CORRELATION BETWEEN TIDAL FLOW AND ENTEROCOCCI AT SELECTED RECREATIONAL SITES IN BISCAYNE BAY

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INTRODUCTION

- Fecal pollution is a major global threat to coastal ecosystems, especially as population rises. Monitoring recreational beaches for fecal pollution is important for human safety, coastal economies, and environmental health.
- Enterococci is a fecal indicator bacteria (FIB) that is used in many monitoring interventions globally as an indicator of microbial quality of recreational waters because it is strongly associated with several diseases, including gastrointestinal, respiratory, and skin disorders (Aslan et al. 2018).
- In Florida, the DOH Florida Healthy Beaches program both monitors the water quality (enterococci concentration) at beaches and provides swimming advisories to the public. Miami Waterkeeper monitors seven recreational use sites that are not tested by the DOH Healthy Beaches program, sampling them weekly and testing for enterococci. Miami Waterkeeper's sites are on the Biscayne Bay side, whereas the DOH sites are on the Atlantic Ocean side.
- Miami Waterkeeper's monitoring efforts have generated a historical data set at the seven sites they test. While regular and efficient monitoring is undeniably important to public health, a deeper understanding of the impacts of environmental parameters on enterococci is necessary to understand whether high enterococci counts are caused by actual pollution events and to investigate chronic beach advisories
- Despite its importance to water quality monitoring and many studies, the effect of tidal patterns on enterococci concentrations is not yet fully understood, particularly in the unique environment of the Biscayne Bay.
- The goal of this study was to 1) utilize Miami Waterkeeper's historical public health advisory water quality data in conjunction with historical tide records to understand the relationship between tidal phase and microbial water quality and 2) understand the limitations of the data set.

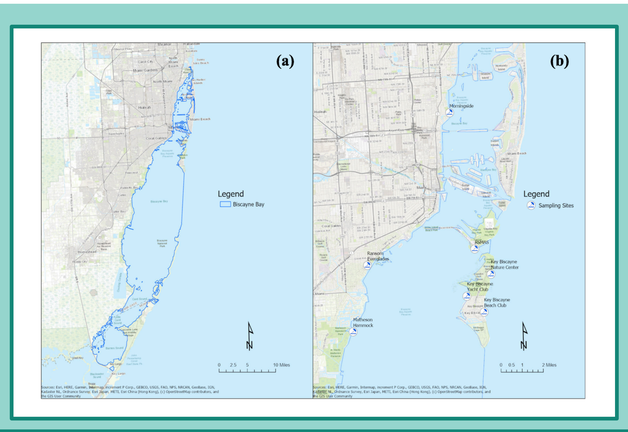

Fig 1. (a) Biscayne Bay (b) seven recreational beach sites sampled by Miami Waterkeeper

METHODS

Study Area: This study uses samples collected from seven recreational use sites along Biscayne Bay, on the Atlantic coast of south Florida, USA (Fig. 1). The seven sites are Key Biscayne Yacht Club, Matheson Hammock Park, Key Biscayne Nature Center, the Rosenstiel School of Marine and Atmospheric Science (RSMAS) campus, Morningside Park, the Ransom Everglades campus, and Key Biscayne Beach Club (Fig. 2).

Sample Collection: Water samples were collected weekly by Miami Waterkeeper staff from January 2018-January 2020 for 7 sites. Samples were collected at a depth of 6-12 inches below the surface, without contacting the bottom of the water body (to avoid collection of sediment as part of the sample). A total of 386 collected samples were used for this study: 45 for Key Biscayne Yacht Club, 63 for Matheson Hammock, 42 for Key Biscayne Nature Center, 64 for RSMAS, 64 for Morningside Park, 60 for Ransom Everglades, and 48 for Key Biscayne Beach Club.

Sample Analysis: The samples were analyzed within six hours after collection following the protocol established in EPA Method 1600. In the laboratory, 10mL of sample were diluted in 90mL of distilled water (10:1 dilution) per manufacturer instructions for salt or brackish water. The sample was mixed with IDEXX Enterolert, a nutrient indicator that fluoresces when metabolized by enterococci. The sample and indicator were incubated for 24 hours at 41°C. A black light was used to view the trays of sample. The number of wells fluorescing were counted and the most probable number (MPN) of enterococci for each sample was calculated.

Statistical Analyses: Tide data was sourced from NOAA tidal station 8723232 at Key Biscayne Yacht Club, visible in Fig. 4 (NOAA 2020). A t test was performed, for each site, between samples collected during ebb tides and samples collected during flood tides to understand the relationship between tides and enterococci counts. A one-way ANOVA was conducted to compare enterococci counts for the seven sites. Percent exceedances were also calculated for each site as a metric of overall water health.

RESULTS

Comparison of Sites

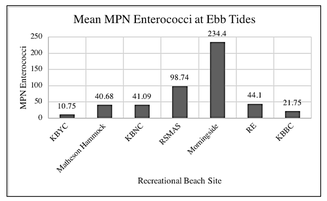

Fig 2. There were no statistically significant differences between enterococci mean counts at the seven different sites for samples collected at ebb tides.

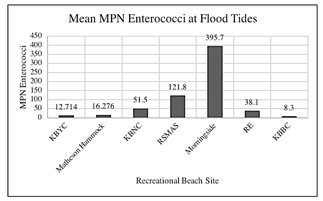

Fig 3. There were no statistically significant differences between enterococci mean counts at the seven different sites for samples collected at flood tides.

Relationship between Tides and Enterococci

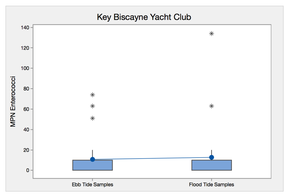

Fig 4. There was no significant difference between enterococci counts of samples collected at ebb tides (M=10.75, SD=21.031) and flood tides (M=12.714, SD=31.169) for Key Biscayne Yacht Club.

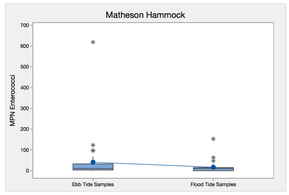

Fig 5. There was no significant difference between enterococci counts of samples collected at ebb tides (M=40.68, SD=106.75) and flood tides (M=16.276, SD=30.033) for Matheson Hammock.

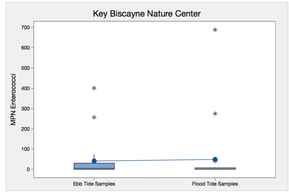

Fig 6. There was no significant difference between enterococci counts of samples collected at ebb tides (M=41.09, SD=97.69) and flood tides for Key Biscayne Nature Center.

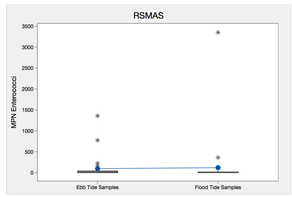

Fig 7. There was no significant difference between enterococci counts of samples collected at ebb tides (M=98.74, SD=274.21) and flood tides (M=121.8, SD=583.5) for RSMAS.

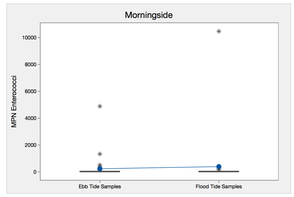

Fig 8. There was no significant difference between enterococci counts of samples collected at ebb tides (M=238.7, SD=870.4) and flood tides (M=395.7, SD=1902.2) for Morningside.

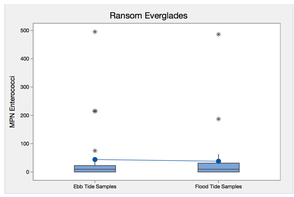

Fig 9. There was no significant difference between enterococci counts of samples collected at ebb tides (M=44.1, SD=100.34) and flood tides (M=38.1, SD=91.81) for Ransom Everglades.

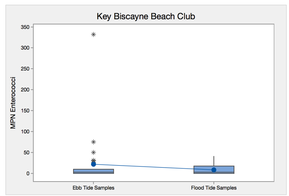

Fig 10. There was no significant difference between enterococci counts of samples collected at ebb tides (K=21.75, SD=63.31) and flood tides (M=8.3, SD=11.07) for Key Biscayne Beach Club.

Percent Exceedance for Sites

Site	Percent Exceedance
Morningside	20.313
RSMAS	12.5
KBNC	11.905
RE	10
Matheson Hammock	9.524
KBYC	4.444
KBBC	4.167

DISCUSSION

- There is insufficient evidence to reject the null hypothesis that enterococci count does not vary based on tidal phase for any of the seven sites used in this study. Mean MPN of enterococci did not vary significantly at any individual site between ebb tide samples and flood tide samples.
- There is insufficient evidence to reject the null hypothesis that enterococci count does not vary significantly between the seven sites of this study.
- There are several limitations and potential issues with our use of this historical water quality monitoring data for our study: nearly all data sets had many outliers (Fig. 4-10), and the number of samples per site and per tidal cycle varied widely (Fig. 11-12). The data set itself had some large temporal gaps, often dictated by external factors (i.e. beach advisory from DOH for another reason, resulting in no need to take a sample for weekly public health advisory).
- This study utilized mean concentrations out of an interest in the exact changes in concentration based on tides at time of sampling, and to distinguish water quality. Utilizing percent exceedance, as many others studies on environmental parameters have, could produce different results and should be considered in the future. Percent exceedance values indicate that Morningside has poor water quality (>70 CFU/MPN per 100 mL) 20.313% of the time, nearly double any other site.
- Although our study found no significant difference between enterococci counts as ebb and flood tides, it is possible that microbial water quality in Biscayne Bay is tidally influenced. Past research into the association between environmental parameters and FIB concentrations in Biscayne Bay illustrates that many of these parameters do significantly impact concentrations.
- A previous study at Hobie Beach, in close proximity to our study sites, evaluated enterococci levels in water and sand during different tidal phases. Tides were observed to significantly impact enterococci levels. Sand samples showed elevated levels of enterococci within the inter-tidal zone, suggesting a connection between sand enterococci concentration and enterococci concentration in the inter-tidal water column. Dry sand immediately above the water column was observe to have the highest enterococci levels of all. This suggests that enterococci accumulated in beach sand may be washed into the water column during extreme high tide, further contributing enterococci inputs from the intertidal zone (Wright et al. 2011).
- Sample collection protocols for this study were designed to rapidly inform the public about immediate potential health risks to swimming at recreational use beaches. Modifications to data collection protocols and supplemental data collection could enable Miami Waterkeeper to better utilize water sampling data for longer-term studies. Integrating other approaches to our data collection could also enrich studies of these recreational sites.

ACKNOWLEDGEMENTS

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