Delineation of an offshore swim zone at Sam Myers Beach: A novel application of Virtual Beach and mapping software.

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Abstract

Elevated E. coli cell levels within ~15 meters of the shoreline had to have a permanent swim ban at Sam Myers Park, an enclosed beach, in Racine, Wisconsin. However, recent studies indicate water quality improves with increasing depth and distance from shore, suggesting safe swimming is possible in an offshore swim zone. To evaluate this area requires detailed geospatial and temporal information, which could be costly and prohibitive. The selection of an offshore swim zone is based on identifying factors that could be used in lieu of E. coli cell measurements. Offshore surface water samples were collected at 17 sites from 2012-2014. Training data (80% of data collected) included 9 points for E. coli concentration, water depth, water temperature, turbidity, air temperature, wave height, cloud cover and precipitation (n=799, R²=0.66). The regression model was used to identify points of highest E. coli cells (n=103) and was compared with a GPS system (Garmin 12x, GPS units) and water temperature and turbidity readings every minute (corresponding with in water measurements approximately every 20 meters). A survey was conducted to determine the bathymetry of the embayment at Sam Myers Park on 6/2/2015. A hand-held depth finder was paired with a GPS unit and the depth was recorded at 100 locations throughout the embayment, and model results, represented as a five day geometric mean, indicated E. coli concentrations were lower than 0.3 (USEPA) to identify an empirical relationship between potential explanatory variables (sanitary coverage), and precipitation amounts. Based upon study results, recommendations were made to establish an offshore swim zone that could be accessible by boats, small craft and kayaks and through wading offshore.

Methods

Data Collection - Gridded water samples were collected from two transects along the shoreline, at water depths of 0.6, 1.2, and 1.8 meters, and offshore locations, near the center of the embayment on 17 days during the summers of 2013 and 2014 (Figure 2). Offshore samples were collected with the aid of a kayak. Daily beach sanitary surveys were conducted concurrently with sample collection to describe and quantify hygienic-ecological variables. E. coli concentrations were quantified at the City of Racine water department laboratories using Colilert-2000 (IDEXX, Westbrook, ME), and were reported in the unit of most probable number per 100 milliliters of water (MPN/100mL). Specific conductivity and turbidity were also quantified in each sample to determine units of measurements (µS and Nephelometric Turbidity Units (NTU) respectively). On the day of 27 August 2013, a Fixed wing mapping aircraft (Kongsberg Vario, Hamelin, Germany) was used to map the location of offshore samples. The sonde was synchronized with a GPS unit (Garmin 12x, GPS units) and was paired to simultaneously record bathymetry, air temperature, wave height and water temperature readings every minute (corresponding with in water measurements approximately every 20 meters). The bathymetry values were later used to compare with offshore surveys, and were gridded in ~5 meter intervals (Figure 3) and exported to a database with associated coordinates (Surfer 14, Golden Software, Golden, CO).

Geostatistical models for turbidity, water temperature and bathymetry showed spatial variation. Turbidity levels were highest closer to the shoreline likely due to a combination of suspended shoreline sediments and algal blooms (noted in sanitary surveys). Water temperatures were higher closer to the shoreline likely due to a combination of shallow waters and higher turbidity values, which increases the absorption of solar radiation per unit mass. Water temperatures were lower in the embayment in comparison to the bordering Great Lakes (Lake Michigan) likely due to exchange with cooler waters from Lake Michigan. Water depths were shallow on the north end of the embayment likely due to sedimentation. Increased water depths near the opening of the embayment likely did not occur.

Joint Geospatial Model Results - Model results for spatially predicted E. coli concentrations indicate water quality standards should be met approximately 90 meters from the shoreline. The model was well constrained in these locations, which should represent the northern boundary for the offshore swim zone. Future monitoring should target this location and confirm if offshore water is suitable for recreational activities. Extrapolated E. coli concentrations (~1000 MPN/mL) were predicted in the shallow waters near the shoreline. This analysis is subject to unknown error that may exist in those areas, it was not the goal of the model to provide accurate values at these locations and thus they should be treated as suspect.

Conclusions

This model indicates it is possible to use multiple linear regression models to predict E. coli concentrations, both spatially and temporally. Although acceptable fits were achieved, caution must be used when applying this model to other environments. Predictions from the regression model need to be evaluated in conjunction with the data used to create the model in order to recognize where predictions are poorly constrained or arbitrary.

This approach shows a novel use for Virtual Beach when combined with spatial analysis software and sensors that are available in the field. This approach could be used to evaluate the impacts of coastal and offshore sewage and nutrient inputs on water quality when setting up monitoring programs and defining swim zones.

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Work Cited