The Effects of Hurricane Harvey on Oyster Restoration

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Background

- The eastern oysters (*Crassotrea virginica*) provide many essential ecological and economical services. However, oyster populations have been declining due to overfishing, direct habitat loss, and acute storms (ie. hurricanes).
- The Galveston Bay Foundation has been engaging in ongoing efforts to restore oyster habitats through the construction of bagged reefs. Mesh bags are filled with shells, reclaimed through a restaurant recycling program, as material oyster larvae can attach to in intertidal environments.
- Long term monitoring of the restoration efforts helps provide more information on reef placement, construction efficiency, larval recruitment, and even hurricane resilience. Hurricane Harvey impacted the Galveston Bay and the greater Houston area with unprecedented levels of rainfall. The influx of freshwater caused a significant decrease in salinity which has been an indicator for growing eastern oyster mortality rates (Du 2019).
- The objective of this project was to determine how oyster abundance and size changed on restored reefs in Sweetwater Lake, Galveston Bay over 4 years (2016-2019), particularly focusing on these oyster population characteristics before and after Hurricane Harvey.

Reef Number	Date of Creation
One	June 2015
Two	May 2014
Three	May 2015
Four	May 2014
Five	May 2015

Table 1. Reef Creation Dates.

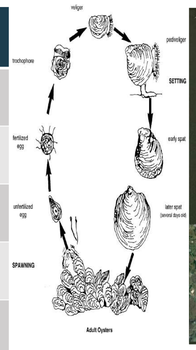

Figure 1. Oyster Life Cycle.

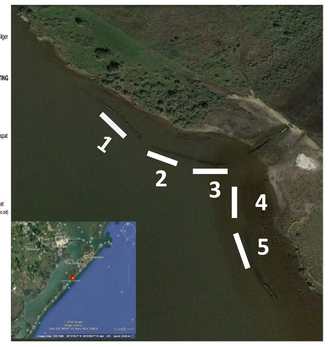

Figure 2. Location of reefs in Galveston Bay.

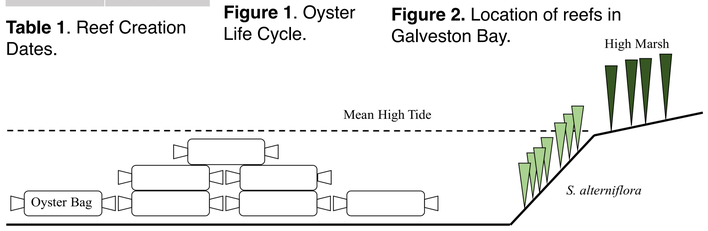

Figure 3. Conceptualized diagram of reef construction with mesh bags in 4-2-1 pyramid.

Methodology

- Created intertidal oyster reefs (n=5) constructed in Sweetwater Lake (Fig. 2), a semi-enclosed embayment off West Galveston Bay Texas, USA. The reefs were constructed by filling mesh bags with recycled oyster shell and then deploying bags in a 4-2-1 pyramid, with four bags placed on the sediment, two bags on the base row, and one bag on the top row (Fig. 3). Reefs ranged between 16 and 78 meters in length (Fig. 2); however, for the longest two reefs, one and five, only distances similar to other reefs were sampled.
- Over the last 4 years (2016-2019), five individual bags were haphazardly selected from each reef and brought to shore. From each bag, the first 20 oysters were measured (Shell Height (SH) in mm), the remaining oysters enumerated, and then the bag was immediately returned to the original location on the reef.
- Spat settlement to the reefs was measured across three years (2017-2019), beginning in June through August or November to capture peak larval settlement within this system (Soniat & Ray 1985). Spat settlement was collected by deploying 0.04 m^2 caged trays constructed from 1x1 cm hardware cloth, filled with ten pieces of similar sized shells (70-90 mm), and then closed with a hardware cloth lid and attached to the reefs.

Oyster Population Demographics

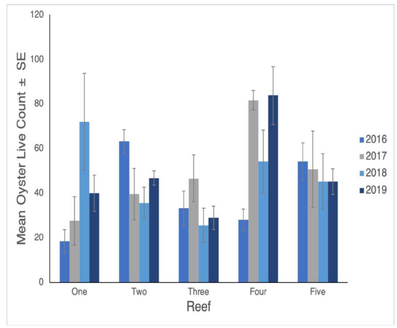

Figure 4. Mean oyster count varied significantly only for reef number ($F_{4,80}$=4.32, P = 0.0032) and interactive effect of year and reef ($F_{12,80}$=3.28, P = 0.0007).

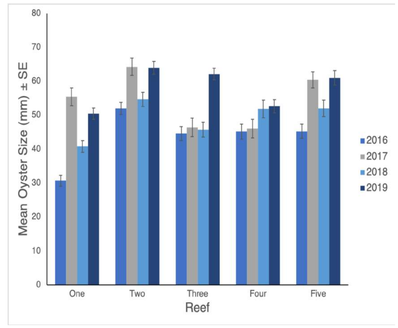

Figure 5. Mean oyster size varied significantly for reef number ($F_{4,1864}$=25.33, P<0.0001), year ($F_{3,1864}$=37.42, P <0.0001), and interactive effect of year and reef ($F_{12,1864}$=4.85, P<0.0001).

Monthly Rainfall in Galveston County

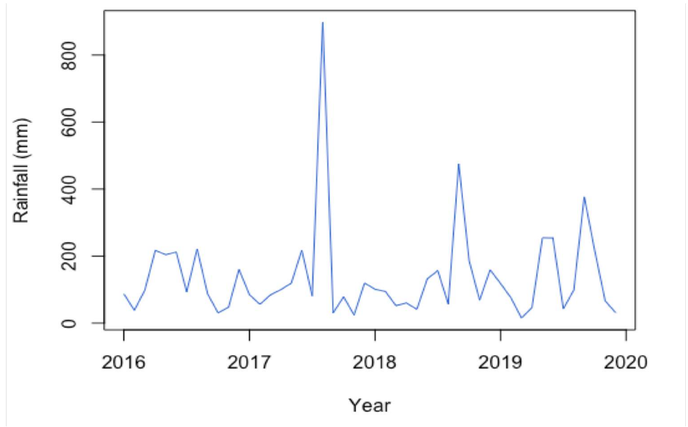

Figure 6. The monthly rainfall of Galveston County from January 2016 to December 2019, according to the National Oceanic and Atmospheric Administration data. There is a sharp increase in rainfall in August 2017 due to Hurricane Harvey.

Larval Recruitment

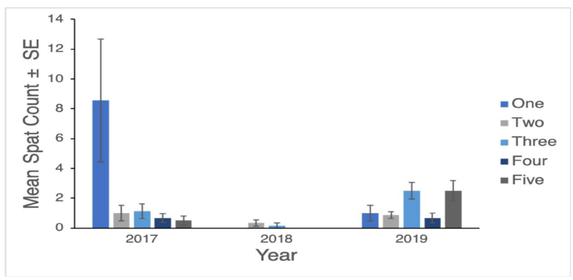

Figure 7. Mean oyster spat count varied significantly by year ($F_{2,94}$=10.81, P < 0.0001) and interactive effect of year and reef ($F_{8,94}$=2.42, P = 0.02020).

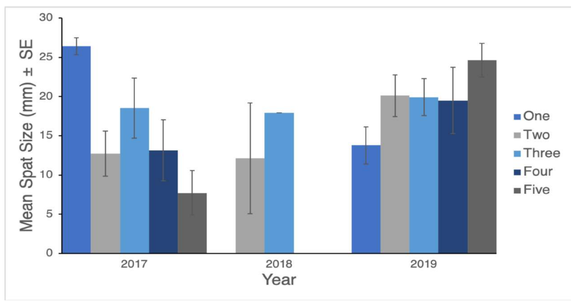

Figure 8. Mean oyster spat size varied significantly by the interactive effect of year and reef ($F_{5,171}$=5.74, P < 0.0001).

Results

- Across the four years, mean oyster abundance did not vary significantly (Fig. 4). However, there was significant variability across the reefs, with Reef 4 having comparatively greater oyster abundance (Fig. 4). Interannual variability by reef influenced oyster abundance significantly (P=0.0007).
- There were significant differences in oyster size based on year, reef, and the interactive effect of year and reef (P<0.0001). Reefs one, two, and five increased in size before Hurricane Harvey and had a significant decrease in size after (Fig. 5).
- In August 2017, Harvey brought 824-1043 mm of rain to the Houston area in three days and the estimated freshwater discharge was three times the Bay's normal volume (Fig. 6).
- Spat abundance varied significantly by year and interactively by year and reef (Fig. 7). Spat count decreased following Hurricane Harvey and increased again as the reefs recovered in 2019. Average spat size across the reefs in the first year was much lower than the average size two years later (Fig. 8). The interactive effect of year and reef produced significant variation of sizes. (Fig. 8).

Figure 9. Adult Oyster found on reef prior to Hurricane Harvey.

Figure 10. Spat Recruitment Cages on each reef.

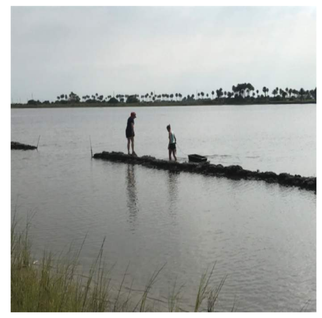

Figure 11. Students collecting mesh bags oyster population demographics.

Conclusion

- Overall, the results from this study indicate:
  - Oyster abundance varied significantly based on reef number, showing the importance of reef location for restored intertidal oyster reefs. The variation of oyster abundance between the reefs indicated that local hydrodynamics or predator abundances may play a role in structuring oyster abundances.
  - Oyster size was minimal during the first year of the study while the reefs were still being established and continued to increase until Hurricane Harvey. After the hurricane, oyster sizes decreased likely due to the constraining of oyster growth through tidal dynamics and adult oyster mortality. Mean size increased following the year of Harvey, indicating reef resilience.
  - Spat recruitment decreased to the reefs following Hurricane Harvey because with an influx of freshwater lowering the salinity, larval oysters faced decreased transport success in finding a suitable habitat as well as increased adult oyster mortality leading to less larval production. However, the population began to respond in 2019 with an increased mean recruitment, suggesting the population was able to respond to the storm. For spat size, the variation due to the interactive effect of year and reef indicated slow larval growth after Harvey because of the freshwater influx.
- More research needs to be conducted on which reef positions offer optimal protection for oysters in hurricane situations and how long the salinity effects last after a historic amount of rainfall.

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Du, J., Park, K., Dellapenna, T. M., & Clay, J. M. (2019). Dramatic hydrodynamic and sedimentary responses in Galveston Bay and adjacent inner shelf to Hurricane Harvey. *Science of The Total Environment, 653*, 554-564.

Soniat TM, Ray SM (1985). Relationships between possible available food and the composition, condition and reproductive state of oysters from Galveston bay, Texas. Contribution in *Marine Science,* 28:109–121