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Final Report

Nueces Bay Demonstration/Restoration Oyster Reef Project
CBBEP Project 1923

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Introduction

The Coastal Bend Bays and Estuaries Program (CBBEP) has hardened island shorelines and created breakwaters in Nueces Bay using rocks and armoring stones for the purpose of conserving and restoring habitat for bird rookeries and coastal marshes. Oysters (*Crassostrea virginica*), which were historically prolific in Nueces Bay, rely on hard substrates for their planktonic larvae to settle upon and grow as sessile oysters. However, it is unknown whether the hardened shorelines and breakwaters construction by CBBEP also act as structural foundation materials for creating artificial oyster reefs. This study aims to detect and quantify oyster populations on constructed materials within Nueces Bay to determine if the methods CBBEP uses to retore and conserve bird rookeries and coastal marshes also serves to restore lost oyster reef habitat.

Methods

Sampling Design

Oyster populations were investigated on 8 November 2022 on three islands in Nueces Bay: Rookery Island 1 (Island 1), Rookery Island 3 (Island 3), and the outer-most breakwater of the Nueces Bay Marsh Restoration Project (Breakwater) (Table 1, Figure 1 to Figure 5). The marsh breakwater was sampled at the northern and southern ends (BWN and BWS) but were combined for statistical analyses.

Data Collection

Rookery Islands Oysters

The armoring stone, which made up the hardened shoreline of both islands, was sampled at five locations within each island by visually estimating the spatial coverage by oysters within a 0.25 m^2 quadrat. A subsample of live and dead oyster shells was then removed from each quadrat so that heights of live shells could be measured, and the proportion of live oysters (of live + dead) could be estimated. The subtidal area adjacent to the armoring stones sampling locations were then sampled more precisely for oysters by excavating all shells within a 0.25 m^2 quadrat, and enumerating live and dead oysters, and measuring all live oysters. These ten sampling locations (five sites per island) represent unrestored, reference conditions and were dominantly bare ground. Two subtidal locations at Island 1 also contained patches of submerged bull rock. These bull rock locations were sampled using the same quantitative method as the bare ground.

Marsh Breakwater Oysters

Spatial coverage, oyster heights, and the proportion of live oysters were determined at two stations each on the northern and southern ends of the central breakwater, which is made of armoring stones. Oysters at two stations on bull rock amendments to the north and south of the central breakwater were sampled more precisely by excavating all shells within a 0.25 m^2 quadrat, and enumerating live and dead oysters, and measuring all live oysters. Two armoring stone and two bull rock samples were taken at each end of the breakwater (for a total of eight samples).

Figure 1. Map of Nueces Bay showing sampling locations at Rookery Island 1 (Island1), Rookery Island 3 (Island3), and Marsh Breakwater -South (MarshBWS), and Marsh Breakwater -North (MarshBWN)

Figure 2. Aerial image of Rookery Island 1. Courtesy of CBBEP.

Figure 3. Aerial image of Rookery Island 3. Courtesy of CBBEP.

Figure 4. Aerial image of the Marsh Breakwater. Courtesy of CBBEP.

Table 1. Latitude and longitude of sampling locations

Station Name	Abbreviated Station Name	Latitude (Decimal degrees)	Longitude (Decimal degrees)
Rookery Island #1	Island1	27.857704	-97.490570
Rookery Island #3	Island3	27.851161	-97.478878
Marsha Breakwater North	MarshBWN	27.870963	-97.344339
Marsha Breakwater South	MarshBWS	27.862714	-97.353867

Shoreline at Rookery Island 1

Quadrat on armored rock/bull rock mixture at Island 1

Shoreline and Rookery Island 3

Shoreline and Rookery Island 3

Bull rock at Breakwater North

Armoring stones at Breakwater South

Figure 5. Photos of each sampling location

Dermo Disease

A subsample of 24 oysters from the rookery islands and 19 oysters from the breakwater locations were brought back to the laboratory and assessed for the protozoan oyster parasite, *Perkinsus marinus*, the causative agent of Dermo disease. Dermo is known to cause severe mortalities in Gulf of Mexico oyster populations. Dermo causes reduction in oyster growth followed by mortality of susceptible infected oysters, and thus is of interest when considering the health and viability of oyster populations.

In the laboratory, the collected oysters were assessed for *P. marinus* infection using Ray's Fluid Thioglycollate Method (Ray 1966). Briefly, a 5 x 5 mm section of mantle tissue was removed and incubated in Ray's Fluid Thioglycollate Media (RFTM) for 2 weeks. Tissue cultures were then stained with 75% Lugol's solution and examined microscopically for *P. marinus* hypnospores. Infection intensity was scored using a 6-point scale (uninfected (0) - heavily infected (5)) adapted from Mackin (1962) by Craig et al. (1989). Prevalence of infection (the proportion of oysters infected with *P. marinus*) was calculated by dividing the number of infected oysters by the number of oysters sampled. Weighted prevalence, a measure of the relative severity of *P. marinus* infection in a population, was calculated by multiplying mean infection intensity by prevalence. Weighted prevalence values ≥2.0 denote many severe infections and the potential for high oyster mortality (Mackin 1962, Burreson et al. 1994). Because *P. marinus* accumulates in oyster tissue over time and large oysters tend to have higher infection levels and parasite-related mortality than small individuals, data were separated into submarket (25-75 mm, 1-3" shell height) and market (≥76 mm, ≥3") size classes.

Water Quality

At each station, discrete measurements of water depth, temperature, conductivity, dissolved oxygen, salinity, pH, and turbidity were taken at the surface (0.1 m from surface) and bottom of the water column (0.1 m from bottom) using a YSI ProDSS multiparameter instrument (YSI 2016). A depth measurement was taken at each sampling location using a weighted measuring tape.

Results

Oyster Populations

Live oyster density was much greater on bull rock (289 n m^{-2}) than unrestored bare ground (3 n m^{-2}) (Table 2, Figure 6). Live density was greater on the Breakwater bull rock (383 n m^{-2}) than at Rookery Island 1 (100 n m^{-2}), but so too was the density of dead oysters (Breakwater = 217 n m^{-2}, Island 1= 30 n m^{-2}). Although not quantified, the volume of bull rock was also greater at the Breakwater sites than at Island 1. This difference in bull rock volume combined with a similar proportion of live oysters between the Breakwater (63%) and Rookery Islands (71%) indicates that live oyster density is likely at least partially related to the amount of rock surface area available at the sampling sites.

Spatial coverage of armored rocks was similar among sampling stations, ranging from 42% cover at Rookery Island 3, to 48% cover on the breakwater, to 56% at Rookery Island 1 (Table 3, Figure 7). However, the proportion of live oysters was lower on the Breakwater armored rocks (48%) than the Rookery Island armored rocks (Island 1 = 71%, Island 3 = 84%).

Mean oyster height on rocks (armoring stones and bull rock combined) is greater at Rookery Island 1 (55 mm) than both Rookery Island 2 (47 mm) and Breakwater (45 mm) (Table 4, Figure 8). However, there is considerable overlap in the range of heights at each station (Figure 9). Oysters were on average larger in the bare substrate at Island 1 (62 mm) than on the rocks (Figure 10), but there were only seven live oysters so not much can be interpreted about this difference.

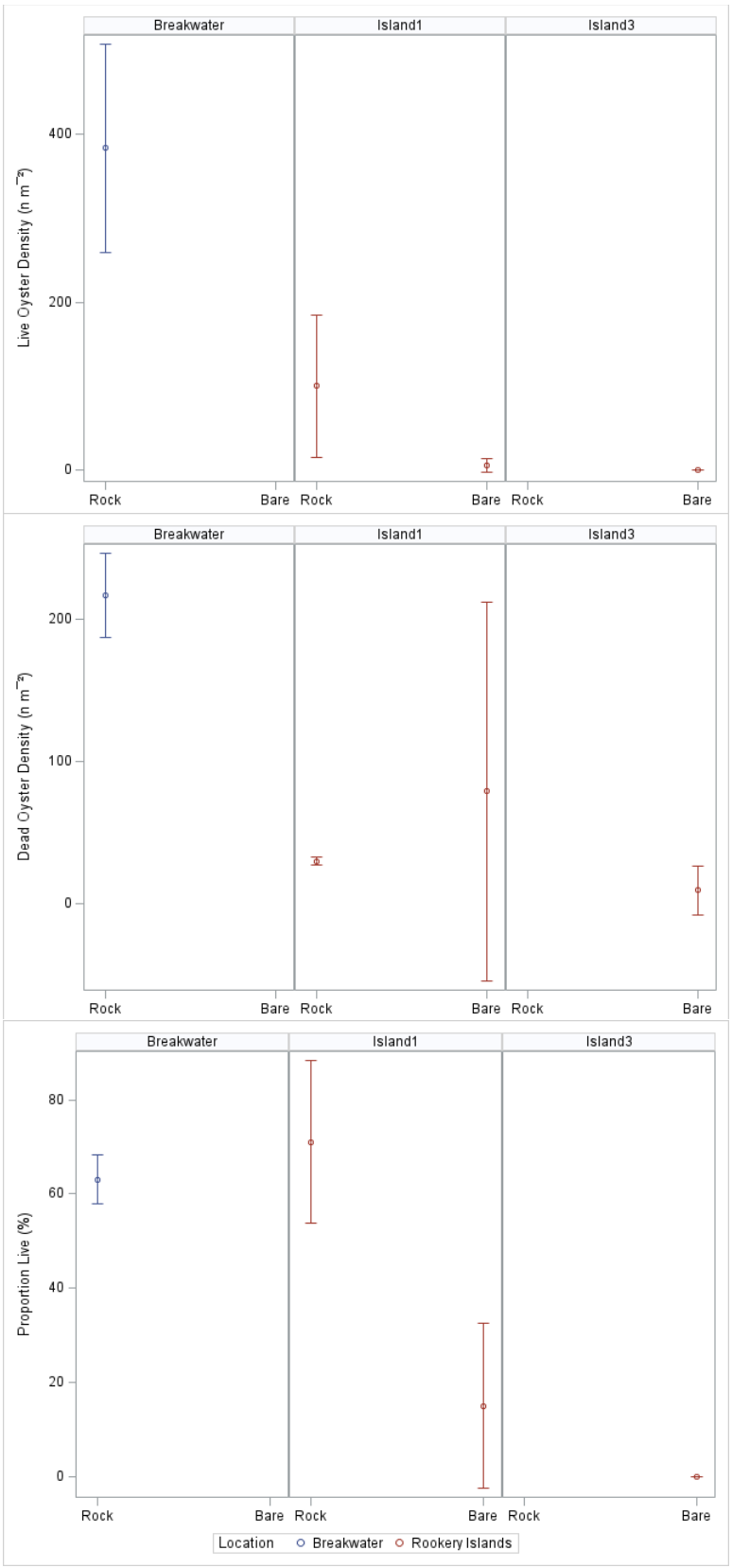

Figure 6. Density of live and dead oysters, and proportion of live oysters (live /(live+dead)) in bare areas and bull rock adjacent to armored shores. Error bars represent one standard deviation about the mean.

Table 2. Density of live and dead oysters and proportion of shells that were live on bull rock and bare substrates.

Substrate	Location	Station	Live oysters (n m^{-2})		Dead oysters (n m^{-2})		Proportion Live (%)	
			Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Bull Rock	Breakwater	Breakwater	383	124	217	30	63	5
	Rookery Islands	Island1	100	85	30	3	71	17
		Island3					0	0
		Mean	100	85	30	3	71	17
	Mean		289	179	155	99	66	10
Bare	Breakwater	Breakwater					0	0
	Rookery Islands	Island1	6	8	79	133	15	18
		Island3	0	0	10	17	0	0
		Mean	3	6	44	97	10	16
	Mean		3	6	44	97	10	16

Table 3. Spatial coverage by oyster shell and the proportion live (based on subsamples) on armoring stones.

Substrate	Location	Station	Proportion live (%)		Cover (%)	
			Mean	Standard Deviation	Mean	Standard Deviation
Armoring Stones	Breakwater	Breakwater	48	24	48	13
	Rookery Islands	Island1	71	17	56	13
		Island3	84	14	42	18
		Mean	77	16	49	17
	Mean		69	22	49	15

Table 4. Summary of live oyster heights from rocks (armoring and bull) and bare ground.

Substrate	Location	Station	Oysters measured (n)	Height (mm)	
				Mean	Standard Deviation
Rock	Breakwater	Breakwater	162	45	14
	Rookery Islands	Island1	122	55	20
		Island3	70	47	17
		Mean	192	52	19
	Mean		354	48	17
Bare	Breakwater	Breakwater	0		
	Rookery Islands	Island1	7	62	25
		Island3	0		
		Mean	7	62	25
	Mean		7	62	25

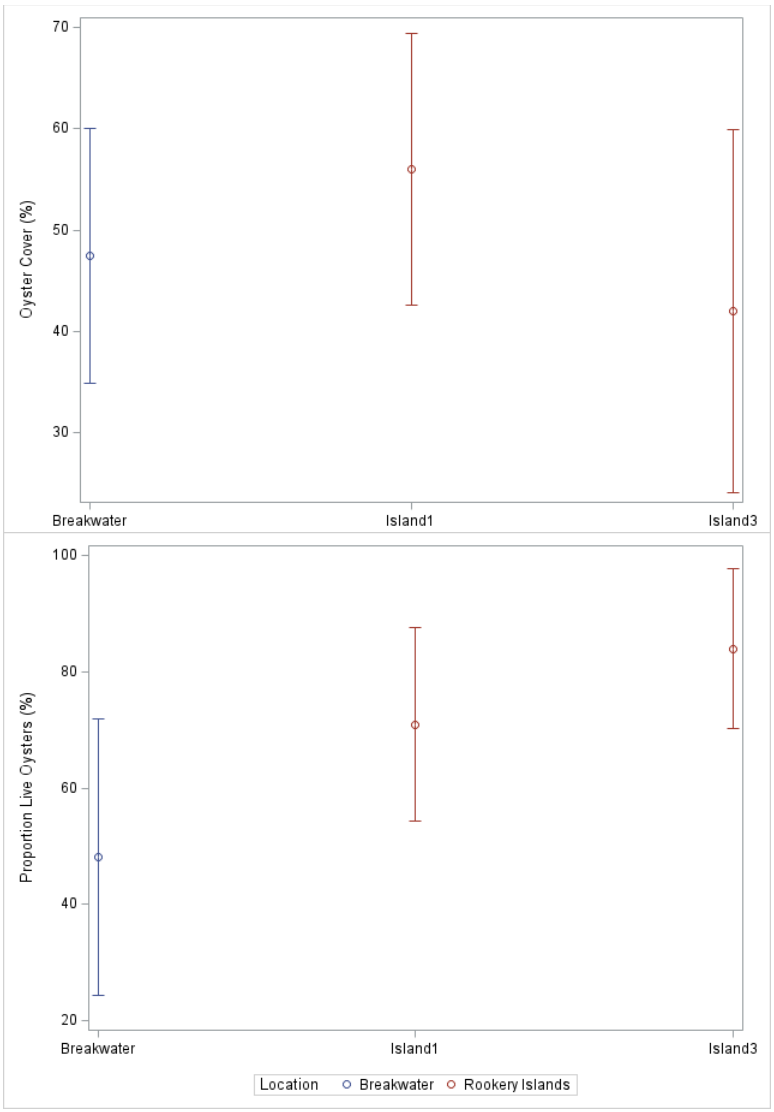

Figure 7. Spatial coverage by oyster shell and the proportion live (based on subsamples) on armoring stones. Error bars represent one standard deviation about the mean.

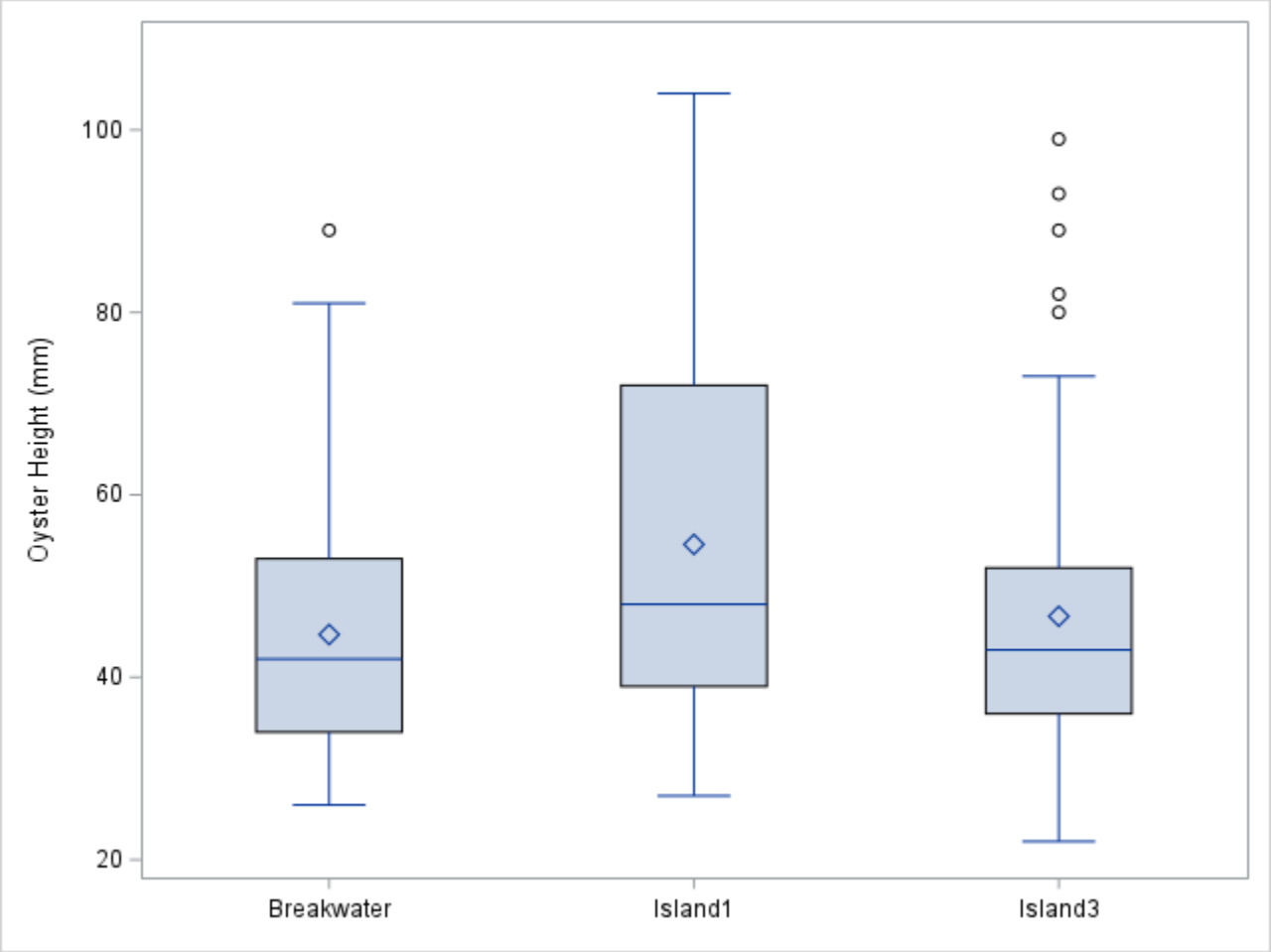

Figure 8. Box and whisker plot of oyster heights occurring on rocks at the three sampling areas. The circles above the whiskers indicate heights greater than 1.5x the interquartile range of heights of each station. The diamond shape represents the mean height of each station.

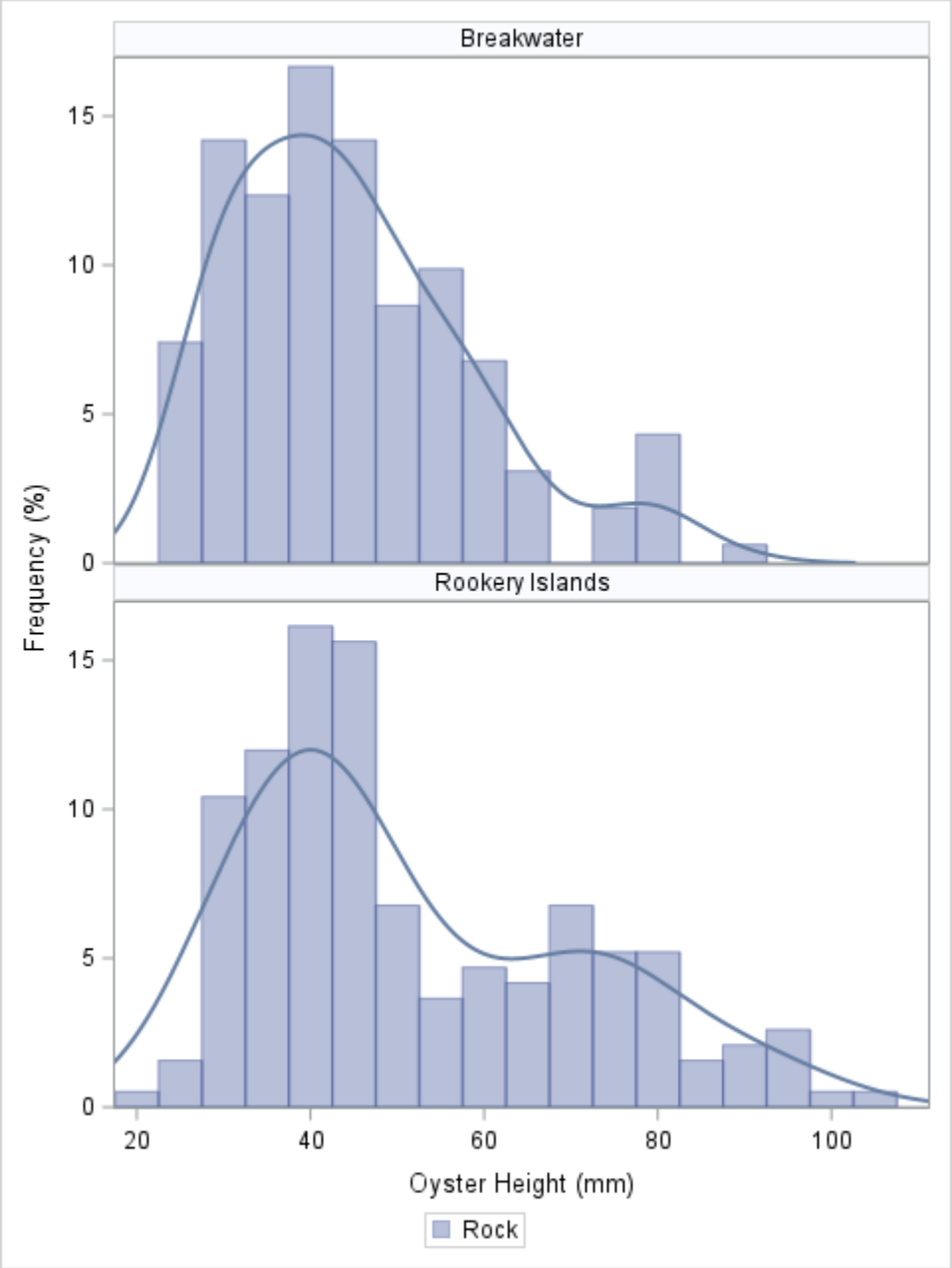

Figure 9. Histogram and kernel density plot of oyster heights occurring on rocks at the Rookery Islands and Marsh Breakwater

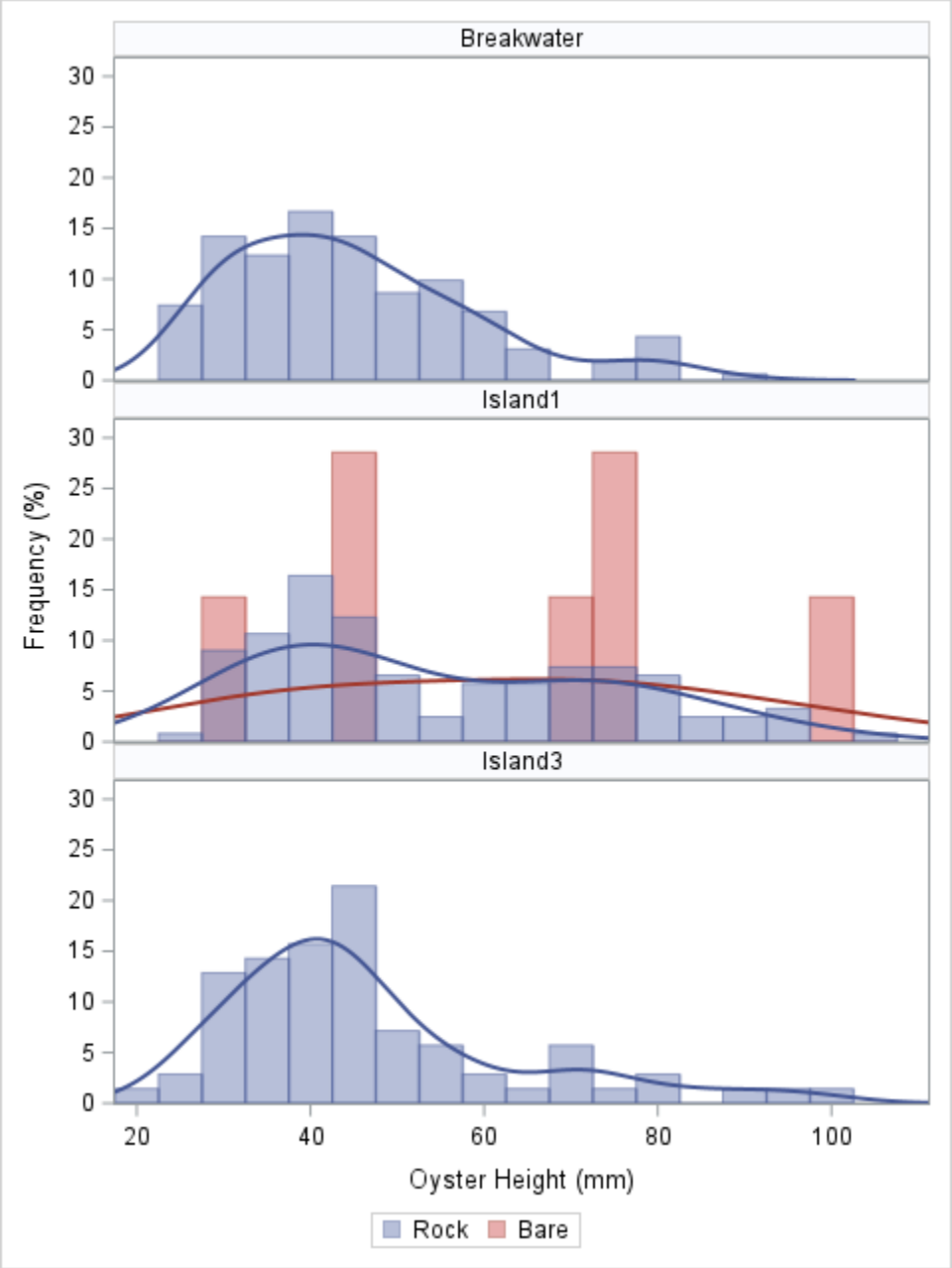

Figure 10. Histogram and kernel density plot of oyster heights occurring on rocks and bare substrates at the Rookery Islands and Marsh Breakwater

Dermo infection

Dermo infection prevalence (proportion infected) was similar between breakwater and islands oysters, but lower in submarket-sized (both 36%) than in market-sized oysters (breakwater = 75% and islands = 69%; Table 5). Infection intensity was low and ranged from 0 to 1.67 (out of 5) in all oysters, with means for locations and size classes ranging from 0.33 to 0.75 (out of 5). Consequently, weighted prevalence was also low at both locations and size classes (0.12 to 0.56 out of 5).

Table 5. Salinity, temperature and dermo infection characteristics in oysters collected from the breakwater and rookery islands.

Location	Size class	Oysters sampled (n)	Oysters infected (n)	Infection prevalence (%)	Mean intensity (0-5)	Weighted prevalence (0-5)
Breakwater	Market	8	6	75	0.75	0.56
	Submarket	11	4	36	0.33	0.12
Rookery Islands	Market	13	9	69	0.38	0.27
	Submarket	11	4	36	0.33	0.12

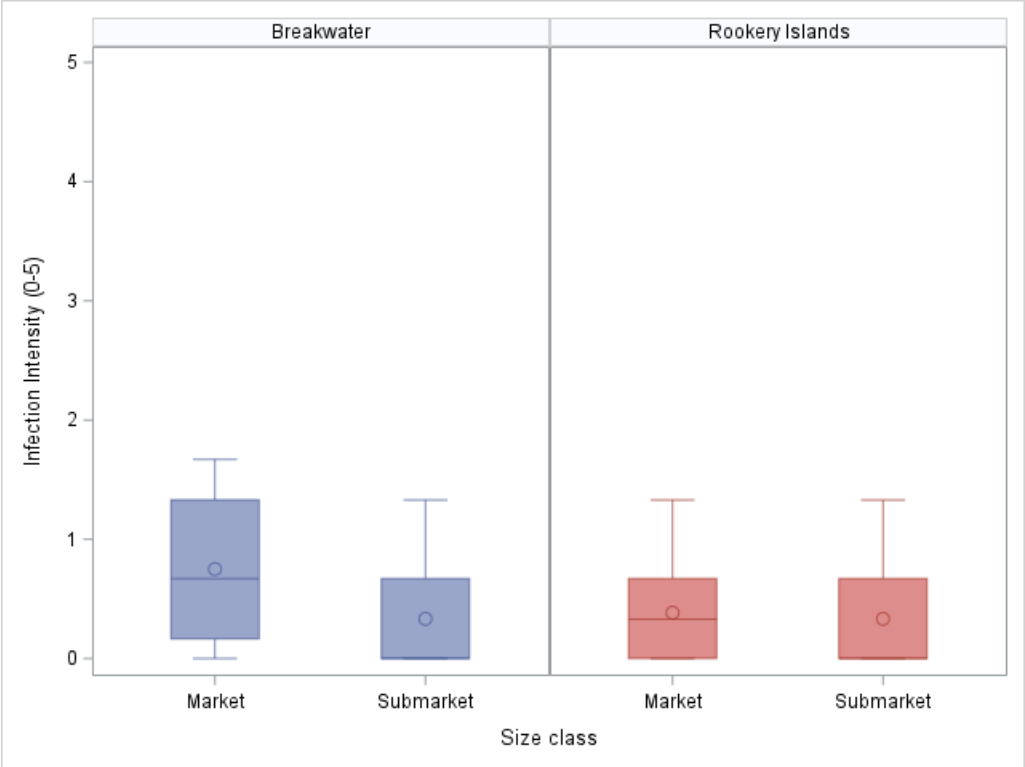

Figure 11. Dermo infection intensity in submarket and market-sized oysters at the breakwater and rookery islands

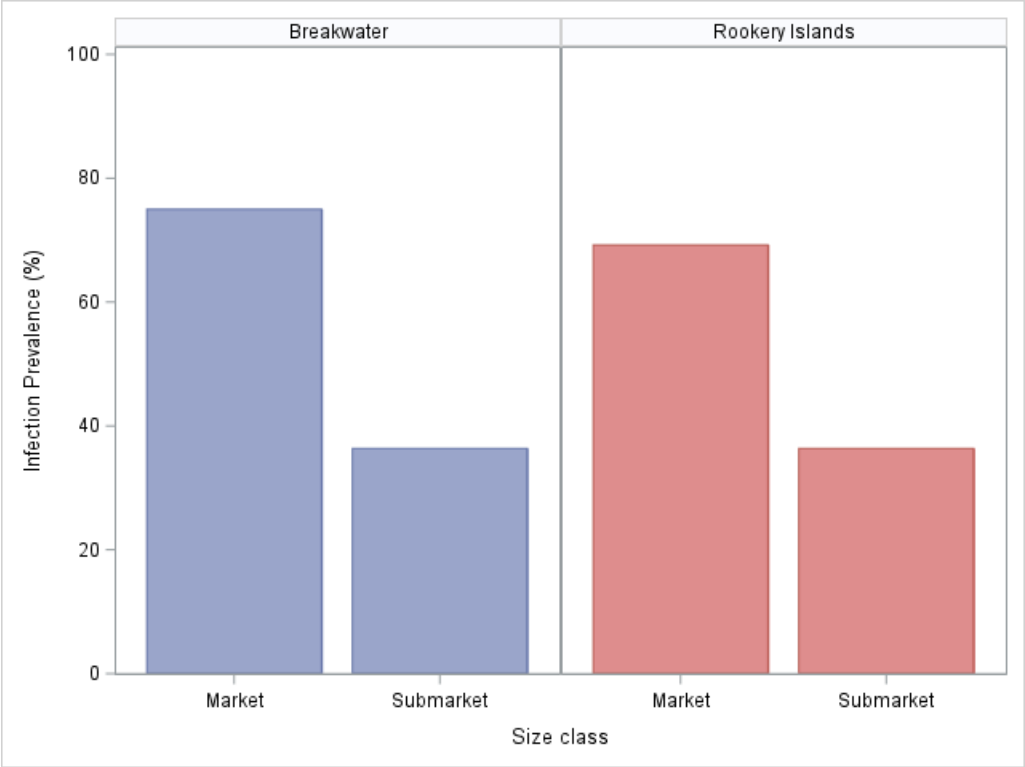

Figure 12. Dermo infection prevalence in submarket and market-sized oysters at the breakwater and rookery islands

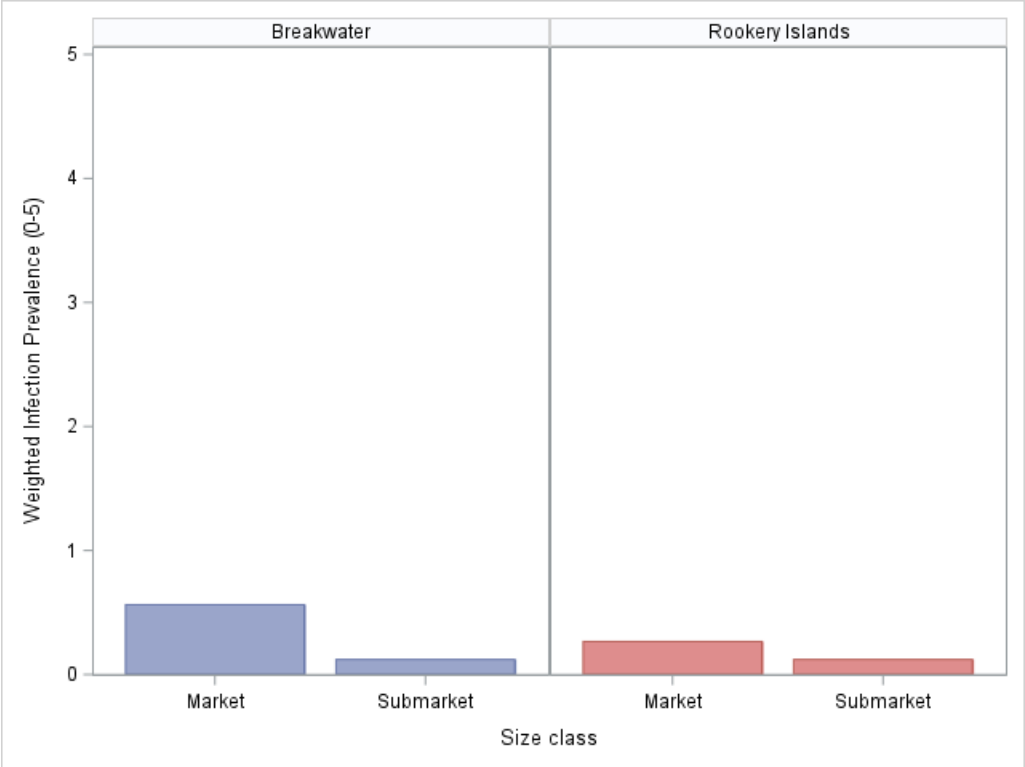

Figure 13. Dermo weighted prevalence in submarket and market-sized oysters at the breakwater and rookery islands

Water Quality

Mean salinity was lower closer to the Nueces River at Rookery Islands 1 and 3 (27.8 and 28.0) than closer to the mouth of Nueces Bay at the Marsh Breakwater (32.5) (Table 6). Temperature, pH and dissolved oxygen concentration were similar among stations. Turbidity was much greater at the Breakwater (24 NTU) than the Rookery Island stations (8.4 and 9.5 NTU). The Breakwater sampling areas were slightly more exposed to the northeast wind than the Rookery Islands at the time of sampling, but it is uncertain if the wind or other factors (e.g., bottom grain size) caused the difference in turbidity at the time of sampling.

Table 6. Water quality at the Marsh Breakwater and Rookery Island stations

Station	Salinity	Temperature (°C)	pH	Turbidity (NTU)	Dissolved Oxygen (mg l^{-1})
Breakwater	32.5	26.3	8.1	24.2	7.0
Rookery Island 1	27.8	25.0	7.9	9.5	6.1
Rookery Island 3	28.0	25.6	8.1	8.4	6.9

Summary

The hard substrates introduced by CBBEP when creating a Breakwater and hardening the shorelines of Rookery Islands in Nueces Bay has created a viable habitat for oysters to grow on. Despite the high salinities observed in Nueces Bay relative to areas with other healthy oyster reefs (e.g., within the Mission-Aransas Estuary), oysters appear to have successfully established themselves on these introduced substrates. Larger quantities of smaller oysters at the Breakwater locations indicates more recent recruitment of oysters there than at the Rookery Islands. The greater density of live and dead oysters where there is more available submerged bull rock substrate (at Breakwater) gives evidence that oyster settlement is substrate limited, and introducing more rock may help oyster populations to increase in Nueces Bay.

Dermo disease has the potential to harm oyster populations, especially where water temperatures and salinities can get high, such as in Nueces Bay. Dermo disease is prevalent in market-sized oysters (69 to 75 %) in this study, but the intensity is consistently low (≤1.7 out of 5). The resulting weighted prevalence values ≤0.6 (out of 5) are much lower than a score of 2.0, which indicates many severe infections and the potential for high oyster mortality (Mackin 1962, Burreson et al. 1994).

This study has identified that CBBEP has unintentionally provided oyster habitat in their efforts to protect bird and wetland habitat. The added value of increasing oyster habitat is especially important in Nueces Bay because of historic extensive oyster shell removal. Future restoration managers introducing hard substrates to estuarine waters in the coastal bend should include increasing oyster habitat as a potential project benefit as long as a planned habitat restoration

doesn't directly impact existing oyster reefs, and salinity and other water quality variables are suitable for oysters to survive.

References

Burreson EM, Alvarez RS, Martinez W, Macedo LA (1994) *Perkinsus marinus* (Apicomplexa) as a potential source of oyster *Crassostrea virginica* mortality in coastal lagoons of Tabasco, Mexico. Dis Aquat Org 20(1): 77-82. https://doi.org/10.3354/dao020077

Craig A, Powell EN, Fay RR, Brooks JM (1989) Distribution of *Perkinsus marinus* in Gulf Coast oyster populations. Estuaries 12:82-91. https://doi.org/10.2307/1351499

Mackin JG (1962) Oyster diseases caused by *Dermocystidium marinum* and other microorganisms in Louisiana. Publ Inst Mar Sci Univ Tex 7:132-229.

Ray SM (1966) A review of the culture method for detecting *Dermocystidium marinum*, with suggested modifications and precautions. Proc Natl Shellfish Assoc 54:55–69.

YSI Inc. (2016) ProDSS User Manual. Document #626973-01REF, Rev D, September 2016. Yellow Springs, Ohio, USA