Shell Bank: Oyster shell recycling, restoration resources, and reef resilience

Final Report for GLO Contract # 20-038-000-B746

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August 31, 2021

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Acknowledgements

The Shell Bank is the first oyster shell reclamation, recycling, and restoration program in Texas. We would like to thank the Texas General Land Office's Coastal Management Program, especially Jessica Chappell, Julie McEntire, Sharon Moore, and Melissa Porter, for their support of this project. We also thank members of the Coastal Conservation and Restoration Ecology Lab and the Harte Research Institute of Gulf of Mexico Studies at Texas A&M University-Corpus Christi, for their hard work on the project. Accomplishments of this CMP Cycle 24 project would not have been possible without support from our project partners, including Water Street Seafood Restaurants, the Port of Corpus Christi, Austin Oyster Festival, Groomer's Seafood, Fiesta Oyster Bake, Scuttlebutt's Restaurant, and Virginia's on the Bay. These partners donated shucked oyster shells, contributed their time and resources, and provided support for public education and habitat restoration efforts. We also thank the community volunteers who have contributed their time to our oyster shell recycling and reef restoration efforts. Lastly, we would like to recognize that oyster shells reclaimed from CMP 24 and previous CMP cycles have been used to restore over 30 acres of oyster reef with external funds, with the most recent restored reef being constructed in July 2021.

Project Partners

— THE —

OYSTER BAR

FOOD. SERVICE. PEOPLE.

SINCE 1983

Fiesta Oyster Bake®

The Heartbeat of Fiesta®

AUSTIN OYSTER FESTIVAL

Groomers SEAFOOD

"Your Hometown Seafood Experts"

PORT CORPUS CHRISTI®

Scuttlebutt's

SEAFOOD BAR & GRILL

Introduction

Oysters were once dominant habitat builders in estuarine and coastal ecosystems, but have experienced substantial declines over the past two centuries. When the physical reef structure is degraded or lost—due to unsustainable harvest, storms, sedimentation, or other disturbances—larval recruitment can be limited, impeding reef recovery and affecting provision of critical ecosystem services. Despite recognized losses, restoration of oyster reefs has tended to lag behind other structured habitats in estuarine and coastal ecosystems, necessitating a targeted focus on this important habitat.

The Gulf of Mexico has become a target region for oyster reef restoration efforts. Although Gulf estuaries have experienced substantial reef loss associated with storms and petrochemical spills, leading to declines in commercial harvest (Figure 1), it has also been identified as the last region in the world to maintain both viable oyster fisheries and functional reef habitats. Because coastal ecosystems are more expensive to restore than freshwater and terrestrial systems, there is a need for information and approaches that can be used to improve the efficiency and effectiveness of restoration practices.

In order to support habitat restoration efforts moving forward, it is critical to incorporate sustained measurements of restored habitats to improve our understanding of changes over time and in response to disturbances. The importance of resilience, or the ability to bounce back after a disturbance, came into focus in the aftermath of the 2017 hurricane season. Nature-based solutions such as oyster reef restoration can help communities become more resilient and less vulnerable by enhancing and protecting the coastal environment and providing associated benefits. Unfortunately, many restoration projects have had limited or no monitoring, impeding our ability to learn from past successes and failures. Understanding the response of restored reefs to disturbances from storms is important for predicting future restoration outcomes.

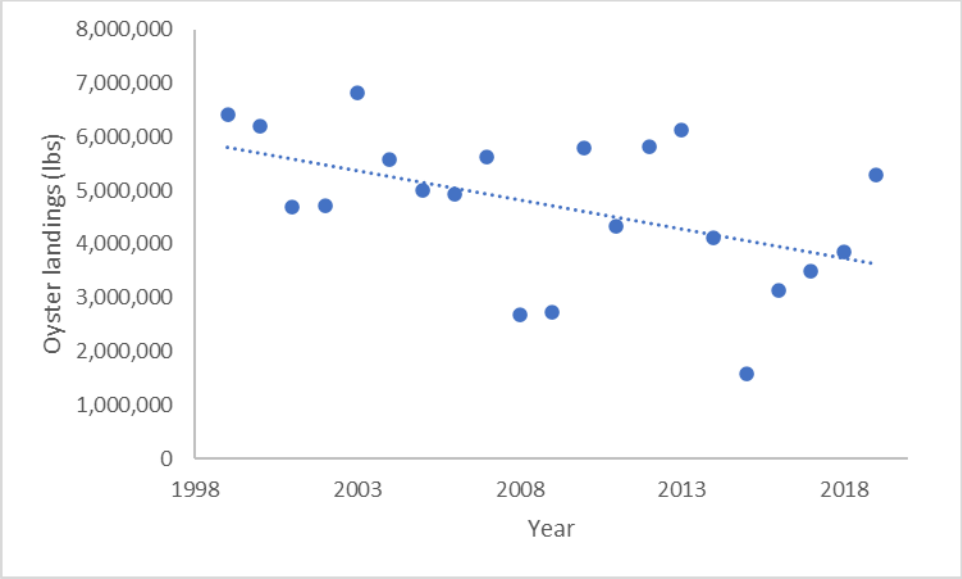


Figure 1. Annual commercial oyster landings in Texas, 1999-2019. Linear regression analysis indicates that harvests are declining at >108,000 pounds per year. NOAA Commercial Fisheries Data. https://www.fisheries.noaa.gov/foss/

Community-based restoration projects provide opportunities for volunteer groups to implement restoration projects to improve habitat conditions within their own communities. Although community-based restoration efforts are typically conducted at the relatively small scale, these opportunities help to build local capacity for environmental stewardship and demonstrate the value of healthy coastal habitats. The restored habitats then provide much larger benefits back to the community, supporting recreational and sport fishing, tourism, and protecting coastal shorelines.

This project aimed to support coastal resilience on the Texas coast by recycling oyster shells, involving community volunteers in hands-on habitat restoration, creating educational materials for use by teachers, and evaluating the factors promoting success of restored reefs. Specifically, we sought to: (1) reclaim shucked shells from restaurants, seafood wholesalers, and festivals for use in oyster reef habitat restoration, (2) host community-based restoration events; educating volunteers on the importance of oyster reefs, the ecology of the habitat they are helping restore, and the benefits of habitat restoration, (3) create activities for students to experiment with restoring the coastal environment and observing how conservation promotes resilience, and (4) assess restored oyster reefs to evaluate what characteristics promote sustainability and resilience.

This project implements CMP goal 1) "to protect, preserve, restore and enhance the diversity, quality, quantity, functions, and values of coastal natural resource areas (CNRAs)" and CMP goal 10) "to educate the public about the principal coastal problems of state concern and technology available for the protection and improved management of CNRAs". This project also supports the TX Coastal Resiliency Master Plan and principal goals and priorities defined in the Coastal Bend Bays Plan, including Bay Tourism and Recreation (BTR-1, BTR-4), Habitat and Living Resources (HLR-1, HLR-2), and Public Education and Outreach (PEO-3, PEO-5).

Project accomplishments

Goal 1: Oyster shell recycling

Oyster reefs have been severely degraded over the past century, resulting in loss of natural habitat and associated ecological functions and ecosystem services. Habitat restoration has become a best practice for ameliorating the effects of habitat loss and increasing coastal resilience. Recycled shell is the preferred substrate for restoring oyster reefs, but because of its limited supply, can constrain the size of restoration efforts. As part of CMP Cycle 24, we reclaimed shucked oyster shells from restaurants, seafood wholesalers, and festivals across Texas for use in rebuilding and restoring oyster reefs.

Our network of shell recycling partners includes: Groomer's Seafood, Water Street Restaurant group, Scuttlebutt's Restaurant, Virginia's on the Bay Restaurant, Austin Oyster Festival and St. Mary's Fiesta Oysterbake in San Antonio. Every week, oyster shells were picked up from our restaurant partners and transported via truck and trailer to the Shell Bank stockpile location at the Port of Corpus Christi. On February 29, 2020, we participated in Austin Oyster Festival, hosted at Republic Square in Austin, TX (Figure 2, Figure 3). Oyster shell was transported via truck and trailer to the Shell Bank stockpile location immediately following the event. All reclaimed shells from restaurants and festivals were quarantined for at least 6 months after collection.

From October 2019-February 2020, we reclaimed between 10,000-15,000 pounds of oyster shells per month (Figure 4). However, project activities began to be impacted by the COVID-19 pandemic starting in March 2020. St. Mary's Fiesta Oyster Bake in San Antonio was canceled in spring 2020 (and then again in spring 2021) due to the pandemic. We temporarily discontinued shell recycling activities due to restaurant closures and shelter-in-place orders on March 21,

2020. We restarted collecting oyster shells from project partners on May 11, 2020. Our shell collection activities quickly increased in late spring of 2020 as people were eager to return to restaurants. The amount of shells recycled remained within the range of 15,000-20,000 pounds per month through the end of the project period.

Figure 2. Sink Your Shucks staff and volunteers at the 2020 Austin Oyster Festival, February 29, 2020.

Figure 3. Performing public outreach at the 2020 Austin Oyster Festival, February 29, 2020.

Starting in mid-May of 2020, we began to work with our partner restaurants again to reclaim shucked oyster shells for use in habitat restoration activities. A total of 330,600 pounds of oyster shells were reclaimed with support from CMP Cycle 24 funds.

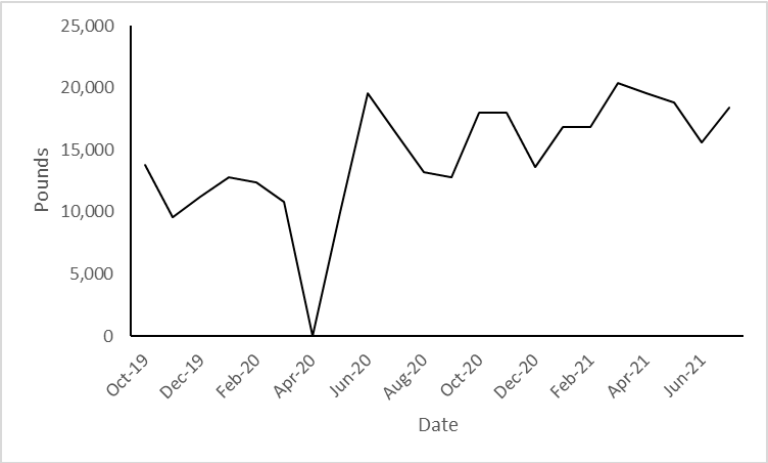


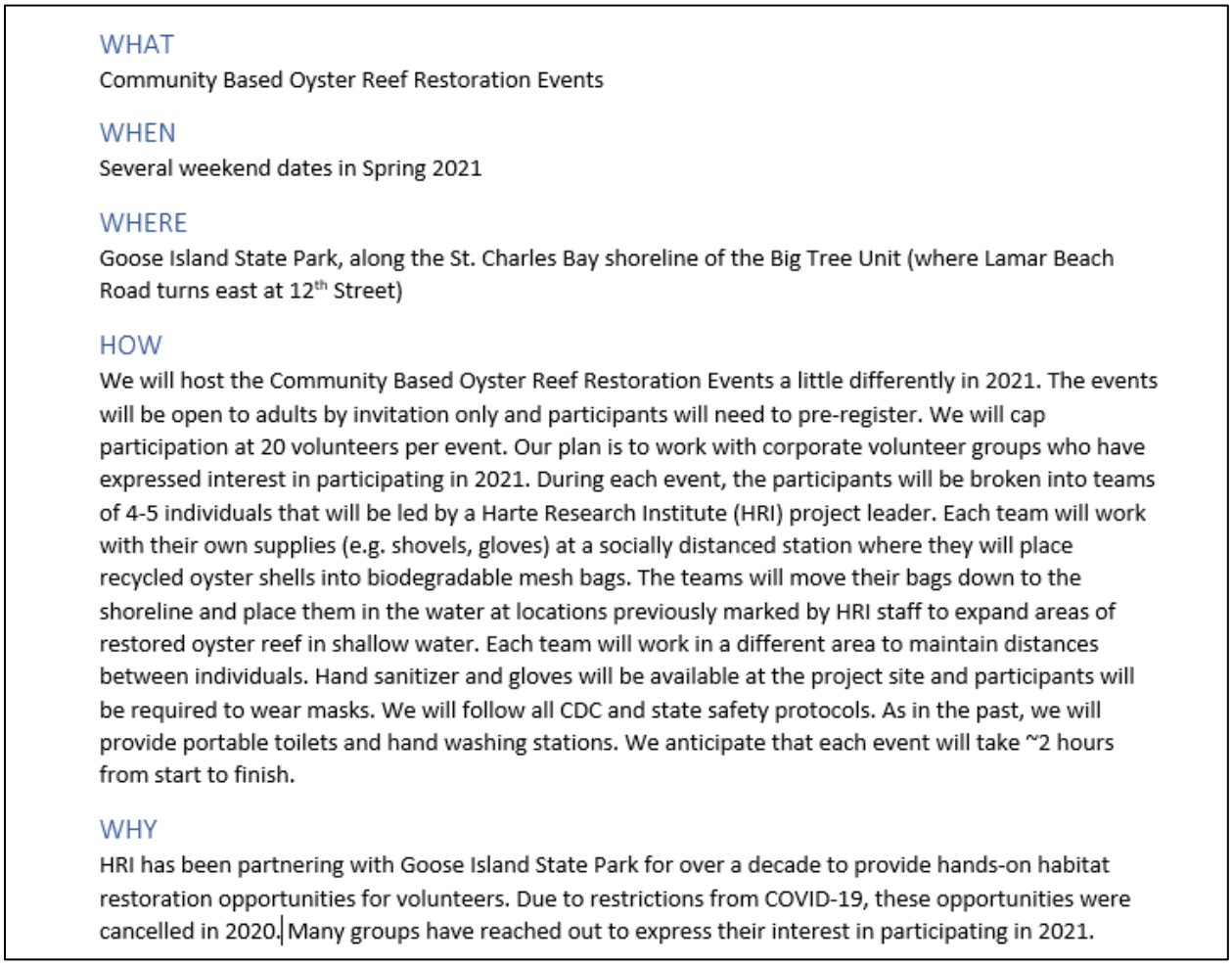
Figure 4. Pounds of oyster shells reclaimed by the Shell Bank Program during CMP Cycle 24.

Goal 2: Community Reef Restoration

Habitat restoration projects are primarily recognized for the ecological benefits they provide. However, oyster reef restoration also provides an ideal platform for incorporating hands-on, participatory educational experiences for community volunteers. Involving volunteers in habitat restoration activities can help connect communities to their coastal environment and create a culture of environmental stewardship. As a result, community outreach and education are essential components of Shell Bank Program habitat restoration efforts.

We worked with Texas Parks and Wildlife Department (TPWD) staff to select March 28, 2020, and April 25, 2020, as dates to host community reef restoration events at Goose Island State Park. However, because of COVID-19 health and safety regulations, we were forced to cancel both events. We stayed in regular contact with Edwin Quintero and T.J. Hinojosa—superintendent and assistant superintendent of Goose Island State Park—to develop acceptable solutions, which centered on hosting smaller, adult-only groups with modified methods to keep participants safe. We developed a proposal for event modifications (Figure 5) and submitted a

special events request for TPWD and Texas A&M University (TAMU) System review in December 2020.



WHAT

Community Based Oyster Reef Restoration Events

WHEN

Several weekend dates in Spring 2021

WHERE

Goose Island State Park, along the St. Charles Bay shoreline of the Big Tree Unit (where Lamar Beach Road turns east at 12th Street)

HOW

We will host the Community Based Oyster Reef Restoration Events a little differently in 2021. The events will be open to adults by invitation only and participants will need to pre-register. We will cap participation at 20 volunteers per event. Our plan is to work with corporate volunteer groups who have expressed interest in participating in 2021. During each event, the participants will be broken into teams of 4-5 individuals that will be led by a Harte Research Institute (HRI) project leader. Each team will work with their own supplies (e.g. shovels, gloves) at a socially distanced station where they will place recycled oyster shells into biodegradable mesh bags. The teams will move their bags down to the shoreline and place them in the water at locations previously marked by HRI staff to expand areas of restored oyster reef in shallow water. Each team will work in a different area to maintain distances between individuals. Hand sanitizer and gloves will be available at the project site and participants will be required to wear masks. We will follow all CDC and state safety protocols. As in the past, we will provide portable toilets and hand washing stations. We anticipate that each event will take ~2 hours from start to finish.

WHY

HRI has been partnering with Goose Island State Park for over a decade to provide hands-on habitat restoration opportunities for volunteers. Due to restrictions from COVID-19, these opportunities were cancelled in 2020. Many groups have reached out to express their interest in participating in 2021.

Figure 5. Proposal for modified community restoration events at Goose Island State Park in Spring 2021.

At the beginning of April 2021, we received all necessary permissions to host restoration events at Goose Island State Park using new COVID-19 protocols. We hosted two events on April 10, 2021, with smaller-sized groups of adult-only volunteers from Gulf Coast Growth Ventures. Event 1 took place from 8:00 am – 10:00 am and had 28 volunteers. Event 2 took place from 11:00 am – 1:00 pm had 21 volunteers. Each group of volunteers was divided into smaller teams to allow for adequate social distancing. Masks were required. During each event, recycled shells were placed into biodegradable mesh bags and then mobilized along the shoreline. Shell bags

were then used to restore degraded reef in shallow water using external funds. During Event 1, volunteers bagged 3,300 pounds of recycled oyster shell, and during Event 2, volunteers bagged 3,784 pounds of recycled oyster shell for a total of 7,084 pounds of reclaimed shells used in reef restoration (Figure 6-Figure 10).

Figure 6. Volunteers place recycled oyster shells into biodegradable mesh bags.

Figure 7. Volunteers learn about the process of oyster reef restoration.

Figure 8. Volunteers work together to prepare to fill biodegradable bag with recycled shells.

Figure 9. Volunteers mobilize filled shell bags along the St. Charles Bay shoreline.

Figure 10. Volunteers from the April 10, 2021, restoration Event 1.

Goal 3: Mobile Conservation Science for Underserved Youth

The foundation for the mobile conservation task was to create a "Shuck Truck" that would be used as an environmental learning center to travel to schools, festivals, and throughout South Texas communities. Within the Shuck Truck there would be a "habitat conservation corner" with hands-on activities to bring science to the participants, especially our underserved youth.

The grant started in October 2019, and the first step was to host focus groups to get input from local aquatic science teachers from King High School, Moody High School, Aransas Pass Middle School, and Port Aransas Middle and High Schools to get their input on design and assistance with mobile curriculum. Our focus groups were planned for the week prior to spring break 2020. At that point all meetings had to be cancelled due to the beginning of the COVID 19 pandemic. During the following months we stayed in touch with our focus group teachers. The teachers quickly became overwhelmed with online teaching and having to change all lesson plans for the new online environment that would end up lasting for the residual of the school year. We eventually cancelled the focus groups and spoke with our Project Manager at Texas General Land Office about the issues with executing this task.

The decision was made to modify the task by making videos of the "habitat conservation corner" activities. The videos were centered on 3-D models representing *Wetland and Floodplain Management, Coastal Watershed, and Watershed/Nonpoint Source Pollution* (Figure 11 - Figure 13). Captain Jay Tarkington, M.S. and Gail Sutton, M.S. wrote the outline and scripts for three videos. Jay Tarkington also holds a teaching certificate, so he led the instruction of each activity that was filmed. The filming occurred in late spring and through the summer of 2021. We worked very hard to relate the activity and information to local bays and estuaries so the viewer could imagine the content and utilize it in daily life. The filming was harder than we expected due to the glare from the models so filming and redone numerous times. In future videos we hope to have participants included so a question-and-answer section could be included; however, due to COVID restrictions we were unable to have an audience.

The videos were reviewed by scientists, teachers (both formal and informal), and local resource managers prior to finalizing each video. All agreed the content was very good and the videos would be useful tools to various age groups and vocations. The videos are posted at the Texas Oyster Conservation YouTube Channel hosted by the Sink Your Shucks Program, Harte Research Institute for Gulf of Mexico Studies, Texas A&M University-Corpus Christi: https://www.youtube.com/channel/UCgQiuD7jdi1lEoTvUgfus1g

Figure 11. Enviroscape Watershed/Point & Nonpoint Source Pollution Model Video (Click on caption or image to link to video).

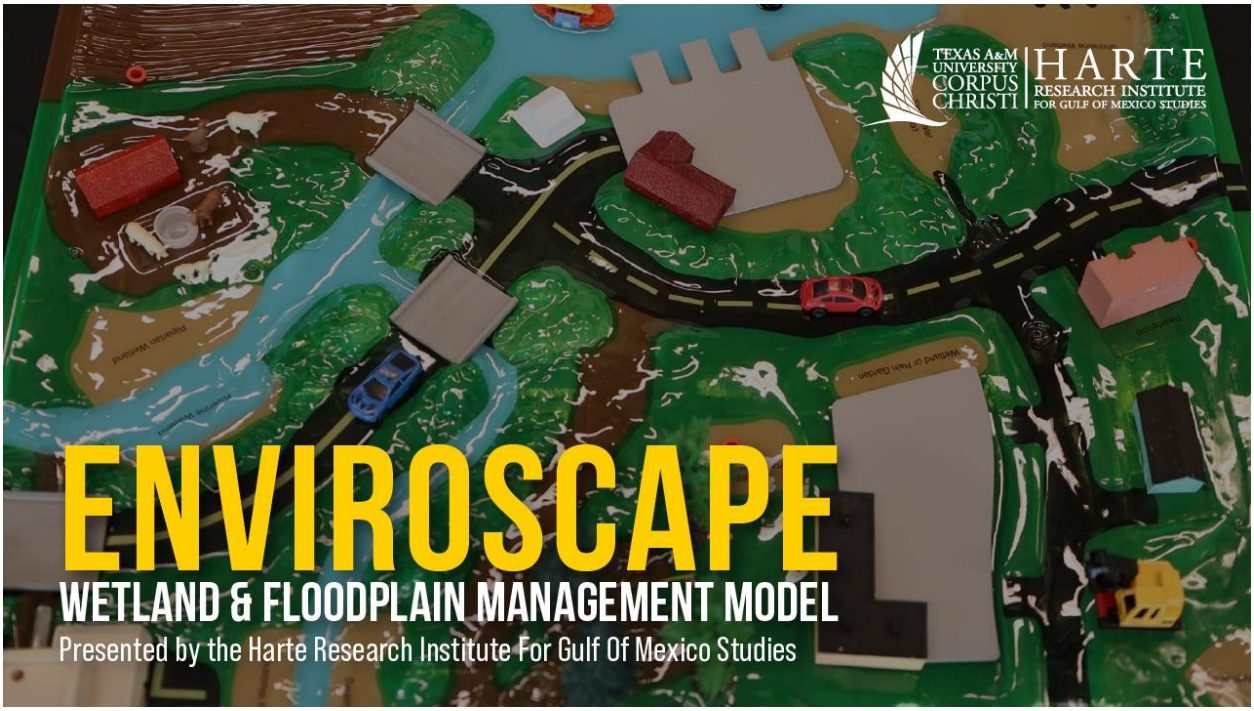


Figure 12. Enviroscape Wetland & Floodplain Management Model Video (Click on caption or image to link to video).

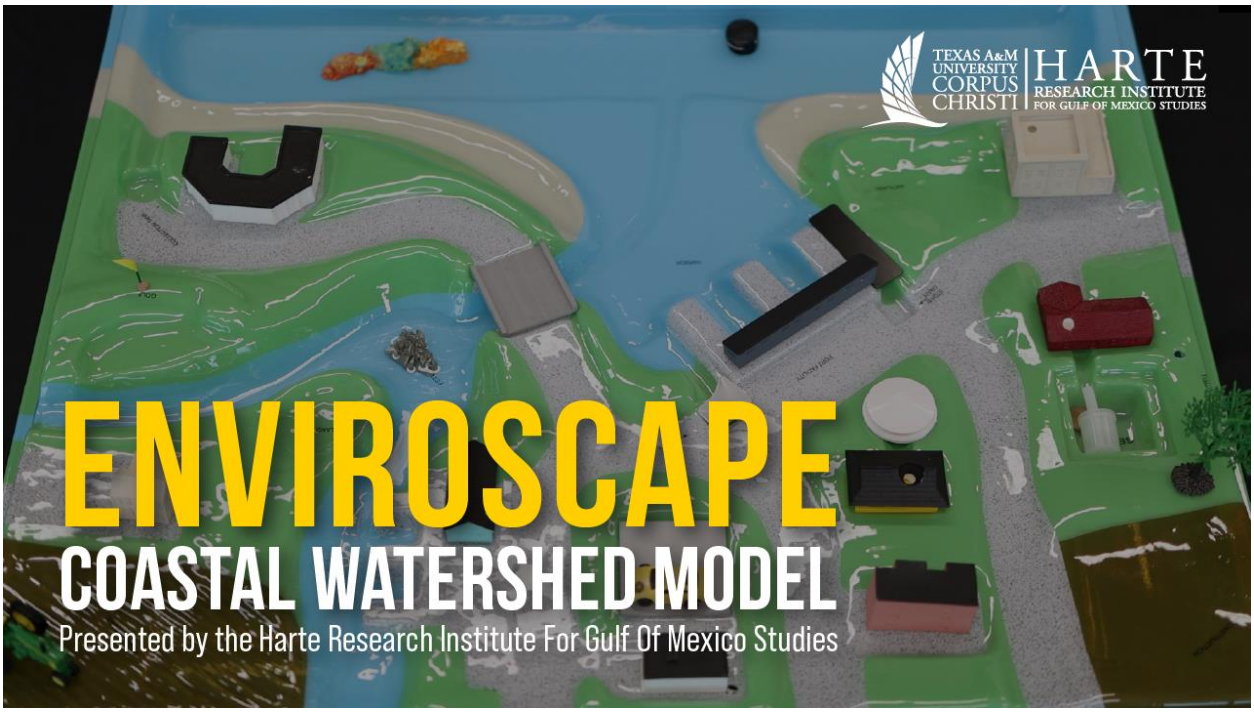


Figure 13. Enviroscape Coastal Watershed Model Video (Click on caption or image to link to video).

Goal 4: Reef Restoration and Resilience

On August 25, 2017, Hurricane Harvey made landfall as a Category 4 storm near Port Aransas and Rockport, Texas (Figure 14). The storm moved slowly across coastal Texas for six days, delivering up to 130 cm of rain and producing catastrophic river flooding. The large-scale disturbance created by Hurricane Harvey provided an opportunity to evaluate what parameters of habitat restoration projects best promoted resilience and recovery. We assessed oyster reefs along the mid-Texas coast that were constructed using shells from CMP. Determining the response of these reefs post-storm helps provide key information, at a large scale, about the role of physical and biological complexity in resilience of restored habitats.

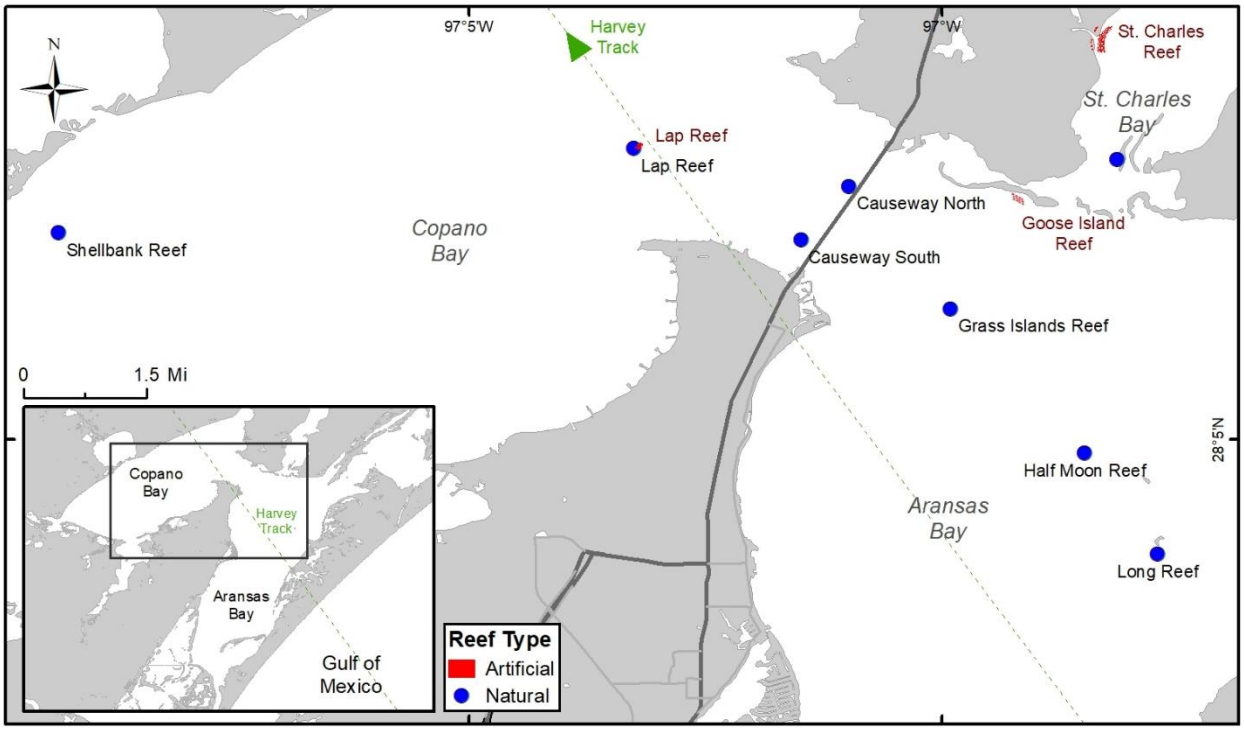


Figure 14. Map of natural and restored (artificial) reefs sampled in the Mission Aransas Estuary, in addition to the approximate track of Hurricane Harvey's eye (source: NOAA).

In this study, three restored/artificial reefs were monitored after the passing of Hurricane Harvey: (1) Lap Reef (Copano Bay; ~2.2 ha x 0.33 m vertical relief, rock and oyster shell substrate, restored 2011 & 2013), (2) Goose Island Reef (Aransas Bay; ~3 ha x 0.33 m vertical relief, rock and oyster shell substrate, restored 2012 & 2013), and (3) St Charles Reef (St Charles Bay; ~2 ha x 0.33 m vertical relief, oyster shell substrate, restored 2017) (Figure 14). Oyster size, abundance and *Perkinsus marinus* (the causative agent of Dermo disease) were monitored at these restored reefs until 2021. Natural reefs were also monitored, and the results of the restored reef monitoring were compared with natural reef counterparts. Biotic sampling was conducted using 30-second dredge tows and quadrats, and water quality sampling was conducted using a YSI data sonde. Direct comparisons of artificial reefs with close proximity and water quality occurred between restored and natural reefs at Lap Reef, the restored Goose Island Reef and natural Grass Islands Reef, and restored and natural reefs in St. Charles Bay.

Salinity decreased by approximately 10 at both Lap Reef and Goose Island/Grass Islands as a consequence of the rainfall associated with Hurricane Harvey (Figure 15 and Figure 16) and by

15 to 17 in St Charles Bay (Figure 17). Visual and tactile observations determined that the restored/artificial reef structure was minimally impacted by Hurricane Harvey aside from some possible movement of soft sediment around the reefs. The artificial reef in St. Charles Bay was monitored one month after the passing of Hurricane Harvey. Despite being newly constructed in July 2017, the mean height of the oysters at the restored St. Charles Reef quickly resembled the heights of the natural St. Charles reef within a year of sampling (Figure 18). Densities of the St. Charles restored reef surpassed the densities of the natural reef, although densities at the artificial reef for the first year can be partially attributed to having many smaller oysters and spat rather than fewer, larger oysters. Oyster size (shell height, mm) and adjusted densities (number m^{-2}) at the restored Lap Reef and Goose Island Reef were similar to those on the corresponding natural reefs (Lap Reef and Grass Islands Reef) over time, despite some minor differences in variability.

The prevalence (proportion infected, %) and weighted prevalence (severity of infection, ranked from 0-5 with 5 being the most severe) of Dermo disease was similar between Goose Island and Grass Islands oysters, both for juvenile (26 – 75 mm shell height) and market (≥76 mm shell height) size classes, both before and after the occurrence of Hurricane Harvey (Figure 19). Dermo disease dynamics for juvenile and market size oysters at Lap Reef were similar to that observed in Goose Island and Grass Islands oysters (Figure 20). Dermo prevalence and weighted prevalence decreased in both juvenile and market size oysters concurrent with the large drop in salinity at the St. Charles Bay natural reef and then increased after a period of higher salinity in 2018, mirroring the pattern observed on other reefs (Figure 21). Dermo prevalence remained low at the St. Charles artificial reef during the reefs initial 1.5 years but increased with a coinciding rise in salinity in 2019.

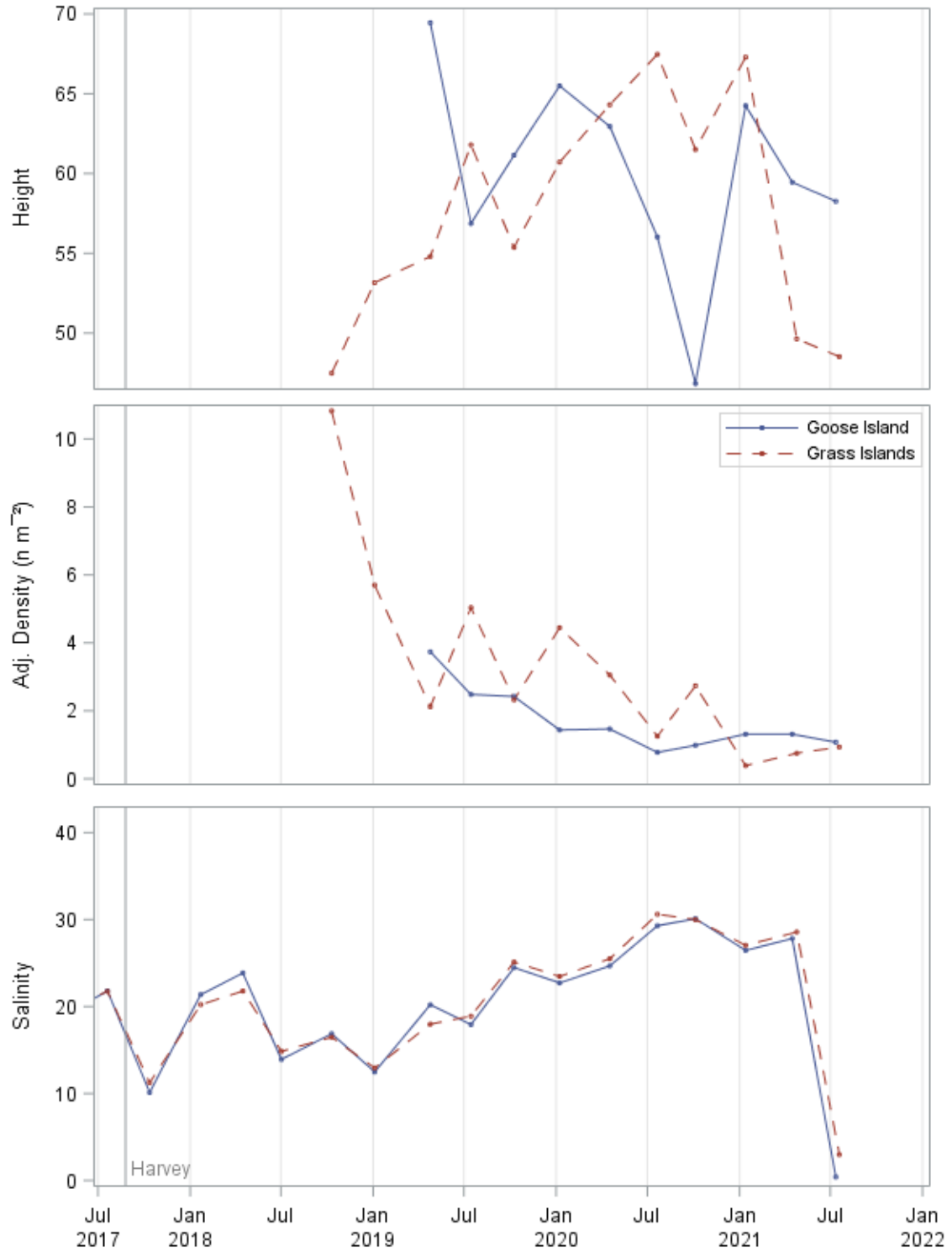


Figure 15. Mean oyster heights, densities and salinities at Goose Island (blue, artificial reef) and Grass Islands (red, natural reef) from 2017-2021. Densities at Goose Island are adjusted to match those collected by a 30-second trawl using by dividing quadrat-collected densities 44.6.

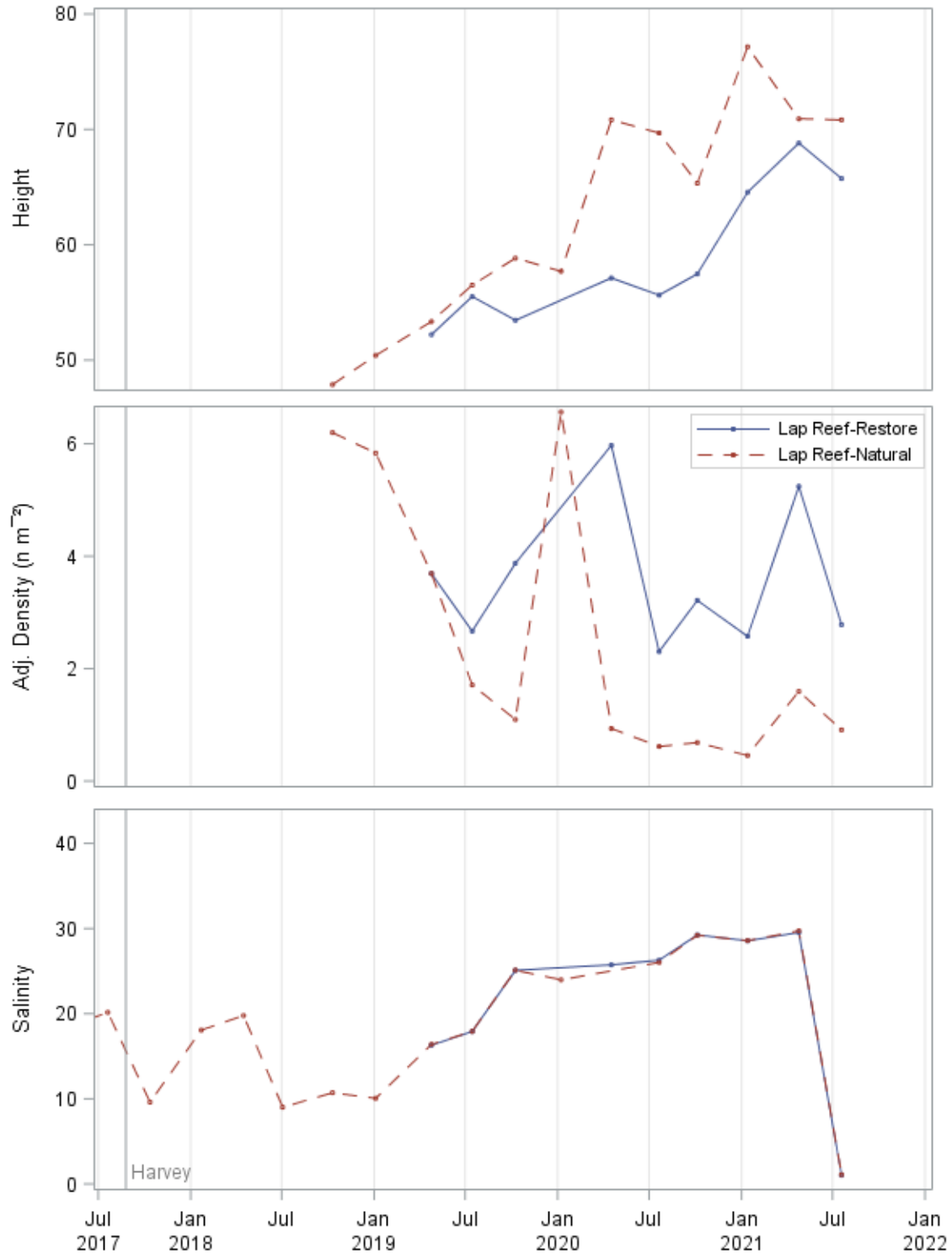


Figure 16. Mean oyster heights, densities and salinities at an artificial (blue) and natural (red) reef at Lap Reef from 2017-2021. Densities are taken from triplicate 30-second trawls.

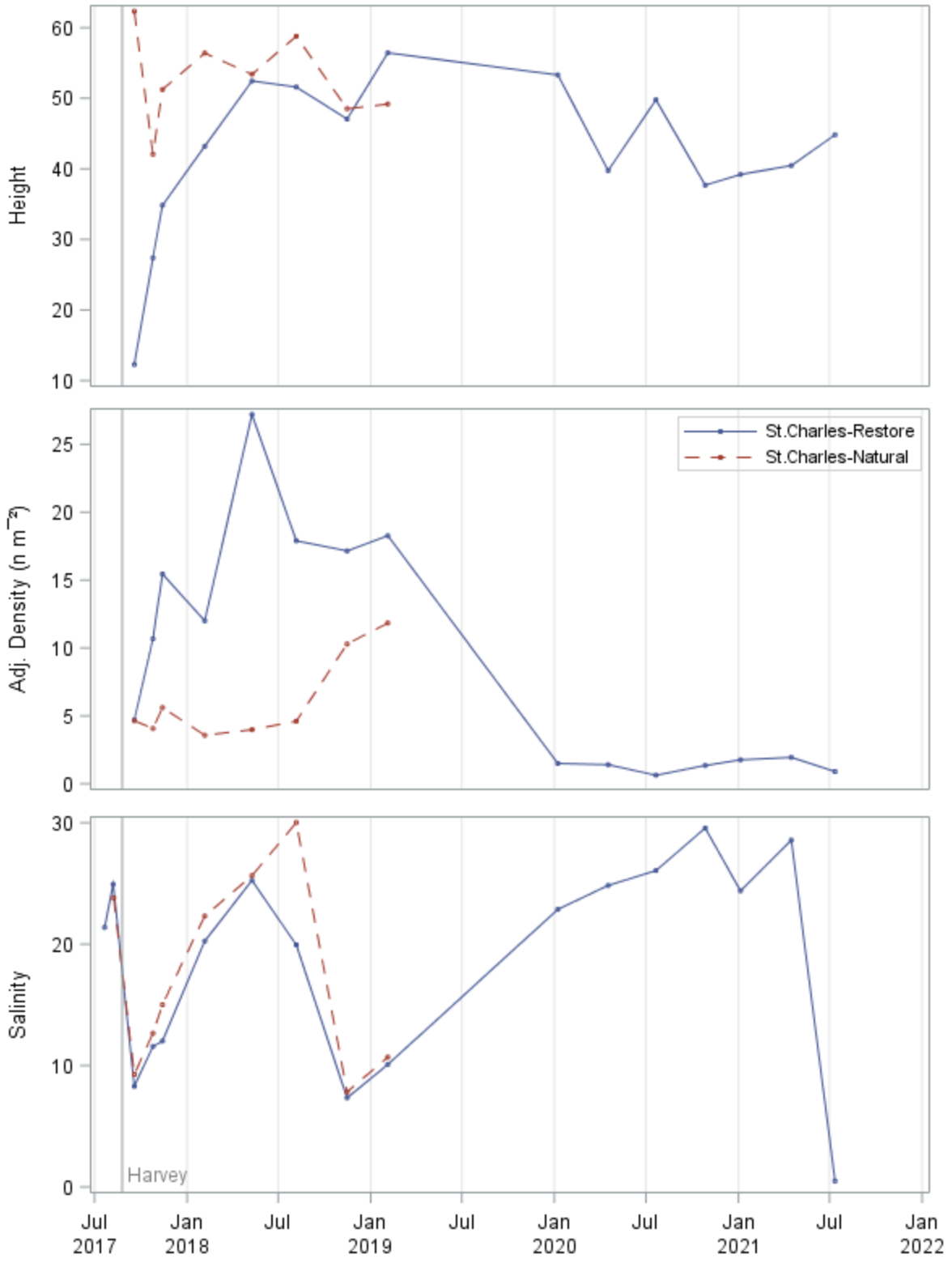


Figure 17. Mean oyster heights, densities and salinities at an artificial (blue) and natural (red) reef in St Charles Bay from 2017-2021. Densities are adjusted to match those collected by a 30-second trawl by dividing densities by 44.6. The artificial reef was created a month before Hurricane Harvey.

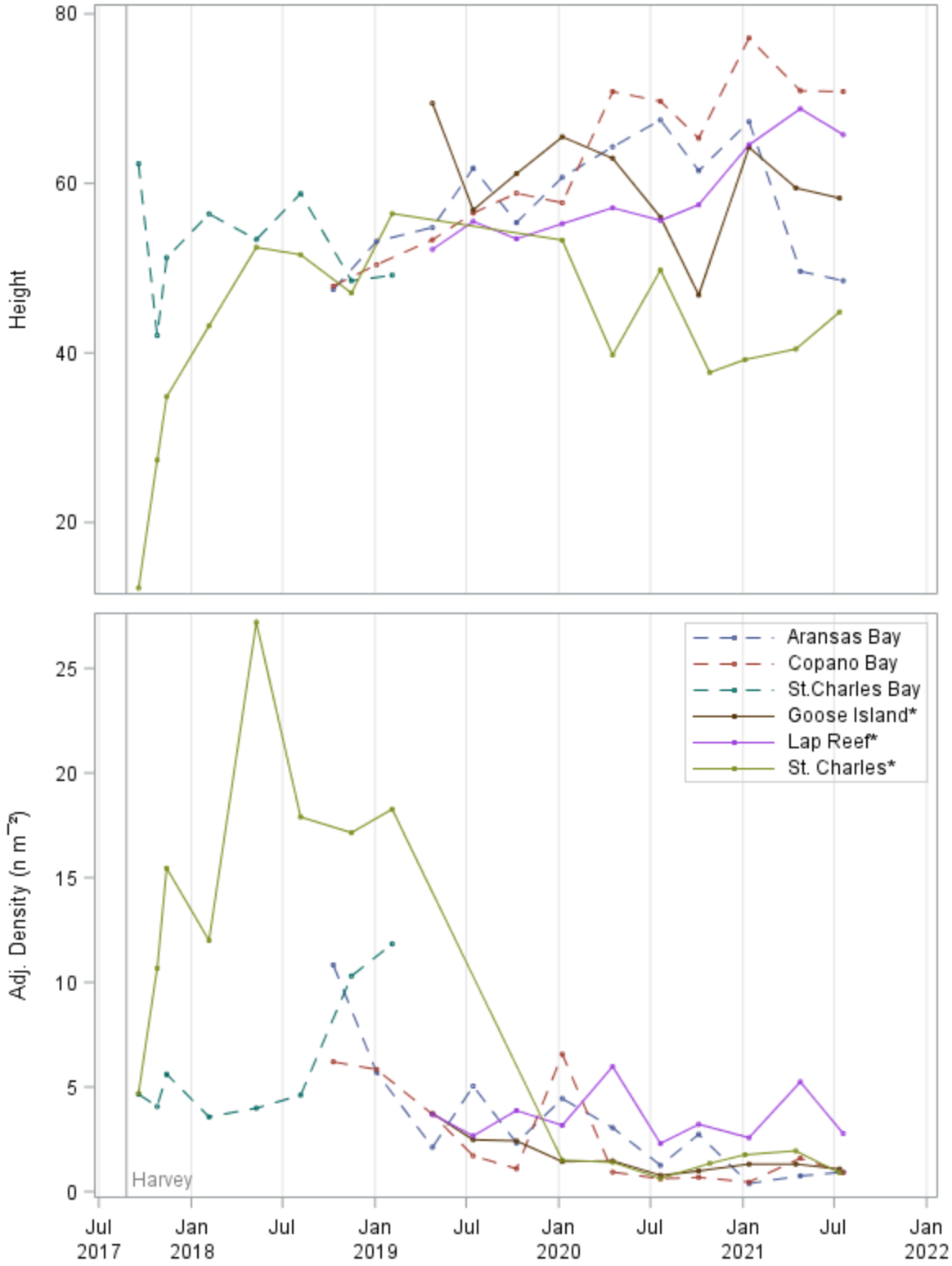


Figure 18. Mean oyster heights and densities at natural (dashed) and artificial (solid) reefs in the Mission Aransas-Estuary from 2017-2021. Artificial reef densities are adjusted to match those collected by a 30-second trawl by dividing densities by 44.6.

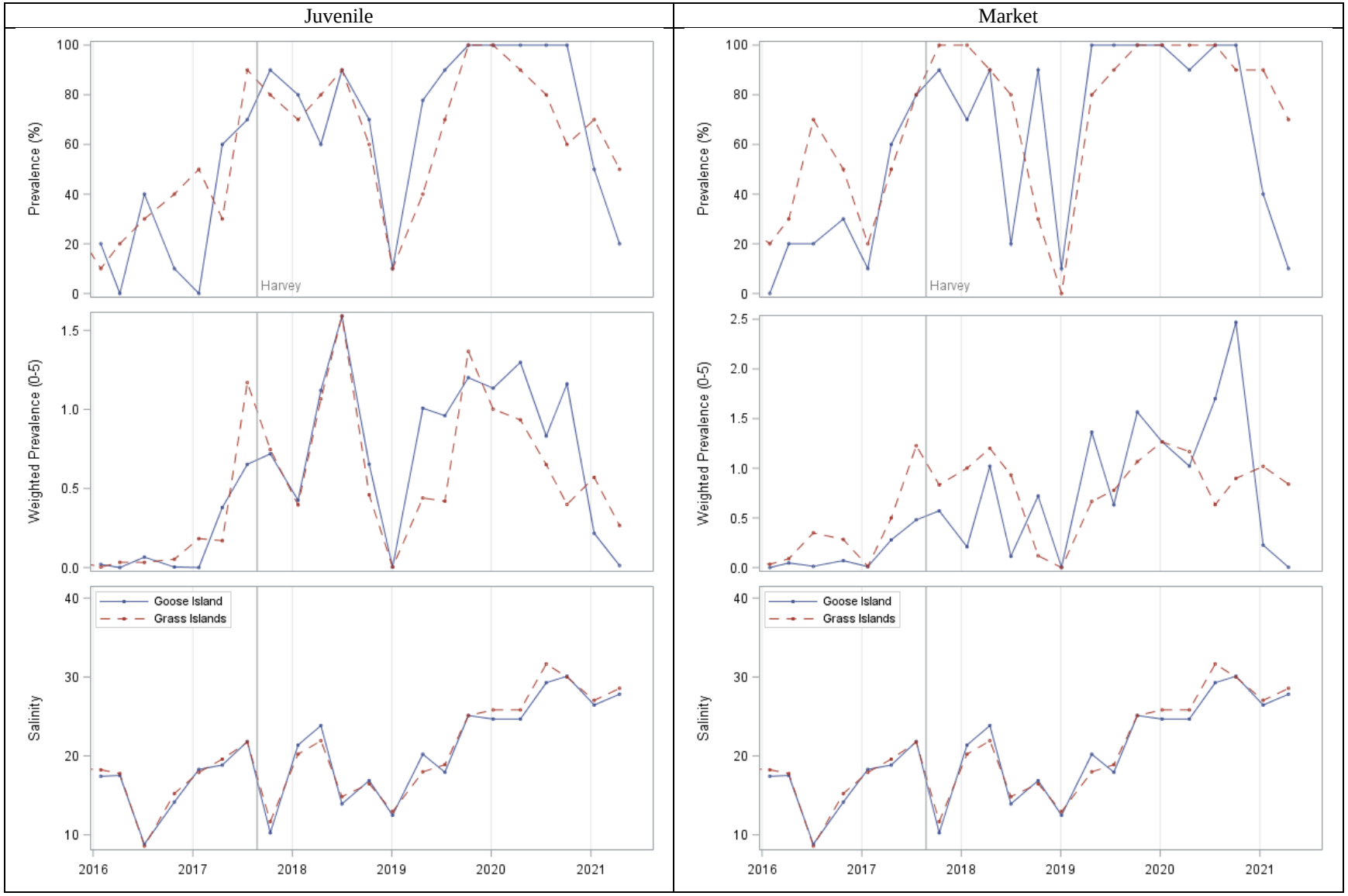


Figure 19. Dermo infection levels for juvenile (left) and market-sized oysters (right) and coincident salinities from an artificial reef in Goose Island (blue) and a natural reef at Grass Islands (red) from 2016-2021. Hurricane Harvey is indicated as the grey vertical line in the figure.

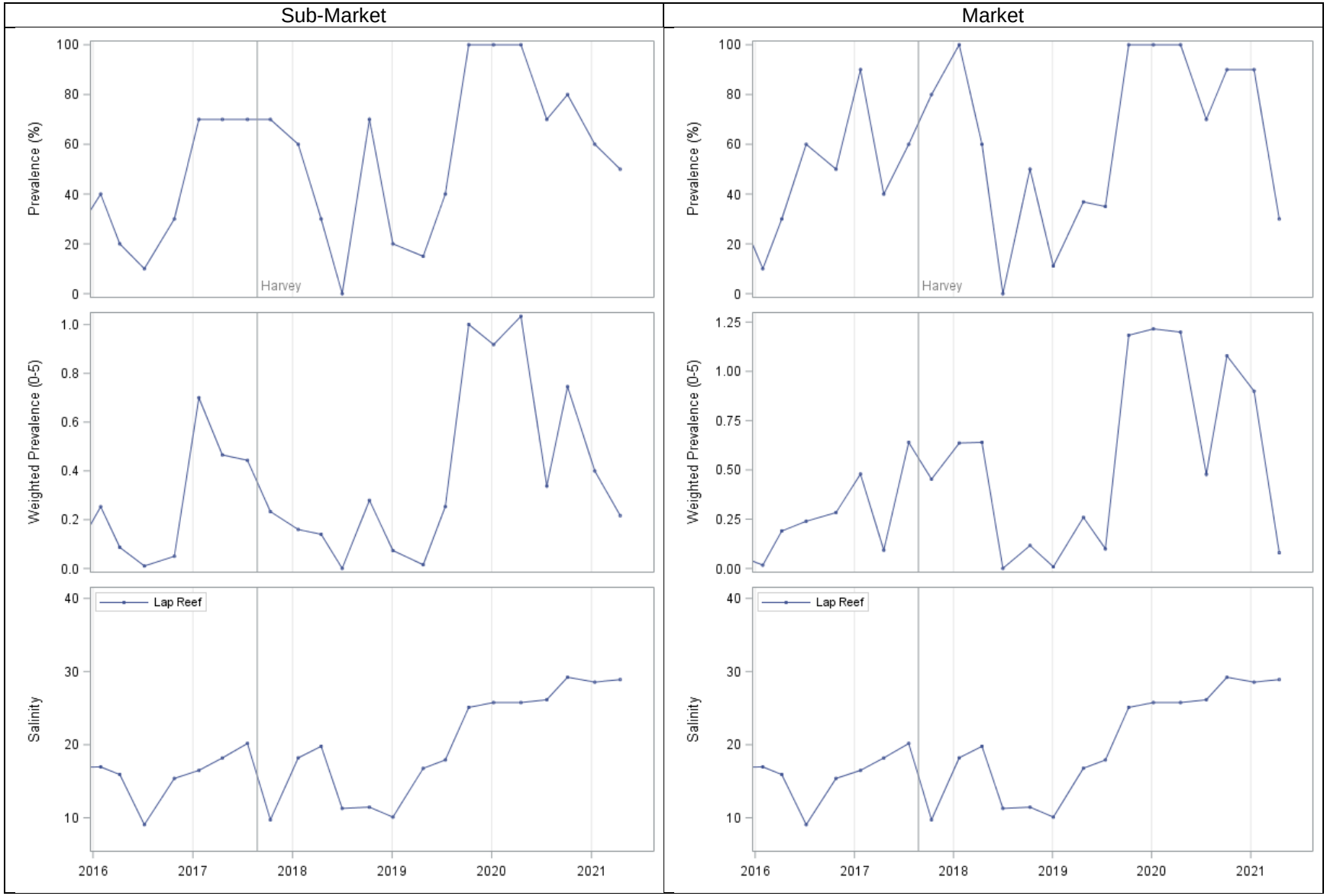


Figure 20. Dermo infection levels for juvenile (left) and market-sized oysters (right) and coincident salinities collected from the natural Lap Reef from 2016-2021. Hurricane Harvey is indicated as the grey vertical line in the figure.

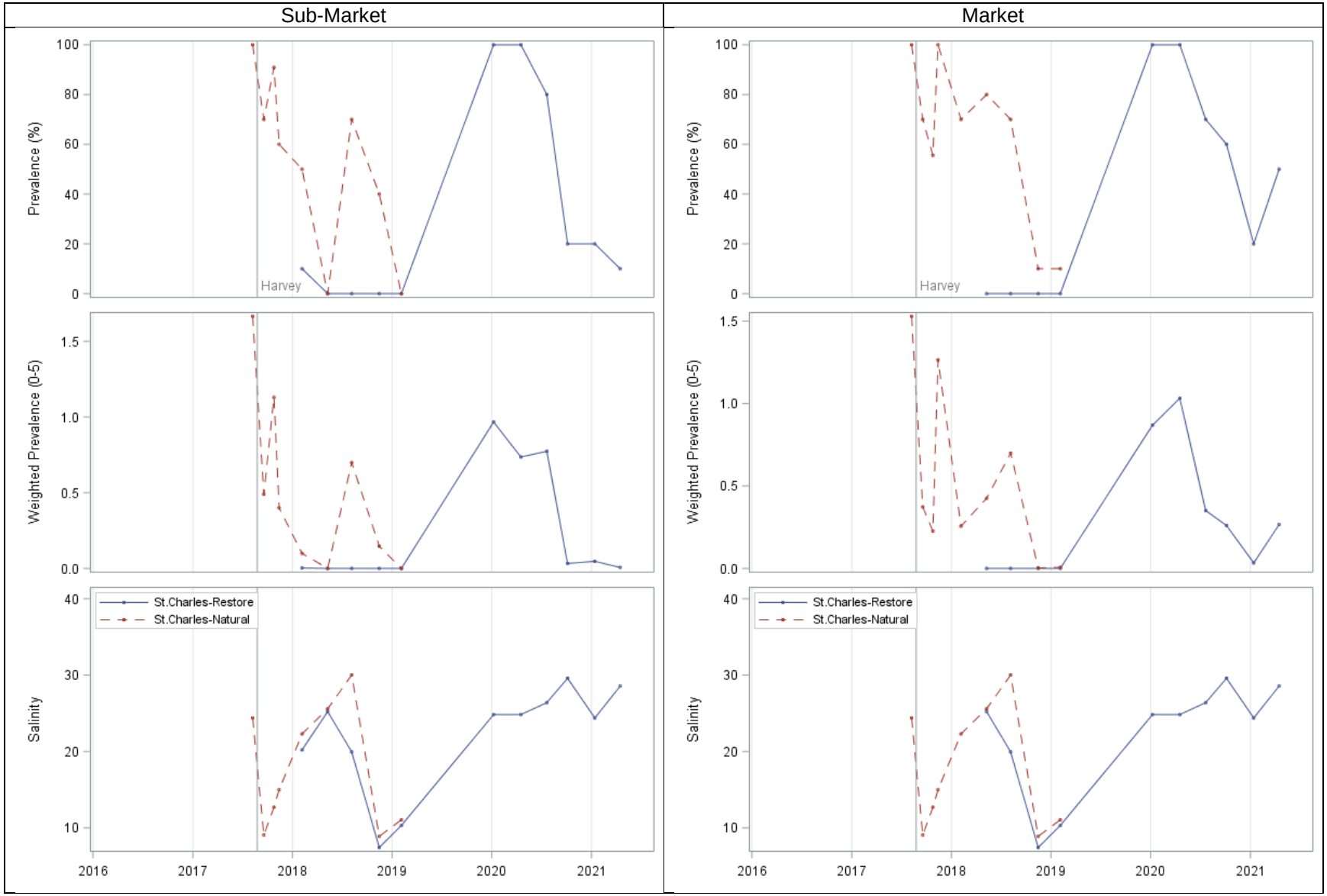


Figure 21. Dermo infection levels for juvenile (left) and market-sized oysters (right) and coincident salinities collected from an artificial reef (blue) and a natural reef (red) in St Charles Bay from 2016-2021. Hurricane Harvey is indicated as the grey vertical line in the figure.

The large-scale disturbance created by Hurricane Harvey provides an opportunity to evaluate what parameters of best promoted resilience and recovery on natural and restored reefs. Trends in oyster size, density and disease dynamics were generally similar between restored reefs and their natural counterparts, regardless of restoration age, indicating that restored habitats can quickly replace lost ecological functions for oysters. We were unable to assess the effects on reef-associated motile fauna such as fish and crabs because they were inefficiently collected by the available gear types (e.g. dredge, quadrat). Future work is warranted to better understand how changes in oyster abundance, size, and disease influence reef fauna. However, similarities in the response of oyster metrics (e.g. density, size, disease) between restored and natural reefs indicate that faunal recovery would be supported in comparable ways (e.g. analogous recovery of reef structure) across reef types. Results provide useful information about the response and resilience of restored and natural reefs to large-scale disturbance.

Conclusion

As part of CMP Cycle 24, this project supported coastal resilience on the Texas coast by (1) reclaiming shucked shells from restaurants, seafood wholesalers, and festivals for use in oyster reef habitat restoration, (2) hosting community-based restoration events and educating volunteers on the importance of oyster reefs, the ecology of the habitat they are helping restore, and the benefits of habitat restoration, (3) creating activities for students to experiment with restoring the coastal environment and observing how conservation promotes resilience, and (4) assessing restored oyster reefs to evaluate what characteristics promote sustainability and resilience. The COVID-19 pandemic presented challenges to the project, but we were able to work with the Texas General Land Office Coastal Management Program staff and our project partners to identify flexible approaches to accomplish project goals. Project accomplishments include (1) reclaiming 330,600 pounds of shucked oyster shells for use in habitat restoration activities, (2) hosting scaled back community restoration events using new COVID-conscious protocols, (3) creating videos of the “habitat conservation corner” activities, focused on 3-D models representing Wetland and Floodplain Management, Coastal Watershed, and Watershed/Nonpoint Source Pollution, and (4) demonstrating how oysters on restored and natural oyster reefs in the mid-Texas coast exhibited similar characteristics of recovery and resilience after Hurricane Harvey. Funding from the Texas General Land Office Coastal Management Program has been

critical to the establishment and success of the Shell Bank Program by providing natural oyster shell materials for restoring over 30 acres of oyster reef, creating opportunities for hands-on participation of the public in habitat restoration, and increasing scientific and public understanding of the value of coastal natural resources.