Concentrations of *Escherichia coli* in Water and Bed Sediments in Maumee Bay, Toledo and Oregon, Ohio (2003-2005)

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Abstract

Water and sediment samples were collected and analyzed for concentrations of *Escherichia coli* (*E. coli*) at nearshore and offshore sites within Maumee Bay and at sites in the Maumee River and the shipping channel. Samples were collected during the recreational seasons of 2003 and 2004 to examine spatial and temporal distributions of *E. coli* concentrations within the bay and in contributing waters. Ancillary water-quality and environmental data were collected or compiled to determine their relations to *E. coli* concentrations.

Sampling in 2003 identified areas where *E. coli* concentrations in bed sediment and water were elevated. In 2004, these areas were sampled intensively to determine possible sources of fecal contamination to the Maumee Bay State Park beach. During this synoptic sampling, the Maumee River sites and the Berger Ditch site were found to have elevated concentrations of *E. coli* in both bed sediments and water compared to sites within the bay. For bed sediment, significant positive correlations were found for concentrations of *E. coli* and depth of water in the offshore and Maumee River areas. Turbidity was significantly and positively correlated to *E. coli* concentrations in water.

Introduction

Maumee Bay is a popular recreational destination in Ohio for swimming, boating, fishing, and visiting wildlife preserves. Maumee Bay State Park (MBSP) has a swimming beach along the Lake Erie shoreline (site N10 on Figure 1). The beach, however, often is impaired for recreational use because of high *Escherichia coli* (*E. coli*) concentrations. Possible contributions to the high concentrations include the resuspension of accumulated *E. coli* from bed sediments within the bay, incoming fecal contamination from the Maumee and Ottawa Rivers and from drainage ditches, and elevated temperatures from heated effluents from a nearby powerplant. Of particular concern is Berger Ditch, which drains into the marina at MBSP, the mouth of which is 250 ft east of the Lake Erie bathing beach (site N14 on Figure 1).

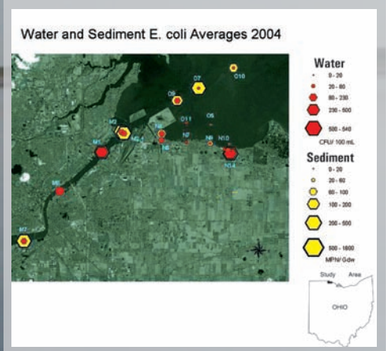

Figure 1. Map of Maumee Bay showing site locations and average concentrations of *Escherichia coli* in water and bed-sediments samples collected during the 2004 recreational season (Toledo and Oregon, Ohio). The sites are categorized as nearshore (N), offshore (O), or Maumee River (M) sites. [CFU/100mL, colony forming units per 100 milliliters; MPN/gdw, most probable number of colonies per dry gram weight of sediment]

A 3-year investigation (2003-2005) by the U.S. Geological Survey (USGS) and University of Toledo, in cooperation with Toledo Metropolitan Area Council of Governments, Ohio Water Development Authority, City of Oregon, and City of Toledo, is underway to (1) investigate the spatial and temporal distribution of *E. coli* in sediments of Maumee Bay and (2) examine the relations between environmental and water-quality variables and densities of *E. coli* in bed sediment and lake water in the nearshore area.

Methods

During synoptic studies, two crews sampled between 9:00 a.m. and 2:30 p.m. on any given sampling day. For the nearshore sites, a small 2-3 person boat was used to collect samples, and a larger boat was used to collect samples at the Maumee River and offshore sites. Water samples were collected by filling the sample bottle about 1 foot below the water surface. To collect bed sediments from the large boat, the field crew lowered a clean and sterile Petite Ponar Grab sampler (Wildlife Supply Company, Buffalo, N.Y.) through the water column and collected three subsamples at each loacation (Picture 1). From the small boat, the sediment was collected by diving or wading (Picture 2).

Picture 1. Petite Ponar Grab sampler is used to collect bed sediment at Maumee River and Offshore sites.

Picture 2. USGS scientist sampling bed sediment at a Maumee Bay nearshore site.

Water samples were analyzed for concentrations of *E. coli* within 6 hours of collection using the modified mTEC membrane-filtration method (U.S. Environmental Protection Agency, 2002). After plating for *E. coli*, turbidity was determined in all water samples using a Hach Model 2100P turbidimeter (Hach Company, 1989). Bed-sediment samples were analyzed for concentrations of *E. coli* within 24 hours of collection by use of the Colilert Quantitray method (Idexx Laboratories, Westbrook, Maine). For sediment samples, additional sample-processing steps and calculations were done as described in Francy and Darner (1998).

Results And Conclusions

In 2003, synoptic sampling was used to identify areas where *E. coli* concentrations in bed sediment and water were elevated and to eliminate areas with low *E. coli* concentrations from further investigation. Heated effluents from the powerplant were found to not affect *E. coli* concentrations in the bay. *E. coli* concentrations at the mouth of the Ottawa River and at many offshore sampling sites were low. The Maumee River, the shipping channel, and the mouth of Berger Ditch were identified as areas with elevated concentrations of *E. coli*.

Mouth of Berger Ditch, site N14 and marina.

During synoptic investigations in March–August 2004, concentrations of *E. coli* in bed sediments ranged from <1 to >7,900 most-probable number of colonies per gram dry-weight of sediment (MPN/g_{dw}) (Figure 1). The highest concentrations of *E. coli* in bed sediments were found at sites in the shipping channel, the Maumee River, and Berger Ditch. *E. coli* concentrations in water ranged from <1 to 2,400 colonies per 100 milliliters (col/100mL) (Figure 1). The highest water concentrations in 2004 were found at some of the Maumee River sites, at the mouths of two drainage ditches, and (or) near boat docks.

Comparisons of *E. coli* concentrations in bed sediments and in water, based on type of site (nearshore, offshore, or Maumee River), during 2003 and 2004 are shown in Figure 2. The median bed-sediment *E. coli* concentration in the Maumee River sites was significantly higher than those of the nearshore and the offshore sites (Tukey-Kramer p value of <0.0001 for both comparisons). For water, the median *E. coli* concentration of the Maumee River sites was significantly higher than that of the nearshore sites (p = 0.0040), which was significantly higher than that of the offshore sites (p<0.0001).

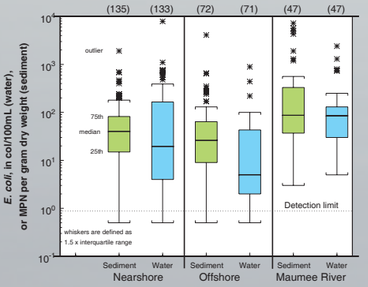

Figure 2. Distribution of *Escherichia coli* concentrations in water and bed sediments by type of site (nearshore, offshore, and Maumee River), 2003 and 2004. The number of samples is indicated in parentheses along the top of the figure.

In 2004, intensive sampling was done in Berger Ditch, at Maumee Bay sites around the mouth of Berger Ditch, and at MBSP. *E. coli* concentrations in the ditch often were higher than those at Maumee Bay sites. Further, water *E. coli* concentrations tended to decrease with increasing distance from Berger Ditch (Figure 3).

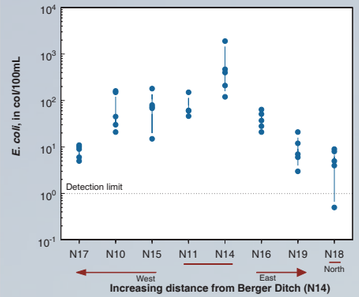

Figure 3. Distribution of *Escherichia coli* concentrations in water by site with increasing distance from Berger Ditch, 2004.

Analysis of ancillary data and other water-quality variables were also examined to determine relation to *E. coli* concentrations for samples collected in 2003 and 2004. In Figure 4, *E. coli* concentrations in bed sediments were compared to water depths for each of the three types of sites. Although there was no significant correlation at the nearshore sites, positive correlations at the offshore and the Maumee River sites were significant at $\alpha = 0.05$. A statistically significant positive correlation was also found between *E. coli* concentrations in water and turbidity (Figure 5). Further analysis of *E. coli* concentrations in relation to ancillary data and other water-quality variables could help further identify possible sources of fecal contamination.

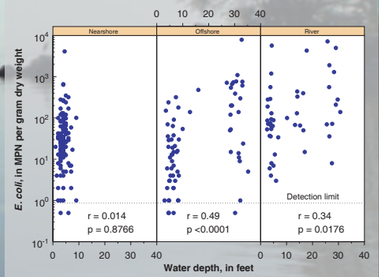

Figure 4. Comparison of *Escherichia coli* concentrations in bed sediment to water depth by type of site (nearshore, offshore, and Maumee River), 2003 and 2004. [r is the Pearson's correlation coefficient, and p is the significance of the correlation.]

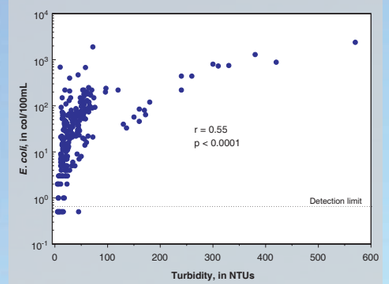

Figure 5. Comparison of *Escherichia coli* concentrations in water to turbidity, 2003 and 2004. [r is the Pearson's correlation coefficient, and p is the significance of the correlation.]

On the basis of results from two years of synoptic sampling, the Maumee River has elevated concentrations of *E. coli* in both water and bed sediments as compared to the nearshore and offshore sites. Additionally, concentrations of *E. coli* in water were also shown to be elevated in certain nearshore areas, especially Berger Ditch. These results indicate that *E. coli* from Berger Ditch and from the Maumee River may be affecting water quality at the bathing beach.

Maumee Bay State Park beach, site N10.

References

Francy, D.S., and Darner, R.A., 1998, Factors affecting *Escherichia coli* concentrations at Lake Erie public bathing beaches: U.S. Geological Survey Water-Resources Investigations Report 98-4241, 41 p.

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.

Note

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