

Effects of wet and dry weather events on bacteria (enterococci) levels and detection of hotspots in a brackish water marina in Texas

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Introduction

Approximately 50% of Texas surface waters are impaired with bacteria from fecal waste, including several tributaries and segments within the Galveston Bay system. Environmental issues associated with fecal bacterial impairment of recreational waters continue to pose a threat to public health and local economies. Recreational waters are vulnerable to microbial pollution through human sources, animal sources, and stormwater runoff. The presence of human pathogens in water can lead to gastroenteritis, vomiting, hepatitis, diarrhea, fever, and ear, eye, and respiratory infections.

Bacterial pollution has negatively affected recreational activity, shellfish industries, and marine ecosystems of Galveston Bay and its tributaries. As a result, there is great interest in finding feasible solutions for bacterial remediation and prevention. Current EPA limits for fecal enterococci, the bacterial indicator for tidal waters, is 104 CFU/100 mL (single-grab sample) and 35 CFU/100 mL (geometric mean).

While Clear Lake and Galveston Bay are booming recreational boating areas, little water quality data is available in marinas. The objective of this preliminary study was to determine bacteria concentrations throughout surface waters of Marina Del Sol, a marina on Clear Lake in Kemah, Texas, examine their spatial relationship within the marina, and compare bacteria concentrations during wet and dry weather sampling events.

Materials and Methods

Samples were collected in June and July of 2013 and 2014 at Marina Del Sol (Fig 1). In 2013, samples were collected from 10 locations every Thursday, Saturday, and Monday, while in 2014 they were collected from 8 locations every Thursday and Monday. Dates were chosen to capture samples before and after weekend boater activity; in 2014 it was determined that Saturday samples were extraneous.

The sampling design was refined from 2013 to 2014 in order to increase randomness and cost effectiveness, which introduces variability to our data, however this design will eventually be finalized and repeated for the long-term. All sites were selected based on potential inputs of bacteria (stormwater outfalls, retention pond culvert, residential yard runoff, boat sewage, inflow from Clear Lake) into different parts of the marina.



Figure 1. Intern, Tanu Uppal, sampling at Marina Del Sol.



Figure 2. Enterolert Quanti-Tray® with positive wells illuminated.

Three-day rainfall accumulation (in inches) and number of days since last precipitation (runoff) were recorded using Harris County's Flood Warning System website (Gauge 200: A104 Taylor Lake @ NASA Road 1).

Enterococci concentrations were determined using IDEXX Enterolert® (Fig 2). Data was analyzed using the Analyse-It® add-on to Microsoft Excel.

Conclusions

This preliminary study aimed to better understand the state of fecal bacteria contamination in Marina Del Sol, if any spatial patterns existed, and if rainfall was a significant factor causing elevated enterococci concentrations. Based on these results, we concluded that the marina design may impact bacteria concentrations due to poor circulation (Fig 8a), but that other confounding variables may be at play (Fig 8b).

Additionally, stormwater runoff can play a major role in increased bacteria levels (Fig 6), but other sources (i.e. birds, illegal dumping) need to be accounted for in order to tell the entire story (Fig 7). Overall, bacteria concentrations in Marina Del Sol decreased in 2014. It is possible that boater waste education, increased pump-out usage (Fig 3), and enforcement by marina management may have had some effect on reduced bacterial pollution in Marina Del Sol waters. We hope to see this trend continue and hope to better quantify boater knowledge and attitudes through a newly implemented Dockwalker survey program. This data has and will continue to guide decision-making around the bay.



Figure 3. Pump-out station and cart at Marina Del Sol.

Limitations and Proposed Improvements

This study was limited by a small sample size, variability inherent when using two different sampling designs, and other confounding variables that were not yet addressed (e.g. bird activity, boater activity, illegal sewage discharge). Each of these studies served as a "snapshot" of marina conditions and does not reflect rapidly changing environmental conditions.

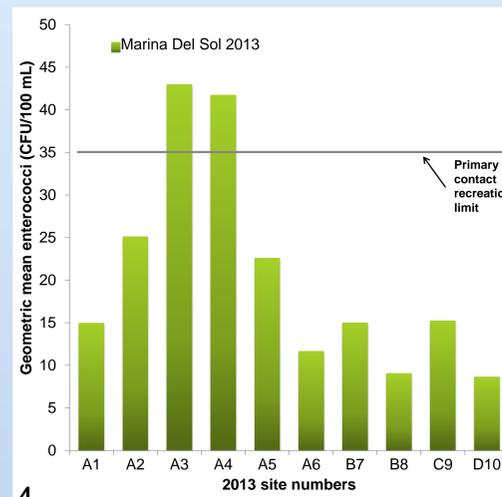
Future studies will continue to refine the sampling design in order to decrease variance and improve statistical analysis to address confounding variables. Improvements will also include using molecular source tracking methods to identify the origin of enterococci in marina waters (human, avian, other). This will help to identify dominant sources of fecal bacteria, to aid in implementing effective preventative and remedial measures, minimize economic loss, and reduce the risk of adverse health outcomes for recreational boaters.

References

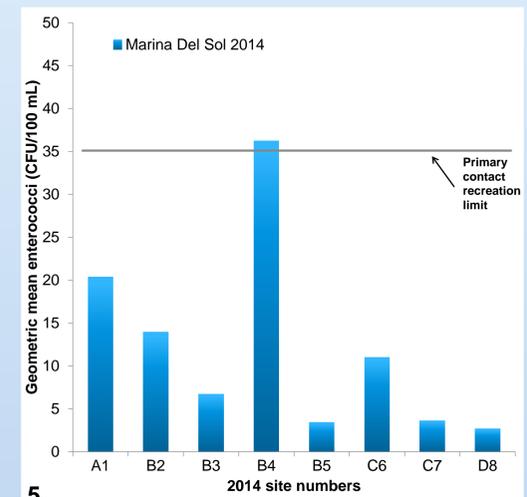
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Results

Do fecal bacteria hotspots exist in Marina Del Sol?



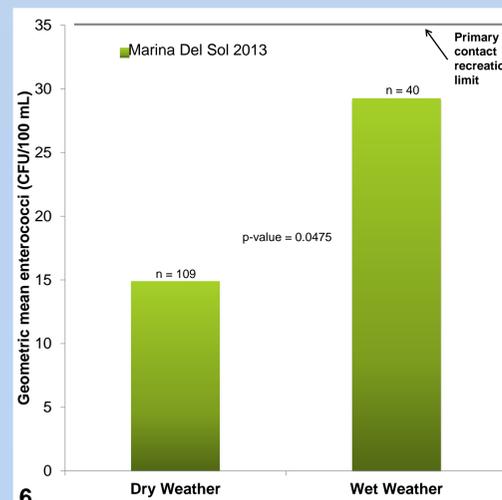
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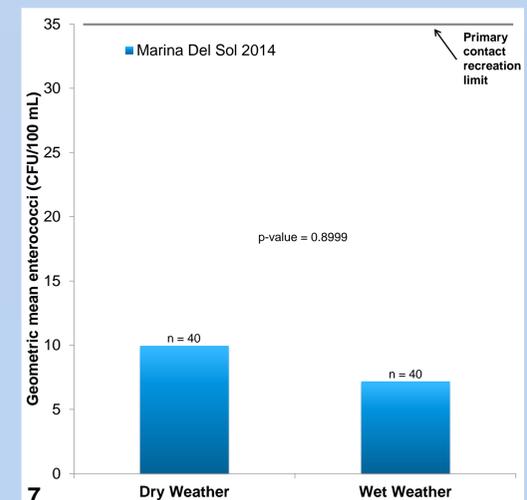
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Figures 4-5. Geometric mean enterococci concentrations at all 2013 and 2014 Marina Del Sol sites.

Is there a significant difference between bacteria concentrations during wet and dry weather?



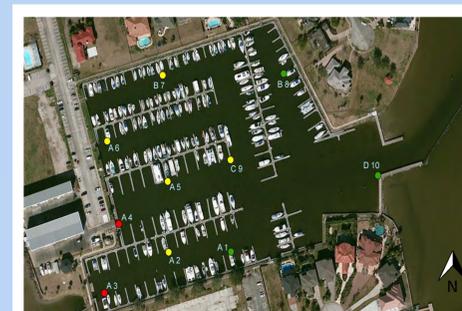
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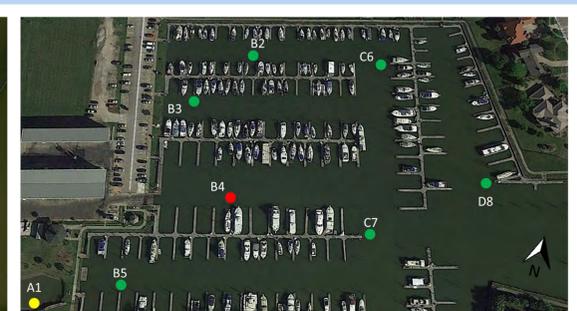
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Figures 6-7. Geometric mean enterococci concentrations at all 2013 and 2014 Marina Del Sol sites during dry weather and wet weather events. Data were analysed using 2 x k contingency tables and Pearson's X².

Do bacteria concentration gradients exist in Marina Del Sol?



8a. 2013 sampling sites



8b. 2014 sampling sites

Figure 8a - b. Comparison of geometric mean enterococci concentrations at Marina Del Sol sampling sites in 2013 and 2014.

Overall, enterococci concentrations in Marina Del Sol were lower in 2014 compared to 2013 (Fig 4 - 7), however hotspots were still present during both study periods. Results showed hotspots present at sites A3 and A4 in 2013 (Fig 4 and 8a) and at site B4 in 2014 (Fig 5 and 8b). In 2013, bacteria concentrations formed a gradient from low concentrations at the marina entrance to high at the back of the marina (Fig 8a); no gradient was formed in 2014 (Fig 8b). Rainfall had a significant impact on bacteria concentrations in 2013 (Fig 6), but there was no significant difference in dry and wet weather concentrations in 2014 (Fig 7).

Acknowledgements

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