URBAN MARINER
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Sea Grant
University of Southern California

Photo credit: Charlotte Stevenson

Heavy Metals Take a Heavy Hit from the Clean Water Act

Ship to Shore: Linking Science to Policy and Management

These days, it seems that good news stories about the environment are few and far between. Particularly when it comes to the ocean, the nightly news and morning papers seem to be filled with disturbing stories of ocean acidification, overfishing, marine debris, oil spills, and beach closures. Because of this, Angelinos were pleasantly surprised on May 3rd, 2012 when they opened their Los Angeles Times and discovered that water quality along the Southern California coast has actually improved over the last 30 years!

Sure enough, USC Sea Grant funded researcher, Professor Sergio Sañudo-Wilhelmy at USC found a clear overall reduction in toxic metal levels along the Southern California coast between the early 1970s and 2009, results he and Ph.D. student Emily Smail published in the journal Environmental Science and Technology this year (Smail et al., 2012). The largest reductions were in copper, cadmium (400-fold decrease), and lead (100-fold decrease). Dr. Sañudo-Wilhelmy and his research team used a study done in the early 1970s by UC Santa Cruz researchers as a guide (Bruland and Franks, 1978), and they took new samples in the same locations using the same techniques as the researchers did 30 years prior. In many locations along the Southern California coastline, the levels of toxic metals reached levels as low as the natural background levels of these metals off the undeveloped coast of Punta Banda, Mexico, where the team also sampled.

Dr. Sañudo-Wilhelmy and his research team credit the implementation of the federal Clean Water Act in 1972, which was responsible for regulations that led to large reductions in toxic metals and other contaminants to U.S. water bodies such as the ocean, rivers, and lakes. They also credit the phase-out of leaded gasoline that began in the 1980s. (*Con't on page 3*)

At the Helm: From USC Sea Grant

Phyllis Grifman,
Associate Director,
USC Sea Grant

Welcome to the ninth issue of the Urban Mariner, *USC Sea Grant's Urban Ocean Report.*

There is nothing more rewarding than to see that decades of research and policy changes are beginning to have positive effects on the marine environment. Dr. Sañudo-Wilhelmy's research provides this kind of direct positive reinforcement of the changes in law and policy that have led to infrastructure improvements since the implementation of the Clean Water Act in 1972.

Although enormous strides have been made in the treatment of point-source pollutants, non-point source pollution, such as stormwater runoff from streets, channels and rivers continues to contribute large concentrations of pathogens and heavy metals to the urban coast. In fact, just recently, the Los Angeles Regional Water Quality Control Board mandated improved nonpoint wastewater management by cities in Los Angeles County. New permit regulations seek to reduce pollution by limiting stormwater flows, doing so in ways that would also replenish aquifers and boost local water supplies.

USC Sea Grant has been and will continue to be involved in research and outreach projects intended to address watershed runoff and coastal ocean pollution by bacteria and viruses, heavy metals, as well as contaminants of emerging concern. Many of the projects USC Sea Grant funds or manages not only try to determine the level of contamination throughout urban watersheds and along the Southern California coast, but also develop faster and less costly ways to measure these levels. USC Sea Grant will also continue to connect researchers and policy makers in the Southern California region to ensure the most up-to-date research is being used to inform policy decisions regarding wastewater and stormwater management and treatment.

Previous issues of the Urban Mariner can be found at: http://urbanmariner.urbanocean.org

What is Sea Grant?

Sea Grant is a nationwide network--administered through the National Oceanic and Atmospheric Administration (NOAA)--of 32 university-based programs that work with coastal communities. The Sea Grant Program at the University of Southern California has served the Southern California coastal region since 1972, funding research, transferring results to government agencies and user groups, and providing information about marine resources, recreation and education to the public.

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Ship to Shore: (con't from page 1)

However, despite the overall reductions for the Southern California coast as a whole, there remain particular areas of concern. Sampling locations closest to the two major wastewater treatment plant outfalls and two major river mouths in Los Angeles County still show elevated levels of toxic metals such as copper, cobalt and iron. This indicates that current human activities (treated wastewater, stormwater runoff, and industrial discharge) are still the main sources of toxic metals to coastal waters.

Dr. Sañudo-Wilhelmy and graduate student Emily Smail took water samples along the Southern California coast from the same locations using the same techniques as Bruland and Franks in the early 1970s, prior to the implementation of the Clean Water Act. (Photo credit: Dr. Sañudo-Wilhelmy)

Dr. Sañudo-Wilhelmy and his team took this extensive study one step farther, by determining whether a local phytoplankton species, *Synechococcus sp*., at the base of the marine food chain, could uptake trace metals along with the nutrients it takes in from the water. Most of the metals the team tested increased inside the phytoplankton within three hours, suggesting that most toxic metals can enter the food chain within one tidal cycle. Over 12 hours of exposure, lead and copper were internalized in the largest amounts, resulting in the death of the phytoplankton after 48 hours of exposure.

The good news is that the policy changes made over the last thirty years to better manage and prevent heavy metal runoff into the coastal ocean are working. Improvement is visible and the water is cleaner. The bad news is that the work is not finished. Toxic metals continue to reach Southern California's coastline through wastewater and stormwater discharges, resulting in localized areas of concern. Not only is continued research into the sources and impacts of toxic metals necessary; equally important is the ongoing dialogue between science and policy to improve technology and management using the best available science.

Scientist's Quarters: About the Researcher

Dr. Sergio Sañudo-Wilhelmy

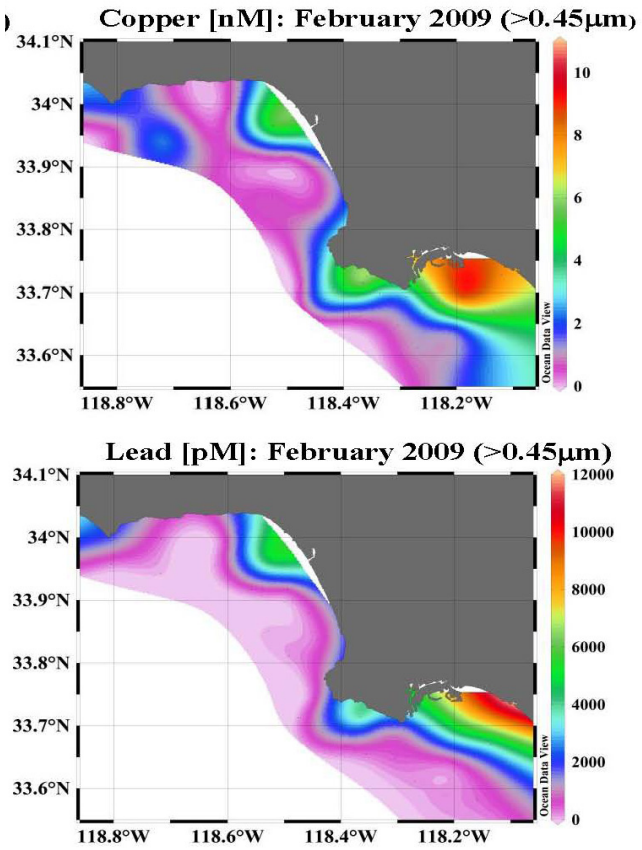
Dr. Sergio Sañudo-Wilhelmy is a Professor of Biological and Earth Sciences and a Dornsife Faculty Fellow in the Dornsife College of Arts and Sciences at University of Southern California. He has been at USC since 2006, focusing his research on environmental geochemistry. He and his research group study the cycling of trace metals, B-vitamins and mineral nutrients in ecosystems in order to elucidate how bioactive substances influence biological processes and phytoplankton dynamics. One reason Dr. Sañudo-Wilhelmy's research is such a good fit for Sea Grant support is because it tries to link anthropogenic processes to environmental quality and then immediate apply those findings to local policy issues in Los Angeles, particularly those related to water quality and public health. Dr. Sañudo-Wilhelmy's work is a great example of that connection between science and policy that Sea Grant seeks to encourage.

Professor Sergio Sañudo-Wilhelmy, USC (Photo credit: Emily Smail)

Before coming to USC in 2006, Dr. Sañudo-Wilhelmy was an Assistant Professor (1993-2000) and then Associate Professor (2000-2006) at the Marine Sciences Research Center at Stony Brook University. Professor Dr. Sañudo-Wilhelmy received his Ph.D. in Earth Sciences from University of California Santa Cruz in 1993. He also received a Masters of Marine Sciences from University of California Santa Cruz in 1989, and a Bachelors of Science of Oceanography from Universidad Autonoma de Baja California in Ensenada in 1983.

In Depth: About the Research

Dr. Sañudo-Wilhelmy and his research team collected surface water samples (1-2 meters depth) in February and September of 2009 along the coastline from Point Dume in Santa Barbara to Long Beach. Particulate and dissolved trace metal concentrations from the samples were determined using the same laboratory methods as Bruland and Franks (1978), who had taken surface samples in the same locations along the coast in the early 1970s prior to the implementation of the Clean Water Act. Using the same laboratory techniques as well as sample collection techniques, locations, and timing was quite important to rule out the influence of these factors on the results. Surface water concentrations of all metals had decreased, especially lead (100-fold drop), copper and cadmium (400-fold drop) over the last 33 years compared to the levels measured by Bruland and Franks. This is consistent with the reductions of mass discharges from the large wastewater treatment plants in Los Angeles County over time due to regulations under the Clean Water Act. There was one exception to the pattern; barium concentrations were actually 1.5 times higher in 2009 than in the early 1970s. Dr. Sañudo-Wilhelmy and his team guess (based on other published research) this is due to the inclusion of barium in antifouling paints and processed gasoline.



Although on average toxic metal concentrations have dropped dramatically off the Southern California coast since the early 1970s, the hotspots of contamination are still the areas near the waster-water treatment discharges and river mouths, as shown by these concentration gradient maps which where completed for each metal tested. (Figure from Smail, et al., 2012. Environ. Sci. Technol. 46: 4304-4311.)

Although the surface water concentrations of some metals such as lead, copper and cadmium had fallen significantly over the last 33 years, trace metals were still present and detectable in the Southern California Bight. Geographic patterns presented as one might expect, with the highest levels of most metals present near the ocean discharge sites for the two major wastewater treatment plants in Los Angeles County (Hyperion Treatment Plant and the Joint Water Pollution Control Plant) as well as at the mouths of the Los Angeles and San Gabriel Rivers near Long Beach. Although this study could not rule out other sources such as atmospheric deposition, the geographic pattern of the higher concentrations on metals strongly suggests that the main sources of trace metals in the Southern California Bight are wastewater treatment discharges and power plant discharges (both covered under the National Pollution Discharge Elimination Systems permits) and stormwater.

Dr. Sañudo-Wilhelmy and his team also determined whether a local phytoplankton species, *Synechococcus sp*., could uptake trace metals, allowing for the introduction of trace metals into the food chain. Most of the metals (cadmium, cobalt, iron, nickel, molybdenum, copper, and lead) tested increased inside the phytoplankton with three hours, suggesting that most toxic metals can enter the food chain within one tidal cycle. After six hours, silver had also accumulated in the phytoplankton. Over 12 hours of exposure, lead and coppers were internalized in the largest amounts, resulting in the death of the phytoplankton after 48 hours of exposure. Aluminum and Zinc were the only metals not internalized by the phytoplankton. This study used much lower concentrations of metals (nanomolar) than other studies have previously (micromolar) in an effort to demonstrate that even small inputs of toxic metals in the ocean can have potential harmful effects on the base of the food chain.

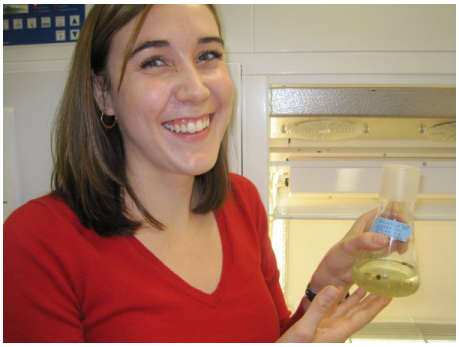
A complete description of this research can be found in: Smail, et al., 2012. *Environ. Sci. Technol.* **46**: 4304-4311.

Getting Underway: Young Researchers

In addition to funding and facilitating research and developing partnerships to address some of the critical issues facing the Los Angeles' urban ocean environment, USC Sea Grant places great importance on developing the next generation of scientists, policymakers, and educators. Below we feature Emily Smail, a Sea Grant Trainee and Ph.D. candidate advised by Dr. Sañudo-Wilhelmy.

Emily Smail, Ph.D. Candidate, USC

Emily Smail is a Sea Grant Trainee and Ph.D candidate at USC working with Dr. Sañudo-Wilhelmy. Emily studies the impact of trace metal and vitamin availability on phytoplankton and microbial growth an activity and environmental trace metal contamination. In addition to a busy schedule of research at USC, Emily works as a teaching assistant and mentor for undergraduate students and serves as a volunteer judge and mentor for school science challenges in the Los Angeles region. Before coming to USC in 2008, Emily received her B.S. from Pennsylvania State University in Biology. After graduating, Emily worked in the Northwest Province of South Africa in the U.S. Peace Corps in three primary schools, helping to develop science curriculum and student activities. After returning to the U.S., Emily worked as an analyst for ICF International and a lab and research specialist at Virginia Commonwealth University.



Emily Smail Ph.D Candidate, USC

Has your Sea Grant funded graduate work influenced what you are doing/want to do in the future?

Upon graduating, I will be a legislative Knauss fellow. My Sea Grant funded project let me see the firsthand the impact that legislation can have on the environment and how important it is to understand the science requirements of good policy formation. These experiences encouraged me to pursue a career in environmental policy.

Congratulations on being accepted as a National Sea Grant Knauss Fellow for 2013! Why did you choose to apply for the fellowship and what are you hoping to learn from it?

I have always had an interest in policy and I thought that the Knauss Fellowship would allow me to get firsthand experience working in policy. Also, before graduate school, I worked as an environmental consultant and I saw how public policy does (and does not) work for protecting the environment and human health. I became interesting in working towards developing more efficient policies and I thought the Knauss Fellowship would be useful towards that goal.

How has working with Sea Grant changed or helped you develop your understanding of how science and policy interact?

Having a Sea Grant program at USC allowed me to have access to people that are actively working in policy, which, in turn, allowed me to develop my interest and knowledge in that area. The Sea Grant funding provided me with an opportunity to complete an interesting and exciting study on metal contamination in Los Angeles. I also gained many scientific skills while working on this project such as trace metal clean laboratory techniques and technical writing.

If a 10 year old asked you what you liked most about being a marine scientist, what would you say?

I like being able to have job that allows me to work on things that I find interesting and go out on boats! I also like being able to be creative at work which being a marine scientist allows you to do.

And just for fun...what is your favorite marine creature?

Cuttlefish are my favorite marine creatures! I do not study them but I think they are fantastic.

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