Beaches and Bacteria

"Bacteria Keep Newport News Beach Closed," *Newport News Daily Press*, June 2, 2004.
"Beach Closed Again," *Fredericksburg Free Lance-Star*, June 25, 2004.
"Norfolk Warns Against Swimming at Beach Because of Bacteria," *Virginian-Pilot*, July 15, 2004.

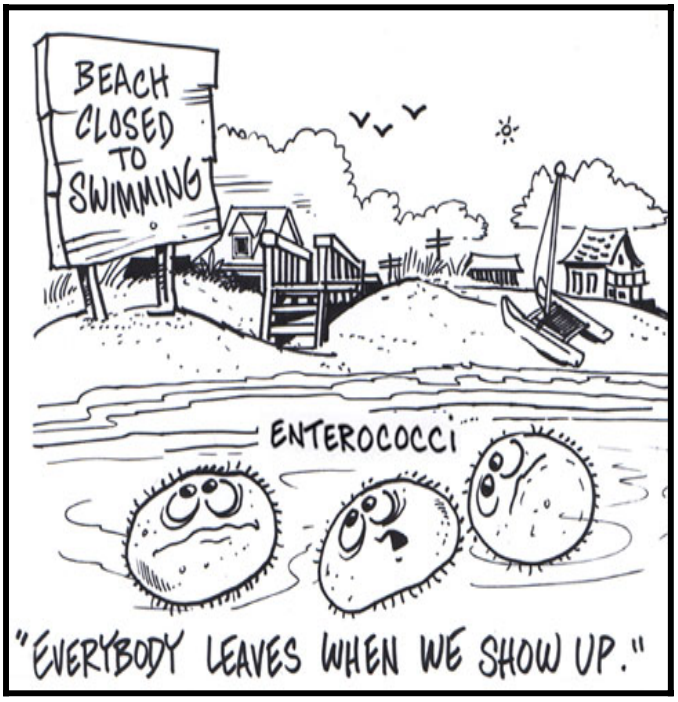
If you live near Virginia's coastal waters, you may have seen these recent headlines, or you may even have been one of the beach-goers who were told, "Enjoy the sun, but the water is off-limits."

Similar beach closings and advisories occur occasionally at beaches nationwide. The local economy in beach areas typically depends on tourist revenue, and closing a beach—especially on a weekend or holiday—can be costly. Officials responsible for closing beaches must weigh their responsibility both to the health and safety of beach-goers and to a healthy economy.

The cause of the beach closures in the three articles mentioned above was **bacteria**: certain kinds used to indicate pollution were found at levels above the state's legal maximums. Elevated bacteria levels are also the cause of a large percentage of closures nationwide. This article, therefore, is designed to help Virginians be more informed about the causes of beach closures, the regulations and legislation behind them, and the role of bacteria in beach water-quality monitoring.

Issuing a Beach Advisory or Closure

The difference between a beach advisory and closure is that an advisory *recommends* people stay out of the water while a closure seeks to *prohibit* anyone from entering the water until the water is believed to be safe. An advisory might also recommend special precautions, such as showering immediately after exposure or reducing exposure time.



How do the people responsible for beach closures or advisories make a decision about what is "safe"? Generally, the basis for such a decision is whether or not the coastal waters in question meet a state's water-quality **standards**. Under the Clean Water Act, the U.S. Environmental Protection Agency (EPA) requires each state to set water-quality standards; in Virginia, the State Water Control Board, assisted by the staff of the Department of Environmental Quality (DEQ), is responsible for promulgating regulations that establish water-quality standards.

A water-quality standard for a given body of water identifies the **designated uses** that the body of water is intended to provide. In Virginia, according to the DEQ, "All…waters are designated for the following uses: recreational uses, e.g., swimming and boating; the propagation and growth of a balanced, indigenous population of aquatic life, including game fish, which might reasonably be expected to inhabit them; wildlife; and the production of edible and marketable natural resources, e.g., fish and

shellfish."[1] Many water bodies also have a designated use as a public water supply.

A water-quality standard also identifies specific indicators, known as **criteria**, which are measured or otherwise assessed to determine whether the water body will support its designated uses. The DEQ describes criteria as "general narrative statements that describe good water quality and specific numerical concentrations that are known to protect aquatic life and human health."[2] Water-quality criteria in Virginia address, for example, the minimum *amount of dissolved oxygen* allowed, the minimum and maximum *temperature* allowed, and the maximum *level of bacteria* allowed (the section below, "Elevated Bacteria," will discuss Virginia's bacteria standards more specifically).

Typically, beach advisories and closures are issued when the water at the beach fails to meet one or more state standards, and often the bacterial standard is the issue. In Virginia, the state government is responsible for monitoring and testing state waters, and beach monitoring for bacteria has been delegated to local offices of the Virginia Department of Health (VDH). According to Michele Monti, Virginia's state beach monitoring coordinator, the local VDH district director decides whether to issue a beach closure or advisory, in cooperation with local government officials. "If [a] water sample exceeds the single sample maximum [for bacteria], the beach is posted with a Swimming Advisory sign, a press release is issued, and the water is re-sampled. If the re-sample meets [state] standards, the advisory is lifted," Ms. Monti said.[3]

Occasionally local officials will close a beach *preemptively*, that is, when they believe the potential exists for unsafe conditions, even though no measurements have yet indicated violation of a water-quality standard.[4]

National and Regional Beach Closure and Advisory Statistics

In March 2004, the U.S. EPA released the *Draft National Coastal Condition Report II* ("NCCR II"), a draft report on the nation's overall coastal water quality from 1997 to 2000, compiled from information provided by states. [Ed. note: The EPA's fact sheet on this draft report appears on pages 8 and 9 of this issue of *Water Central*.] The draft NCCR II reported on beach closures and advisories for the 2002 swimming season and compared causes for closures nationwide and in the Northeast Coastal Region, which includes Virginia (Table 1).[5] Elevated bacteria levels were the leading cause of swimming-beach closures and advisories both nationally (79 percent) and regionally (43 percent).

Table 1. Reasons for Swimming-beach Advisories or Closures in 2002.

	National	Northeast Coast
Elevated Bacteria Levels	79%	43%
Preemptive		
For Rainfall	13%	35%
For Sewage	3%	4%
Other	5%	18%

Source:
U.S. EPA, *Draft National Coastal Condition Report II.*

[1] Virginia Department of Environmental Quality. "Designated Uses," www.deq.state.va.us/wqs/designated.html, accessed July 21, 2004.

[2] Virginia Department of Environmental Quality, "Water Quality Criteria," www.deq.state.va.us/wqs/criteria.html, accessed July 29, 2004.

[3] E-mail message from Michele Monti to Alan Raflo, August 3, 2004.

[4] For example, in late June 2004, swimming beaches in Colonial Beach, Virginia, were closed and re-opened based on the sightings of a potentially harmful algae bloom, according to the Fredericksburg *Free Lance-Star*, June 30, 2004.

[5] Nationwide information is in Chapter 2; information for the Northeast Coast is in Chapter 3. The report is available online at www.epa.gov/owow/oceans/nccr2/downloads.html.

According to the Draft NCCR II, "of the 826 coastal beaches in the Northeast Coast that have reported information to the EPA, only eighteen percent (151 beaches) were closed or under any advisory for any period of time in 2002."[6] Two states in the region—Virginia and New Hampshire—did not have any coastal beach advisories or closures in 2002. This report covers closures and advisories only for recreational use (swimming); it does not include closures of coastal waters for other designated uses, such as shellfish or fish-consumption advisories.

Elevated Bacteria

As noted above, high levels of bacteria cause of a large percentage of beach closures and advisories, both nationwide and in the Northeast. Three types of bacteria are monitored in various water-quality standards: **fecal coliform bacteria**, *Escherichia.coli* (***E. coli***), or **enterococci bacteria** (please see the accompanying box for more details on these kinds of bacteria). These are **indicator organisms**: they do not cause disease but indicate contamination by human or animal waste, which may contain other, disease-causing (or **pathogenic**) organisms, including other bacteria, viruses, single-celled animals (Protozoa), fungi, and parasites. (Some varieties of *E. coli* do cause human illness, but different strains are used as indicator organisms.) Using actual pathogens as indicator organisms would pose a contamination risk for laboratory personnel; instead, labs test for non-pathogenic indicator organisms that are easier and safer to monitor.

The EPA, in the Beaches Environmental Assessment and Coastal Health (BEACH) Act of 2000, stipulates that states must use enterococci as indicator bacteria for marine and transitional waters, whereas freshwater sources may be tested for either *E. coli* or enterococci. According to the EPA, *E. coli* and enterococci "are considered to have a higher degree of association with outbreaks of certain diseases than fecal coliforms and were recommended as the basis for bacterial water quality standards in the [EPA's] 1986 *Ambient Water Quality Criteria for Bacteria* document (both for fresh waters, enterococci for marine waters)."[7]

The BEACH Act gave states until April 2004 to comply with the EPA bacterial requirements established in 1986. It also redefined coastal waters to include the Great

Indicator Bacteria

Fecal Coliform Bacteria

Refers to a group of many different species of bacteria most (but not all) of which live in the intestines of warm-blooded animals (mammals and birds).

Escherichia coli (*E. coli*)

A single species (but with many varieties, or strains) within the fecal coliform group; found only within the intestines of warm-blooded animals.

Most strains of *E. coli* do not cause illness, but strain 0157:H7 produces a toxin and can cause serious illness.

Enterococci

A group of species within the larger group known as fecal streptococci bacteria, which typically inhabit the intestines of warm-blooded animals; normally enterococci are found only in humans.

Can survive in salt water, so are useful as an indicator of contamination of marine waters.

Some species can cause infection of the urinary tract, wounds, or bloodstream.

Sources:

U.S. Department of Health and Human Services/Centers for Disease Control, "*Escherichia coli* O157:H7," www.cdc.gov, accessed July 21, 2004; and online articles on enterococci, accessed July 30, 2004.

U.S. Environmental Protection Agency, *Volunteer Stream Monitoring: A Methods Manual* (EPA 841-B-97-003), 1997, pp. 180—181.

[6] U.S. EPA, *Draft National Coastal Condition Report II*, Chapter 3, page 34.

[7] U.S. EPA, *Bacterial Water Quality Standards for Recreational Waters (Freshwater and Marine Waters) Status Report* (EPA-823-R-03-008), June 2003, p. 3.

Lakes and marine coastal waters (including estuaries) designated by states under the Clean Water Act for swimming, bathing, surfing, or similar water-contact activities. The definition excludes any location upstream of the mouth of a river. The EPA provides grants, authorized under the BEACH Act, to help states meet the Act's tougher monitoring requirements.

Virginia's bacteria standards are in compliance with the BEACH Act. The current bacteria regulations were published in the June 17, 2002, *Virginia Register*. Those regulations designate enterococci as the indicator bacteria in Virginia's marine waters.[8] The standards are listed in Table 2; explanation of the terms used in the table follows after the table.

Table 2. U.S. EPA Criteria and Virginia Standards for *E. coli* and Enterococci Bacteria in Surface Waters.

	Fresh Water	Marine Water
EPA	*E. coli* = 235/126* Enterococci = 62/33	*E. coli* = Not applicable. Enterococci = 104/35
Virginia	*E. coli* = 235/126	Enterococci = 104/35

*All values in the table are in colony-forming units per 100 milliliters of water. Numbers before the slash are the maximum-allowable instantaneous levels; numbers after the slash are the maximum-allowable geometric means.

Sources:

U.S. EPA, *Implementation Guidance for Ambient Water Quality Criteria for Bacteria,* May 2002 Draft, p. 81.

Virginia Administrative Code, 9 VAC 25-260-170 (June 17, 2002).

When water containing bacteria is sampled and processed appropriately in a laboratory, bacterial **colonies** will form on special growth plates. Bacterial standards refer to the number of bacterial **colony-forming units**, or **CFUs**, found in a sample of water. Two measurements are regulated and monitored: 1) the number of CFUs in any single sample; and 2) the geometric mean of two or more samples.[9] The **instantaneous standard** is the maximum number of bacteria colonies allowed in any single sample, whereas the **geometric mean standard** is the upper limit allowed for two or more samples taken within any calendar month (see Table 2). The geometric mean standard is lower than the instantaneous standard (regulations allow occasional high levels but aim for a lower level over time). News stories about Virginia beach closures in 2004 due to bacterial levels exceeding a standard typically cited the *instantaneous* standard (104 CFUs for enterococci, as shown in Table 2).

Finding a source

If a coastal water source consistently fails to support its designated uses (by exceeding its instantaneous standard or geometric mean), it can be categorized as "impaired" in the state's biennial water quality report to the U.S. EPA. This can lead to a "total maximum daily load" (TMDL) process. This extensive and costly process determines a maximum amount of pollutant that a water body can receive and still meet state standards. The next step is to reduce the current amount of that pollutant in the water. In cases of bacterial pollution, it is often important to identify the source of fecal matter contributing the bacteria.

A relatively new technology being developed to do just that is **Bacteria Source**

[8] The pertinent regulations are in 9 VAC 25-260 of the *Virginia Administrative Code*. As part of these regulations, the state also mandated a transition to using *E. coli*, instead of fecal coliforms, as the bacterial indicator in *freshwater*. That transition is to be completed no later than June 2008.

[9] A geometric mean is *n*th root of the product of *n* numbers. For example, the geometric mean of 8 and 8 (two numbers in the series, so n = 2; product = 64) is the square root of 64, or 8; and the geometric mean of 8, 8, and 8 (n = 3) would be the cube root of 512, also 8; but the geometric mean of 2, 4, and 8 would be the cube root of 64, or 4.

Tracking (BST). The varied diets of humans, wildlife, and livestock result in different communities of intestinal bacteria. These differences make it possible, with genetic or biochemical BST techniques, to distinguish what kind of animal the bacteria in a sample (or series of samples) formerly inhabited.

If one knows the general source of the bacteria that is impairing a coastal water body, it's then possible to focus on land uses or other activities that may be causing the contamination. For example, if the contamination is from human sources, the focus might be on malfunctioning septic systems, sewer-line leaks, boat discharges, or wastewater treatment system overflows. If the source were domestic animals, the focus might be on educating pet owners to clean up their pets' waste or on restricting pets from beach areas. If the source were livestock or wildlife, the focus might be on better ways to manage stormwater runoff in the watershed.

[Ed. note: For an introduction to bacterial source tracking, please see the October 1999 *Water Central*, p. 8.]

Conclusion

Elevated bacteria are one of the most common reasons for public officials to issue a beach closure or advisory. Closures and advisories occur infrequently in Virginia, but even an occasional situation can have important social and economic consequences. Recent expansion by the EPA of beach water-quality monitoring requirements may result in more days when bacteria get the beach to themselves.

References and Further Reading

U. S. Environmental Protection Agency. *Draft National Coastal Condition Report II*. Mar. 2004. Available online at www.epa.gov/owow/oceans/nccr2/downloads.html. Accessed July 30, 2004.

U. S. Environmental Protection Agency. *Ambient Water Quality Criteria for Bacteria – 1986*. Jan. 1986. Available online at www.epa.gov/ost/pc/ambientwqc/bacteria1986.pdf Accessed July 30, 2004.

U. S. Environmental Protection Agency. *Bacterial Water Quality Standards for Recreational Waters (Freshwater and Marine Waters) Status Report June 2003*. Available online at www.epa.gov/waterscience/beaches/local/statrept.pdf. Accessed July 30, 2004.

U. S. Environmental Protection Agency. *Implementation Guidance for Ambient Water Quality Criteria for Bacteria* (EPA-823-B-02-003), May 2002 draft.

U.S. Environmental Protection Agency, *Volunteer Stream Monitoring: A Methods Manual* (EPA 841-B-97-003), 1997.

Beach and Coastal Information Online

Information about beach water quality nationwide, local protection programs, and other beach-related programs is available online at the **U.S. EPA's "Beach Standards, Monitoring, and Notification"** site, www.epa.gov/watrscience/beaches/.

The **"Healthy Swimming" page** from the U. S. Department of Health and Human Services' Centers for Disease Control is located online at www.cdc.gov/healthyswimming/.

The Web site for the Virginia Department of Environmental Quality's **Coastal Management Program** is www.deq.state.va.us/coastal. The program publishes Virginia Coastal Management twice a year (available online). For more information about the program: phone (804) 698-4320, or e-mail vgwitmer@deq.state.va.us.

The Web site for the **Virginia Department of Health's beach assessment and coastal health program** is located at www.vdh.state.va.us/whc/external_whc/BeachMonitoring.asp. You can use this site to check for open/closed beaches and for bacterial monitoring results. For more information about the state beach monitoring program, contact the program director, Michele Monti, at (804) 864-8141 or michele.monti@vdh.virginia.gov.

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Water Central thanks Julie Jordan, Virginia Tech Department of Biological Systems Engineering, and Michele Monti, Virginia Department of Health, for reviewing this article. Water Central takes responsibility for any errors that may remain.