NSF Support for Probe of Microbes

USC researchers with the Wrigley Institute for Environmental Studies have received a $2 million grant from the National Science Foundation (NSF) to study the composition and complexity of marine microbial communities that are ubiquitous in the world’s oceans.

The six marine and computational biologists are interested in how marine microbial communities respond to natural events and human-induced disturbances such as wastewater release—which organisms thrive, which don’t and how the communities adjust and function over time. They will also search for links between microbial communities and harmful algal blooms.

Marine microbial communities are critical components of the Earth system. They draw carbon dioxide out of the atmosphere to make organic compounds and provide half the oxygen we breathe. This process of photosynthesis is the foundation of life in the sea and on land.

What makes this project unique is that the researchers now have the tools to examine entire microbial communities at the genetic level. The researchers will determine how taxonomic and genetic diversity of microbes influence their function in the marine realm.

“Microbes are critical parts of...continued on page 7

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From the Director

Recently, I attended the 12th National Conference on Science, Policy and the Environment in our nation’s capital. The meeting unites academic experts from the natural and social sciences, policy makers from our own federal government and other nations, military officials, and representatives from nongovernmental organizations and foundations, to discuss emergent environmental problems and solutions. The focus of this meeting—Environment and Security.

What does the environment have to do with our security, and why are so many federal agencies, and the military, involved? The answer is deceptively simple—our lifestyle is fueled by the Earth’s natural capital and our government is tasked to secure “life, liberty and the pursuit of happiness.” Food, water and energy are provided by the environment, are vital to our existence and must be safeguarded. Accordingly, panel discussions included members of the U.S. Armed Forces, the Department of Energy, the Department of Agriculture, the National Oceanic and Atmospheric Administration, and the United States Geologic Survey, as well as scientists and environmentalists from the U.S. and abroad.
USC Wrigley Institute • Waves Newsletter

From the Director
continued from page 1...

This diversity is astounding, but then again, so is the breadth of the issues. It is easy to see how energy fuels our national interests, but perhaps harder to see how energy fuels food production and water use (it takes fuel to produce fertilizer and to water crops) and how agriculture impacts regional climate systems (e.g., the Gulf of Mexico dead zone owes its presence to agricultural practices in the Midwest). Our own government recognizes these challenges and is asking the research community for their ideas on topics that run the gamut from basic research (how does global change affect regional climate systems?) to highly applied topics (what biofuel crops can be sustainably raised?). It takes a village of scientists, economists and policy makers to chart the course for a more sustainable existence. It’s an exciting time to think about the future and be part of the solution!

How is the USC Wrigley Institute involved? We are revving the engines for a new research focus on sustainable shellfish aquaculture. Our scientists have long-standing interests in shellfish physiology and genetics, and are ready to apply them toward raising high quality protein. Shellfish grow rapidly and feed at a relatively low level within the oceanic food web—they consume small plants and microbes that are naturally in the water, and don’t require an external food source. Very efficient! As the U.S. imports most of its seafood, local production will help with the trade deficit.

How else is the USC Wrigley Institute contributing to the national discussion on sustainability? By promoting environmental literacy. Our scientists and staff bring knowledge from the university to the public, provide awareness and understanding, and help to train the workforce for the future.

We invite you to stay tuned as our projects develop. As always we welcome your suggestions, participation, and ideas!

Best wishes,

Roberta Marinelli, Ph.D.
Mussel Genes Reflect Rhythms of Light and Darkness by Richard Hoops

Mussels that inhabit intertidal zones along California’s coastline live in a demanding physical environment where the land and sea converge, a habitat that can change radically four times a day as the tides come and go. The mussels are underwater for hours at a time, then exposed to the sun and air, and then submerged again. The mussels’ capacity to adapt is the result of a strategy that buys them at least a few hours every day to survive out of water, a strategy that runs 12.4 hours—and yet they do it every 27 or 28 days, and a tidal cycle marks change over the course of a lunar cycle, mussels that are high on a beach during the time they’re out of the water would have a bigger effect on the mussels than the light-dark cycle, said USC biologist Andrew Gracey. “It’s a testament to the evolution of life that from the time of the earliest organisms on Earth, the light-dark cycle has been the biggest environmental cycle. Life evolved in that light-dark regime, and the consequences can be seen today.”

Gracey is an assistant professor of biological sciences in the USC Dornsife College of Letters, Arts and Sciences and a faculty member of the USC Wrigley Institute. Gracery and members of his lab are focused on understanding how temperature, oxygen concentration, salinity and other environmental factors affect the physiological processes of animals. Gracery and one of his graduate students, doctoral candidate Kwasi Connor, recently published a paper on the circadian rhythms of California mussels in the prestigious journal Proceedings of the National Academy of Sciences (PNAS).

The research, supported by the National Science Foundation, examined the mussel’s gene expression over numerous tidal cycles. Gene expression is the “molecular fingerprint” for the physiological status of cells at any one time. The NSF effort was focused on environmental cues that create oscillations in gene expression as well as the connection between these oscillations and other physiological rhythms.

“Going into this work, we expected that the tidal cycle would have the more profound effect,” Gracey said. “Being in and out of water would seem to be such a dramatic shift in habit that it would have a greater effect on gene expression.” Instead the project revealed the extraordinary influence of the planet’s rotation on the molecular workings of life.

Connor and Gracey ran two experiments to document the gene expression of the California mussels over a series of tidal cycles. Their first experiment used an aquarium in the basement of the Allan Hancock Foundation building where they exposed more than 200 mussels to an artificial tidal environment by pumping water in and out of the tank every six hours. They repeated the same experiment in a more natural setting on Catalina Island, where they put more than 200 mussels in two separate cages and hung them in seawater off the pier of the USC Wrigley Marine Science Centre. One cage was hung deep enough to stay submerged for the duration of the experiment; the second cage was suspended just enough to put it underwater at high tide but then leave it above water and exposed at low tide.

Connor took samples of the mussels’ tissue to analyze them for gene transcripts, the “messages” from DNA that direct cells to create specific proteins. The research project yielded thousands of these transcripts, and Gracey says the “high resolution” of this data is due to Connor’s extraordinary effort while the two experiments were underway. In each of the experiments, Connor took tissue samples every two hours, day and night. During the first experiment, Connor camped in the Hancock building and made 48 sampling efforts over the course of 96 hours. “It got lonely at night,” he said, “but it was all in the name of good science.” Connor took another 25 samples during a 50-hour experiment on Catalina Island.

Connor said data from the two experiments indicate that a significant portion of the mussels’ gene expression—40 percent of it—follow rhythmic patterns. It also showed that 80 to 90 percent of those rhythmic oscillations are connected to circadian cycles, not tidal ones.

“Only a small percentage of the mussel genes respond to the large shift in oxygen availability during tidal cycles,” Connor said. “More genes appear to respond to daily cues.”

Connor was the co-author with Gracey on the paper published last fall in PNAS and on another paper published recently in the American Journal of Physiology—Regulatory, Integrative, and Comparative Physiology. Connor is working on third journal article related to this research and on the last chapter of his dissertation for a Ph.D. in the USC Dornsife Marine Environmental Biology program. He expects to graduate from USC this summer, and he plans to start a post-doctoral position afterwards at the University of California—Irvine in the laboratory of Dr. Dinoon F. German with the Department of Ecology and Evolutionary Biology.

Connor said the subject of the experiments—the mussel Mytilus californianus—provides a remarkable opportunity to study a species that has adapted to a range of Pacific Coast habitats that reach from Southern California and Baja California to the shores of Alaska. The mussels also manage to cope with tidal cycles that create slightly different conditions for them every day. “The tides are not the same every day, the high-water marks and low-water marks change over the course of a lunar cycle,” Connor said. “At some points in the cycle, mussels that are high on a beach might only be underwater a few hours a day for several days at a time. That’s the only time they’ll get cooled off and the only time they’ll have access to dissolved oxygen.”

The physiology of the mussels can handle adjustments to a challenging and unpredictable environment, and it might even be able to adjust for those changes ahead of time. Connor said the experiments revealed the expression of genes that might be preparing the mussels for upcoming environmental conditions in a tidal cycle. The experiments were not designed to test any connection between gene expression and “advance planning” by the mussels at the cellular level, but Gracey said it would make sense if the mussels could do that.

“If animals only respond when the environment changes, they’re late,” Gracey said. “There’s an advantage to animals if they anticipate the environment rather than simply respond directly to changes.

The mussels appear to anticipate an environment shaped by a lunar clock and calendar—an orbit around the Earth every 27 or 28 days, and a tidal cycle that runs 12.4 hours—and yet they do it according the circadian rhythms, the 24-hour rotation of the Earth.

“My colleagues and I are interested in how environmental cues affect the physiology of animals. We’ve discovered that the mussels can synchronize their biology to the tides,” Gracey said. “That’s the next big challenge for our lab, to elucidate what that clock might be.”

“The place looks great—better than new,” said Sean Connor, operations manager for WMSC. “And this was a ‘live-in renovation.’ Nobody had to move out while the work was going on.”

USC maintains 11 duplexes in Two Harbors near Venice. All of the units were inspected for general wear and tear, water infiltration problems and setting. After repair work was completed, the entire complex received a custom paint job. While the carpenter and painting crew were on the island during the work week they stayed in the WMSC Residence Hall.

Work on the renovation began in October and was completed in early January, and the final walk-through was conducted Jan. 11. Steve Hall, a construction project manager with USC Campus Development and Facilities Management, handled contracting for the project. James McElwain, a senior administrator in the USC Dornsife Office of the Dean, oversaw the planning and architectural project management.

“Everyone here on the island is grateful to Steve and I am for making this happen,” Connor said. “This project is straightforward job as can be imagined.”
Scholarship, SCUBA and Tuba by Richard Hoops

Christopher Suffridge has lived near the ocean all his life, and he’s visited Catalina Island every summer that he can remember onboard his grandparents’ sailboat. That connection to the sea and Catalina continues as he completes the first year of his Ph.D. program in Marine Biology and Biological Oceanography at USC, inspired in part by seven months living at the USC Wrigley Marine Science Center on the island.

Suffridge came to USC in 2007 from Dana Point, California, where he was active in marine science as a student at Dana Hills High School. He was captain of the school’s team at the National Ocean Sciences Bowl for two years, and he worked throughout high school as a science instructor at the Ocean Institute in Dana Point. Since joining the Trojan Family, he has appeared on the Dean’s List (Fall 2010), finished two degrees—a B.A. in Biological Sciences and a M.S. in Marine and Environmental Biology (both in May 2011)—and started a Ph.D. program under the advisement of USC Wrigley Institute faculty members Sergio Sat vad-Wilhelmy and Eric Webb.

Suffridge has worked with the Wrigley Institute for much of his USC career. In 2010, he lived at the USC Wrigley Marine Science Center on Catalina Island for almost seven months, first as a participant in the spring Catalina Semester and then as a summer fellow working for USC Wrigley Institute faculty member Karla Heidelberg.

“I had been thinking about going into research, but I wasn’t sure about marine science,” he said. “After the Catalina Semester and living out there that summer, I realized that marine science was what I wanted to do.”

In addition to academic work, Suffridge serves as the student representative on the USC Diving Control Board (he has been a certified diver since 2009 and completed the USC scientific diving program) and he has volunteered as a moderator for the local competition in the National Ocean Sciences Bowl, which the Wrigley Institute has hosted for more than a decade. He also has played tuba for five years with the Trojan Marching Band, and he’s one of only six graduate students in its more than 300 members.

“The marching band is a lot of work,” Suffridge said. “To be honest, I don’t like to fit it in.”

During the first year of his Ph.D. program, Suffridge has focused on organizing a dissertation research proposal. His interests are in microbial oceanography; specifically the role that trace compounds, such as vitamins, play in controlling microbial production in the world’s oceans.

“We often think of macronutrients—phosphorus and nitrogen—as the main factors that control primary production,” Suffridge said. “But a lot of other trace compounds, like vitamins or trace metals, also control primary production. If we can better understand the controls on primary production, we can better understand the global carbon cycle.”

Microbes Probe continued from page 1...

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The other researchers include two faculty in residence at the Wrigley Marine Science Center, John Heidelberg, associate professor of biological sciences, and William Nelson, assistant research professor of biological sciences; David Caron, professor of biological sciences and former interim director of the Wrigley Institute; Fengshu Sun, professor of molecular and computational biology; and Ting Chen, associate professor of biological sciences and computer science.

The four-year project that began Oct. 1 builds on data collected by Fuhrman and Caron at a microbial laboratory located midway between the Port of Los Angeles and the USC Wrigley Institute’s Wrigley Marine Science Center on Catalina Island. That NSF-funded project has been ongoing for more than 10 years.

The new NSF award will provide support for the research team to continue sampling between the mainland and Catalina Island and will allow for new sampling near the Port of Los Angeles and in the waters off the USC Wrigley Marine Science Center.

Microbial communities do much of the heavy lifting in the ocean—meaning they decompose dead organisms and convert chemical compounds into new life forms. Entire microbial communities have never before been studied this thoroughly.

“When you change the microbes, you don’t just change that community, you change the food web,” Caron said.

Rather than concentrating on a specific organism, “We’re trying to study pretty much all the microbes to see how they’re connected to the larger organisms that rely on them.”

An enormous amount of data is generated by sequencing entire microbial communities. That is where the molecular and computational biologists come in.

“Bioinformatics is a way of analyzing that massive dataset,” Fuhrman said. “It’s a field that tries to handle this large amount of sequence data and process them into an intelligible form that we can then analyze.”

**“Do Marine Protected Areas Really Work? The Scientific Evidence”**

Wrigley Institute sponsors dinner and special presentation February 29 at King’s Pine Avenue Fish House in Long Beach

Director Roberta Marinielli and the USC Wrigley Institute for Environmental Studies invites you to a special presentation on scientific studies of measures to protect marine biodiversity within 200 mile Marine Protected Areas or MPAs. California has a rich network of Marine Protected Areas in the south coast region (Point Conception in Santa Barbara County to the California-Mexico border since Jan. 1). This south coast network encompasses 37 new or modified MPAs, plus 14 pre-existing MPAs and two special closures located at the northern Channel Islands.

Speaker: Mark Hoogenboom, Professor of Marine Ecology and Conservation Biology at Oregon State University and past chair of the Marine Protected Areas Federal Advisory Committee.

Time and place: 6 p.m., King’s Pine Avenue Fish House, 105 West Broadway Avenue, Long Beach.

Cost: $55 per person. Advance registration required. Please respond online by Feb. 22 to secure your place. usa.edu/w/wish (Code: WISH)

For questions or more information, please contact Kate Cheval at (310) 503-4715 or kcheval@usc.edu

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Christopher Suffridge

Photo by Ann Cox
Mark Your Calendars

**FEB 29**
Do Marine Protected Areas Really Work? The Scientific Evidence: Dinner and special presentation at King’s Pine Avenue Fish House, 100 West Broadway Avenue, Long Beach
Speaker: Mark Hixon, Professor of Marine Ecology and Conservation Biology at Oregon State University and past chair of the Marine Protected Areas Federal Advisory Committee.
Cost: $60 per person. Advance registration required by Feb. 22. Register online at: usc.edu/esvp (Code: WIES).
For more information, contact Katie Chvostal, Reservation and Events Coordinator, (310) 510-4015.

**MAR 3**
National Ocean Sciences Bowl, “Los Angeles Surf Bowl” regional competition: Mark Taper Hall of Humanities, Room 101, USC University Park campus
The NOSB Surf Bowl will bring together 24 teams of high school students to test their knowledge of the marine sciences including biology, chemistry, physics, and geology. The winning team will advance to the Finals Competition in Baltimore on April 19-22. The Los Angeles Surf Bowl is co-hosted by the USC Wrigley Institute and the NASA Jet Propulsion Laboratory. For more information, contact Ann Close at USC, (213) 740-6705.

**SUMMER 2012**
Enrollment for USC Family Science Programs: USC Wrigley Marine Science Center on Catalina Island
Staff of the Wrigley Institute offer summer “science vacations” for families that feature educational activities as well as hiking, snorkeling and kayaking around “the quiet end” of Catalina Island. Dates are as follows:
  - Session 1: May 25-28
  - Session 2: June 25-June 29
  - Session 3: July 20-July 23
For more information, contact the Wrigley Marine Science Center at famsci@usc.edu or (310) 510-4090.

*To update your contact information please email: jennifdd@usc.edu*