Use of a Phased and Multiple-Method Approach to Identify Sources of Fecal Contamination at Two Lake Erie Beaches in Ohio

By Donna S. Francy and Erin E. Bertke

Introduction

Sources of fecal contamination that trigger most beach closings and advisories at Lake Erie beaches and elsewhere remain unknown. Identifying and mitigating the source of fecal contamination to a beach is often complicated by the spatial and temporal variability of bacterial-indicator concentrations and the dynamic lake currents, weather patterns, and natural processes that affect these concentrations. In addition, many of the sources are of nonpoint origin and not easily identified.

Because of the complexity of coastal environments, the USGS, in cooperation with local agencies, used a phased and multiple-method approach to help identify sources of fecal contamination at several Lake Erie beaches (figure 1). The approach included (1) documenting the spatial variability of fecal contamination in surface water and ground water, (2) identifying the environmental and meteorological factors that affect indicator concentrations, and (3) applying several microbial source tracking (MST) techniques to corroborate earlier findings.

Preliminary results from one beach in northeast Ohio—Lakeshore, Ashtabula, Ohio—are presented as an example. At Lakeshore, beach advisories based on elevated *E. coli* concentrations are often posted during the recreational season (Ohio Department of Health, 2005).

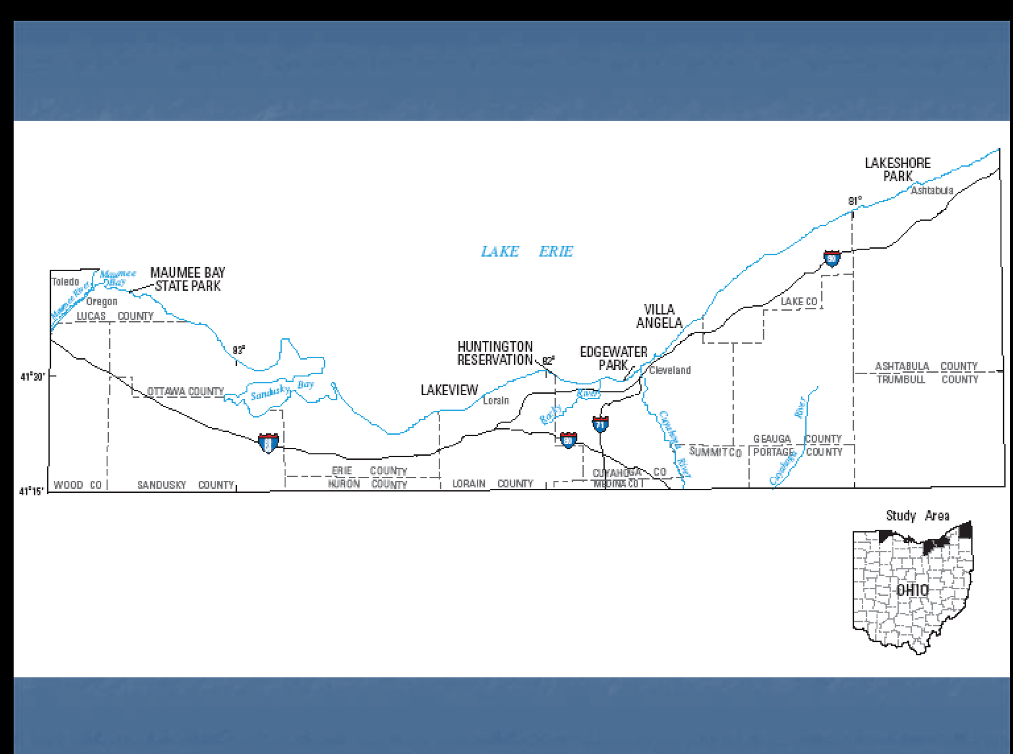

Figure 1. Studies were done during 2004 and 2005 at several Lake Erie beaches.

Objective

The objective of this study is to demonstrate the use of a phased and multiple-method approach to identify sources of fecal contamination at coastal beaches so that appropriate mitigation measures can be taken in the future.

Methods

Studies were done during the recreational seasons of 2004 and 2005. Daily samples were collected on Monday through Thursday by dipping a sterile 500-mL sampling bottle at 3-ft depths at east, central, and west beach sampling sites; a daily average concentration was used for data analysis. Daily samples were analyzed in a USGS field laboratory for *E. coli* using the modified mTEC method (U.S. Environmental Protection Agency, 2002). During spatial synoptic studies, samples were collected in the bathing areas, at nearshore sites, and from the parking lot. Water samples for *E. coli* were collected at nearshore sites by taking a grab sample from a jon boat or from the shore. Parking-lot sediment samples were collected by scooping sediments into a sterile jar, and analyzed in the USGS Ohio Water Microbiology Laboratory (OWML) in Columbus, Ohio, using the Colilert Quanti-Tray method (Idexx Laboratories, Westbrook, ME).

Samples for microbial source tracking were collected on four days during 2005. Samples included bird droppings, beach water samples, sewage from a local sewage treatment plant, sediment parking lot samples, and water samples from two sites west of the bathing beach. In the OWML, samples were diluted and plated for *E. coli* on modified mTEC agar. For multiple antibiotic resistance (MAR) testing, 80 colonies were picked from each source, isolated, and subjected to MAR testing on ampicillin (10 and 20 µg/mL), nalidixic acid (25 µg/mL), streptomycin (25 µg/mL), sulfathiazole (2,000 µg/mL), and tetracycline (25 and 50 µg/mL). If growth of the isolate on the antibiotic plate was at least 50 percent of the growth on the control plate containing no antibiotics, the isolate was recorded as resistant. Additionally, two methods that rely on genetic markers specific to human contamination were applied to these samples—a marker in *Enterococcus faecium* (Scott and others, 2005) and a marker in *Bacteroides* (Bernard and Field, 2000).

Results

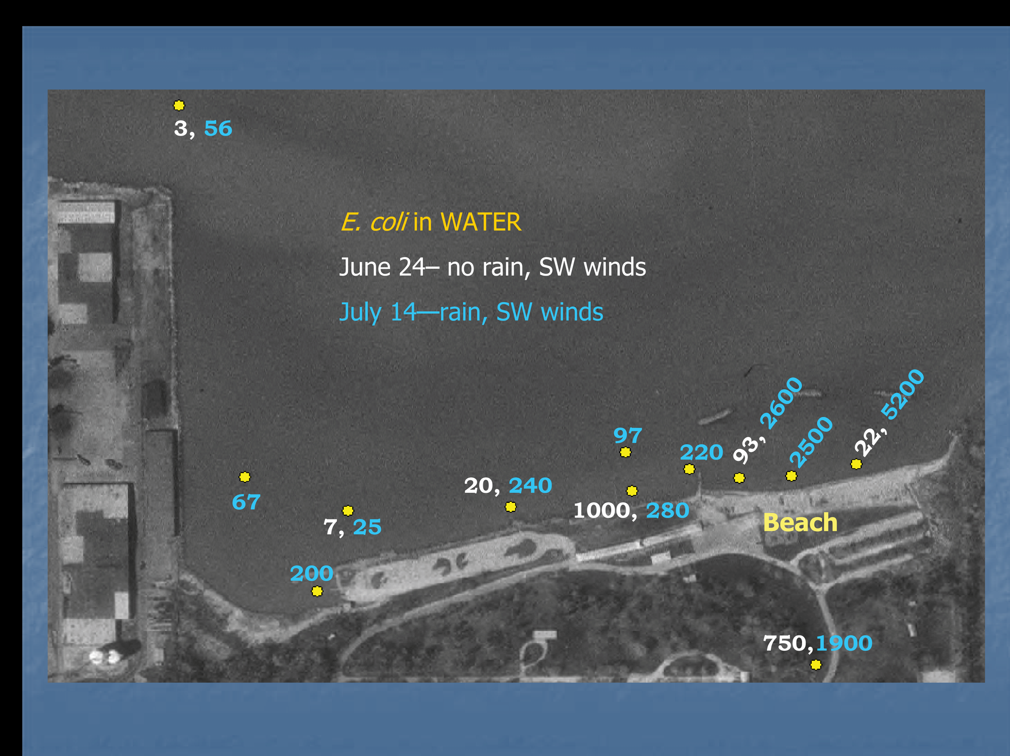

Figure 2. Spatial sampling at Lakeshore during dry weather showed the presence of a possible source west of the beach. During wet weather, concentrations of *E. coli* were highest at beach sampling sites.

Figure 3. On July 12, 2004, it rained 0.68 inch between 6 and 8 a.m. The field crew observed the formation of a conduit to the beach from a pipe draining the parking lot. The *E. coli* concentration from the flowing pipe was 26,000 col/100 mL.

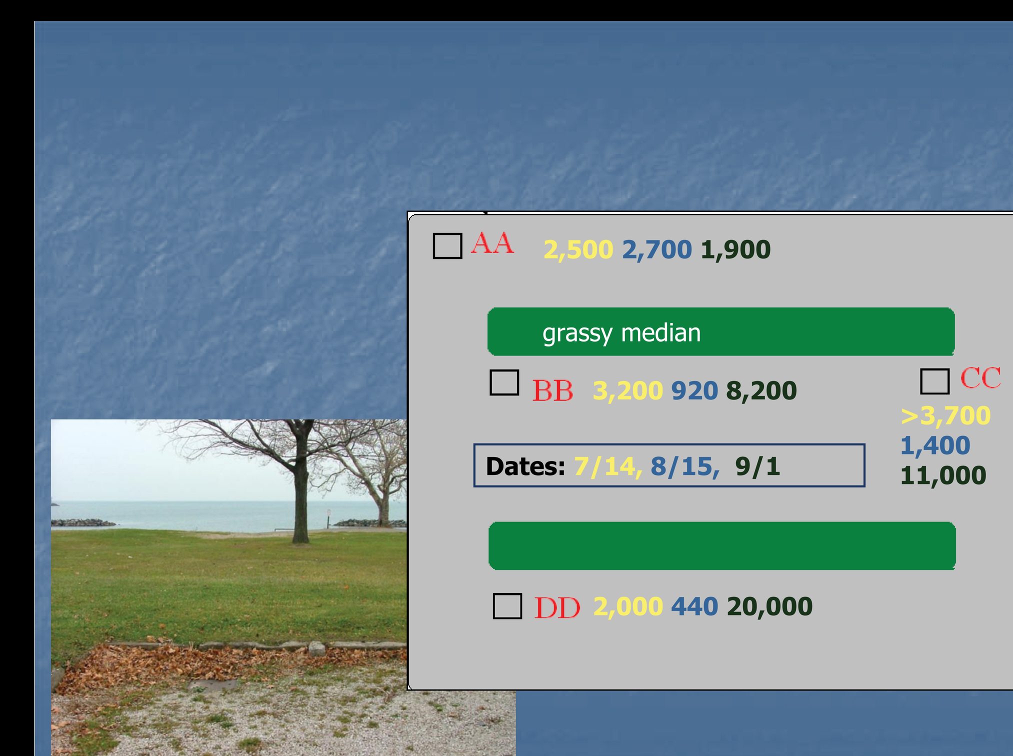

Figure 4. Sediments were collected on three days from four parking-lot locations (AA – DD). *E. coli* concentrations are in col/g_{DW} sediment.

Discussion and conclusions

Preliminary results at Lakeshore indicate that fecal contamination is most likely of local origin. Spatial sampling showed that concentrations of *E. coli* at offshore locations were low, whereas concentrations were high at beach sampling sites and selected sites along the shoreline. By physically observing conditions after a significant rain event, one source of *E. coli* was hypothesized to be from drainage from the parking lot. Tests showed that concentrations of *E. coli* in sediments from the parking lot ranged from 440 to 20,000 col/g_{DW} sediment. Local rainfall amounts were more strongly related to *E. coli* concentrations than were airport rainfall amounts. The sources of fecal contamination were hypothesized to be human and (or) waterfowl. Multiple antibiotic resistance tests showed that on a day with only local rainfall, the MAR index was similar to the MAR index for bird droppings; on a day with widespread rainfall, the MAR index was different from that of birds and sewage indicating a possible mixed source. The presence of human specific markers of *Bacteroides* and enterococci will be compared to the results from other tests.

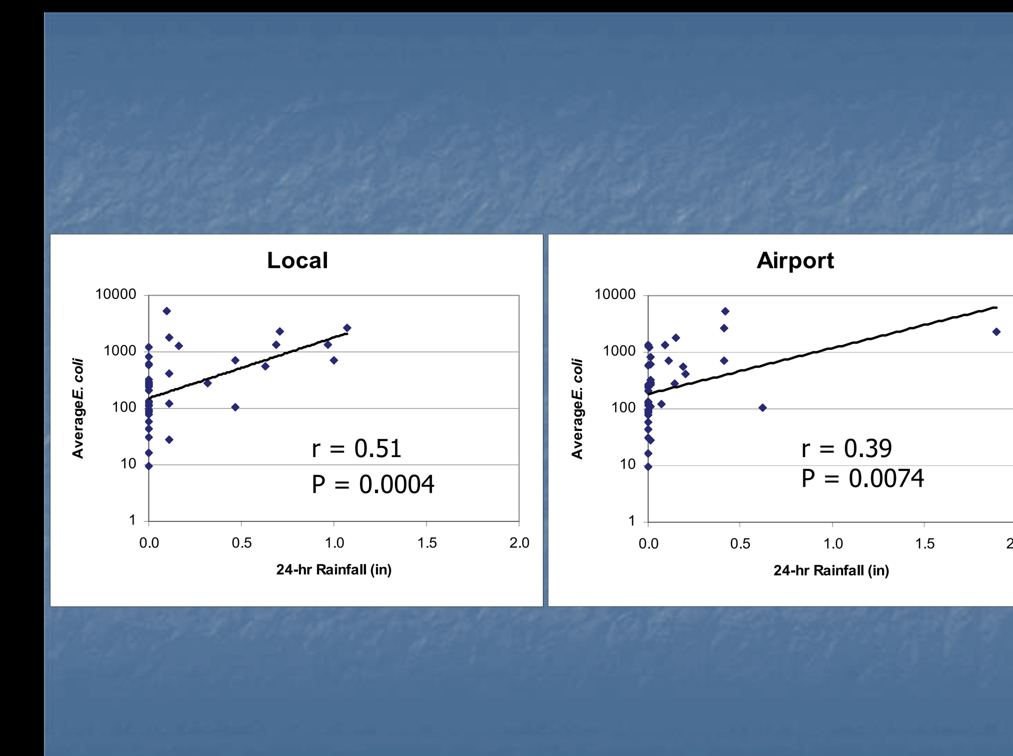

Figure 5. Relations between *E. coli* concentrations and local and airport rainfall. The airport is about 11 miles inland (r is the Pearson's correlation coefficient and p is the significance of the correlation).

Date and Source		MAR Index	Contingency Table Results			
			X^2		P-value	
			Bird	Sewage	Bird	Sewage
July 14 Local Rain	Bird	0.003	—	74.3	—	<0.0001
	Water	0.010	1.4	73.7	0.2311	<0.0001
	Sewage	0.198	—	—	—	—
Sept 1 Widespread Rain	Bird	0.008	—	40.7	—	<0.0001
	Water	0.056	13.4	11.4	0.0002	0.0007
	Sewage	0.129	—	—	—	—

Figure 6. The fraction of multiple antibiotic resistance (MAR Index) of *E. coli* isolates from three sources on two dates. (MAR Index = number of isolates resistant / number of isolates with results.) Results of contingency table analysis of MAR testing are given as X^2 and p-values.

References

Bernard, A.E., and Field, K.G., 2000, A PCR assay to discriminate human and ruminant feces on the basis of host differences in *Bacteroides-Prevotella* genes encoding 16S rRNA: Applied and Environmental Microbiology, v. 66, no. 10, p. 4571-4574.

Ohio Department of Health, 2005, Bathing beach monitoring program, accessed October 2005 at *http://www.odh.state.oh.us/odhPrograms/eh/bbeach/beachmon.aspx*

Scott, T.M., Jenkins, T.M., Lukasik, J., and Rose, J.B., 2005, Potential use of a host associated molecular marker in *Enterococcus faecium* as an index of human fecal pollution: Environmental Science & Technology, v. 39, no. 1, p. 283-287.

U.S. Environmental Protection Agency, 2002, Method 1603—*Escherichia coli* in water by membrane filtration using modified membrane-thermotolerant *Escherichia coli* agar: Washington, D.C., EPA 821-R-02-23, 9 p.

This study was done in cooperation with Ohio Water Development Authority and the Northeast Ohio Regional Sewer District. The authors thank the Ashtabula Township Park Commission for help in project planning and for providing the use of their facility for meetings and laboratory analysis.