Oyster Reef Health and Restoration Potential Along a Salinity Gradient in Naples Bay, Florida

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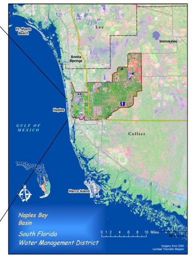
Naples Bay 1950 vs. Present



Naples Bay Watershed

Abstract

Naples Bay, a highly urbanized estuary, has lost an estimated 82% of its oyster reefs since the 1950's due to dredging and development activities. Artificial canals, primarily the Golden Gate Canal, have increased freshwater flows into Naples Bay causing extreme swings in salinity. This study characterized the health of the remaining American oyster, *Crassostrea virginica,* reefs at four sites along a salinity gradient by investigating various responses and their relationship to salinity, dissolved oxygen, and temperature. Prevalence and intensity of *Perkinsus marinus* infection varied significantly between sites, with the northernmost upstream Site 1, showing the lowest infection. Condition index varied significantly between sampling months and sites, and decreased during the spawning period April through October. Sites 1 and 2, with more optimal salinities for the first 8 months of the study, had the highest mean condition index. Spat recruitment varied significantly between sampling months and sites and peaked in August. Spat recruitment was greatest at the southernmost Site 4 which is furthest from the freshwater influence and therefore has higher salinities. Living densities (# live oysters/m^2) also varied significantly between sampling months and sites showing a greater number of live oysters per m^2 when moving downstream. A greater number of living oysters/m^2 was found in the wet season vs. the dry season reflecting the recruitment that occurs in the wet season. Freshwater flows and resulting salinities are a driving force for oyster reef health in Naples Bay. This study provides a baseline assessment of the oyster population that will allow for a comparison when future water diversions begin from the Golden Gate Canal and freshwater into the bay is reduced. This study also assists resource managers in determining potential oyster restoration sites in the bay.

Introduction

Altered hydrology has been documented to have negative impacts on oysters and other estuarine organisms by upsetting the balance of marine and freshwater inputs within an estuary. Oysters are the ultimate filter feeders and cleansers of estuarine waters. They provide many ecological goods and services including clean water, stabilization of shorelines, food for a variety of animals, and habitat for hundreds of invertebrates; that makes them a keystone species (Wells 1961).

Naples Bay, once a mangrove-lined, shallow estuary was channelized, dredged, and armored beginning in the 1950's. Instead of slow, natural filtration through shallow wetlands, pollutant-carrying stormwater now rapidly enters the bay via canals and outfalls. The Golden Gate Canal was dredged and connected to the Gordon River in the 1960's, increasing the Naples Bay watershed tenfold, dumping an average of 200 million gallons of freshwater per day into Naples Bay. This excess freshwater disrupts the delicate freshwater/saltwater balance that sustains the estuary and creates a longitudinal salinity gradient that varies greatly between wet and dry seasons as well as causes severe stratification in the wet summer months. Oyster reefs were once prolific prior to development activities that began in the 1950s, and an approximate 82% loss has occurred (Schmid et al. 2006).

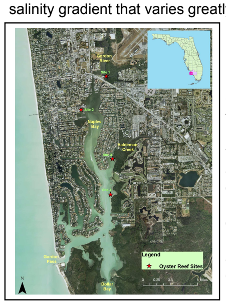


Figure 1: Study Locations—Sites 1, 2, 3, & 4 are upstream to downstream

Objectives of this study were to investigate the health of the American oyster, *Crassostrea virginica,* at four sites (Fig. 1) along a salinity gradient in Naples Bay using various oyster responses: condition index, prevalence and intensity of *Perkinsus marinus* infection, living densities (# live oysters/m^2), and spat recruitment. Effects of water quality parameters—temperature, dissolved oxygen, and salinity—in relation to oyster responses is examined. This study provides a baseline assessment of the oyster population that will allow for a comparison when future water diversions begin from the Golden Gate Canal and freshwater into the bay is reduced. This study also assists resource managers in determining potential oyster restoration sites in the bay.

Methods

➢**Sampling frequency:** Monthly for one year (Nov '10-Oct '11), 15 oysters collected from each site for lab analysis of prevalence and intensity of infection of the parasite *Perkinsus marinus*, and for Condition Index.

➢ **Water Quality:** Temperature, dissolved oxygen, and salinity were recorded in situ monthly at each site. Long term dataset from adjacent water quality sites (2005-2011) collected monthly by the City of Naples was also used for calculation of mean values.

➢**Spat recruitment:** Three shell stringers (12 shells/stringer) per site were deployed from Apr '11-Oct '11 and replaced monthly (Haven & Fritz 1985) to quantify settlement of juvenile oysters.

➢**Prevalence and Intensity of *P. marinus:*** Ray's fluid thioglycollate medium technique (Ray 1954) used for tissue processing, percent of infected oysters and intensity recorded using a Mackin scale of 0-5 (Mackin 1962, Volety et al. 2000).

➢**Net oyster recruitment:** Three trays (Fig. 3) per site were deployed for one year. Number of live oysters were enumerated and represent likelihood of oyster survival when exposed to natural elements such as salinity swings between wet/dry seasons, predation and disease.

➢**Condition Index:** Ratio of dry tissue weight: shell weight allows for comparison of physiological condition of oysters between sites (Lucas & Beninger 1985).

➢**Living Densities:** Four 0.25m^2 quadrats were randomly placed at each site near the mean low waterline—once in the dry (Nov-May) and once in the wet season (Jun-Oct, Fig. 2). Number of living oysters were quantified and 50 randomly selected oysters from each quadrat were measured for length (Fig. 4).

Figure 2: Measuring living densities

Figure 3: Shell stringers and trays

Figure 4: Measuring oyster lengths

Results

➢**Water Quality:** Temperature showed an expected seasonal trend and steadily increased from 14°C in Dec '10, peaking at 33°C in July '11. Values remained within 2°C of each other. Data averaged from 2005-2011, showed sites averaged approximately 25°C. Salinity remained relatively constant at all 4 sites during the dry season (Nov '10 – May '11, Fig 5). With a late start to the wet season, salinities dropped noticeably starting in July '11 at all sites. Site 1 had the most varied salinity, and long term means show statistically lower salinities from the other 3 sites (Fig. 6).

➢**Prevalence and Intensity of *P. marinus:*** Varied significantly between months and sites. Prevalence (% of infected oysters) was lowest in April and peaked in January. Site 1 had the lowest intensity and % infections (Fig. 8). Site 3 had the highest intensity and % infection by *P. marinus* (Fig. 8).

➢**Condition Index:** Varied between sampling months and sites. Mean condition index remained above 2.5 in the dry season (Nov.-May) and fell below 2.5 for the remainder of the wet season (June-Oct.). Sites 1 & 2 had a mean condition index of 2.8 with Sites 3 & 4 showing 2.1 and 2.5 respectively (Fig. 7).

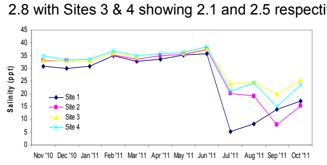


Figure 5: Salinity at each site during study period.

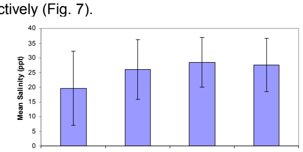


Figure 6: Salinity at each site using 2005-2011 data

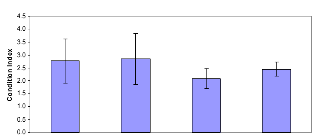


Figure 7: Condition index of oysters at each site

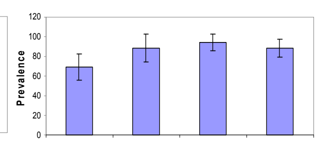


Figure 8: Disease prevalence (% infected oysters)

Results Continued

➢**Net oyster recruitment:** Varied significantly between sites (Fig. 9); Site 4, with a mean number of 2169 live oysters per m^2, was higher than Sites 1, 2, & 3 which had 1176, 1080, 853 respectively.

➢**Living Densities:** Varied significantly between sites and seasons (Fig.10). Site 4 had the greatest number of live oysters per m^2 in both seasons; Site 1 had the lowest in the wet season. Living oyster density was higher at all sites in the wet season than the dry season reflecting spawning activities and increased recruitment of juvenile oysters.

➢**Spat recruitment:** Varied significantly between sampling months and sites, peaking in August (Fig. 11). Site 4, the southernmost site and furthest from the freshwater influence, had significantly higher recruitment (Fig. 12). Sites 1, 2, & 3 mean recruitment were all similar.

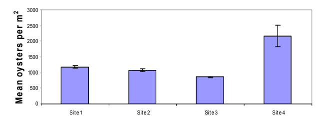


Figure 9: Net oyster recruitment per m^2 using shell trays

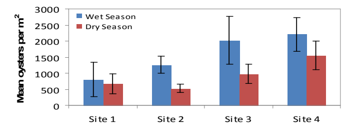


Figure 10: Living densities (# live oysters/m^2)

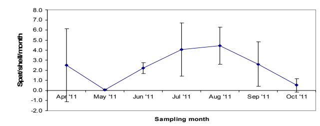


Figure 11: Oyster spat recruitment at all sites during study period.

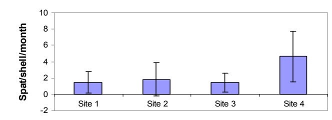


Figure 12: Oyster spat recruitment

Discussion

Freshwater inflows from the Golden Gate Canal starting in the wet season (Jun-Oct), and the resulting extreme swings in salinity, is best demonstrated by the northernmost Site 1 where salinity values fell by 31 ppt between June and July. This can cause significant stress on oysters since they cannot adapt that rapidly to water quality changes. Site 1 had the lowest living oyster density in the wet season in addition to having low recruitment in comparison to the downstream Site 4. Freshwater flows can be great enough to flush larval stages of organisms from the northern part of the bay and even the entire estuary (Simpson et al. 1979) which may limit oyster recruitment upstream. Freshwater and the resulting lower salinities can limit *P. marinus* infections, so as expected, Site 1 had the lowest mean prevalence and intensity of infection.

Sites 2, 3, and 4 generally had higher salinities than Site 1 over the study period as well as higher long term salinities. Higher salinities can produce conditions favorable to higher infection prevalence and intensity as seen in the downstream sites. This can stress oysters and may result in a lower condition index as observed at Sites 3 and 4. In addition, for several months, oyster reefs at Site 3 were observed having heavy mats of filamentous algae blanketing them. This could have not only stressed the oysters resulting in the lowest condition index of the four sites, but also have limited recruitment onto the recruitment trays. This algae may be indicative of nutrient enrichment coming from Haldeman Creek or the adjacent canals.

Site 4, the furthest downstream, had the highest living densities in both the wet and dry season and the highest net and monthly spat recruitment. Greater numbers of juvenile oysters may recruit to this site due to higher numbers of living oysters at downstream stations as well as spat potentially being flushed downstream by freshwater flows. This suggests that the Site 4 area is a suitable location for oyster restoration using shell bags since oyster stock is naturally present to seed created reefs.

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