PVC (Polyvinyl chloride) was found in Seatrout and Rubber (SBR) in oysters. Our results show that oyster seemed to have the highest concentration of N66, PE and PP. There seems to be a trend with oyster showing the highest concentrations of plastics followed by Catfish and Seatrout. Red drums had the lowest concentration. Overall, the highest levels detected in biota are in range of up to ~3000 µg/g of tissue.

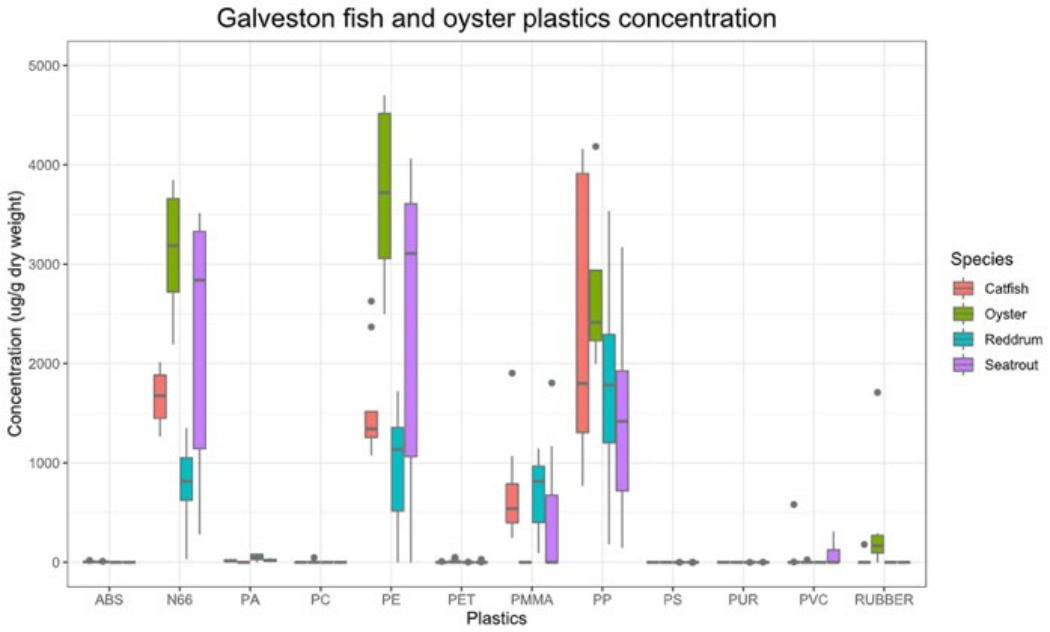


Fig. 2. Micro- and nanoplastics concentrations of fish (Catfish, Red drum, Seatrout) and oyster collected from Galveston Bay, reported in µg/g dry weight.

Potential Impact and Project Outcomes: The data generated will allow for correlation of micro- and nanoplastics levels with physiological effects (i.e., induced biomarker responses) and provide a framework for the risk assessment of exposure and adverse effects in aquatic biota, and by extension, likely human exposure through the consumption of tainted seafood.

References cited:

Andrady, A. L. (2011). Marine pollution bulletin, 62(8), 1596-1605.
Cullen, J. A., et al., (2019). Science of The Total Environment, 650, 1158-1172.
Dawson, A., et al., (2018). Environmental science & technology, 52(5), 3195-3201.
Gall, S. C., & Thompson, R. C. (2015). Marine pollution bulletin, 92(1-2), 170-179.
LeMoine, et al., (2018). Environmental pollution, 243, 591-600.
Summers et al., in press. Science of the Total Environment.

Latitude/Longitude (Optional):

N/A

Location:

Field sampling in Galveston Bay will comprise randomized sampling for biota (as performed by TPWD), and dockside sampling for surface water samples at sites including (but not limited to): Port of Houston, Trinity Bay, Smith Point, Clear Creek, San Leon, Dickinson Bayou, and Seawolf Parkway. Laboratory analysis will be performed at the research facilities of Texas A&M University at Galveston (TAMUG).

Projects Map

Not Applicable

Supplemental Photos/Graphics (Optional):

Not Applicable

SECTION FIVE: BUDGET DETAILS

BUDGET CATEGORIES:		Budget
a.	Personnel/Salary	$38,489
b.	Fringe Benefits	$9,243
c.	Travel	$2,000
d.	Supplies	$14,000
e.	Equipment	Not requested
f.	Contractual	Not requested
g.	Construction	Not requested
h.	Other*	$17,630
i.	Total Direct Costs (Sum a - h)	$81,362
j.	Indirect Costs	$36,944
k.	Total (Sum of i & j)	$118,306

*Other: If Budget Category "Other" is greater than $25,000 or more than 10% of budget total, identify the main constituents:

-$5,000: Maintenance service costs for analytical instruments
-$600: Conference registration
-$12,030: Graduate student tuition & fees

Indirect Cost Agreement

Indirect Cost Reimbursable Rate: The reimbursable rate for this Contract is 52.5% (Year 1) and 54.0% (Year 2) of (check one):

☐ salary and fringe benefits
☒ modified total direct costs
☐ other direct costs base
If other direct cost base, identify:

This rate is less than or equal to (check one):
☒ Predetermined Rate—an audited rate that is not subject to adjustment.
☐ Negotiated Predetermined Rate—an experienced-based predetermined rate agreed to by Performing Party and TCEQ. This rate is not subject to adjustment.
☐ Default rate—a standard rate of ten percent of salary/wages may be used in lieu of determining the actual indirect costs of the service.

Indirect Cost Rate Agreement dated 9/2/2022 is attached as an Appendix.
Cognizant Federal Agency: Department of Health & Human Services, Denise Shirlee, (214) 767-3261

Please Submit Project Proposals (Microsoft Word Only – No PDFs) by August 4, 2023 to:

WSQ Subcommittee
Christian.Rines@tceq.texas.gov

NRU Subcommittee
Lindsey.Lippert@tceq.texas.gov

PPE Subcommittee
Kari.Howard@tceq.texas.gov

M&R Subcommittee
Cassandra.Taylor@tceq.texas.gov

Galveston Bay Estuary Program
FY 2025 M&R Project Proposal

Please complete the proposal form and submit to the appropriate Subcommittee Coordinator (end of form) by August 4, 2023. No late submittals will be considered for funding.

SECTION ONE: GENERAL INFORMATION

Subcommittee:

Monitoring and Research (M&R)

Project Name:

Tracking *Perkinsus marinus* (Dermo) Infection in Sun-Cured Oysters: Informing Oyster Shell Recycling Programs in Galveston Bay

Project Previously Funded by GBEP? Yes ☐ No ☒

Lead Implementer:

Public University: University of Houston-Clear Lake

☐ Federal, State, or Local Government ☐ Council of Government ☒ Public ISDs or Universities
☐ Nonprofit ☐ Other*

* If lead implementer not listed above, the proposing party will need to partner with an interlocal/interagency entity to be selected for funding. Please reach out to GBEP staff with any questions.

Contact Information:

Project Representative Name	Jenny Oakley
Project Representative Phone	281-283-3947
Project Representative Email	oakley@uhcl.edu

Amount Requested:

$166,898.11

Is the project scalable? ☒

Amount Requested per year (if applicable):

FY 2025 (09/01/2024-08/31/2025)	$85,503.21
FY 2026 (09/01/2025-08/31/2026)	$81,394.89
FY 2027 (09/01/2026-05/31/2027)	$0.00
Total	$166,898.11

Total Project Cost:

Requested Project Cost: $166,898.11
+ Estimated Leverage: $150,000.00
= Total Project Cost: $316,898.11
* note: the project is scaleable, resulting in a negotiable budget.

Is this an estimate? ☐

Project Duration (beginning no earlier than September 1, 2024 – 2.5 year maximum project length):

2 years: September 1, 2024 – August 31, 2026

Project Urgency:

In an effort to expand on the limited previous work on Dermo persistence in sun-cured oysters (current recommendations are based on a single study conducted in South Carolina in 2002 – Bushek et al. 2004), the Galveston Bay Foundation (GBF), in partnership with the Environmental Institute of Houston at the University of Houston-Clear Lake (UHCL), and the University of Houston, secured funding through the Texas General Land Office Coastal Management Program, Cycle 26. Beginning in 2022, a study to track Dermo presence, prevalence, and intensity in sun-cured oysters was initiated.

This study was designed to test a "worst-case scenario" for Dermo infection in sun-cured oysters in Texas. Oysters were collected from Confederate Reef in Galveston Bay in early October, 2022. This reef has the highest historic Dermo incidence (Silvy et al. 2020), and was sampled at the end of the summer when Dermo infection rates are typically highest. Oysters were shucked and a sample of the tissue was dissected and tested for Dermo (Ray 1966). Oysters were individually numbered and the shells were closed around the tissue with bailing wire and deployed in four replicate piles of recycled oyster shell at the GBF Red Bluff Curing Site. This was done to mimic a situation where a whole un-shucked oyster was included in the shell recycling material. The oysters were deployed for 8 months and while Dermo prevalence and severity significantly decreased after just one week at the curing site, trace levels of Dermo were detected throughout the entire study timeline.

After consultation with the Texas Parks and Wildlife Department, commercial distributors, retailers, and restaurants, the proposed project (herein) has been designed to demonstrate more "typical" conditions of oysters that are included in recycling programs, without being shucked. The proposed study focuses on clear next steps to evaluate current recommendations and, if necessary, provide updated recommendations on sun-curing procedures for oyster recycling programs in Texas.

Over the last decade, GBF has expanded its operations and now collects an average of 150 tons (300,000 pounds) of shells per year from over 30 restaurants ranging from the Inner Loop of Houston to Galveston Island (Figure 1). To date, GBF has collected over 1,600 tons (3,200,000 pounds) of oyster shell and returned approximately 840 tons of these recycled shells to Galveston Bay to help replenish hard substrate and sustain the local oyster population. GBF's shell-based reef restoration and shoreline protection efforts have resulted in 0.80 acres of oyster habitat created and 2,600 linear feet of shoreline protected. With the goal of acquiring larger volumes of shell to support larger reef restoration efforts, it is imperative to test and validate sun-curing procedures. The information derived from the proposed study will help ensure only clean and safe shell is returned to Galveston Bay and other state waters. With any conservation effort, it is important to make sure you are not inadvertently introducing or increasing disease in native reefs.

The GBF currently has two new oyster restoration projects scheduled for FY 2025/26 (Dickinson Bay Reef and Baytown Nature Center Reef/Living Shoreline) that will be using recycled oyster shell. With these oyster restoration projects, and others, in Galveston Bay, the proposed project is urgently needed to ensure that future projects which utilize recycled oyster shell are completed using best management practices informed by best available science to minimize the risk of infecting native oyster reefs with Dermo from the sun-cured recycled shell material without delaying the use of recycled materials for future restoration projects.

Literature Cited provided in "Appendix 2 – Literature Cited – Oakley M&R Proposal.pdf"

Leveraging (in-kind and/or cash):

Partial salary and fringe for the PI (Oakley) and Co-PI (Guillen) will not be requested in the enclosed proposal. The majority of their time spent on the project will be funded by the lead implementer institution (UHCL).

Additionally, the GBF's Oyster Shell Recycling Program (OSRP) has external funding that supports the collection of recycled shell and the sun-curing location where the proposed experiment will take place. The OSRP has secured funding through the following programs: Texas General Land Office - Costal Management Program ($80,000 NOAA funds), Restore America's Estuaries ($665,000 NOAA funds), and an estimated $90,000 in pending/tentative funds through private and corporate donations and fundraising through the Houston Oyster & SeaFest which is managed by the GBF to support these efforts.

The total value of the leveraged funds directly applicable to the proposed study is estimated at $150,000.

Partners and Their Roles:

Key Personnel: Name, Email, Institutional Affiliation, Professional Title
George Guillen, guillen@uhcl.edu, University of Houston-Clear Lake, Executive Director and Professor
Shannon Batte, sbatte@galvbay.org, Galveston Bay Foundation (GBF), Habitat Restoration Coordinator
Sally Clark, sclark@galvbay.org, GBF, Restoration Manager
Haille Leija, hleija@galvbay.org, GBF, Director of Program Operations

SECTION TWO: *GALVESTON BAY PLAN, 2ND EDITION* IMPLEMENTATION

Galveston Bay Plan, 2nd Edition References
https://gbep.texas.gov/inform-science-based-decision-making/

The proposed project will inform science-based decision making under the Galveston Bay Plan in the following ways:

The proposed project will evaluate the effectiveness of best management practices and make, and disseminate recommendations for updates to best management practices related to sun-curing oyster shells to be used in restoration efforts in an effort to reduce the biological stressor (Dermo) in native oyster reefs. It will accomplish this while addressing the following Action Plans and Actions:

Collaborate with Research Institutions to Support Focus Area Applied Research and Monitoring (RES)-This project is a collaboration between the Environmental Institute of Houston, at the University of Houston-Clear Lake (a research Institution), and the Galveston Bay Foundation (a non-profit, NGO) to conduct applied research and monitoring to directly inform oyster restoration efforts in Galveston Bay. The proposed work will address the following actions: **RES-1** (Conduct Biological Stressor Monitoring and Research), and **RES-6** (Evaluate Best Management Practice (BMP) Projects).

Increase Access to Galveston Bay Ecosystem Information (ACS)-The results of the proposed work will be disseminated according to the timeframe and outputs by activity for the following actions: **ACS-2** (Provide Access to Monitoring and Research Data), and **ACS-3** (Track Galveston Bay Plan Implementation).

Galveston Bay Plan Priority Area Actions Addressed:

Plan Priority 4: Inform Science-based Decision Making

RES-1 ☒	RES-2 ☐	RES-3 ☐	RES-4 ☐
RES-5 ☐	RES-6 ☒	RES-7 ☐	RES-8 ☐
ACS-1 ☐	ACS-2 ☒	ACS-3 ☒	

Plan Priority Area Actions Detail:

The proposed project will address the following actions, and corresponding activities and outputs.

RES-1: Conduct Biological Stressor Monitoring and Research – The proposed applied research will aid in the understanding of the biological stressor "Dermo" on oysters in Galveston Bay.

Specific Activities and Outputs: The results of the proposed work action RES-1, specifically the evaluation of the biological stressor "Dermo" on oysters, particularly restored oysters in Galveston Bay, will be presented at the State of the Bay Symposium. The final report and best management practices document will be made available to be shared through the GBEP website. The results of the proposed work will be disseminated through technical presentations at a regional conference, integrated into public outreach and education materials, included in a Master's Thesis, and developed into a peer-reviewed journal article for publication. The results of the proposed work will be made available for inclusion in the State of the Bay Report.

RES-6: Evaluate Best Management Practice (BMP) Projects – Current best management practices for shellfish restoration include using reclaimed materials (oyster shells) from a variety of commercial and retail sources and sun-curing them for a minimum of 6 months. The proposed research will evaluate the persistence of Dermo in the tissue residue of recycled oysters throughout this sun-curing process. The results will be used to evaluate the effectiveness of the current BMP and if necessary, make recommendations for updates to the BMP to protect native oyster reefs while also not delaying the use of reclaimed materials for restoration projects.

Specific Activities and Outputs: The results of the proposed work action RES-6, especially as related to the action of evaluating/updating the best management practices for sun-curing oysters for use in oyster restoration projects, will be presented at the State of the Bay Symposium. The final report and best management practices document will be made available to be shared through the GBEP website. The results of the proposed work will be disseminated through technical presentations at a regional conference, integrated into public outreach and education materials, included in a Master's Thesis, and developed into a peer-reviewed journal article for publication. The results of the proposed work will be made available for inclusion in the State of the Bay Report.

ACS-2: Access to Monitoring and Research Data – The project team will disseminate the monitoring and research results realized for the proposed project through a variety of outreach activities for different audiences, including GBEP partners, decision makers, bay user groups, and the public.

Specific Activities and Outputs: The data collected throughout the project will be provided to the GBEP data and mapping research hub. The results and best management practices document will be published as a white paper and technical presentations will be given at least one regional conference and local workshops. Finally, the resulting report will be included in the research synthesis report created by GBEP which provides an annotated bibliography of new research on Galveston Bay.

ACS-3: Track Galveston Bay Plan Implementation – The project team will work with the GBEP and its partners to integrate the proposed project results into the Comprehensive Conservation and Management Plan for the Galveston Bay estuary and share it with the council and stakeholders.

Specific Activities and Outputs: The results of the proposed project will be shared at the State of the Bay Symposia following the completion of the project timeline. If requested the project team will help to incorporate the results into the state of the bay report, and if needed revise the Galveston Bay Plan.

Does the project implement any other Galveston Bay Plan Priority Area Actions, or the other Subcommittee priorities?

☒ WSQ (Ensure Safe Human and Aquatic Life Use)
☒ NRU (Protect and Sustain Living Resources)
☒ PPE (Engage Communities)

Other Subcommittee Detail:

The proposed project will implement the following other Galveston Bay Plan Priority Area Actions. We ask that the submitted proposal be considered in these sub-committees as well should funding be unavailable through the M&R subcommittee.

Ensure Safe Human and Aquatic Life Use – Developing best management practices for sun-curing oysters before being returned to Galveston Bay in restoration projects, reducing risk of infecting native oysters with Dermo from cured shell materials.

NPS-2: The project will support education and outreach campaigns focused on the importance, restoration, and health of oyster reefs in Galveston Bay, fostering public awareness and improving education about how oysters improve water quality.

NPS-3: The best practices publication will create recommendations for sun-curing reclaimed oyster shell for use in restoration projects in Galveston Bay minimizing risk of newly implemented oyster restoration projects (structural measures) to improve water quality.

Protect and Sustain Living Resources – Supporting oyster restoration that enhances overall function and productivity and sustains and restores native oyster reefs by reducing risk of infecting native oysters with Dermo from cured shell materials.

HC-2: The best practices publication will present recommendations for sun-curing reclaimed oyster shell for use in restoration projects in Galveston Bay which will help inform future projects that restore lost or degraded oyster reef coastal habitats.

HC-3: The best practices publication will produce recommendations for sun-curing reclaimed oyster shell for use in restoration projects in Galveston Bay which will help inform future projects that enhance oyster reef coastal habitats.

SC-1: The best practices publication will produce recommendations for sun-curing reclaimed oyster shell for use in restoration projects that enhance oyster reefs (native species and coastal habitats) in Galveston Bay.

Engage Communities – Support existing and new stewardship programs, volunteer opportunities, and public outreach to engage the public in a dialogue about the importance of oysters, oyster restoration, and the challenges they face in Galveston Bay.

SPO-1: The project will support stewardship programs and volunteer opportunities such as oyster gardening and oyster restoration project installments providing experiential learning and education allowing participants to become ambassadors of Galveston Bay.

SPO-2: The project will support workshops and events providing opportunities for the public to receive education on the role of oysters in Galveston Bay and how management and restoration implementation can help improve the oyster habitat and water quality.

PEA-1: The project will support meaningful public engagement and awareness through programs like oyster gardening, and hands-on volunteer oyster restoration project installments, starting a dialogue with the public about key issues affecting Galveston Bay (the decline in oyster reefs) and what can be done to mitigate those issues (oyster recycling and restoration projects).

Other Plans Implemented:

The proposed project aligns with the following state and gulf-wide plans and strategies.

The Texas Coastal Resiliency Master Plan: Aligns with the key "Ecological Resiliency Strategies", specifically R1-45: Galveston Bay Oyster Reef Planning & Restoration.

The Gulf of Mexico Alliance's Governor's Action Plan: Aligns with two priority issue items: Habitat Resources & Wildlife and Fisheries which focus on assessing status and trends, threats, and needs of priority wildlife species, which include Oysters.

Gulf Region Oyster Network Program: (Restore America's Estuaries & National Oceanic and Atmospheric Administration): Aligns with primary initiative: Oyster Shell Recycling and Restoration.

Finally, this project aligns with a number of projects supported by both corporate and individual donations through the GBF through their oyster reef restoration programs: 1) Oyster Shell Recycling, 2) Volunteer Oyster Gardening, 3) Volunteer Reef Restoration, and 4) Large-Scale Reef Restoration.

Please see attached "Appendix 3 – TPWD Letter of Support – Oakley.pdf" which summarizes the support and coordination with the Coastal Fisheries team and their anticipation of the resulting best management practices publication to inform resource management decisions regarding restored oyster reefs moving forward.

SECTION THREE: SUBCOMMITTEE PRIORITIES

M&R Subcommittee Identified Priorities
Proposals must address one or more of the following actions:

☒ Meaningful and effective monitoring of existing and new projects (NRU/WSQ/PPE support)
☐ Exposure and response to emerging contaminants across trophic levels
☒ Reestablishing dermo monitoring programs (Ex. Oyster Sentinel)
☒ Project Component: Results translated to plain language/practical knowledge

Subcommittee Priority Detail:

Meaningful and effective monitoring of existing and new projects: The proposed project will provide meaningful and effective monitoring of existing and new projects which will result in a best management practices document that is published using plain language and practical knowledge gained for the use of recycled oyster shells in oyster reef restoration projects. Oyster reefs are an important component of Galveston Bay, providing numerous ecosystem services such as shoreline stabilization, water filtration, habitat creation, and it is one of Texas' most economically important fisheries (Coen et al. 2007, DePiper and Lipton 2016, Grabowski et al. 2012). Oyster reefs face a myriad of pressures including predators, water pollution, overfishing, sedimentation, extreme weather events, and disease (Beck et al. 2011). Because of these reasons, resource managers, state agencies, academics, and non-governmental organizations have identified oyster reef restoration as a priority action area and work together to address these threats through regulation and restoration.

The Galveston Bay Estuary Program is currently funding 2 projects that are focused on restoring oyster reefs in Galveston Bay. The Baytown Nature Center Oyster Reef Restoration and Shoreline Protection Project and the Jones Bay Oystercatcher Habitat Restoration Project both have objectives of creating oyster habitat. Oyster reef restoration can be accomplished by introducing hard substrate, typically in the form of reclaimed shucked shells, back into the local environment to be colonized by native spat. With projects actively funded through the GBEP to create and restore oyster reefs, it is critically important to make sure these efforts are not inadvertently introducing or increasing Dermo in native reefs.

Reestablishing Dermo Monitoring Programs:
While the proposed project does not directly monitor Dermo in Galveston Bay, it does monitor Dermo in commercially-available oysters procured in the Greater Houston-Galveston Area that are used in oyster shell recycling programs and will help resource managers and restoration practitioners to use best available science to inform their oyster shell curing process to protect native reefs from the introduction of Dermo through restoration efforts that utilize recycled oyster shell.

Project Component: Results translated to plan language/practical knowledge: The proposed project will result in a best management practices (BMP) publication providing updated recommendations on sun-curing procedures for oyster reef restoration in Galveston Bay, being the first official document that provides best available science and recommendations on this topic in Texas. The publication providing practical knowledge will be distributed to resource managers and GBEP partners and will be presented in plain language and will inform safe and effective oyster reef restoration into the future.

Literature Cited provided in "Appendix 2 – Literature Cited – Oakley M&R Proposal.pdf"

Does the Project work with new, smaller communities/partnerships?
☒ Yes
☐ No

The proposed project will work with oyster restaurants, retailers, and distributors to obtain recycled oyster shell as well as un-shucked oysters for use. Additionally, they will have the opportunity to contribute to the project by participating in a questionnaire to better understand the pathways oysters follow from the oyster boat to the recycling program. Aligned with the questionnaire will be a short presentation educating these oyster handlers about Dermo in oysters and the oyster recycling process. Additionally, this project will be inclusive of interested oyster aquaculture operations (per House Bill 1300 and Senate Bill 682), which are a new and small community that is developing in Texas.

SECTION FOUR: PROPOSAL DETAILS

Project Summary:

The proposed study will provide a characterization of current oyster shell recycling practices in Texas and provide outreach and education related to oyster restoration. It will also expand on on-going research to track the prevalence and severity of Dermo in commercially sourced sun-cured oysters, resulting in a best practices publication for oyster restoration efforts in Galveston Bay.

Full Project Description (1,000 words or less):

INTRODUCTION

The Eastern Oyster (*Crassostrea virginica*) is the only species of oyster native to Texas. It is an important component of Texas Bays providing numerous ecosystem services such as shoreline stabilization, water filtration, habitat creation, and it is one of Texas' most economically important fisheries (Coen et al. 2007, DePiper and Lipton 2016, Grabowski et al. 2012) (Figure 2). Oyster reefs face a myriad of pressures including predators, water pollution, overfishing, sedimentation, extreme weather events, and disease (Beck et al. 2011). Resource managers, academics, and non-governmental organizations work together to address these threats through regulation and restoration.

Oyster reef restoration is accomplished by introducing hard substrate, typically in the form of reclaimed/recycled oyster shells, into the estuary to be colonized by native spat. The Galveston Bay Foundation's (GBF) Oyster Shell Recycling Program (OSRP) gathers shells from local seafood restaurants for reuse in reef restoration in Galveston Bay. The parasite *Perkinsus marinus*, otherwise known as "Dermo" is a spore-forming protozoan that negatively affects the fitness and longevity of Oysters. Dermo can be transmitted from one infected oyster to another by both living and dead oysters (Figure 3), so sun-curing is used to minimize the prevalence of Dermo before reclaimed shells are returned to an estuary. There are currently no published, standardized curing procedures for restoration efforts to follow, however many groups sun-cure oyster shells for up to 6 months. The current best practices are based off of a study conducted by Bushek et al (2004) in South Carolina, which used oysters from a reef in Galveston Bay (Confederate Reef). This study found that Dermo prevalence declined significantly after one month and was virtually eliminated after three months.

In an effort to expand on the limited previous work on Dermo persistence in sun-cured oysters, GBF, in partnership UHCL, secured funding through the Texas General Land Office Coastal Management Program, (Described in "Project Urgency" section). The proposal described herein will build on this recently conducted work and has been developed after consultation with the Texas Parks and Wildlife Department, commercial distributors, retailers, and restaurants to demonstrate more "typical" conditions of oysters that are included in recycling programs, without being shucked. The proposed study focuses on clear next steps to evaluate current recommendations and, if necessary, provide updated recommendations on sun-curing procedures to inform oyster recycling programs in Texas.

The objectives of the proposed study are to:
1) characterize current oyster shell recycling practices in Texas,
2) compare background Dermo prevalence and severity in oysters based on source,
3) track the prevalence and severity of Dermo in sun-cured oysters,
4) compare seasonal impacts to Dermo prevalence and severity in sun-cured oysters,
5) support outreach and education related to oyster restoration, and
6) create a best practices publication with recommendations for sun-curing protocols, grounded in science, for oyster restoration efforts in Galveston Bay that utilize reclaimed shells.

PLAN OF WORK

Commercial oyster distributors and retailers with lease holdings and restaurants in the Galveston Bay area will be interviewed in order to characterize oyster handling procedures and protocols. Oysters will be procured from a number of sources that are commercially available including: distributors, restaurants, and retailers (see Projects Map). The goal is to characterize the background Dermo levels in oysters that could be included in the shell recycling process. Oysters from sources with representative background levels of Dermo, as determined through Objective 2, will be procured and processed to measure (length, width and weight, shuck, characterize the oyster tissue condition (Figure 4), percent cover, and sample for initial Dermo levels. Each oyster will be individually numbered and the two shells of each oyster will be turned perpendicular to one another, loosely secured, and placed into a gabion cage allowing individual oysters to be re-sampled and tracked through the study. Oysters will be deployed at the GBF's Red Bluff Sun-Curing site.

Four experimental piles of oysters will be created using shell gathered through the GBF's OSRP (see Projects Map). Ten oysters will be deployed in the interior and ten at the top of each of the four piles. Half of the oysters (five from each group) will be monitored for Dermo prevalence and intensity (Figure 5), which requires removal of a small (5mm) piece of tissue at each sampling (using Ray's Fluid Thilglycollate Method). Because this method alters the tissue, the other half of the oysters will not be sampled for Dermo, but

monitored to track natural tissue degradation. Temperature and relative humidity sensors will be co-located with each group of oysters. Deployed oysters will be sampled twice during the first week, weekly for the first 6 weeks, and biweekly after that, until no tissue remains or 6 months has passed (whichever happens first). After three months, two of the experimental piles of oysters will be mechanically turned (to mimic the current sun-curing procedure employed by GBF). The deployment and sampling protocol will be conducted twice; once over the winter (deployment in December, 2024) and once over the summer (June, 2025). This will allow for investigation into differences in Dermo persistence and tissue degradation by season to determine if the same sun-curing procedure should be used regardless of the time of year.

The GBF provides education and outreach programs designed to enhance the knowledge of local citizens so they may become stewards of Galveston Bay with an understanding of the benefits a healthy bay system provides to the entire Houston-Galveston region. Supported outreach efforts through the OSRP specifically aim to educate the public on the importance of oysters in Galveston Bay. The results and importance of the proposed study will be integrated into at least three, up to five, outreach/education activities each year of the grant cycle. Finally, the project team will create a final report for submittal to the GBEP office summarizing all of the work associated with the proposed project, including a best practices publication with recommendations for sun-curing protocols for oyster restoration efforts in Galveston Bay.

Literature Cited provided in "Appendix 2 – Literature Cited – Oakley M&R Proposal.pdf"

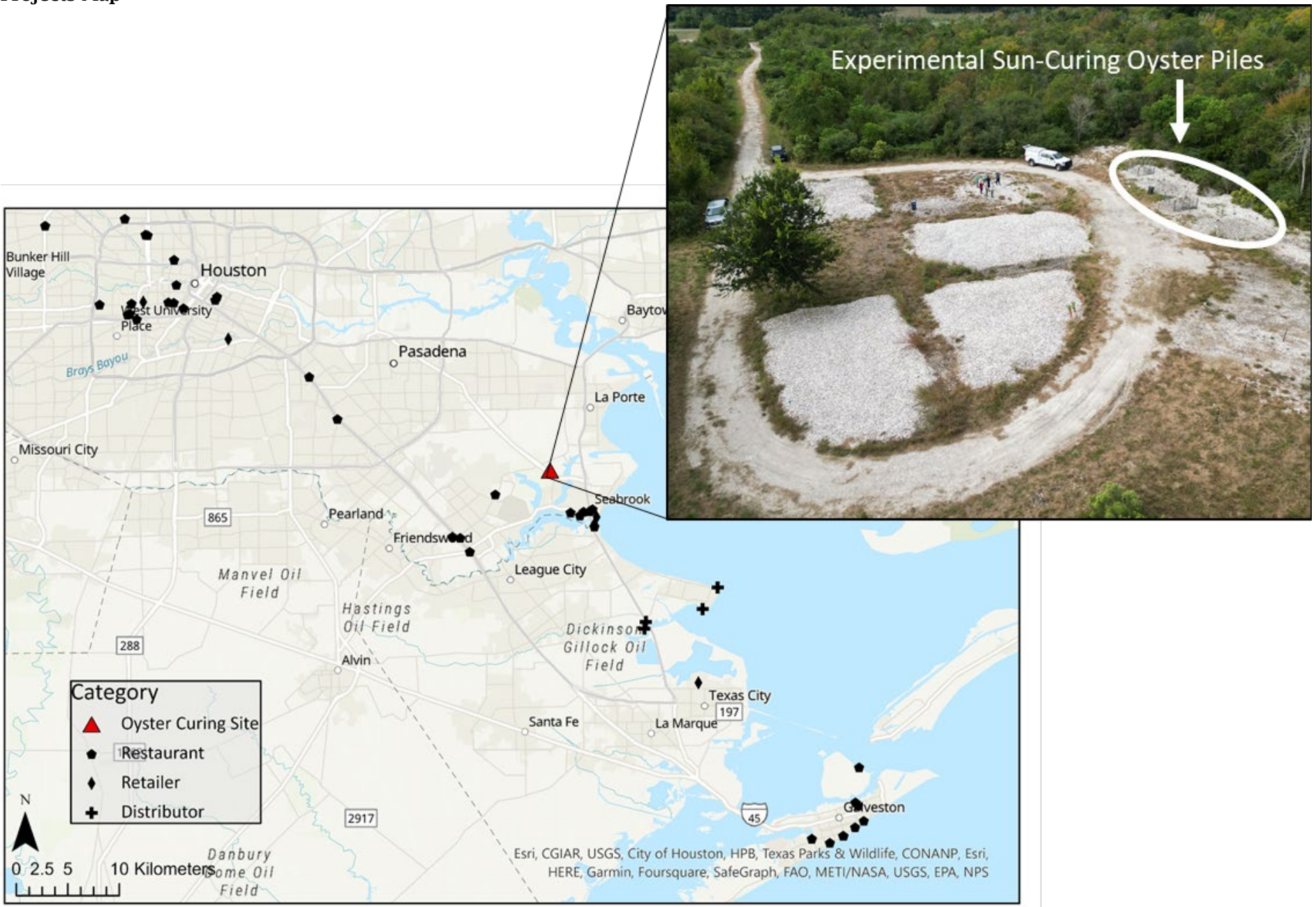
Latitude/Longitude (Optional):

GBF's Red Bluff Oyster Curing Site: 29˚35'55.26"N, 95˚3"35.61"W

Location:

Oysters for use in the proposed project as well as oyster shell used to build the sun-curing piles for the project will be procured from a sub-set of restaurants, retailers, and distributors located around the greater-Houston-Galveston Area (see Projects Map below). The experimental sun-curing oyster piles will be located at the GBF's Red Bluff Sun-Curing Site located at the latitude and longitude provided above and illustrated in the Project Map below. Oyster shell that is recycled through the GBF's OSRP is used in oyster restoration projects throughout Galveston Bay.

Projects Map



Project Map illustrating locations of restaurants that participate in the Galveston Bay Foundation's (GBF) Oyster Shell Recycling Program, and local oyster retailers and distributors that may be used to procure oysters for use in the study. Aerial image of the GBF's Red Bluff Sun-Curing Site which will be used to house the experimental sun-curing piles.

Supplemental Photos/Graphics (Optional):

Figure 1. Schematic illustrating the oyster shell recycling pathway through the Galveston Bay Foundation's Oyster Shell Recycling Program (OSRP) and some example images of each step. a. photo of oyster recycling bins from participating restaurants that are picked up by the OSRP., b. photo of the recycling bins being emptied at the sun-curing site c. photo of a dump truck load of recycled oyster shells being emptied at the sun-curing site. d. photo of a large-scale oyster restoration using sun-cured oyster shells, and e. photo of a volunteer oyster restoration event where bags of the sun-cured oysters are placed back into the bay.

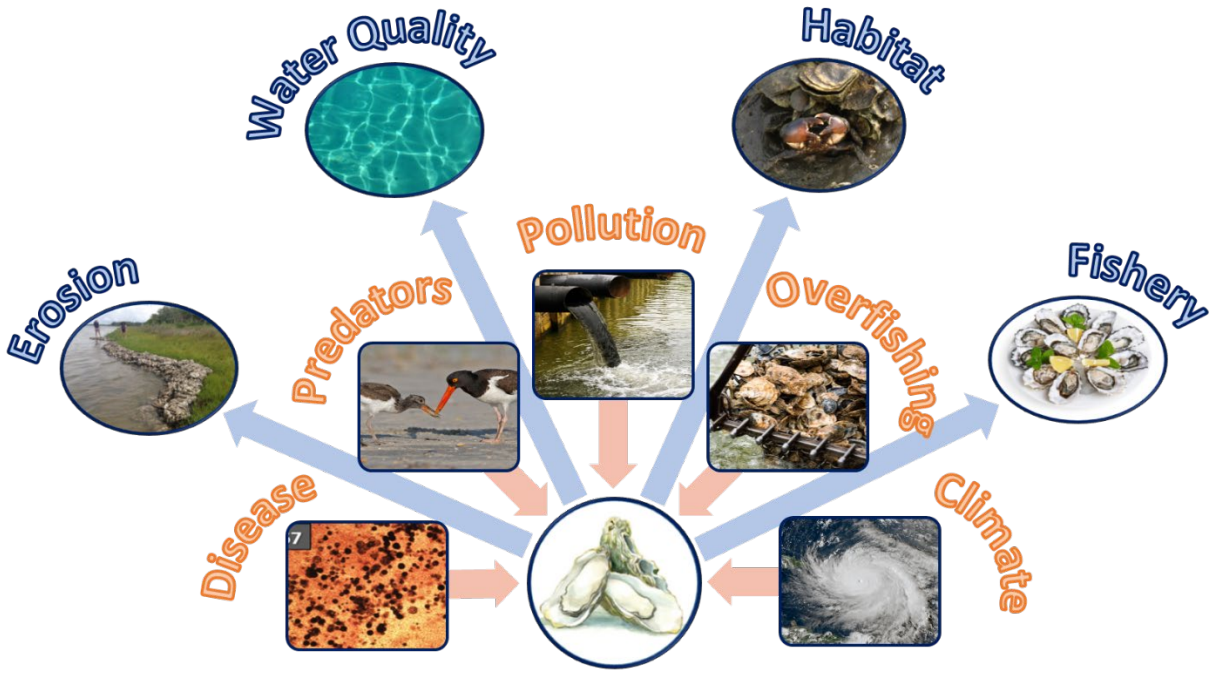


Figure 2. Eastern Oysters (*Crassostrea virginica*) provide many ecosystem services (blue arrows), but they also face threats (orange arrows).

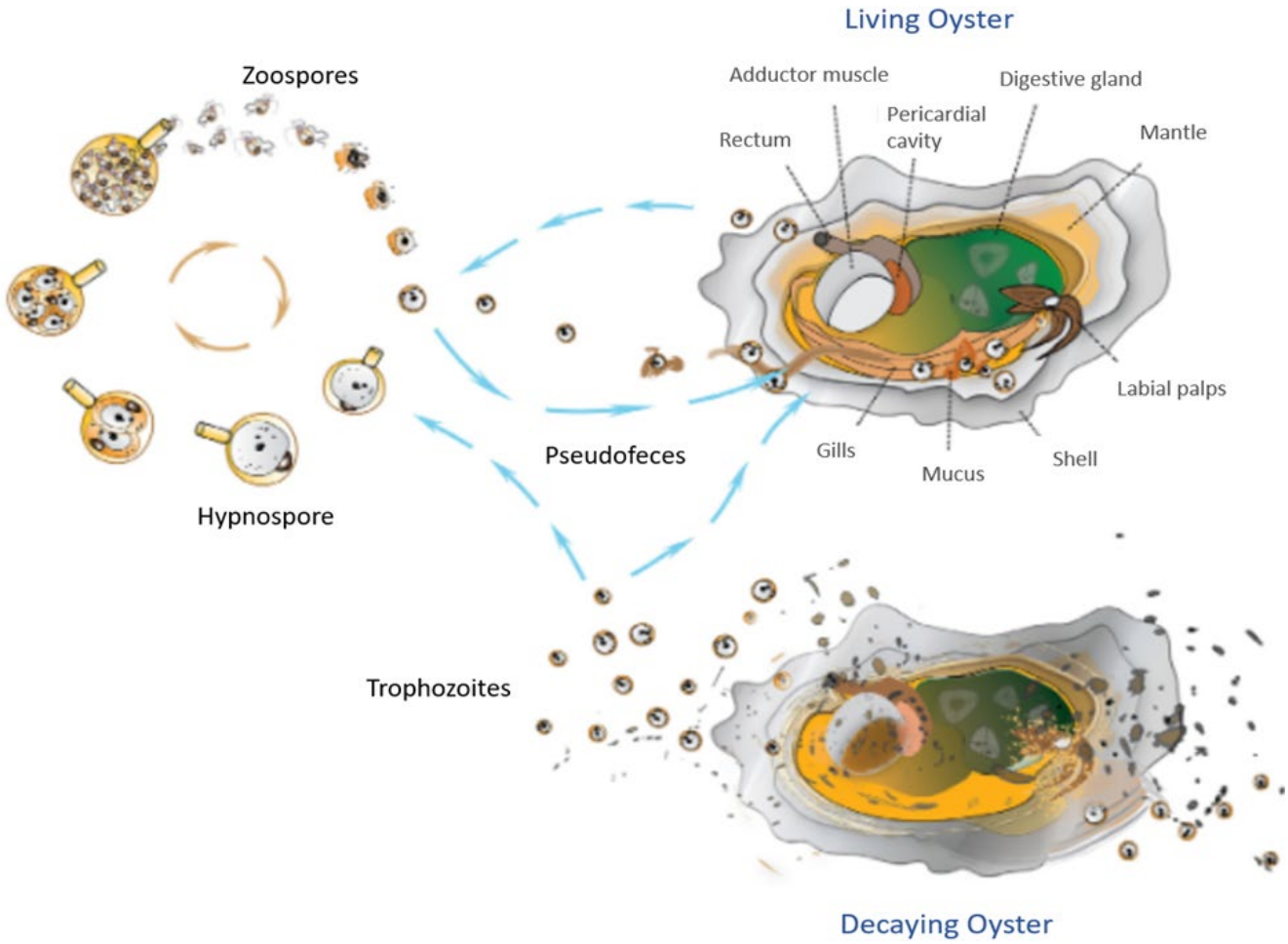


Figure 3. Lifecycle and infection mechanisms of Dermo (Perkinsus marinus) in Eastern Oyster (*Crassostrea virginica*) adapted from: Fernández Robledo et al. 2018

Figure 5. Examples of the five tissue condition categories used to describe decaying oyster tissue deployed at GBF's sun-curing site from the on-going Texas General Land Office study by GBF and UHCL.

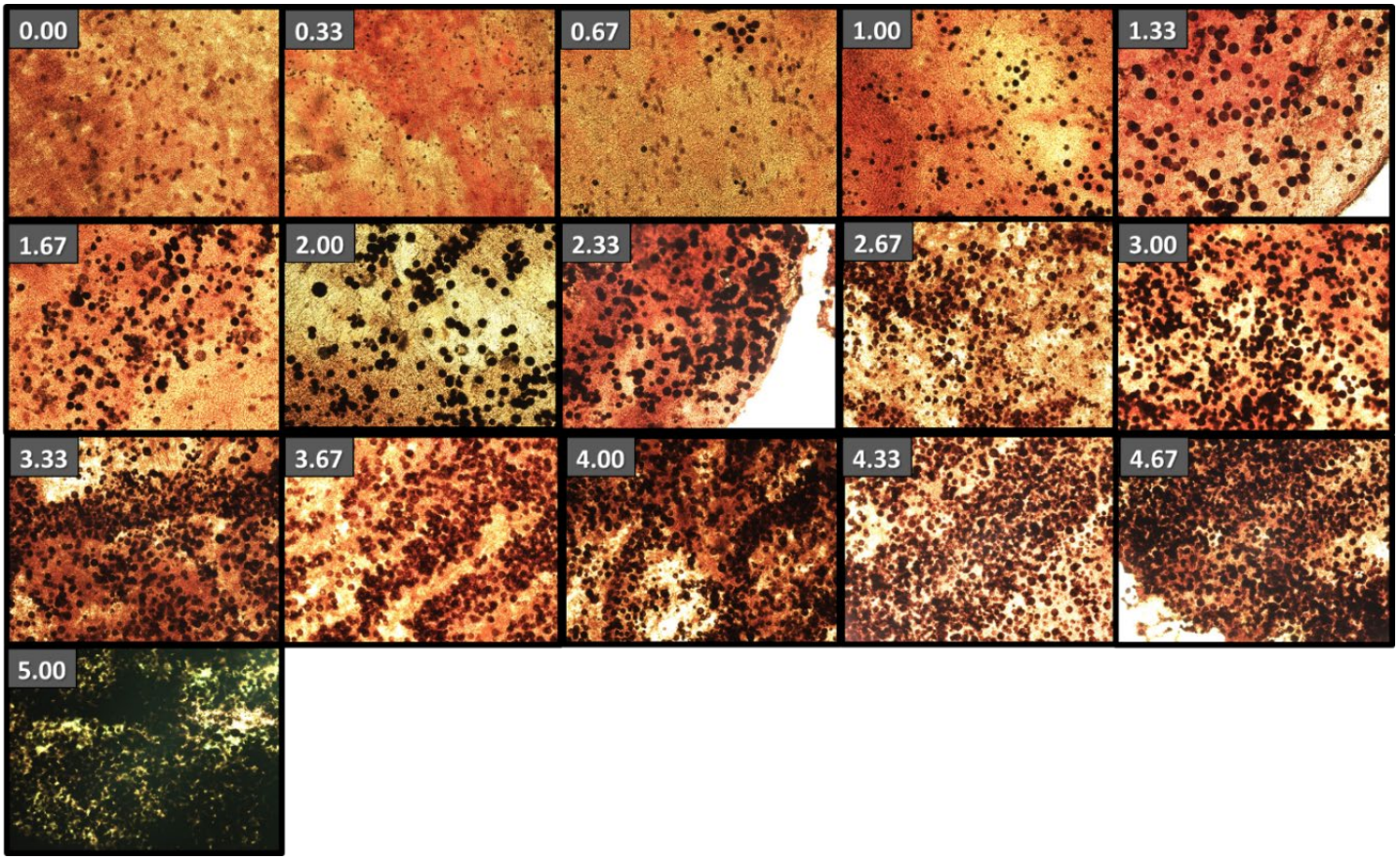


Figure 4. Examples of tissue pathology slides showing the range of Dermo intensity rating using the Ray's Fluid Thioglycollate Method.

SECTION FIVE: BUDGET DETAILS

	BUDGET CATEGORIES:	Budget
a.	Personnel/Salary	$ 93,843.75
b.	Fringe Benefits	$ 15,165.00
c.	Travel	$1,500.00
d.	Supplies	$3,942.00
e.	Equipment	$ 0.00
f.	Contractual	$ 15,624.40
g.	Construction	$ 0.00
h.	Other*	$ 8,169.20
i.	Total Direct Costs (Sum a - h)	$138,244.35
j.	Indirect Costs	$28,653.76
k.	Total (Sum of i & j)	$166,898.11

*Other: If Budget Category "Other" is greater than $25,000 or more than 10% of budget total, identify the main constituents: N/A

Indirect Cost Agreement

Indirect Cost Reimbursable Rate: The reimbursable rate for this Contract is 22 % of (check one):

☐ salary and fringe benefits
☒ modified total direct costs
☐ other direct costs base
If other direct cost base, identify:

This rate is less than or equal to (check one):
☒ Predetermined Rate—an audited rate that is not subject to adjustment.
☐ Negotiated Predetermined Rate—an experienced-based predetermined rate agreed to by Performing Party and TCEQ. This rate is not subject to adjustment.
☐ Default rate—a standard rate of ten percent of salary/wages may be used in lieu of determining the actual indirect costs of the service.

Please see attached "**Appendix 1- 2020 UHCL IDC Agreement**" for the federally negotiated indirect cost agreement for the University of Houston-Clear Lake which is 22% of the modified total direct costs (which excludes equipment over $5,000 in value) for all "off campus" grants or contracts.

Please Submit Project Proposals (Microsoft Word Only – No PDFs) by August 4, 2023 to:

M&R Subcommittee
Cassandra.Taylor@tceq.texas.gov

Galveston Bay Estuary Program
FY 2025 M&R Project Proposal

Please complete the proposal form and submit to the appropriate Subcommittee Coordinator (end of form) by August 4, 2023. No late submittals will be considered for funding.

SECTION ONE: GENERAL INFORMATION

Subcommittee:

M&R

Project Name:

Distribution of key emergent pollutants in the aquatic biota (oysters and fish), sediments and surface waters of Galveston Bay.

Project Previously Funded by GBEP? Yes ☐ No ☒

Lead Implementer:

Texas A&M University at Galveston

☐ Federal, State, or Local Government ☐ Council of Government ☒ Public ISDs or Universities
☐ Nonprofit ☐ Other*

* If lead implementer not listed above, the proposing party will need to partner with an interlocal/interagency entity to be selected for funding. Please reach out to GBEP staff with any questions.

Contact Information:

Project Representative Name	Dr. Antonietta Quigg
Project Representative Phone	409-740-4990
Project Representative Email	quigga@tamug.edu

Amount Requested:

$203,660

Is the project scalable? ☐

Amount Requested per year (if applicable):

FY 2025 (09/01/2024-08/31/2025)	$47,244
FY 2026 (09/01/2025-08/31/2026)	$156,416
FY 2027 (09/01/2026-05/31/2027)	$0.00
Total	$203,660

Total Project Cost:

$203,660

Is this an estimate? ☒

Project Duration (beginning no earlier than September 1, 2024 – 2.5 year maximum project length):

2 years: 9/1/2024 – 8/31/2026

Project Urgency:

Contaminants of emerging concern (CEC) is a term used by water quality professionals to describe pollutants that have been detected in environmental monitoring samples, that may cause ecological or human health impacts, and typically are not regulated under current environmental laws. According to the US EPA (https://www.epa.gov/wqc/), the CECs of greatest concern are per- and polyfluoroalkyl substances (PFAS) chemicals, pharmaceuticals, and micro-plastics.

PFAS are often called "forever chemicals" due to their very slow breakdown in the environment which also allows them to accumulate in people and animals. Some estimates suggest 98% of humans have some level of PFAS in their blood. In March 2023, the US EPA made its first attempt to nationally regulate PFAS in drinking water. It is thought that ~500,000 Texans live in communities with contaminated groundwater. Yet, Texas does not have any established metrics because of the paucity of available data. This project will measure the proposed US EPA PFAS of greatest concern in the Galveston Bay: PFOA, PFOS, PFNA, PFHxS, PFBS, and GenX.

Annually, billions of prescriptions are filled across the U.S. The potential for hormones and **pharmaceuticals** to be present in drinking water is of great concern because unintentional exposure to some of these bioactive compounds could result in adverse effects on human health. At low doses, they can exert a wide range of effects including endocrine disruption and antibiotic resistance. Pharmaceuticals are known to be entering the environment, particularly after storms and/or flood events, but again there is a paucity of information available for levels in Texas, and in particular in the water and aquatic life in Galveston Bay.

With the help of the Galveston Bay Estuary Program funding, the community is beginning to understand the extent of **plastic** pollution in Galveston Bay. For example, the team at UHCL is measuring the microplastics found in oysters, while others at TAMU(G) are looking at levels in fish, and a diverse group of stakeholders meets annually at the Texas Plastic Pollution Symposium.

These CEC's are present in aquatic biota (oysters and fish), sediments, drinking and surface waters, but we do not know the spatial extent, nor do we know what are "typical" concentrations occurring in Galveston Bay. A meta-analysis is proposed to bring together available data on these and other CEC's as well as measuring their concentrations in collected materials.

Leveraging (in-kind and/or cash):

None declared at this time.

Partners and Their Roles:

Given the cost of field work, we will work with GBEP researchers and stakeholders interested in collaborating to use a "split" sample approach. By this we mean that we will share samples, collection protocols and locations. In this way, the overall number of samples and data available will be significantly higher than working in a traditional mode. Thus far the following partners have agreed to participate:

Texas Parks & Wildlife Department (TPWD), Dickinson, TX - shellfish and fish samples from their regular monitoring program

Dr George Guillen (UHCL) – oyster samples; new proposals pending

Dr Anna Armitage (TAMUG) – marsh sediment and plant samples; new proposals pending

Dr Heidi Whitehead (TMMSN) – dolphin blubber and liver samples

Dr David Hala (TAMUG) – fish samples; new proposals pending

All interested partners are welcome to split/share sample materials for analysis.

SECTION TWO: *GALVESTON BAY PLAN, 2ND EDITION* IMPLEMENTATION

Galveston Bay Plan, 2nd Edition References
https://gbep.texas.gov/ensure-safe-human-and-aquatic-life-use/
https://gbep.texas.gov/protect-and-sustain-living-resources/
https://gbep.texas.gov/engage-communities/
https://gbep.texas.gov/inform-science-based-decision-making/

Plan Priority One: Ensure Safe Human and Aquatic Life Use
The proposed project will measure nonpoint sources and potential point sources of CECs in Galveston Bay in order to raise publica health and awareness.
Action Plan: NPS-2 Support Nonpoint Source Education and Outreach Campaigns
Action Plan: PS-3 Increase Wastewater Treatment Facility Compliance
Action Plan: PHA-1 Improve Seafood Advisory Awareness

Plan Priority Three: Engage Communities
The proposed project will support public education and awareness initiatives.
Action Plan PEA-1 Key Issue Engagement

Plan Priority Four: Inform Science-Based Decision Making
The proposed project will collaborate with research institutions to support research and monitoring and to increase access to Galveston Bay ecosystem information.
Action Plan: Collaborate with Research Institutions to Support Focus Area Applied Research and Monitoring (RES), specifically
RES-1 Conduct Biological Stressor Monitoring and Research
RES-5 Conduct Monitoring and Research to Address Limits to Seafood Consumption.

Galveston Bay Plan Priority Area Actions Addressed:

Plan Priority 4: Inform Science-based Decision Making

RES-1 ☒	RES-2 ☐	RES-3 ☐	RES-4 ☐
RES-5 ☒	RES-6 ☐	RES-7 ☐	RES-8 ☐
ACS-1 ☐	ACS-2 ☐	ACS-3 ☐	

Plan Priority Area Actions Detail:

This project aims to increase the current understanding of the distribution of CECs in Galveston Bay. The project will use sophisticated instruments (e.g., GC-MS, LC-MS) to quantify the levels of priority chemicals in the waters and biota (oysters, fish) from Galveston Bay. The specific priority area actions addressed are as follows:

Plan Priority One: Ensure Safe Human and Aquatic Life Use
In accordance with the Galveston Bay Plan, there are several crucial factors that determine safe human and aquatic life use of Galveston Bay. The foremost of these is the quality of the surface water in the lower watershed. Water quality is a key indicator of the health of the bay. The 2017 Galveston Bay Report Card, deemed it as generally good, especially in the open bay. Seafood consumption safety however received a grade of C in the same Report Card, and a grade of D for rivers and bayous. Contamination from polychlorinated biphenyls (PCBs) and dioxins (toxic pollutants that are driving factors in seafood consumption advisories). People who eat fish or shellfish contaminated by PCBs and dioxins can develop long-term, serious illnesses. *Little is known however about emergent pollutants including CEC's*.

Plan Priority Three: Engage Communities
Protecting and promoting the health of Galveston Bay are important, but communicating to residents and visitors is a challenge. Long-term success in environmental awareness and stewardship takes time and is not

simple. To adequately engage communities, two Action Plans were identified by the PPE subcommittee. By working with available tools (e.g., the Galveston Bay Action Network), GBEP and its stakeholders, we will raise awareness in the community of CECs in Galveston Bay. Given that pharmaceuticals are materials that all residents are aware off, while there is a growing body of interest in microplastics in the environment, especially biota that people consume (oysters, fish), we will leverage interest in these materials primarily to raise overall understanding of CECs in Galveston Bay. In doing so, we want to preserve Galveston Bay through stakeholder and partner outreach activities.

Plan Priority Four: Inform Science-Based Decision Making
RES-1: Conduct Biological Stressor Monitoring and Research

The surface waters of Galveston Bay have been shown to be polluted with CECs. However, there is a general lack of knowledge on concentrations in associated with the known major contaminant sources (see project map) and biota. Most data to date has been collected in response to major events (hurricanes, fires) and so there is a strong need to develop baseline data/levels. We will determine CECs (**PFASs, pharmaceuticals and microplastics**) levels in water, sediments and biota (oysters, fish, dolphins) sampled from Galveston Bay. The results of this project will contribute to the US EPA database of CEC concentrations which is needed to develop policies to protect communities. The bay must be managed to ensure its productivity and ecological diversity on a long term, sustainable basis while also supporting a diverse group of stakeholders. This research will help stakeholders better understand the health of the bay which will hopefully translate to better stewardship decisions and actions by both residents and visitors. GBEP and its partners support science-based decision making; this project will provide necessary data to help preserve Galveston Bay for future generations.

Does the project implement any other Galveston Bay Plan Priority Area Actions, or the other Subcommittee priorities?

☒ WSQ (Ensure Safe Human and Aquatic Life Use)
☒ NRU (Protect and Sustain Living Resources)
☒ PPE (Engage Communities)

Other Subcommittee Detail:

The results of this project will be of relevance to the WSQ, NRU and PPE Subcommittees as it will quantify the extent to which CECs are present in Galveston Bay, potential point and non-point sources, as well as body burdens in a variety of biota. This knowledge will contribute to goals to understand pollution sources, fate and distributions. With a broad watershed understanding, we will work with PPE to engage communities to help them understand potential sources of risk.

Other Plans Implemented:

This project contributes to the Texas Coastal Management Plan, particularly as it concerns (i) supporting protection of natural habitats and wildlife and (ii) provides baseline data on the health of gulf waters (https://www.glo.texas.gov/coast/grant-projects/cmp/grants).

SECTION THREE: SUBCOMMITTEE PRIORITIES

M&R Subcommittee Identified Priorities
Proposals must address one or more of the following actions:

☐ Meaningful and effective monitoring of existing and new projects (NRU/WSQ/PPE support)
☒ Exposure and response to emerging contaminants across trophic levels
☐ Reestablishing dermo monitoring programs (Ex. Oyster Sentinel)
☒ Project Component: Results translated to plain language/practical knowledge

Subcommittee Priority Detail:

The proposed project addresses the M&R Subcommittee's identified priorities as follows:

1) **Exposure response across trophic levels:**

The project will use highly sophisticated instruments (e.g., LC– GCMS) to quantify the concentrations of a variety of CECs including the 6 US EPA priority PFASs. pharmaceuticals and microplastics

- in surface water at the mouths of the major rivers and bayous entering Galveston Bay (during a low and high flow period),
- in biota (phytoplankton, zooplankton, oysters, fish, dolphins) from Galveston Bay,
- in drinking water from major industrial facilities (5), wastewater treatment plants (5), formerly used defense sites (5) and major airports (2) (see project map) known to be important sources of PFASs and potentially other CECs,
- The proposed project complements existing GBEP funded studies as it focuses attention on quantifying important emergent chemicals or CEC's.
- By collaborating with other funded GBEP scientists, we will "split" samples whenever possible to increase the overall knowledge of emergent chemicals in Galveston Bay. For example, we will work with teams from the Hala, Guillen and other labs to split oyster and fish samples and measure PFAS concurrently with microplastics and other chemicals being measured. This will reduce the overall cost of the project and increase the overall spatial and temporal distribution of samples collected (and concurrent data such as lat, long, salinity, temp, etc…)
- The knowledge of PFAS body-burdens in biota will enable a dietary risk assessment to be performed to estimate likely human exposure from the consumption of PFAS-tainted seafood (oysters, fish muscle).

2) Project Component: Results translated to plain language/practical knowledge:

- The results of this project will contribute to the US EPA database of CEC concentrations which is needed to develop policies to protect communities.
- We will work with GBEP and their stakeholders to translate the findings to enable stewardship decisions and actions. GBEP and its partners support science-based decision making; this project will provide necessary data to help preserve Galveston Bay for future generations.
- A flyer (one pager) will be developed to explain the significance of the research and distributed to TCEQ personnel, extension agents and others.
- We will visit with the various working groups to increase stakeholder engagement and the distribution of the project findings.

Does the Project work with new, smaller communities/partnerships?

☒ Yes
☐ No

If funded, the PI's will work with other funded GBEP researchers to develop new partnerships and enhance existing partnerships.
In addition, the findings will be shared with the US EPA database of CEC concentrations and for example, the "PFAS project lab" which is developing a nationwide database of PFAS measurements (see Salvatore et al. 2022). If other similar such databases exist for the CECs being measured, we will share our findings with them too.

SECTION FOUR: PROPOSAL DETAILS

Project Summary:

Contaminants of emerging concern (CEC) is a term used by water quality professionals to describe pollutants that have been detected in environmental monitoring samples, that may cause ecological or human health impacts, and typically are not regulated under current environmental laws. CECs of greatest concern are per- and polyfluoroalkyl substances (PFAS) chemicals, pharmaceuticals, and micro-plastics. US EPA attempts to nationally regulate CECs is struggling because of the paucity of available data yet we know these chemicals maybe present in the drinking water and biota that we consume. This project will measure the *exposure response across trophic levels* to a selection of CECs and then translate the results to both *plain language/ practical knowledge*. At low doses, these CECs may exert a wide range of adverse effects on the biota and perhaps, the humans that consume the biota. *These CEC's are present in aquatic biota (oysters and fish), sediments and surface waters, but we do not know the spatial extent, nor do we know what are "typical" concentrations occurring in Galveston Bay.* A meta-analysis is proposed to bring together available data on these and other CEC's as well as measuring their concentrations in newly collected materials.

Full Project Description (1,000 words or less):

Contaminants of emerging concern (CEC) is a term used by water quality professionals to describe pollutants that have been detected in environmental monitoring samples, that may cause ecological or human health impacts, and typically are not regulated under current environmental laws. According to the US EPA (https://www.epa.gov/wqc/), the CECs of greatest concern are per- and polyfluoroalkyl substances (PFAS) chemicals, pharmaceuticals, and micro-plastics[1-3]. At this time, nearly 500,000 Texans live in communities with CEC contaminated groundwater, but there is little to no information available on the kinds present. Without this critical information, citizens cannot advocate for policy or mitigation strategies or protect themselves. Following the contamination of ecosystems (**Fig. 1**), CECs may disrupt biological processes and elicit a wide range of toxic effects on aquatic species (e.g., fish), including inhibiting growth, disrupting reproduction and increasing oxidative stress. These chemicals are also known to negatively impact humans either directly (e.g., through aerosols) or indirectly (e.g., through diets). *The persistent nature of these chemicals, combined with their toxicity, illustrates a necessity for contemporary research to investigate their distributions*.

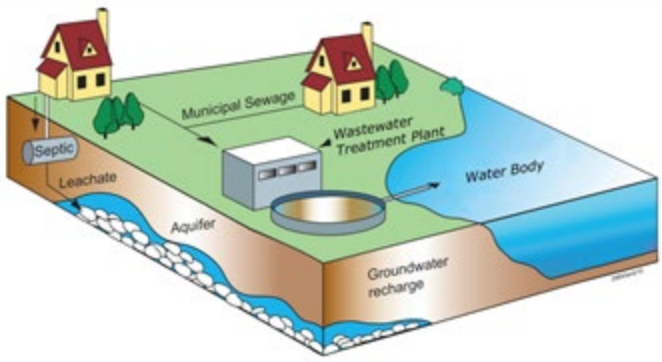


Fig. 1: Movement of CECs in the environment (USEPA).

Galveston Bay is the nexus of water/food/energy and other sectors in the region. It is home to a billon dollar commercial and recreational fishery. It is located south of Houston (4th largest city in US) and the Dallas/Fort Worth metroplex. Concurrently, Houston is the leading domestic and international center for virtually every segment of the energy industry (e.g., 14.3% of the nation's oil production is done in the refineries clustered in the Houston area), making the watershed/bay at risk from this vast commerce[4]. For example, in response to a major fire which blazed for more than a week (storage tanks at the International Terminals Company in Deer Park (Houston, TX, March 2019), US EPA priority PFASs were measured in Galveston Bay (**Fig. 2**)[2]. In surface waters in the months after the fire, there were 4× to ~300× higher PFASs than what would be found a year later. PFOS was the most abundant homolog, was found in eastern oysters (*Crassostrea virginica*), red drum (*Sciaenops ocellatus*), gafftopsail catfish (*Bagre marinus*), and spotted seatrout (*Cynoscion nebulosus*)[2]. As a result, we calculated the hazard ratio for seafood safety and suggested an advisory of 1–2 meals of fish per week to be protective for human exposure; levels in oysters indicated no immediate concerns for the dietary exposure of humans[2]. These results highlight the need for continual monitoring to assess the fate and seafood advisories for PFASs. Further, Galveston Bay is often impacted by major floods or hurricanes. After Hurricane Harvey, pharmaceuticals, PAH, PCBs and other CECs and legacy chemicals were measured in the bay[3].

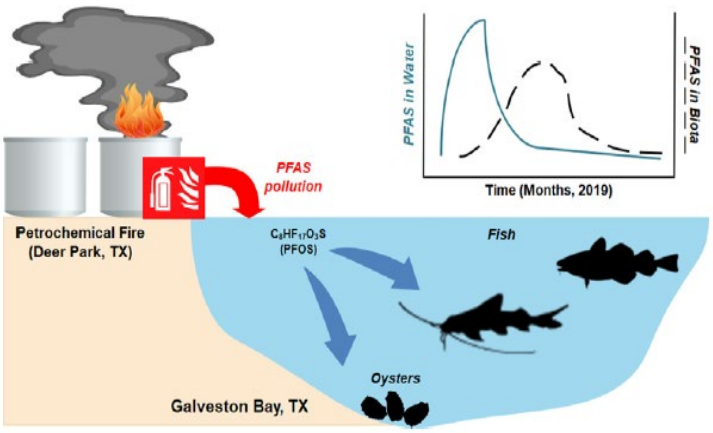


Fig. 2: Movement of PFAS after fire at tanker farm (Nolen et al. 2022).

Objectives:

Overall objective: *To determine CEC levels surface and drinking waters, sediments and biota of Galveston Bay in order to assess potential adverse health effects to biota and humans.*

Specific Objective 1: Measure CECs (PFASs, pharmaceuticals and microplastics) levels in water, sediments and biota (oysters, fish, dolphins) sampled from Galveston Bay.

Specific Objective 2: Contribute to the US EPA national database of contaminant concentrations.

Specific Objective 3: Support GBEP and its partners in science-based decision making and stewardship decisions and actions.

.

Experimental Design and Methods: Surface water and drinking water samples will be sampled from various dock-side locations, focusing on areas that are thought to be sources of CECs including the 'forever chemicals' known as PFASs around Houston Galveston Bay (see project map below for target areas). We will sample major industrial facilities (5), wastewater treatment plants (5), formerly used defense sites (5) and major airports (2) based on these maps.

By working with project partners (see above), we will examine previously archived tissue samples of dolphins and collect fresh samples of oysters and fish (i.e., red drum, spotted seatrout) which will be analyzed for CEC body-burdens using standard protocols for each CEC. We have experience measuring PFASs, pharmaceuticals and microplastics, hence our focus will be these emergent pollutants[2,3].

This will allow us to examine the source(s), fate and transport of CECs to determine the overall spatial distributions in water, biota (oysters, fish), and in sediments associated with marshes around Galveston Bay. Given the large scope of the project, we will coordinate with other funded GBEP projects to leverage sampling opportunities. For example, GBEP is already funding projects examining microplastics, so we will partner with those entities to split samples (e.g., Guillen, Hala). This will allow us to develop a "big picture" view of CECs in Galveston Bay food webs, without bearing the entire expense in one project.

Potential Impact and Project Outcomes: The data generated will be submitted to national databases as well as developing a database associated with the project in which all the CECs and ancillary data (e.g., lat, long, water quality) will be deposited to provide an overall portfolio of emergent pollutants in Galveston Bay. The work contributes to the Galveston Bay Plan by addressing 3 key areas: Plan Priority One: Ensure Safe Human and Aquatic Life Use (NPS-2, PS-3, PHA-1), Plan Priority Three: Engage Communities (PEA-1) and Plan Priority Four: Inform Science-Based Decision Making (RES-1, RES-5).

References cited:

1. Prevedouros, K., et al. 2006 *Environmental Science and Technology* 40, 32–44.
2. Nolen, R. M. et al. et al. 2022 *Science of The Total Environment* 805, 150361.
3. Steichen, J. L. et al. 2020 *Frontiers in Marine Science.* 7, 186.
4. Barrientos, M. et al. 2022 Houston Facts. *Greater Houston Partnership*. 62 pages.

Latitude/Longitude (Optional):

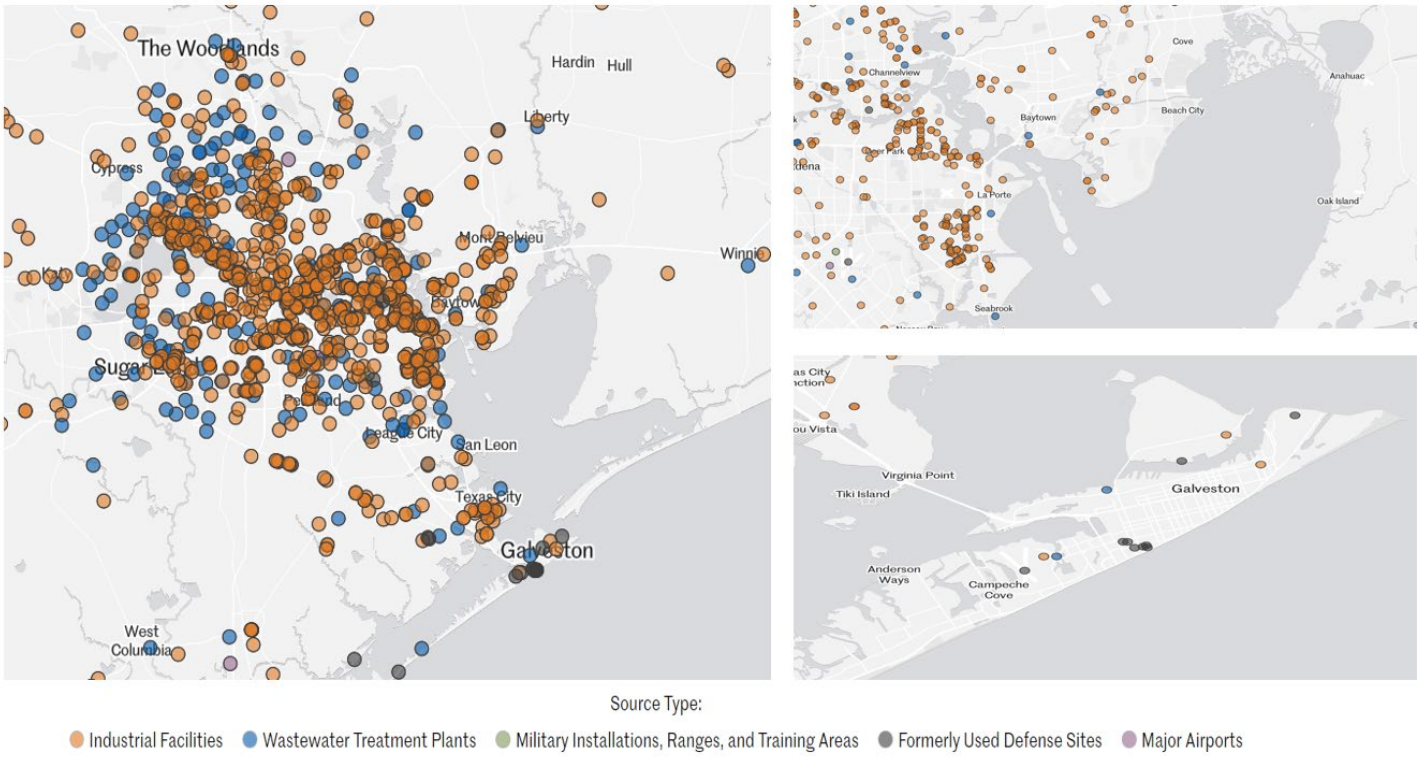
N/A

Location:

Sampling for biota will be opportunistic (e.g., that performed by TPWD, TMMSN and colleagues such as those included in the partner list above), and dockside sampling for surface water samples at sites including (but not limited to) major industrial facilities (5), wastewater treatment plants (5), formerly used defense sites (5) and major airports (2) (see project map). Laboratory analysis will be performed at the research facilities of Texas A&M University at Galveston (TAMUG).

Projects Map

Map shows likely sources of 'forever chemicals' aka PFASs around Houston Galveston Bay. EPA is attempting to nationally regulate this type of chemical in drinking water. Though there is no comprehensive national tracking of the origins of PFAS pollution, researchers from the PFAS Project Lab have compiled a nationwide database of *likely* sources of contamination (Salvatore et al. 2022). We will sample major industrial facilities (5), wastewater treatment plants (5), formerly used defense sites (5) and major airports (2) based on these maps. We will measure concentrations of other CECs collected from the same sample locations.



Supplemental Photos/Graphics (Optional):

N/A

SECTION FIVE: BUDGET DETAILS

BUDGET CATEGORIES:		Budget
a.	Personnel/Salary	$78,583
b.	Fringe Benefits	$28,792
c.	Travel	$3,000
d.	Supplies	$10,500
e.	Equipment	0
f.	Contractual	0
g.	Construction	0
h.	Other*	$12,684
i.	Total Direct Costs (Sum a - h)	$133,559
j.	Indirect Costs	$70,101
k.	Total (Sum of i & j)	$203,660

*Other: If Budget Category "Other" is greater than $25,000 or more than 10% of budget total, identify the main constituents: $12,684 (6.2% of total budget and includes tuition for student, fees and publication costs)

Indirect Cost Agreement
Indirect Cost Reimbursable Rate: The reimbursable rate for this Contract is 52.5% in Year 1 and 54% in Year 2 of (check one):
☐ salary and fringe benefits
☒ modified total direct costs
☐ other direct costs base
If other direct cost base, identify:

This rate is less than or equal to (check one):
☒ Predetermined Rate—an audited rate that is not subject to adjustment.
☐ Negotiated Predetermined Rate—an experienced-based predetermined rate agreed to by Performing Party and TCEQ. This rate is not subject to adjustment.
☐ Default rate—a standard rate of ten percent of salary/wages may be used in lieu of determining the actual indirect costs of the service.

Indirect Cost Rate Agreement dated 9/2/2022 is attached as Appendix A.
Cognizant Federal Agency: Department of Health & Human Services, Denise Shirlee, (214) 767-3261

Please Submit Project Proposals (Microsoft Word Only – No PDFs) by August 4, 2023 to:

WSQ Subcommittee
Christian.Rines@tceq.texas.gov

NRU Subcommittee
Lindsey.Lippert@tceq.texas.gov

PPE Subcommittee
Kari.Howard@tceq.texas.gov

M&R Subcommittee
Cassandra.Taylor@tceq.texas.gov

Galveston Bay Estuary Program
FY 2025 M&R Project Proposal

Please complete the proposal form and submit to the appropriate Subcommittee Coordinator (end of form) by August 4, 2023. No late submittals will be considered for funding.

SECTION ONE: GENERAL INFORMATION

Subcommittee:

M&R (with cross interest in NRU)

Project Name:

Best practices for future restoration of ground nester habitat in Galveston Bay: Partner interviews and past project database of completed nesting sites

Project Previously Funded by GBEP? Yes ☐ No ☒

Lead Implementer:

Texas A&M University Galveston

☐ Federal, State, or Local Government ☐ Council of Government ☒ Public ISDs or Universities
☐ Nonprofit ☐ Other*

* If lead implementer not listed above, the proposing party will need to partner with an interlocal/interagency entity to be selected for funding. Please reach out to GBEP staff with any questions.

Contact Information:

Project Representative Name	Dr. David Retchless
Project Representative Phone	(409) 741-7130
Project Representative Email	retchled@tamug.edu

Amount Requested:

$87,315

Is the project scalable? ☐

Amount Requested per year (if applicable):

FY 2025 (09/01/2024-08/31/2025)	$39,763
FY 2026 (09/01/2025-08/31/2026)	$40,905
FY 2027 (09/01/2026-05/31/2027)	$6,647
Total	$87,315

Total Project Cost:

$87,315

Is this an estimate? ☐

Project Duration (beginning no earlier than September 1, 2024 – 2.5 year maximum project length):

9/1/2024 – 2/28/2027 (2.5 years)

Project Urgency:

No contract related urgency.

Leveraging (in-kind and/or cash):

Proposals have been submitted to other agencies for completion of an earlier phase in this project that would run spatial models to determine habitat “hotspots” for BLSK and AMOY in Galveston Bay and collect data on known foraging, roosting, and non-breeding season habitat use via GIS spatial models. Additionally, we expect to collect similar project data from European Oystercatcher researchers in the Netherlands in summer 2024 via an NSF program through TAMUG. This Netherlands data would incorporate novel island designs in an environment that has been heavily dredged and managed for major flood control for decades.

Partners and Their Roles:

The Gulf Coast Bird Observatory (GCBO) will be acting as a subcontractor on this project. GCBO will assist with field data collection of AMOY and BLSK habitat data and with boat transportation.

Various partners involved in restoration and construction of rookery islands will be interviewed for this project. Individuals that are experts in rookery island work or specific ground nesting species will also be interviewed.

SECTION TWO: *GALVESTON BAY PLAN, 2ND EDITION* IMPLEMENTATION

Galveston Bay Plan, 2nd Edition References
https://gbep.texas.gov/ensure-safe-human-and-aquatic-life-use/
https://gbep.texas.gov/protect-and-sustain-living-resources/
https://gbep.texas.gov/engage-communities/
https://gbep.texas.gov/inform-science-based-decision-making/

This project seeks to collect on-the-ground and individual experience data that has not previously been gathered into one final product. To plan the best future restoration projects targeting bare ground nesters, parameters on "ideal" productive sites and non-productive "failure" sites should be analyzed. Our conservation community holds a wealth of experience in planning, restoration, managing, and monitoring of rookery sites. To date, little data exists on macro and micro habitat variables on AMOY and BLSK preferred nesting sites. By comparing field collected data from both successful and unsuccessful locations, we expect to produce a set of ideal habitat metrics. We aim to capture all of this knowledge into one central reference to be used to inform science-based decision making on future projects, ensuring the highest quality habitat is created with future funding.

This project also supports protecting and sustaining living resources. Only three natural rookery islands still exist in Galveston Bay: North Deer, South Deer, and West Bay Bird Island (old). The remainder of sites used by birds are the product of extensive dredging projects, some dating back to the 1930s. As caretakers of the bay, future sites will only be created and persist with human intervention. By collecting data on what makes a functional, successful island work, this project will ensure that data is available for construction and planning.

Galveston Bay Plan Priority Area Actions Addressed:

Plan Priority 4: Inform Science-based Decision Making

RES-1 ☒	RES-2 ☐	RES-3 ☒	RES-4 ☐
RES-5 ☐	RES-6 ☐	RES-7 ☐	RES-8 ☒
ACS-1 ☒	ACS-2 ☒	ACS-3 ☐	

Plan Priority Area Actions Detail:

RES-1 Conduct Biological Stressor Monitoring and Research- Direct research on ground nesting waterbird species that have populations affected by anthropogenic land use changes. Specific targets will include American Oystercatchers and Black Skimmers, but results will apply to other colonial nesters using similar habitat (Gull-billed Terns, Royal Terns, Caspian Terns, Least Terns).

RES-3 Conduct Physical Stressor Monitoring and Research- Direct research on physical changes to restoration projects and existing islands used by these species over time and assessment of current and past site parameters like elevation, ground cover percentages, distance to anthropogenic features, etc. Long and short term physical changes to sites will also be assessed: erosion effects on various designs (HC-3), succession of plant communities, and aftermath of hurricane or storm-related damage and associated recovery.

RES-8 Complete Coastal Resiliency and Acclimation Studies- Rookery islands, and bare ground nesting habitat in particular, are extremely vulnerable to threats from intensifying hurricanes and tropical storms as well as sea level rise. Understanding how islands weather storms and regular rates or erosion in normal vs. extreme weather years will allow for best practices in planning and designing new restoration projects.

ACS-1 Tracking Ecosystem Health Indicators- Waterbirds are considered biological indicators of overall bay health and rookery islands provide important habitat for a variety of species.

ACS-2 Access to Monitoring and Research Data- An interactive, online StoryMap will be created project to communicate research objectives and progress in a form understandable to the general public (see https://storymaps.arcgis.com/stories/9b7d40a98df54645a070ad0dd29dddac for a similar project example).

Does the project implement any other Galveston Bay Plan Priority Area Actions, or the other Subcommittee priorities?

☐ WSQ (Ensure Safe Human and Aquatic Life Use)
☒ NRU (Protect and Sustain Living Resources)
☐ PPE (Engage Communities)

Other Subcommittee Detail:

HC-2 Habitat Restoration- This project will provide important vetted, on the ground habitat data to decision makers and engineers working on restoration planning and construction.

SC- 1 Support projects that sustain and restore native species populations- While this project will not physically restore habitat and native species populations, it is expected that project deliverables will drive better-informed project planning and provide region specific successful variables for island construction.

Other Plans Implemented:

- Coastal Resiliency Master Plan
- North American Waterbird Conservation Plan
- Gulf Coast Joint Venture Texas Mid-Coast Initiative Area Plan, GCJV Chenier Plain Initiative Area Plan
- American Oystercatcher Focal Species Business Plan,
- Gulf Coast Joint Venture Priority Science Needs for Landbirds, Shorebirds, & Waterbirds: (Specific identified science needs listed below)
    - 1. Develop and validate a population-habitat model for Black Skimmer in the GCJV region (proposed project will provide needed data)
    - 2. Validate population response of priority colonial nesting waterbirds (e.g., Black Skimmer, Gullbilled Tern, Reddish Egret and Little Blue Heron) to colony site management measures, including erosion control, dredged material placement, vegetation management, disturbance minimization and predator control
    - 6. Assess effectiveness of marsh and beach creation through sediment deposition in providing habitat used by shorebirds with abundant prey

SECTION THREE: SUBCOMMITTEE PRIORITIES

M&R Subcommittee Identified Priorities
Proposals must address one or more of the following actions:

☒ Meaningful and effective monitoring of existing and new projects (NRU/WSQ/PPE support)
☐ Exposure and response to emerging contaminants across trophic levels
☐ Reestablishing dermo monitoring programs (Ex. Oyster Sentinel)
☒ Project Component: Results translated to plain language/practical knowledge

Subcommittee Priority Detail:

We seek to gather meaningful data from shareholders, project managers, and on-the-ground measurements on vital ground nesting rookery island habitat. GCBO has been monitoring for AMOY and BLSK for many years and we seek to compare the metrics of a site's fledge success and outcomes (if known) with physical parameters that can be replicated in future rookery restoration and construction. We will work closely with NRU members to gather information on past projects and use interview questions to assess the success of a site to attract groundnesting species and produced fledglings. This will be combined with on the ground field observations of nesting habitat post breeding season. Data will be collected on variables like elevation, slope, percent vegetation coverage, and possibly nest microhabitat characteristics. This sort of site data has not often been collected, particularly in Galveston Bay. We expect to examine data for sites like: Struvy Lucy, Jigsaw, North and South Deer, Marker 52, Texas City Prairie Preserve Spit, Dickinson Bay, Dollar Bay Terraces, and Bay Harbor Bar Islands, some of the more recent 1-to-2 year use skimmer sites along Galveston Island State Park (like Carancahua Cove), small/unnamed shell rakes used by AMOY, and any other locations where we have at least 2 years of quality monitoring data. By completing this work with a combination of input from past project managers, engineers, site managers, bird biologists, and GIS specialists, we expect our final product to represent the full spectrum of specialists involved in restoration planning and monitoring.

Our final products will also be user friendly and easy to access for partners and engineers. We will construct an online ESRI StoryMap of the sites analyzed, including habitat parameters and fledge success. All information will be summarized in a white paper report, with specific sections designed for quick reference and easy use by engineers and designers. Our model for this final report is a 2021 paper by Ridlon et.al.: Conservation of Marine Foundation Species: Learning from Native Oyster Restoration from California to British Columbia https://link.springer.com/article/10.1007/s12237-021-00920-7 . This paper synthesized oyster restoration projects from the California coast to British Colombia, CA and analyzed project goals, methods and outcomes. We expect our final report to be similar to this article, summarizing goals, methods, and outcomes for ground nester sites with the addition of physical parameters from field work.

Does the Project work with new, smaller communities/partnerships?

☐ Yes

☒ No

SECTION FOUR: PROPOSAL DETAILS

Project Summary:

This project will gather previously unknown or scattered information via partner interviews and literature reviews on best practices for the design and construction of ground nesting bird habitat, particularly Black Skimmer and American Oystercatcher. These interviews will be combined with field data collection to create an end product report and interactive online StoryMap that will offer future designers, engineers, and site managers a collection of known successful habitat metrics for future restorations.

Full Project Description (1,000 words or less):

Coastal regions host a unique habitat type that is vital to the success of many species- overwash beaches. These ecosystems are molded by disturbance (erosion, accretion, overwash) as a result of regular tidal and storm events (Von Holle et al. 2019). While storm events are important to build these habitat patches, they can also be detrimental to sites already weakened by climate change related issues (e.g., accelerated sea level rise and erosion). Coastal habitats already negatively affected by anthropogenic factors are likely to be squeezed even more as sea levels rise (Von Holle et al. 2019).

Many species of North American breeding birds that depend on coastal systems have suffered loss and degradation of vital habitat, raising concern about their population stability (Jodice et al. 2014). These bird species seek out overwash beaches for nesting on Gulf of Mexico facing sites, dredge spoil islands, estuarine marsh ridges, shell rakes, and the (often rare in Texas) natural bay islands. Ideally, overwash activity in the fall and winter provides freshly cleared habitat with minimal vegetation for these beach nesting species. Sparse vegetation allows for clear sightlines to see approaching predators and aids in camouflaging eggs evolved to blend with shell and sand. Some cover in the form of beach debris or nearby marsh plants are important for use by precocial chicks as shade or hiding spaces. However, the unlucky nests laid at lower elevations in these areas are vulnerable to non-typical flooding events in the spring and summer. When selecting a nest site, adult coastal birds must compromise between open beach that allows for surveillance and maintaining an elevation low enough to have past overwash but high enough to be protected from high, high tides.

The Galveston Bay area has long supported populations of beach nesting birds. Coastal nesting waterbirds specifically seek out islands free of mammalian predators; as natural islands disappeared, dredge spoil islands began to replace these necessary habitats. Today, few natural islands exist due to changes in hydrology and erosion rates and those artificial islands that remain are experiencing higher erosion rates due to large ship wakes, altered shorelines, disrupted hydrology, and overall sea-level rise. Depending on the year, Galveston Bay is home to approximately 20-30 active rookery islands (TWS 2023). In 2023, just six Galveston Bay area sites were counted on the annual Texas Waterbird Society rookery surveys.

Real world experience is invaluable when designing new waterbird islands or restoring old locations. Past methodology that has successfully drawn in birds to a new breeding location can be replicated on new islands. While techniques for creating and maintaining shrub-nester habitats are well known, ground nesting species tend to have more nuanced requirements. Information on successful techniques is spread throughout many final report-type documents and as anecdotal in-person conversations.

We will prepare a set of questions for project leaders and land managers involved with past rookery islands hosting bare ground nesting colonies. Answers and materials will be collected into a final report that will be made available for partners.

We will gather data similar to the list below from each interviewee about any projects they have been directly involved with or have managed post-construction:

- Dates of construction.
- Information on site conditions pre-construction.
- Use by ground nesting species before, during, and after construction.
- Materials cost, composition, acquisition.
- Substrates used and any techniques for preparing prior to application.
- Phase timelines, time for permitting, design, construction, eventual use by waterbirds.
- Planned final habitat goals and if they were met.
- Target wildlife species considered during planning.
- Any maintenance or repairs performed after construction.
- Any regular management performed annually.
- When available, copies of project photos and designs.
- Methods used for shoreline protection/ stabilization.
- After effects of major storms on site and habitat composition.
- Any “lessons learned” or suggestions for future work.

We will work to develop a series of interview questions to obtain the most relevant information for engineers and designers. We will contact firms known to work on these restoration sites and obtain suggested construction related parameters their designers need. We will possibly host a series of workshops

to interview partners or may arrange in person/hybrid meetings with individual agencies to ensure the best participation rate possible.

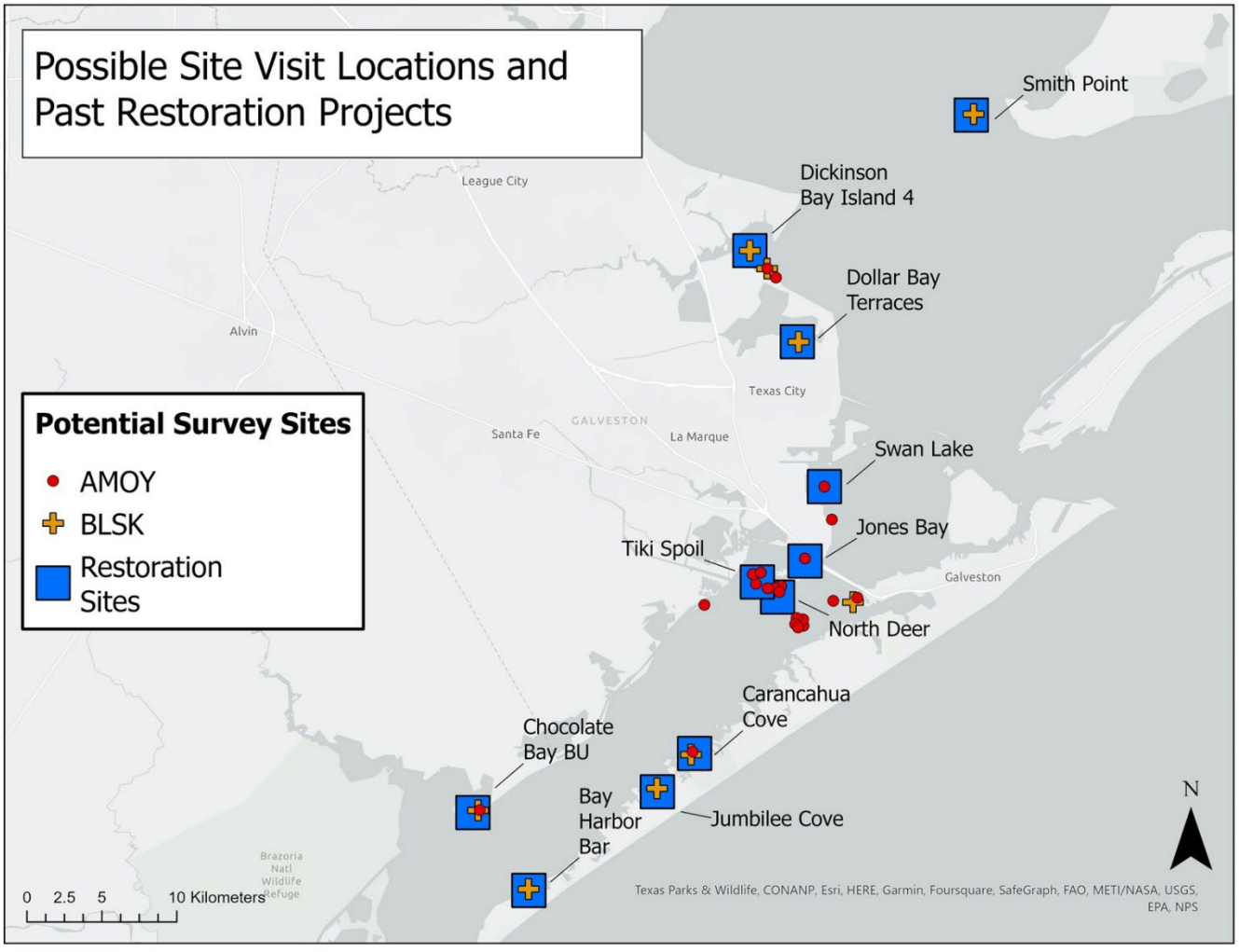
In addition to the partner interviews, we will collect field data on known BLSK and AMOY nesting sites. We expect to examine data for sites like: Struvy Lucy, Jigsaw, North and South Deer, Marker 52, Texas City Prairie Preserve Spit, Dickinson Bay, Dollar Bay Terraces, and Bay Harbor Bar Islands, some of the more recent 1-to-2 year use skimmer sites along Galveston Island State Park (like Carancahua Cove), small/unnamed shell rakes used by AMOY, and any other locations where we have at least 2 years of quality monitoring data. Data will be collected on metrics like elevation, vegetation percent cover, vegetation types, substrate types, and microhabitat parameters around known nests (when possible). GCBO will work with TAMUG to assess these sites, gather field data, and use GCBO's extensive monitoring records to help determine a site's past and present successes or failures for fledging new birds.

All data collected during this phase will be written up in a report with individual sections for each site covered. If possible, photographs and design plans will be included. This report will be made available to all partners and posted on the Texas Waterbird Society website. Additionally, material will be summarized in an online ESRI StoryMap, providing an interactive resource for partners.

Location:

Galveston Bay estuarine habitats: see attached map of known sites hosting ground nesting species.

Projects Map



SECTION FIVE: BUDGET DETAILS

BUDGET CATEGORIES:		Budget
a.	Personnel/Salary	$25,481
b.	Fringe Benefits	$6,084
c.	Travel	$0
d.	Supplies	$1,000
e.	Equipment	$0
f.	Contractual	$17,800
g.	Construction	$0
h.	Other*	$10,100
i.	Total Direct Costs (Sum a - h)	$60,465
j.	Indirect Costs	$26,850
k.	Total (Sum of i & j)	$87,315

*Other: If Budget Category "Other" is greater than $25,000 or more than 10% of budget total, identify the main constituents:

- PhD Student tuition and fees (10 calendar months total over 2.5 years)

Indirect Cost Agreement

Indirect Cost Reimbursable Rate: The reimbursable rate for this Contract is 52.5% (Year 1) and 54.0% (Years 2 & 3) % of (check one):

☐ salary and fringe benefits
☒ modified total direct costs
☐ other direct costs base
If other direct cost base, identify:

This rate is less than or equal to (check one):
☒ Predetermined Rate—an audited rate that is not subject to adjustment.
☐ Negotiated Predetermined Rate—an experienced-based predetermined rate agreed to by Performing Party and TCEQ. This rate is not subject to adjustment.
☐ Default rate—a standard rate of ten percent of salary/wages may be used in lieu of determining the actual indirect costs of the service.

Indirect Cost Rate Agreement dated 9/2/2022 is attached as Appendix A.

Cognizant Federal Agency: Department of Health & Human Services, Denise Shirlee, (214) 767-3261

Please Submit Project Proposals (Microsoft Word Only – No PDFs) by August 4, 2023 to:

NRU Subcommittee
Lindsey.Lippert@tceq.texas.gov

M&R Subcommittee
Cassandra.Taylor@tceq.texas.gov

Galveston Bay Estuary Program
FY 2025 NRU Project Proposal

Please complete the proposal form and submit to the appropriate Subcommittee Coordinator (end of form) by August 4, 2023. No late submittals will be considered for funding.

SECTION ONE: GENERAL INFORMATION

Subcommittee:

NRU

Project Name:

Monitoring and Managing the Threatened Eastern Black Rails in the Galveston Bay Area

Project Previously Funded by GBEP? Yes ☐ No ☒

Lead Implementer:

Dr. Chris Butler, Texas A&M University

☐ Federal, State, or Local Government ☐ Council of Government ☒ Public ISDs or Universities
☐ Nonprofit ☐ Other*

* If lead implementer not listed above, the proposing party will need to partner with an interlocal/interagency entity to be selected for funding. Please reach out to GBEP staff with any questions.

Contact Information:

Project Representative Name	Dr. Chris Butler
Project Representative Phone	405-215-5806
Project Representative Email	Chris.butler@tamu.edu

Amount Requested:

$174,235

Is the project scalable? ☒

Amount Requested per year (if applicable):

FY 2025 (09/01/2024-08/31/2025)	$105,888
FY 2026 (09/01/2025-08/31/2026)	$53,680
FY 2027 (09/01/2026-05/31/2027)	$14,667
Total	$174,235

Total Project Cost:

$174,235

Is this an estimate? ☐

Project Duration (beginning no earlier than September 1, 2024 – 2.5-year maximum project length):

2.5 years

Project Urgency:

Currently have funding from 4 different sources to study Eastern Black Rails (NOAA, USFWS, TPWD, and NPS), of which three (NOAA, USFWS, and TPWD) are currently being used to study Eastern Black Rails in the Galveston Bay watershed. TPWD and NOAA funding expires 31 Aug 2024, USFWS is funded through 2027.

Leveraging (in-kind and/or cash):

USFWS - $60,000 – “Assessing the response of Black Rail populations to management actions in coastal Texas marshes”. Submitted, told that it will be funded, but no official letter yet. Research will be carried out at Texas mid-Coast NWR complex, including Brazoria NWR which falls within Galveston Bay Watershed boundary, as well as two locations in the Galveston Bay area.

Texas Parks & Wildlife Department – $442,817 – “Comparing detectability and efficiency of multiple methods for surveying rails”. Funded, but funding expires 31 Aug 2024. Study sites include research at Galveston Island State Park.

NOAA RESTORE (co-PI on this one) - $3,922,699 – “Fire effects in Gulf of Mexico marshes: Historical perspectives, management, and monitoring of Mottled Ducks and Black and Yellow Rails”. Funded, but funding expires 31 Aug 2024. Planning on submitting 5-year renewal request. Study sites include Bolivar Peninsula (Houston Audubon properties).

National Park Service - $93,605 – “Inventory of Eastern Black Rail to Inform Padre Island National Seashore Prescribed Fire Management”. Study site is at Padre Island National Seashore, but can use equipment and software for the proposed research once fieldwork is complete. Funded through 1 April 2025.

Partners and Their Roles:

US Fish & Wildlife Service – will assist with selection of study sites on USFWS-managed properties, will provide housing for field techs during field season. Will also assist with field work and will oversee some habitat enhancement activities.

Texas Parks & Wildlife Department – will provide access to Galveston Island State Park.

Houston Audubon – will provide access to properties on Bolivar peninsula.

Ducks Unlimited – will be responsible for habitat enhancement and restoration (funded through other grants)

SECTION TWO: *GALVESTON BAY PLAN, 2ND EDITION* IMPLEMENTATION

Galveston Bay Plan, 2nd Edition References
https://gbep.texas.gov/ensure-safe-human-and-aquatic-life-use/
https://gbep.texas.gov/protect-and-sustain-living-resources/
https://gbep.texas.gov/engage-communities/
https://gbep.texas.gov/inform-science-based-decision-making/

The second edition of the Galveston Bay Plan includes four plan priorities, two of which (#2: Protect and sustain living resources; and #4: Inform science-based decision making) are directly relevant to this project. Within plan priority #2, there is an Action Plan, "Support Species Conservation". The International Union for the Conservation of Nature considers Black Rails (*Laterallus jamaicensis jamaicensis*) to be "Endangered" (IUCN 2022) and the American Bird Conservancy considers it to be "At Risk" (American Bird Conservancy 2012). Populations that have been monitored in the eastern U.S. have declined at a rate of 4.7 – 9.2% annually since the late 1980s and it is estimated that the total breeding population along the Atlantic and Gulf Coast states consists of only 455 – 1315 breeding pairs (Watts 2016). The Texas Gulf Coast appears to be one of the few remaining strongholds for this species in the US, with occupancy of suitable habitat in the being approximately 75% (Butler et al. 2015, Butler et al. in press). Based on fieldwork conducted during 2021 and 2022 in the Texas mid-Coast NWR complex, it appears that there may be >200 pairs on these refuges, with good numbers also present at other suitable high marsh sites within the Galveston Bay watershed (e.g., Anahuac, Bolivar Peninsula, Galveston Island State Park, etc.) Consequently, there is an urgent need to monitor Black Rails and evaluate management techniques in order to maintain these birds.

Galveston Bay Plan Priority Area Actions Addressed:

Plan Priority 2: Protect and Sustain Living Resources

HC-1 ☐	HC-2 ☒	HC-3 ☒
SC-1 ☒	SC-2 ☐	
FWI-1 ☐	FWI-2 ☐	FWI-3 ☐

Plan Priority Area Actions Detail:

HC-2 is habitat restoration and **HC-3** is habitat enhancement. One of the grants that will be leverage for this project (the USFWS grant) involves aspects of habitat restoration (e.g., cattle exclosures and woody vegetation removal) as well as habitat enhancement (e.g., modifying habitat microtopography). While the proposed project will not fund these actions (as they are funded elsewhere), it will allow us to better monitor how effective the habitat restoration and habitat enhancement is for enhancing Black Rail populations. Within 2 years we anticipate a measurable increase in Black Rail use of restored and enhanced habitats, as well as a measurable improvement in the quality of the high salt marsh.

SC-1 is to protect and sustain living resources. The proposed project will evaluate how effective we are at sustaining native populations of Black Rails (along with their food sources) by restoring and enhancing high salt marsh. Within 2 years, we anticipated demonstrating that our approach can more efficiently quantify the number of Black Rails using an area and will be able to provide guidance on how management techniques such as cattle exclosures, woody vegetation removal, and modifying microtopography can enhance Black Rail populations.

Does the project implement any other Galveston Bay Plan Priority Area Actions, or the other Subcommittee priorities?

☐ WSQ (Ensure Safe Human and Aquatic Life Use)
☐ PPE (Engage Communities)
☒ M&R (Inform Science-Based Decision Making)

Other Subcommittee Detail:

The existing research is scalable and is part of a larger project examining Black Rails and high salt marsh along the northern Gulf Coast. The proposed research fits in with **RES-6**: Evaluate Best Management Practice (BMP) Project. Although the Atlantic Coast Joint Venture (ACJV) has published the "Black Rail Conservation Plan", there is no similar plan for the Gulf Coast. However, it seems likely that a comparable plan will eventually be adopted for Gulf Coast region as well. The ACJV plan includes the following items:

- Create new non-tidal Black Rail habitat
- Promote targeted impoundment management
- Develop and promote Black Rail-friendly fire best management practices (BMPs)
- Develop and promote Black Rail-friendly agricultural BMPs
- Develop and implement BMPs to facilitate marsh migration
- Develop Landowner Assurances Program

The proposed and ongoing research will help inform fire best management practices (indeed, this is one of the goals of the NOAA Firebird project that would be leveraged with this project), agricultural best management practices (e.g., stocking density and the potential of cattle exclosures), and facilitating marsh migration by evaluating the effects of modifying microtopography.

Other Plans Implemented:

TPWD's Texas Conservation Action Plan identifies the Black Rails as a Species of Greatest Conservation Need that requires additional life history information. Although the GCJV does not yet have a plan specifically for Black Rails (unlike the Atlantic Coast Joint Venture), the Black Rail is one of the priority species for the Gulf Coast Joint Venture.

SECTION THREE: SUBCOMMITTEE PRIORITIES

NRU Subcommittee Identified Priorities
Proposals must address one or more of the following actions:

☐ Habitat Acquisition
☐ Enhancement of Existing or Ongoing Restoration/Conservation Efforts
  ☐ Special emphasis on projects addressing geotubes failing across West Bay through design and/or construction
☒ Benefit to Native Fish and Wildlife, including Federal and State Listed Species, Species of Greatest Conservation Need, or Nongame Wildlife
  ☐ Special emphasis on projects addressing seagrasses, intertidal reef/shell hash, and benthic communities
☒ Brings Funding, Work Leverage, or Multiple Goal Benefits to the Subcommittee
☐ Project Urgency: Project must be completed in next 24 months or opportunity is lost

Subcommittee Priority Detail:

The proposed research directly addresses the action of "Benefit to Native Fish and Wildlife, including Federal and State Listed Species, Species of Greatest Conservation Need, or Nongame Wildlife" by focusing on the restoration and conservation of high salt marsh habitats in the Galveston Bay watershed. These habitats play a crucial role in supporting populations of the federally threatened Eastern Black Rail (*Laterallus jamaicensis jamaicensis*). By implementing management practices to maintain and restore these salt marsh habitats, including prescribed fire, vegetation treatments, and hydrological improvements, this research seeks to improve the suitability of the habitat for these species, support their occupancy, and enhance their prey base. As a result, the project directly contributes to the benefit and conservation of native fish and wildlife, particularly those of conservation concern, fostering their resilience and overall health within the Galveston Bay ecosystem.

Does the Project work with new, smaller communities/partnerships?

☐ Yes

☒ No

SECTION FOUR: PROPOSAL DETAILS

Project Summary:

The project aims to study and conserve the Black Rail (*Laterallus jamaicensis*), a threatened species heavily reliant on high salt marsh habitats. Leveraging multiple grants, the research involves using ARUs and a FLIR-equipped drone to evaluate management techniques and response effects on Black Rail populations, as well as conducting mark-recapture studies and fecal metagenomics to understand their diet.

Full Project Description (1,000 words or less):

Introduction

Salt marshes occur at the interface between the marine and terrestrial environments, and are important locations for primary productivity, biodiversity, and ecological services such as denitrification (Gedan et al. 2009). They may also act as a storm surge buffer (Möller et al. 2014). These coastal wetlands provide vital habitat for several major fisheries and dozens of migratory birds, including multiple species federally listed under the Endangered Species Act (Kelleway et al. 2017). Globally salt marshes have declined in extent by 25-50%, with pollution, development, altered hydrology, and rising sea levels contributing to declines of salt marsh quantity and quality (Crooks et al. 2011, Duarte et al. 2008).

One of the most vulnerable habitats within this landscape, high marsh, is characterized by high salinity soils, infrequent tidal inundation, and a unique suite of wetland plant species (Eddleman et al. 1994, NatureServe 2009, Texas Conservation Action Plan 2012). In Texas, for example, high marsh differs from low marsh in that high marsh generally is dominated by *Spartina patens* whereas low marsh generally is dominated by *S. alterniflora* (USFWS 1999, Elliot et al. 2014). High marsh may be especially susceptible to loss because management in adjacent upland habitats can prevent wetland migration, and high marsh can be overtaken by low marsh as sea level rise pushes it upslope (Borchert et al. 2018).

One species that appears to be heavily reliant upon high salt marsh is the rare and elusive Black Rail (*Laterallus jamaicensis*). In October 2020, the US Fish & Wildlife Service listed the Black Rail as a Threatened species (FWS-R4-ES-2018-0057). Qualitative observations suggest a drastic population decrease between the 1920s and 1970s (Eddleman et al. 1994). Populations that have been monitored in the eastern U.S. have declined at a rate of 4.7 – 9.2% annually since the late 1980s and it is estimated that the total breeding population along the Atlantic and Gulf Coast states consists of only 455 – 1315 breeding pairs (Watts 2016).

The Texas coast appears to be a significant stronghold for the species. Although published population estimates for this area do not exist, surveys on the mid-Coast National Wildlife Refuge (NWR) complex (Brazoria NWR, San Bernard NWR, and Big Boggy NWR) during 2021-2022 detected approximately 130 vocalizing individuals (Butler, unpubl. data). Fieldwork for other projects suggests that the Galveston Bay estuary and environs (e.g., Galveston Island State Park, Houston Audubon properties on the Bolivar peninsula, etc.) also have substantial numbers of this species (Butler, unpubl. data). Consequently, there is an urgent need to effectively manage and monitor this Threatened Species in the Galveston Bay area in order to help maintain one of the last strongholds of this species.

Ongoing research

As noted in Section 1, “Leveraging (in-kind and/or cash)”, we currently have multiple grants for studying Black Rails along the Texas Coast. The USFWS grant, which will begin next year will focus on evaluating management activities that may benefit Black Rails, including grazing exclosures, restoring microtopography, and reducing woody vegetation persistence. The Texas Parks & Wildlife Department focused on evaluating multiple methods of surveying for rails, including call-playback, deploying ARUs (Autonomous Recording Devices), using game cameras, and flying a UAV (unmanned aerial vehicle, i.e., a drone) equipped with a FLIR camera that is capable of detecting heat signatures. The UAV has proven to be effective at finding rails (see Olsen et al. 2023), allowing us to find and photograph a recent fledgling, and to

demonstrate that individuals appear to pair up as early as February (Olsen et al. in prep). However, the UAV, will need to be turned over to TPWD in 2024 as per the grant agreement. The NOAA Firebird grant is a collaborative effort between multiple institutions along the northern Gulf of Mexico, conducting surveys for breeding and non-breeding Black Rails (along with two other species of interest), using rope-drags to flush and band non-breeding individuals, and collecting feathers for a stable isotope analysis. In addition, I have also been collecting fecal samples from individuals that I band in order to perform fecal metagenomics to quantify the diet of these rails and have obtained preliminary results on the invertebrate component of their diet from approximately 15 individuals.

Goals and Objectives

The goal of this project is to leverage the existing grants in order gather additional information that will facilitate surveys and management of Black Rails. Specifically, the objectives are:

1.) Use ARUs and a FLIR-equipped drone to facilitate research on the response effects of different treatment methods on Black Rail populations in marshes in coastal Texas to better understand management techniques and how to manage sites to benefit of this species in the context of other land uses.
2.) While conducting mark-recapture studies of Black Rails during the non-breeding season, collect fecal samples from banded birds that will be used in a fecal metagenomics study that will quantify diet.
3.) Engage with local landowners and stakeholders to provide technical assistance and share the findings of the study to promote the conservation and management of Black Rail populations, as well as the overall health of marsh ecosystems in coastal Texas.

Study sites

This research will be conducted at six sites (Brazoria NWR, Galveston Island, Bolivar Flats, Frost Dean, Gordy Marsh, and Mundy Marsh. See "Projects Map" for locations of these sites

Methodology

Surveys

After consultation with appropriate refuge personnel, ARUs (Autonomous Recording Units) will be deployed to determine when Black Rails recolonize an area after treatments at sites within broader management goals. A FLIR-equipped UAV will also be used to survey for Black Rails in control and treatment areas. Additionally, habitat (such as above-ground biomass) and landscape-level metrics (such as patch size) will be examined to further refine our understanding of how habitat quality influences Black Rail occupancy.

Mark-recapture and fecal metagenomics

During the non-breeding season, rope-drags will be conducted at selected locations in order to determine if Black Rails are present. Individuals that flush will be banded, measured, and any fecal material present will be collected and analyzed in order to quantify the diet.

Latitude/Longitude (Optional):

Various; see "Projects Map" for map of study sites

Location:

The six study sites include: (1) Brazoria National Wildlife Refuge; (2) Galveston Island State Park; (3) Bolivar Flats; (4) Frost Dean (USFWS property); (5) Mundy Marsh (Houston Audubon property); and (6) Gordy Marsh (USFWS property)

Projects Map

Supplemental Photos/Graphics (Optional):

None

SECTION FIVE: BUDGET DETAILS

BUDGET CATEGORIES:		Budget
a.	Personnel/Salary	$34,783
b.	Fringe Benefits	$9,735
c.	Travel	$11,250
d.	Supplies	$31,839
e.	Equipment	$36,950
f.	Contractual	
g.	Construction	
h.	Other*	$3,542
i.	Total Direct Costs (Sum a - h)	$128,099
j.	Indirect Costs	$46,136
k.	Total (Sum of i & j)	$174,235

*Other: If Budget Category "Other" is greater than $25,000 or more than 10% of budget total, identify the main constituents:

Indirect Cost Agreement

Indirect Cost Reimbursable Rate: The reimbursable rate for this Contract is 52.5% of (check one):

☐ salary and fringe benefits
☒ modified total direct costs
☐ other direct costs base
If other direct cost base, identify:

This rate is less than or equal to (check one):
☐ Predetermined Rate—an audited rate that is not subject to adjustment.
☒ Negotiated Predetermined Rate—an experienced-based predetermined rate agreed to by Performing Party and TCEQ. This rate is not subject to adjustment.
☐ Default rate—a standard rate of ten percent of salary/wages may be used in lieu of determining the actual indirect costs of the service.

[Insert Indirect Cost Agreement or Attach as an Appendix if Applicable]

Please Submit Project Proposals (Microsoft Word Only – No PDFs) by August 4, 2023 to:

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PPE Subcommittee
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