

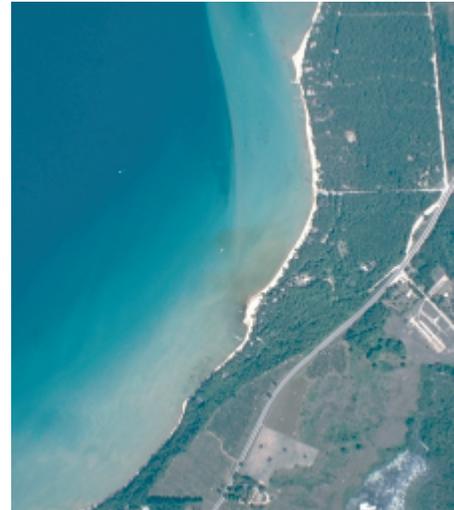
Beach Monitoring and Forecasting Technologies

Today, in order to judge the safety of beach waters, fresh-water beach managers determine the specific numbers of *Escherichia coli* (*E. coli*) or enterococci bacteria and compare these to recommended levels.

USEPA Numerical Criteria for Recreational Waters

For designated fresh water beaches, the U.S. Environmental Protection Agency (USEPA) recommends that no single beach water sample exceed 235 *E. coli* or 61 enterococci per 100 milliliters. In addition, at any given beach, the steady-state geometric mean of multiple beach water samples should not exceed 126 *E. coli* or 33 enterococci per 100 milliliters.

These bacteria are indicators of fecal pollution, and their numbers in recreational waters have been correlated, through epidemiological studies, with the likelihood of contracting gastrointestinal disease through swimming. However, the most cost-effective current methods for counting these indicators take 18-24 hours. Therefore, beach managers must use the previous day's results to evaluate current beach conditions. It has become increasingly clear, as more monitoring has been conducted, that the physical, chemical and biological processes affecting numbers of these indicator bacteria in beach waters are indeed complex. Beach managers are seeking more timely methods for determining indicator bacteria numbers, better information on the complex environmental processes that govern these numbers, enhanced approaches to developing predictive capability, and ultimately, information on pathogens themselves.



A rural beach in the vicinity of Yuba Creek, near Traverse City, Michigan. The dark water comes from the mouth of the creek and moves along the shoreline in response to a complex set of climatologic, geologic, and hydrologic processes. In addition, chemical and biological processes and human influences affect the numbers of pathogen indicators and pathogens at any given beach setting.

DEFINITIONS

Pathogen or fecal Indicators— are microorganisms (typically the bacteria *Escherichia coli* or enterococci) commonly found in the gastrointestinal tracts of humans and other animals. Their presence in water indicates recent fecal pollution. Indicators are not usually pathogens.

Pathogens— agents that cause disease. Among the pathogens of concern in recreational water are bacteria that cause gastrointestinal disease (*Salmonella*, *Campylobacter*, pathogenic *E. coli*), viruses (causing hepatitis, diarrhea, eye infections, meningitis) and protozoa (*Cryptosporidium*, *Giardia*) that also cause gastrointestinal disease.

Beach Monitoring and Forecasting Technologies – USGS Role

Results of U.S. Geological Survey (USGS) studies are being used by resource managers to better understand the complex physical, chemical and biological processes that lead to exceedances of recreational water quality standards. In five Great Lakes States (Illinois, Indiana, Michigan, Ohio, Wisconsin) as well as in Florida and California, USGS has conducted cooperative studies with local, state and Federal customers. These USGS studies have addressed –

- The quantitative significance of various sources of fecal indicator bacteria (including sand, bird and other animal feces, storm drain outfalls, river or stream water and sediments, and ground water)
- The relation between fecal indicator bacteria concentrations and ambient conditions (wind direction, wave height, temperature, numbers of swimmers or birds, and measures of water quality), regional weather patterns, and site-specific hydrologic variables
- New approaches to developing and testing predictive models, to visualizing data using geographic information systems, and for presentation and real-time provision of physical and chemical beach water-quality data via the internet.

The BEACH Act

The Beaches Environmental Assessment and Coastal Health Act (BEACH Act), passed on October 10, 2000, authorized USEPA to award grants to states, tribes and territories to develop and implement beach water-quality monitoring and public notification at marine coastal and Great Lakes public beaches (www.epa.gov/waterscience/beaches). The BEACH Act requires USEPA to publish beach monitoring program performance criteria for detecting pathogens and pathogen indicators, and requires grant recipients to demonstrate how they meet those criteria. The Act also requires USEPA to conduct studies in cooperation with other Federal agencies, to provide additional information for use in developing:

- an assessment of potential human health risks resulting from exposure to pathogens in coastal recreation waters;
- appropriate and effective indicators for improving detection in coastal recreation waters of the presence of pathogens that are harmful to human health; and
- appropriate, accurate, expeditious, and cost-effective methods (including predictive models) for detecting pathogens in a timely manner in coastal recreational waters.



Fecal indicator bacteria (and pathogens) are found in human and animal wastes. They are delivered to beaches in urban, agricultural and even pristine settings by wastewater outfalls, storm drains (seen at the beach above), boating wastes, runoff from the land, sand and sediment suspension, and direct deposition by birds.



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Beach Monitoring and Forecasting Technologies – USGS Role--Continued

USGS microbiologists in Michigan, Ohio, and Wisconsin have the capability to analyze for many common water-borne pathogens. USGS microbiologists and water quality scientists have used state-of-the-art methods to evaluate the significance of particular sources of fecal indicator bacteria at specific beaches. These methods have included:

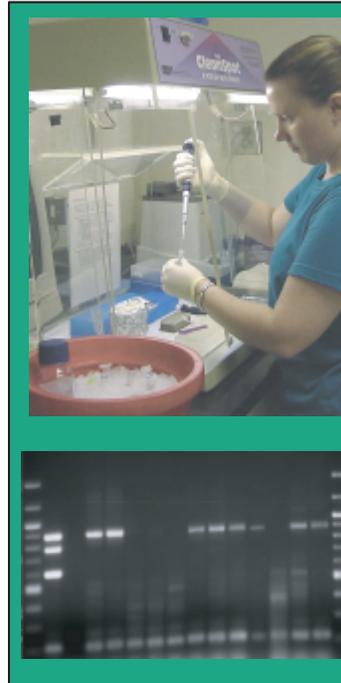
- Determining the DNA-fingerprints or antibiotic-resistance patterns of fecal indicator bacteria from various source materials and comparing these to fingerprints or patterns of indicator bacteria found in beach water and beach sand
- Determining the presence in beach water of chemicals such as caffeine, fecal sterols and other chemical indicators of human or animal waste.

In addition, USGS microbiologists have conducted studies of specific pathogens at beaches. The types of pathogens studied have included:

- *Salmonella* bacteria from birds
- Viruses from septic system wastes
- Pathogenic *E. coli* from urban wastes

USGS scientists have also been involved in evaluation of rapid-testing technologies based on immunological detection (including flow cytometry and fiber-optics) in cooperation with USEPA.

In the summer of 2002, scientists from the USGS and the National Park Service cooperated with USEPA and the Centers for Disease Control on a pilot epidemiological study of swimming-associated disease at Indiana Dunes National Lakeshore.



USGS scientists have used and tested state-of-the-art laboratory methods to provide information on the relation between fecal indicator bacteria and specific pathogens at several beach sites. For example, genes found in pathogenic *E. coli* can be detected by DNA-based technologies (white bands in the image to the left). These methods can be used to detect specific pathogens in water and to determine the DNA-fingerprints of *E. coli* from various source materials.

Communication

In the Great Lakes region, USGS scientists have been instrumental in establishing and maintaining communication networks by which local, state and Federal scientists, and beach-management professionals share information. These networks include web-based information databases and the fledgling Great Lakes Recreational Water Quality Association, which held its first scientific and informational meeting in October, 2002. Proceedings of this meeting will soon be available at a USGS web site.

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