Observational Research

New recreational water quality criteria and their impact on beach advisories in Coastal Georgia

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ABSTRACT

Background: To monitor pollution of marine beaches in Georgia, enterococci have been used as indicators of fecal contamination. For the 1986 Recreational Water Quality Criteria (RWQC), the beach action value (BAV) was 104 colony-forming units (CFU)/100 ml; the new RWQC, instituted in 2012, is 70 CFU/mL, a 32.6% decrease. When the beach action value is reached, authorities are to issue a beach advisory for protection of swimmer health. The present study investigated changes in compliance with the 2012 RWQC at five high-use beaches in Georgia.

Methods: In the summer of 2015, samples of water were collected from five beaches at Tybee Island. Enterococci concentrations were enumerated by USEPA-approved methods. Samples exceeding the 1986 and 2012 RWQC beach action values were compared with times that advisories were posted at these beaches.

Results: At these beaches, advisories were posted four times during the summer. Since, in 2015, the previous RWQC was in use, these decisions were based on the guideline value of 104 colon-forming units (CFU)/100 ml. When the new beach action value (70 CFU/100 ml) was applied, retrospectively, for samples collected at these sites, we found that the number of advisories would have been doubled if this value had been in place at that time.

Conclusions: Staring from January 2016, Georgia has adopted new water quality criteria to monitor beaches. Decreasing the beach action value to 70 CFU/100 ml strengthens beach monitoring programs because it allows for better prevention from waterborne diseases, thus protecting the health of swimmers.

Keywords: Enterococci, beach action value, recreational water quality criteria, Georgia

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INTRODUCTION

Coastal environments are sensitive to anthropogenic stressors, and pollution of these areas affects both the ecosystems and human health (Amorim, Ramos, & Bordalo, 2014). Challenges originating from population increases at coastal communities are adversely affecting the livelihood of individuals residing in or visiting these environments (von Glasow et al., 2013). A main concern due to growing populations in the coastal environment is the elevated concentrations of human pathogenic organisms at beaches and their effects on public health (Colford et al., 2012; Molina et al., 2014; Thoe et al., 2015).

Similar to other coastal communities in the US, Georgia's coastal population is facing challenges, with a 19% population increase in the last 40 years and an increase of 175% in individuals of ages 65 and older (NOAA, 2013). In Georgia, tourism is an economic driver, and 99% of the coastal population is within 20 miles of a water access site for recreational activities (GDNR, 2015). Tybee Island accommodates one of four public beach communities in Georgia, and the population of 4,000 people during the off-season reaches up to 30,000 during summer weekends (Elfner, 2005). Therefore, at this time of the year, any degradation in the quality of beach water would pose a health risk to a greater portion of the population.

Exposure to polluted beaches increases the risk of gastrointestinal, respiratory, and neurological illnesses as well as skin, ear, and eye infections (Boehm and Soller, 2013). The quality of beach water is routinely monitored in order to protect swimmers from potential health risks associated with wastewater discharge and storm water and agricultural runoff (Arnold et al., 2013). Testing water for all waterborne pathogens is not feasible because of the high cost of analyses, time requirements, and the need for highly specialized analysts. Also, these pathogens often occur at levels below detection limits (Girones et al., 2010). Instead of targeting each pathogen, fecal indicator bacteria have commonly been used to test the microbiological quality of water at beaches because their numbers present strong associations with gastrointestinal diseases (Wade et al., 2010).

Swimming advisories are posted when the Recreational Water Quality Criteria (RWQC) beach action value (BAV) for bacteria is exceeded. These advisories involve issuing a

press release and activating the on-site advisory signs at the affected beach. In general, beach water samples are collected on Tuesdays, the test results are posted on Wednesdays. In case a sample exceeds the BAV, sampling is repeated on Thursdays, and the results are re-posted on Fridays.

Georgia has been using the 1986 RWQC as guidelines to protect swimmer health. These guidelines suggested a single sample maximum of 104 CFU/100 ml for enterococci. Starting from January 2016, Georgia adopted the new RWQC with a BAV of 70 CFU/100 ml. The purpose of this study was to i) compare the criteria for a single sample maximum (104 CFU/100 ml) and the new BAV (70 CFU/100 ml) to identify the number of advisories to be posted in both scenarios and ii) investigate the discrepancies between enterococci results from tests performed on a weekend when more people use these beaches.

METHODS

Study area and sample collection

The study was conducted at five locations on Tybee Island, Georgia (Figure 1). These sampling points were also used by the Coastal Resources Division for routine beach monitoring that occurs on weekdays. Samples of beach water were collected on weekends once a month during the offseason (January-April, September-December) and twice a month during the swimming season (May-August). A total of 80 samples were collected into sterile 1-L bottles from water at knee-depth and transported on ice to the laboratory within 1 h of collection. All samples are analyzed within 6 h of collection.

Figure 1. Location of the sampling sites at Tybee Island, GA

Culturable enterococci

Defined-substrate technology was used to process water samples for enumeration of enterococci. Samples (100 ml) were mixed with reagent and placed in a Quantitray®/2000 according to the manufacturer's instructions (Enterolert ®, IDEXX Laboratories, Inc., Westbrook, ME, USA). These trays were incubated at 41±0.5°C for 24 h. At the end of the incubation, wells that were fluorescent (under UV light) were accepted as positive for enterococci. Results were calculated from most probable number (MPN) generator software (IDEXX, 2015) and reported as MPN/100 ml. A blank (sterile deionized water) and a positive control (Enterococci ATCC# 29212) were used to validate the test performance.

Data analysis

Percentages from data exceeding criteria value were calculated for 104 CFU/100 ml (1986 RWQC) and 70 CFU/100 ml (2012 RWQC). All data were log-transferred for normalization. Means for values obtained during the

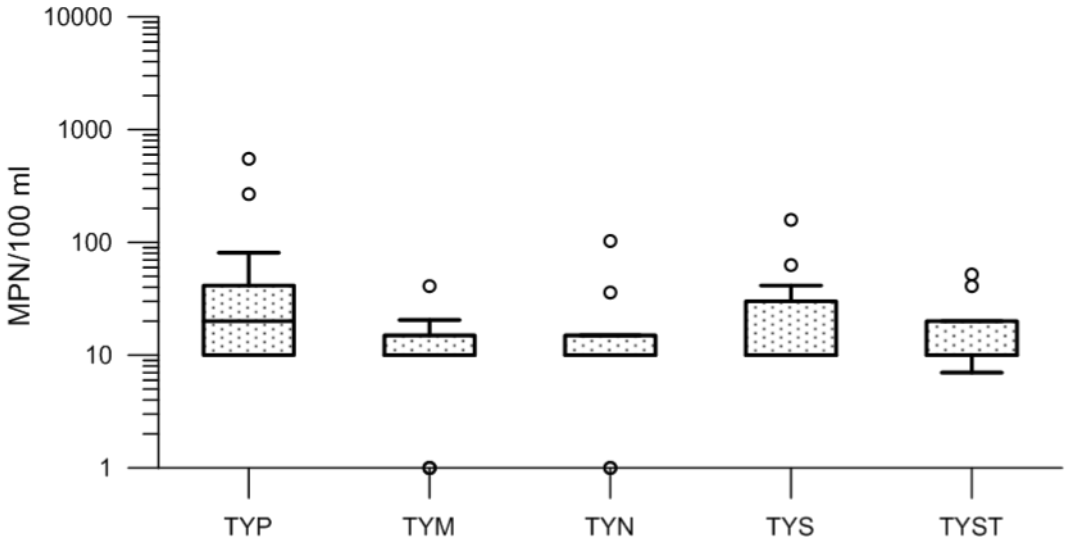
swimming season and off-season as well as enterococci concentrations at the five sites were compared by ANOVA. All statistical analyses were performed with IBM SPSS Statistics for Windows Version 21.0 (IBM Corp, Armonk, NY).

RESULTS

Enterococci concentrations detected during weekends

The highest enterococci concentrations were detected at the location TYP (715±143.1 MPN/100 ml (Figure 2), which is near a wastewater treatment plant Enterococci levels at TYP were significantly different from those collected at other sampling sites (F=8.56, p=0.005). The highest enterococci concentration was detected during the swimming season in July (551 MPN/100 ml), followed by August (269 MPN/100 ml). This site was under advisory in only one of these events. Throughout the study, all other stations had relatively low enterococci concentrations, with the highest concentration detected at TYS in July (159 MPN/100 ml).

Figure 2. Box-whisker distribution of enterococci in Tybee Island beaches



Box ranges from the first quartile (Q1) to the third quartile (Q3) of the distribution; the line across the box indicates the median. The minimum and maximum values are illustrated as end points for the whiskers, and each outlier is represented by an individual circle.

Comparison of weekend enterococci data with the 1986 and the 2012 RWQC BAVs:

Enterococci concentrations exceeded the 1986 RWQC limits for culturable enterococci (104 MPN/100 ml) in only 3.9% of all samples at all sites. When the 2012 RWQC BAV (70 MPN/100 ml) was applied to these results, however, the number of sites that would have been under advisory in all five beaches was doubled, and 7.8% of samples were not in compliance with the new criteria. In TYP only, the exceedance rate increased from 13% to 19% when the new BAV was used.

Comparison of beach advisories based on routine monitoring on weekdays to weekend enterococci data

During the sampling period, four advisories were posted, based on the data collected during the week (Table 1). These advisories lasted from 3 to 27 days. Overall, 75% of the samples coinciding with an advisory during the week had enterococci levels lower than 70 CFU/100 ml in the weekend. When the advisory was lifted within 3 days, the weekend testing results were also below the BAV, indicating agreement with the routine monitoring and advisory decisions.

Table 1. Advisories posted at Tybee Island beaches and weekend testing results compliance rates with the recreational water criteria

Sampling point	Advisory date	Advisory duration (days)	Weekend results exceeded criteria for culture
TYS	04/09/14	3	No
TYST	06/25/14	3	No
TYST	07/16/14	15	No
TYP	07/30/14	27	Yes

DISCUSSION

Associations between fecal indicator bacteria and illness rates have been established for beachgoers (Pruss, 1998; Wade et al., 2003, 2006; Colford et al., 2007), particularly at beaches that receive point source pollution. Earlier studies with samples collected at beaches in close proximity to effluents of wastewater treatment plants have shown that the incidence rate of gastrointestinal diseases increases when there are high numbers of enterococci at these points. The present study showed that the highest number of enterococci occurred most frequently at a beach at the vicinity of a wastewater treatment plant. Most of the advisories in the summer of 2015 occurred at this beach and lasted from 3 days to 27 days. Only the advisory with a longer term was in agreement with the data collected during the weekend.

The effectiveness of routine beach monitoring to protect human health from pathogen-contaminated beaches has been a controversial topic in assessments of water quality. Most research has involved selecting the most representative indicator microorganism as representative for the presence of pathogens (Shah et al., 2011; Love et al., 2014), health risk (Wade et al., 2010; Colford et al., 2012), the type of the assay used for testing (Haugland et al., 2005; Lavender and Kinzelman, 2009; Noble et al., 2010; Shanks et al., 2011; Raith et al., 2014), the location of sampling sites (Kinzelman et al., 2006), or the frequency of sampling events (Whitman and Nevers, 2004; Boehm and Weisberg, 2005; Converse et al., 2012). An issue that is often overlooked is the day of sampling that is most representative for human exposure. In this study, we showed that only short-term advisories were in agreement with routine week-day monitoring results. When the advisories were longer than 3 days, the weekend results were not consistently in agreement with the weekday results. This may be due to day-to-day variability in bacterial levels as well as to decay rates of these intestinal bacteria in the natural environment. Enterococci are known to survive in the marine environment for up to 2.4 days (Noble et al., 2003). The short lifetime of these bacteria also influences the decisions made based on the weekday data. For example, in case of obtaining high enterococci numbers from a Tuesday sampling, even if a resampling occurred on a Thursday, the results posted from this data could be out of date by Sunday. Earlier studies have shown that increasing sampling frequency during the weekdays would not represent all instances of poor water quality at a beach. Leecaster and Weisberg (2001) showed that increasing the sampling frequency from once a week to five times a week resulted in only 80% of exceedance of the standards, and 70% of these exceedances were single-day events. This shows that, Georgia, by sampling their beaches once a week, is ahead of other states in the south. Because the tendency of these increased pollution events is short-term, there are limitations of the survival of these bacteria in the environment, and there are long incubation times required for culture-based methods, it is challenging to identify all incidences of poor water quality unless the beaches are tested every day, including weekends. This issue is challenging, given limitations such as lack of resources, staff, and funding. New approaches that would use minimum resources, such as automated rapid-detection systems can provide a solution to overcome these challenges in beach monitoring.

CONCLUSIONS

The decision for decreasing the BAV to 70 CFU/100 ml is a step toward improving beach monitoring in Georgia, and this change will increase the safety for swimmers at Georgia beaches. Coastal Georgia, in particular Tybee Island, is fortunate to have few problems with microbial contamination. Our study showed that beaches located in close proximity to treatment plants should be taken into consideration with policies and regulations to protect public health. Further studies are needed to identify other sources of high enterococci concentrations, such as pollution originating from bird droppings.

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