Effects of marina flow rate, rainfall, and dissolved oxygen on bacteria concentration in marinas

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Introduction
Elevated levels of fecal bacteria in the Galveston Bay system pose a great threat not only to the environment, but even more so to public health and the economy. The Environmental Protection Agency uses the current limits of 104 Most Probable Number (MPN)/100 mL (single-grab sample) and 35 MPN/100 mL (geometric mean) to determine the safety of water for recreational contact.

Clear Lake, Texas has the third highest concentration of privately owned marinas in the U.S.; yet local water quality research in those marinas is limited. This study looked at the effects of flow rate and rainfall on Enterococci concentrations in Lakewood Yacht Club (LYC) in order to better understand potential impacts on water quality as a result of both marina design and environmental factors.

This project hypothesized that rainfall would result in significant increase in bacteria levels. Further, surface flow rates would show a negative correlation with bacteria levels. Finally, dissolved oxygen levels would be positively correlated with bacteria levels.

Methods
Field sampling was conducted at eight sites in LYC that were selected using a stratified random sampling design. The sampling period began 06/18/2015 and ended 07/23/2015 and took place on Tuesday and Thursday mornings.

Enterococci concentrations were determined using IDEXX Enterolert and measured in MPN/100mL (Figure 1).

Surface currents and flow rates were mapped using EnviroREDI tracing dye and drogues Figure 2). These parameters were measured over seven sampling days at the same eight sites with varying wind and weather conditions at rising tide.

Rainfall accumulation data was obtained from NOAA’s climate data for each sampling date.

Results

How does rate of flow affect Enterococci and dissolved oxygen in LYC?

Does rainfall significantly affect Enterococci levels in LYC?

![Figure 3: Comparison of bacteria concentrations and rates of flow at sampling sites. A paired t-test was used to determine the p-value of 0.0225.](image)

![Figure 5: Comparison of bacteria concentrations after wet weather sampling events and dry weather sampling events in 2014 and 2015. A paired t-test was used to determine the p-values for both years.](image)

![Figure 4: Map of LYC showing rate of flow at each sampling point after wet weather and dry weather. Flow rates were greatest at the south-end of the marina and decreased north-ward. Insufficient flow data was gathered for B4 and D8.](image)

Conclusions

Marina circulation
Based on visual observations, it is clear that wind is a major influence on the circulation and surface flow of the marina. Due to the closed marina at LYC, water flow was low Enterococci concentrations were high at certain sample sites (Figures 3 and 6). An open concept marina would alleviate these problems, preventing the harboring of Enterococci and promote flushing.

Rainfall
Since there was no significant relationship between rainfall and Enterococci concentration (Figure 5), it can be concluded that rainfall is not solely to blame for increased levels of Enterococci.

With this conclusion, it is necessary to look further into what may cause high Enterococci levels, such as boater waste, as macerated sewage has been observed several times, invasive wildlife or a leaking pipe from the pump-out station.

Future Research
Testing the circulation and tidal flushing for longer periods of time and during different tidal stages would provide a more well-rounded conclusion on the effectiveness of flushing in LYC. Also, conducting comparison studies of marinas with diverse design schemes, as well as with and without best management practices to encourage flushing would be helpful. Finally, adding in a system for quantifying the presence of nutrient and boater waste at the sampling sites would be helpful.

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