URBAN MARINER

USC Sea Grant's Urban Ocean Report

June 2009, Volume 1, Number 1

Ship to Shore:
Linking Science to Policy

Is it Safe to Swim?

Are our beaches safe for swimming, surfing, and other activities? This is a central concern to Southern California beachgoers and there have been many reports on this issue over the past several years. University of Southern California (USC) Sea Grant has been working on the answers in its research and outreach programs.

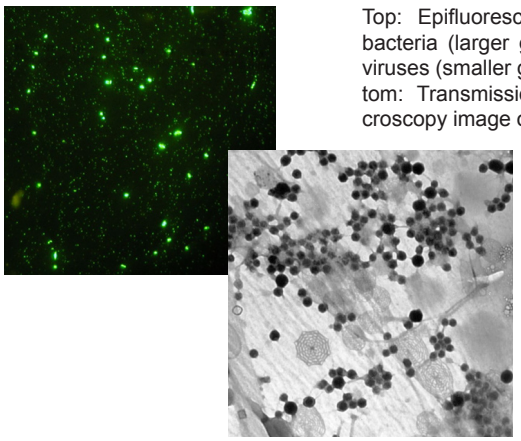
Microbial contaminants such as bacteria and viruses reach coastal water through leaky sewer and septic systems, river mouths, and a storm drain system that transports bacteria and viruses washed off the streets from rainwater or irrigation. Although not all types of bacteria and viruses are threats to human health, those that are pathogenic can cause illnesses such as diarrhea and ear and respiratory infection, among others. Beach tourism plays a crucial role in the state's economy, with an estimated 14.6 million international visitors and 352 million domestic visitors statewide. Ensuring that the water is safe is therefore a priority for the state and for Southern California. Ongoing research in Dr. Jed Fuhrman's lab, in the Marine Environmental Biology program at USC, focuses on investigating the presence and potential threats to human health posed by anthropogenic viruses in nearshore waters off Southern California beaches.

Researchers using Niskin bottles to collect water samples for analysis (photo: J. Fuhrman)

Current state water quality monitoring regulations call for the use of bacteria as indicators of human fecal contamination and as a proxy for pathogenic viruses. These bacterial tests are beneficial because they are relatively rapid, standardized, inexpensive, and simple to perform; however, these standard bacterial tests do not distinguish between pathogenic bacteria and more "natural" safe bacteria. Furthermore, recent research in Dr. Fuhrman's lab at USC reveals that these standard bacterial indicators do not consistently predict the presence of pathogenic viruses.

Beachgoers in Santa Monica (photo: C. Stevenson)

Until recently, little was known about the existence and lifespan of viruses in the ocean, particularly those that threaten the health of bathers, surfers, and divers. "Classic" viral detection tests relied on large sample volumes (approximately 20 gallons) and on cultivation of viral cultures, which took up to weeks for results -- much too long to be useful for management applications such as issuing health warnings or posting beach closures. Beach managers needed alternative, rapid tests for virus detection. *(continued on pg. 3)*



Top: Epifluorescence image of bacteria (larger green dots) and viruses (smaller green dots); Bottom: Transmission electron microscopy image of viruses (black, hexagonal dots, photo: J. Fuhrman)

At the Helm: From the USC Sea Grant Office

Welcome to the first edition of the Urban Mariner: USC Sea Grant's Urban Ocean Report. In this and following reports, we will highlight the work of researchers and educators funded by USC Sea Grant, who are working hard to tackle ocean health issues unique to urban coastal environments.

Phyllis Grifman, Associate Director, USC Sea Grant

Almost a decade into the 21st century, coastal cities continue to face unprecedented population growth and associated development pressures, sea level rise and other threats from global warming -- which present ever-increasing challenges to the marine ecosystems on their seaward boundaries. While we have developed a better understanding of the dependence of urban areas on natural coastal resources, we are still exploring strategies to limit the negative impacts of the growing pressures of urbanization. As the largest urban center on the west coast and the second largest in the nation, the city of Los Angeles is at the heart of the debate about the effects of urbanization on our coastlines.

The University of Southern California's location in the middle of Los Angeles has made the Sea Grant Program at USC an important regional resource, concentrating on issues arising out of the necessity of managing people and resources in an intensely developed coastline. Known as the "Urban Ocean" program, USC Sea Grant is the only program in the Sea Grant Network to offer such a clearly defined identity. For over 30 years, USC Sea Grant program has considered Los Angeles to be the city of the future and treats it as an urban ocean laboratory.

In the Urban Mariner, we will introduce you to researchers and educators working in California and on the myriad issues arising in our metropolis and other urban ocean regions around the nation. We will describe how the results of their work are applied to real world ocean management -- a critical step in bridging science and policy. We hope you enjoy this first edition and the ones to follow.

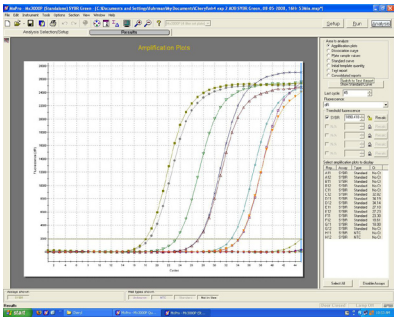
Please contact us with your comments and suggestions (seagrant@usc.edu).

In Depth: About the Research

Currently in the United States, routine water quality monitoring uses *Escherichia coli* and entercocci as proxies for the potential presence of pathogenic viruses, such as enteroviruses, Hepatitis A, Norwalk viruses, and adenoviruses. However, in 2001, Dr. Fuhrman and his then student, Rachel Noble, published an analysis of beach water samples from Santa Monica Bay beaches over a six year period. They found that there was actually a weak correlation between pathogenic viruses and the bacterial proxies used in standard water quality monitoring. Instead of relying on the bacterial proxies or on classic viral detection tests that depend on cultivation and can take up to weeks for results, the Fuhrman lab was able to directly detect the presence of enteroviruses in seawater using a more rapid genetic test called Reverse Transcriptase Polymerase Chain Reaction (RT-PCR).

Researchers sampling off of Catalina Island (photo: J. Fuhrman)

With RT-PCR, a gene fragment in the RNA genome of a virus is amplified and then detected. Over the last several years, the Fuhrman lab has worked to refine the RT-PCR methods; the original methods required approximately 20 gallons of water per sample and took hours of expensive, labor-intensive concentration and extraction of the viral RNA, often leading to inconclusive results. More recently, Fuhrman and colleagues modified existing protocols for viral detection to be able to successfully detect low (but realistic and still potentially hazardous) concentrations of enteroviruses in freshwater and seawater. Moreover, they were able to do so using sample sizes of only 1 liter, in only a few hours, using RNA extraction materials that are readily available in the United States and Europe.



Graph output of data from RT-PCR

Scientist's Quarters: About the Researcher

Dr. Jed Fuhrman

Dr. Jed Fuhrman

Dr. Jed Fuhrman's scientific journey has carried him back and forth across the country from undergraduate studies at MIT and graduate studies at the University of California at San Diego's Scripps Institute of Oceanography to his first teaching/research job at State University of New York at Stony Brook and finally back to California and the University of Southern California where he now holds the McCulloch-Crosby Chair of Marine Biology.

Dr. Fuhrman has spent his career studying aquatic microbial ecology, biological oceanography and the functioning of microbial systems. Specifically, his research investigates: the functioning of microbial systems; microbial biodiversity and identification of nonculturable bacteria and archaea and their functions; interactions with dissolved and particulate organic matter; two-way interactions with other chemical and physical processes; rates of bactivory and viral infection; rates of nutrient regeneration; application of biochemical and molecular biological approaches to these problems; connections to global cycles; human impacts on aquatic systems, pathogens and related health hazards.

Dr. Jed Fuhrman with former lab technician Lisa Gilbane (now with the U.S. Mineral Management Service) in a lab in Avalon on Catalina Island (photo: J. Fuhrman)

Dr. Fuhrman's development of rapid measurements of human pathogenic viruses and bacteria in environmental samples of water is just one of his lab's significant accomplishments. This microbial testing to directly detect viruses in Southern California waters began in 1991 with support from the State of California, USC Sea Grant and local agencies (coordinated through the Southern California Coastal Water Research Project, SCCWRP).

Is it Safe to Swim?

(cont'd from pg. 1)

Beach closure sign at a Southern California beach

Through investment by USC Sea Grant, Dr. Fuhrman's lab has developed and published methods for rapid and sensitive tests of enteroviruses (one category of pathogenic viruses) from reasonably small volumes of fresh and marine water. These rapid, convenient tests, which are suitable for standardized water quality testing, have been developed in coordination with local water quality agencies (e.g. Orange County Sanitation District) and user groups (e.g. Surfrider, Santa Monica Baykeeper) who are interested in the research from a management perspective. This coordination has been facilitated by USC Sea Grant and SCCWRP. SCCWRP Director Dr. Steve Weisberg explains SCCWRP's ongoing collaboration with Sea Grant: "*USC Sea Grant is exceptional at supporting research that is not only applied in its focus but whose objectives are pertinent to the most critical coastal problems and opportunities. They are strategic in their funding and expert at leveraging the impact of their modest financial support by partnering and cooperating with agencies and key user groups.*"

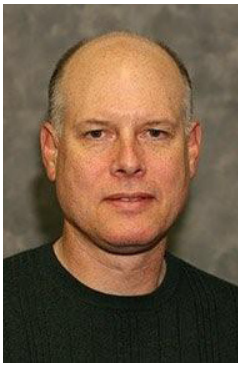
Research programs in Los Angeles and Orange Counties, coordinated through SCCWRP, are already utilizing this new technology -- sampling of a liter or less with rapid results -- to assess water quality along the coastline. The application of this technology may help revolutionize recreational water quality testing and significantly improve protection of human health by making monitoring results more useful for management.

For more information on Professor Jed Fuhrman, his lab, and publications, please visit: http://fuhrmanlab.usc.edu/people/fuhrman.html

Getting Underway: Young Researchers

In addition to funding and facilitating research and developing partnerships which will ultimately help to address some of the critical issues facing the Los Angeles' urban ocean environment, USC Sea Grant places great importance on development of the next generation of scientists, policy-makers, and educators. Below we feature two of Dr. Fuhrman's students, John Griffith and Josh Steele, who have both been influenced by the opportunities for collaboration and policy applications of the Sea Grant funded research in Dr. Fuhrman's lab.

Dr. John Griffith
Ph.D. Graduate from Dr. Fuhrman's Lab, Currently SCCWRP Research Scientist



Dr. John Griffith

Although John Griffith originally began his college career in the pre-med track at University of California, Irvine, his interest in marine biology and his knowledge of the research underway at the University of Southern California prompted him to transfer and seek out hands-on scientific research opportunities with Dr. Jed Fuhrman. Dr. Fuhrman, intrigued by John's willingness to do whatever was needed (including some "housekeeping" in the labs) just to have the opportunity to be around applied scientific research, decided to give John research opportunities in his lab. John participated in ocean research cruises and started working with Rachel Noble (then a graduate student in Dr. Fuhrman's lab) doing beach water sampling.

Just as John's undergraduate career was ending in 1995, Dr. Fuhrman was approached by the California Water Board and Santa Monica Bay Restoration Project with a request to do an epidemiology study (the study of factors causing health and illness) in Santa Monica Bay. Although Dr. Fuhrman did not have time to write a proposal, John did. The proposal was accepted by the Water Board, but funds were not immediately available.

John approached USC Sea Grant for interim funding. John states, *"USC Sea Grant recognized the importance of the viral work immediately. Although at the time it was a sideline research effort in Dr. Fuhrman's lab, the critical importance and possible uses of the research became evident as the work progressed."* USC Sea Grant provided funding under their Sea Grant graduate trainee program to John Griffith and to Rachel Noble, who after completing her doctoral degree accepted a researcher position with the Southern California Water Resource Project (SCCWRP). Dr. Noble is now a faculty member at the University of North Carolina.

Using samples of storm water contaminated from leaky sewage lines, the laboratory analysis represented some of the first attempts at using molecular methods to detect viruses in these kinds of samples. With the expertise gained through this study for his thesis research, John conducted a multi-tiered study of microbial contamination of Ballona Creek, near Marina del Rey in Los Angeles, which empties into nearshore waters.

Now a scientist at SCCWRP, John is conducting the necessary epidemiological studies to determine which rapid viral test methods are measuring the viruses that pose the greatest health risks for humans and to develop the standardization needed for useful management. Once established, these techniques and tools should allow authorities to successfully track fecal and viral pollution to their upstream sources within the region's major urban watershed. John enjoys the opportunity to conduct research and to use it to generate good public policy. Looking back John says: *"The research that I conducted under Sea Grant funding helped shape my professional choices and the direction I took my research after graduating -- it led me to working in an agency (SCCWRP) and pursuing the epidemiological studies and application of my findings rather than following a more academic research path."*

Dr. John Griffith and Dr. Burt Jones (from USC) sampling at Huntington Beach

Joshua Steele
Ph.D. Candidate with Dr. Fuhrman,
Knauss Fellow 2008


Josh Steele

Josh is currently a Ph.D. candidate in Marine Environmental Biology department at USC and expects to defend his thesis in the summer of 2009. His dissertation focuses on marine microbial ecology and molecular detection of microorganisms in seawater. Most recently, from February 2008-2009, Josh was the Knauss Sea Grant Marine Policy Fellow for Representative Sam Farr. As Mr. Farr's Legislative Assistant for oceans and environment, he focused on issues of ocean and science appropriations, ocean governance, fisheries, national ocean policy, national marine sanctuaries, marine protected areas, and climate change. He primarily worked on the Ocean Conservation, Education, and National Strategy for the 21st Century Act (OCEANS-21), the Southern Sea Otter Recovery and Research Act, the Clean Cruise Ships Act, and appropriations for NOAA, NSF, and NASA. Upon his return from his fellowship year, Josh provided his insights about having worked on Sea Grant funded research.

"I was a Sea Grant Trainee during the summer of 2002 and I participated in a study on coastal water quality that looked for a source of human pathogens near the power plant at Huntington Beach, California. We tried to use bacterial markers to discover the source of contamination on the beach. This interdisciplinary study was coordinated with the energy commission, SCCWRP, Professor Burt Jones's Lab, Professor Doug Sherman's lab, and Professor Jed Fuhrman's lab, and was funded by USC Sea Grant.

"Without Sea Grant, my graduate education would have been much more narrowly focused. I gained an understanding of the reach of scientific research beyond the lab and an amazing education in ocean and environmental policy.

"Since my return from my term as a Knauss fellow, I feel more than ever that it is necessary for scientists to be active in the policy world and to ensure that there is open communication between those engaging in scientific research and those who will need to use it or who are affected by it. There is a great need for people who are able to speak the languages of scientific research and the languages of policymaking.

Established in 1979, the Knauss fellowship matches highly qualified graduate students interested in aquatic resrouces and policy with "hosts" in the legislative and executive branch of government located in the Washington, D.C. area, for a one year paid fellowship. The program is named in honor of one of Sea Grant's founders, former NOAA Administrator, John A. Knauss. For more information, please visit: http://www.seagrant.noaa.gov/knauss/


Josh Steele collecting samples
(Photo: J. Steele)

"I would recommend the Knauss fellowship to everyone. I think it is particularly valuable for scientistso put in a year of public service, to demystify the processes and protocols of the policy world, to learn how to work alongside and communicate complicated concepts and processes to people with vastly differtent areas of expertise. I can think of no better way to understand the policy world than by being immersed in it."

USC Sea Grant Staff

- Linda Duguay, Ph.D., Director
- Phyllis Grifman, Associate Director
- Lyndell Whitley, Director of Education
- Linda Chilton, Education Programs Coordinator
- James Fawcett, Ph.D., Marine Transportation/ Seaport Specialist, Marine Outreach Coordinator
- Juliette Hart, Ph.D., Regional Research and Planning Specialist
- Susan Frish Zaleski, Coastal Resources Specialist
- Rick Hayduck, Computer Consultant Specialis
- Ruth Dudas, Office Manager

Urban Mariner Contributors

- Megan Bailiff
- Charlotte Stevenson
- Lori Stassi

USC Sea Grant Contact Information

seagrant@usc.edu | 1.213.740.1961
http://www.usc.edu/org/seagrant/