Sea Grant California

Sea Grant News

"Science Serving California's Coast"

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Cover—Capitola-by-the-Sea, Captain Albert E. Theberge, NOAA Corps (ret.)
p. 7—San Diego marina, Cesar J. Alvarez

Left: Visitors to Cabrillo National Monument.
Below: Point Reyes seashore. Photos: National Park Service digital archives

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Is Groundwater a Source of Beach Pollution?

A Look at Beaches in Santa Cruz and Bolinas

"People have largely ignored submarine groundwater because it is hard to see, because it percolates beneath the surface. But this does not mean it is not important."—Adina Paytan, a marine biogeochemist at Stanford University

With Sea Grant support, two Stanford researchers will soon test a theory that may explain chronic beach pollution in California and elsewhere.

The theory: groundwater discharging to the coast is indirectly or directly increasing the abundance of harmful bacteria—the kind that close beaches to swimming—and may be as important to understanding coastal pollution as the more often implicated urban runoff.

The research, to begin in March, is a follow-up on field experiments conducted in 2003 at Huntington Beach, California—an area well known for a mysterious rash of summer-time beach closures. In this work, Alexandria Boehm, a professor of environmental engineering, and Adina Paytan, a professor of geological and environmental sciences, showed that the amount of submarine groundwater flowing into the surf zone varies with the phase of the moon and that microbial pollution levels are higher when a lot of submarine groundwater is making it to the beach.

Groundwater is water from rain, snow melt, irrigation, etc. that seeps underground, filling pore spaces of rocks and sediments. Unless trapped, groundwater eventually flows to sea. Along the way, it may become contaminated with bacteria and nutrients from leaky sewers, septic tanks, lawn fertilizers, pet waste and the like. "Submarine groundwater" refers to the underground mix of groundwater and saltwater that ebbs and flows into coastal waters with the pull of the tides.

Researchers have shown that bacterial counts vary with lunar cycles at 50 Southern California beaches, but they have yet to observe what would be expected to be

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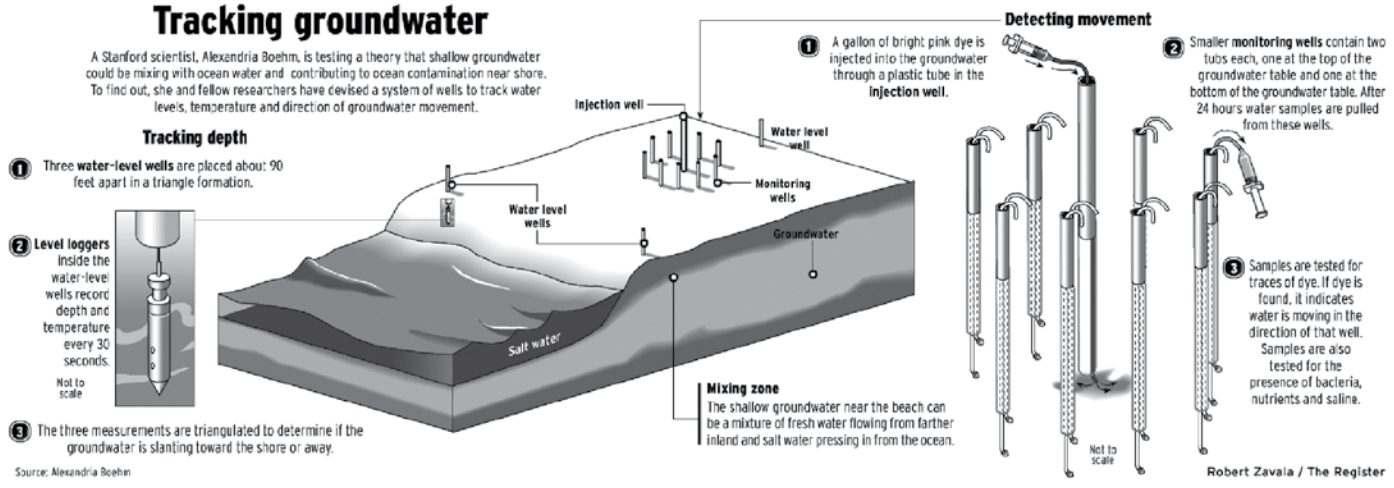

Credit: Pat Brennan—reprinted by permission of *The Orange County Register,* ©2006.

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true—that groundwater itself is a source of bacteria. In fact, only 1 of 26 groundwater samples tested at Huntington Beach had elevated levels of fecal indicator bacteria, the standard by which authorities evaluate beach water quality.

The central question now is to explain how bacterial counts could be so closely linked to submarine groundwater discharges if the groundwater itself is not contaminated?

The new Sea Grant project will allow scientists to investigate possible explanations. A leading hypothesis, Boehm said, is that beach sand may store fecal indicator bacteria. Groundwater may "free" bacteria that would otherwise remain held in sediments.

Another possibility: groundwater contains dissolved organic matter and nutrients such as phosphate, nitrate and ammonia that encourage bacterial growth.

In their 2003 study, the scientists found that nitrate concentrations were 100 times higher in submarine groundwater than in the surf zone. Nitrogen and phosphate might influence plankton growth and could influence occurrences of toxic algal blooms in some areas, Boehm said.

Another issue to be explored is the extent to which land-use patterns influence submarine groundwater and beach water quality. During their Sea Grant project, Boehm and Paytan will collect water samples from beaches in Santa Cruz, which sits within NOAA's Monterey Bay National Marine Sanctuary and Bolinas, which is north of San Francisco and within NOAA's Gulf of the Farallones National Marine Sanctuary.

Stanford professor Alexandria Boehm (wearing the light blue jacket) and graduate students who helped to gather field data. The long white pole is a "well point"—a long hollow tube through which groundwater is extracted. Photo: Stanford University

These sites have different population densities and wastewater management plans. Residents of rural Bolinas are on septic tanks, meaning waste is released into the ground. Santa Cruz, in contrast, is relatively urban, and the city's treated sewage is discharged at sea.

"We are the only researchers studying the connection between submarine groundwater discharges and California coastal water quality," Boehm said. "The Sea Grant research will allow us to document how the quantity and quality of submarine groundwater affects beach water quality. There are many regulations for what is discharged from the land to the sea via runoff. Results from our work may suggest that what is discharged from the land to the sea via the subsurface should be regulated, too." ■ ■ ■

Researchers collected about 11 metric tons of beach water using trash cans, allowing them to test for the relatively low concentrations of radium, a widely accepted tracer of groundwater. Photo: Alexandria Boehm, Stanford University

Caviar Exports Banned—
Environmental Awareness Benefits Sturgeon Farms

Citing concerns about the plight of wild sturgeon, the international body that controls the trade of endangered species in January banned the export of caviar from the Caspian Sea region, the source of about 90 percent of the world's wild caviar. It was not the first such ban, nor will it likely be the last. Past bans have been temporary and roundly criticized by biologists and environmentalists for doing little to prevent continued poaching.

What is changing is greater public awareness of environmental issues associated with "black gold." As a result, consumers who once snubbed cultured caviar as on a par with fake diamonds are now paying top dollar for a product that comes with less guilt, since it does not contribute to the decline of wild sturgeon populations.

California Sea Grant has long supported basic research that has helped make sturgeon farming possible and environmentally sustainable. Our most recent research project is further helping to reduce the impact of caviar consumption on wild sturgeon populations here in California.

In collaboration with Stolt Sea Farm California, a major producer of white sturgeon meat and several lines of caviar products, genetics professor Bernard May of UC Davis and Sea Grant Trainee Jeff Rodzen completed studies in 2001 that showed a high degree of genetic variability among offspring from the farm's white sturgeon brood stock. As part of their work, the investigators also tried—and failed—to find a genetic basis for desired caviar traits such as color and firmness.

The simple discovery that the farm does not have to worry too much about inbreeding has had lasting benefits, however, as it has reduced the need for the farm to periodically replenish its brood stock with sturgeon captured from rivers in Sacramento County. This is of ecological benefit because the number of white sturgeon in the Bay-Delta area has declined significantly in the last century due to water policies, habitat loss and overfishing. "The Sea Grant work showed we have a very broad gene pool," said Peter Struffenegger, general production manager at Stolt Sea Farm California in Sacramento County. "If we manage carefully, we won't have to go back to the river"—at least not for genetic reasons.

Efforts to control disease in sturgeon may keep the farm returning to the wild for fish. It is hoped that further research will resolve this issue, too. ■■■

Caviar extracted from farm-raised white sturgeon, a species native to the Sacramento Bay-Delta. Shortages of wild caviar are increasing public awareness of cultured caviar. Photos: Stolt Sea Farm

"*Five years ago nobody wanted our product because it was not 'the real thing.' With greater public awareness, we are now the better thing.*"—*Peter Struffenegger, general production manager at Stolt Sea Farm California in Sacramento County, which raises white sturgeon for meat and caviar.*

Metabolites from Marine Bacteria Tested for Activity in Fighting Antibiotic Resistance

(Above) Cultures of different marine bacteria extracted from ocean sediments.
(Below) Bill Fenical. Photos this story: Scripps Institution of Oceanography

In 2003, Sea Grant investigator Bill Fenical of Scripps Institution of Oceanography surprised the scientific community with the discovery of a new genus of bacteria in ocean sediments that produces cancer-killing compounds. One of his graduate students is now investigating whether these bacteria, a marine form of Actinomycetes, might also help in finding cures for antibiotic resistance.

Fifth-year doctoral candidate Nicole Turkson is searching for compounds that shut down a cellular mechanism implicated in conferring antibiotic resistance in strains of Group A Streptococcus. The mechanism is an "efflux pump."

An efflux pump is a protein on a cell membrane that grabs compounds it deems toxic and expels them before they can accumulate inside—a cell's personal bouncer. Normally, this function is beneficial since it protects a cell from environmental toxins. In cancer cells or pathogenic bacteria, however, it can have the opposite effect: it can mean medicines are purged before they can do their job.

There are many types of efflux pumps. Turkson studies efflux pumps coded by the MefA gene, short for macrolide efflux gene A. These efflux pumps are particularly good at removing macrolide antibiotics, a class of antibiotics that includes erythromycin and azithromycin.

Her research is motivated, in part, by a recent outbreak of erythromycin-resistant "strep throat" in school children in Pittsburgh, Pennsylvania. Subsequent medical research found that MefA-induced efflux pumps were to blame.

"Antibiotic resistance is a huge public health concern," said Turkson, who is supported by an NIH training grant in marine biotechnology. "Some researchers believe we could find ourselves in a pre-antibiotic era within several decades if the rise in antibiotic resistance is not addressed."

Turkson has found two pure compounds that restore sensitivity in streptococcus to erythromycin, but she is not sure why or how these compounds are working. She is hopeful at least one is targeting MefA activity and might prove useful in developing new antibiotics.

Nicole Turkson is a graduate student studying the properties of metabolites extracted from marine bacteria. California Sea Grant helped support the basic research that has made her studies possible.

Earth to Hollywood—Freeing Nemo: Bad Idea —Educating Aquarium Owners: Good Idea

Emperor angelfish, imported by the U.S. aquarium industry in relatively large numbers, is a most commonly sighted non-native fish. Photo: Paul Humann

In the popular children's movie, a little fish named Nemo is kidnapped, rudely tossed in a fish bowl, but eventually re-united with his reef-dwelling family—a happy ending to what would have otherwise been a sad tale.

In real life, freeing exotic species isn't a good thing. This is not because of the impossibly small odds that your released pet fish will actually find its relatives. What is worrisome is that it might actually like its new home, thrive there and decide to start a family.

Releases of pet fish are a leading cause of non-native fish invasions in Florida and other places. In a recent study, researchers at the University of Washington and the Reef Environmental Education Foundation reported that people who have dumped their home tanks have created "hot spots" of non-native fish species off southeastern Florida, including in the NOAA Florida Keys National Marine Sanctuary.

Volunteer taking survey of fish species. Photo: Heather Dine, Florida Keys NMS

Sea Grant is working with the U.S. Fish and Wildlife Service, the aquarium industry and NOAA to educate the public about the importance of not releasing pet fish.

For more information, visit the Habitattitude Web site at www.habitattitude.net. ■ ■ ■

Habitattitude™
PROTECT OUR ENVIRONMENT

STOP that Hitchhiker!

Managing Hull Transport of Invasive Species Proceedings Available

While ballast water discharges are widely recognized as being a "vector" for the spread of non-native species, boat hulls can also transport species from one area to another. These hitchhikers—creatures like barnacles, tunicates, algae and mussels—are often broadly referred to as fouling organisms, nuisance species that boat owners must periodically scrape off their hulls. These species, as biologists and resource managers are coming to appreciate, however, can be more than just pests. Many common fouling organisms are also non-native species; some are ones wildlife officials are trying to contain.

To help control the spread of exotics, the California Sea Grant Extension Program and California State Lands Commission have published the proceedings of a workshop, "Managing Hull Transport of Aquatic Invasive Species," held May 2005 in San Francisco and attended by boat owners, academics, resource managers, environmentalists and representatives from the boating industry.

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Invasive Species Workshop Proceedings CD (continued)

The publication, edited by Sea Grant Marine Advisor Leigh Taylor Johnson and Program Representative Jamie Anne Gonzalez, gives background information on the kinds of species transported on boat hulls, explains why these can be problematic, and reviews current laws and policies regarding aquatic invasives. It also discusses pros and cons of different methods for removing fouling organisms, as well as emerging technologies. As an opportunity to learn from others who are dealing with similar issues, management plans in Hawaii and New Zealand are also reviewed.

To obtain copies of this and related reports, contact California Sea Grant Communications at (858) 534-4446. This report is also available at: http://seagrant.ucdavis.edu.