URBAN MARINER

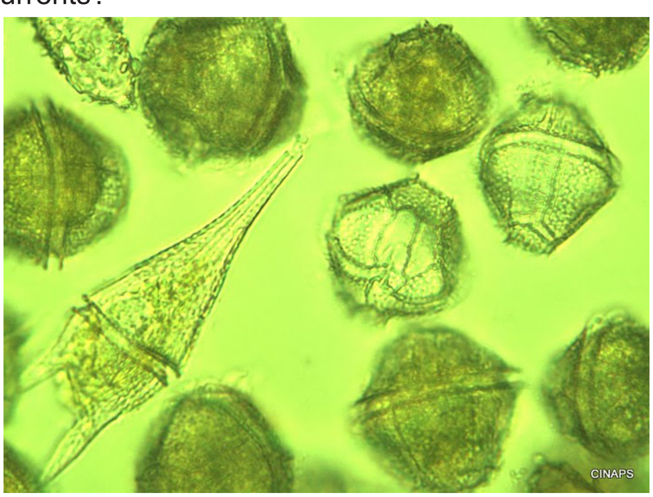
USC Sea Grant's Urban Ocean Report
June 2010, Volume 2, Number 2

Ship to Shore: Linking Science to Policy

Keeping an Eye on the Ocean

If you happen to be in a boat just off the coast and you see a tiny submarine-like apparatus glide by you in the water, there is no need for alarm. This is one of University of Southern California (USC) Researcher Dr. Burton Jones' autonomous underwater vehicles or 'gliders.' These gliders help Dr. Jones and colleagues take the pulse of the coastal ocean waters. Coastal waters, especially those along the urban coastline of Southern California, are some of the most complex places in the earth's ocean. We know that there are often many simultaneous oceanographic processes at play, including large oceanic currents, mixing and stratification, upwelling of deep nutrient rich waters, and freshwater inputs from rivers. Phytoplankton—the base of the marine food chain—bloom only when these processes give them simultaneous access to nutrients and sunlight, the ingredients for photosynthesis. However, this is just part of the picture on a densely urban coastline. Along the Southern California shore, scientists and managers must also consider the effects of often extremely large nutrient inputs from urban stormwater and treated sewage outfalls.

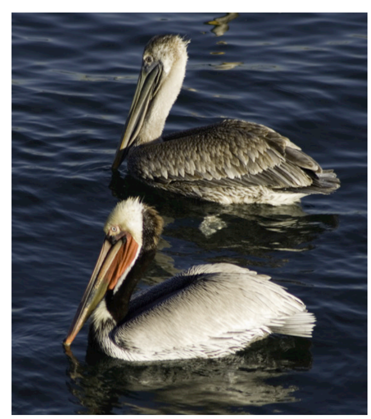
Why do we care about what these tiny creatures are doing beneath the waves? And why are we concerned about the mixing of the different coastal currents?



Lingulodinium poledrum. (Photo courtesy of CINAPS)

Autonomous Underwater Glider. (Photo courtesy of usclab.usc.edu)

It turns out that understanding the patterns of both is quite important for coastal managers. In the event of a storm causing major coastal runoff, it is critical in terms of human health to know how long that plume of bacteria and virus-laden water stays near the coast. It is also critical to know that not all phytoplankton blooms are good. Certain algae (i.e. *Pseudo-Pseudo-nitzschia* and *Alexandrium catenella*) are capable of toxic or harmful algal blooms (HABs), releasing a compound (domoic acid or saxitoxin), which can accumulate up the marine food chain, causing severe illness and death in marine mammals, birds, and even humans. Another species, *Lingulodinium polyedrum* is probably the most common dinoflagellate in the region and causes the red water often seen near the beach; when it's population crashes, it consumes large amounts of oxygen in the surrounding water, cause hypoxia in regions with low circulation (ports, marinas, lagoons, etc.) resulting in fish kills. (Continued on page 2)



Marine mammals and birds such as the California brown pelican can become quite sick from the concentration of toxins which builds up in their system during a harmful algal bloom. (Photo credit: Charlotte Stevenson)

Keeping an Eye on the Ocean

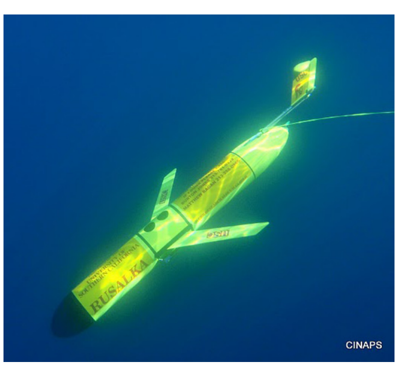
(cont'd from pg. 1)

Scientists still do not know what conditions trigger a toxic algal species to bloom and produce toxin, but understanding the complex coastal oceanographic processes is certainly a key to unraveling this mystery, as well as important for sustainably managing human use and enjoyment of the coast. It is these questions that occupy the time of Dr. Jones and his research team at the USC.

Dr. Jones, joined by other experts in robotics, computer science, and phytoplankton ecology, brings the applied oceanography expertise to the interdisciplinary group, CINAPS (Center for Integrated Networked Aquatic PlatformS), located at USC. CINAPS has designed and now operates an aquatic observing system of static and mobile aquatic sensors—including autonomous underwater vehicles—together with a long-distance communication network off Southern California's urban coastline. CINAPS' goal is to provide timely information on coastal water quality and harmful algal blooms to scientists, policy makers, and the general public.

Center for Interated Networked Aquatic PlatformS

Through the use of his gliders, as well as the stationary sensors placed strategically along the coast, Dr. Jones can monitor the coastal ocean 365 days a year. He and his colleagues can see the latest satellite data downloaded from the gliders on their office computers, providing them with an invaluable real time view of what is happening off the coast of Southern California. Moreover, as he and his research team have become familiar with the oceanographic patterns off the coast, they are actually able to make near-term predictions on the timing, location, and likelihood of toxicity in local algal blooms.



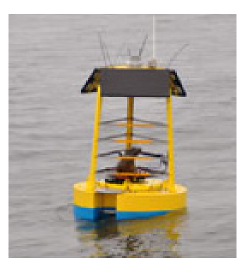
Diving glider. (Image courtesy of CINAPS)

"The ability for research to feed back into real change is difficult—this Sea Grant funded research allows us to do just that. Working closely with management agencies in Los Angeles and Orange counties, the Southern California urban ocean is really able to function as a laboratory where we can not only do scientific research but also immediately share that research with managers who can use it to better manage the urban coast. Sea Grant is able to provide a niche that other funding agencies do not provide."

-Dr. Burton Jones

Although Dr. Jones and his collaborators use Southern California as their testing ground, it is clear that other coastal areas, especially urban coasts, would also benefit greatly from such real time views and the information these views afford scientists. Thus, CINAPS is in collaboration with other ocean observing systems, including the Southern California Coastal Ocean Observing Systems (SCCOOS) sponsored by the California Coastal Conservancy and National Ocean and Atmospheric Administration.

Collaborations like this contribute to the overall national goal of creating a National Integrated Ocean Observing System. While urban environments will always have an effect on their coastal environments, there are ways to minimize negative impacts. A more precise, real-time understanding of coastal processes—both short and long term, on both regional and broad spatial scales—will allow urban managers to reduce any harmful effects, to the benefit of both marine and human health.



Buoys with physical and bio-optical sensors. (Images courtesy of the Jones lab and CINAPS).

At the Helm: From USC Sea Grant

Welcome to the fourth edition of the Urban Mariner: USC Sea Grant's Urban Ocean Report. Previous issues can be found at: http://urbanmariner.urban-ocean.org

The Southern California Bight contains 25% of the nation's coastal population—with Los Angeles as its urban center—making it an ideal outdoor laboratory for a better understanding of the anthropogenic effects on coastal processes. Understanding such complex systems and patterns requires an equally complex collaboration of scientists, technology, and coastal managers. The Center for Integrated Networked Aquatic PlatformS (CINAPS), located at USC, is a model of collaboration between researchers like Dr. Jones and other USC Sea Grant funded researchers like Dr. David Caron in aquatic microbial ecology. Other collaborators include Dr. Gaurav S. Sukhatme in USC's Departments of Computer Science and Electrical Engineering as well as other external partners such as the Southern California Coastal Water Resources Project, the Southern, Central and Northern California Ocean Observing Systems, the Applied Physics Laboratory at the University of Washington, the Center for Embedded Network Sensing at University of California Los Angeles, the Jet Propulsion Laboratory at California Institute of Technology, and the Monterey Bay Aquarium Research Institute.

As the impact of climate change becomes more obvious, it is even more critical that we form these collaborations to better understand the anthropogenic effects on the coastal ocean and to differentiate between natural and human-induced changes. If this can be done along the densely populated Los Angeles coast, one could argue it can be done anywhere.

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

Sea Grant
University of Southern California

For more information on Dr. Burton Jones, his lab, publications, and CINAPS please visit:
http://usclab.usc.edu/ and http://cinaps.usc.edu

Scientist's Quarters: About the Researcher

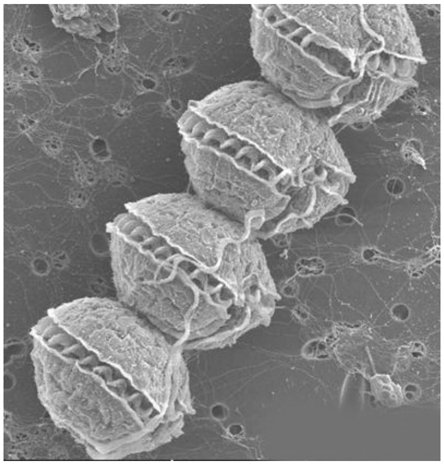
Dr. Burton Jones

Dr. Burton Jones, USC. (Image courtesy of CINAPS)

Although Dr. Burton Jones' lab is located in the basement of a building on USC's campus, the breadth of his view is still extraordinary. From his lab, he can see in real time how the ocean is behaving beneath the surface off the urban coast of Southern California. As a Research Professor in the Marine Environmental Biology section of the Department of Biological Sciences at USC, Dr. Jones is interested in biological oceanography, physical/biological interactions, ocean optics, ocean observing, and coastal urban issues. Specifically, he focuses on the coupling of phytoplankton processes in the ocean with the physical processes that affect the upper layer of the world's oceans. Although coastal California has served as Dr. Jones' main laboratory, he has also been involved in studying the dynamics of physical/bio-optical interactions in a variety of environments that include the Arabian Sea, Japan/East Sea, and the Adriatic Sea. He is involved regionally in the development of collaborations between academic research and regional monitoring agencies, dedicated to keeping an ongoing interaction between science and its application to better manage a complex urban environment like Southern California.

Burton Jones received a B.S. in biological engineering from the Rose-Hulman Institute of Technology in Terre Haute, Indiana in 1971, and Ph.D. in Biological Oceanography from Duke University in 1977. Before arriving at USC, Dr. Jones spent several years as a postdoctoral fellow in the Bigelow Laboratory for Ocean Sciences in the Gulf of Maine, which focuses on research of microbial processes affecting the productivity of the world's oceans, coastal seas, and estuaries. Dr. Jones has been a member of the Oceanography Society since 1987, the American Geophysical Union since 1981, and is currently Co-Chair of the Executive Steering Committee of the Southern California Coastal Ocean Observing System.

In Depth: About the Research

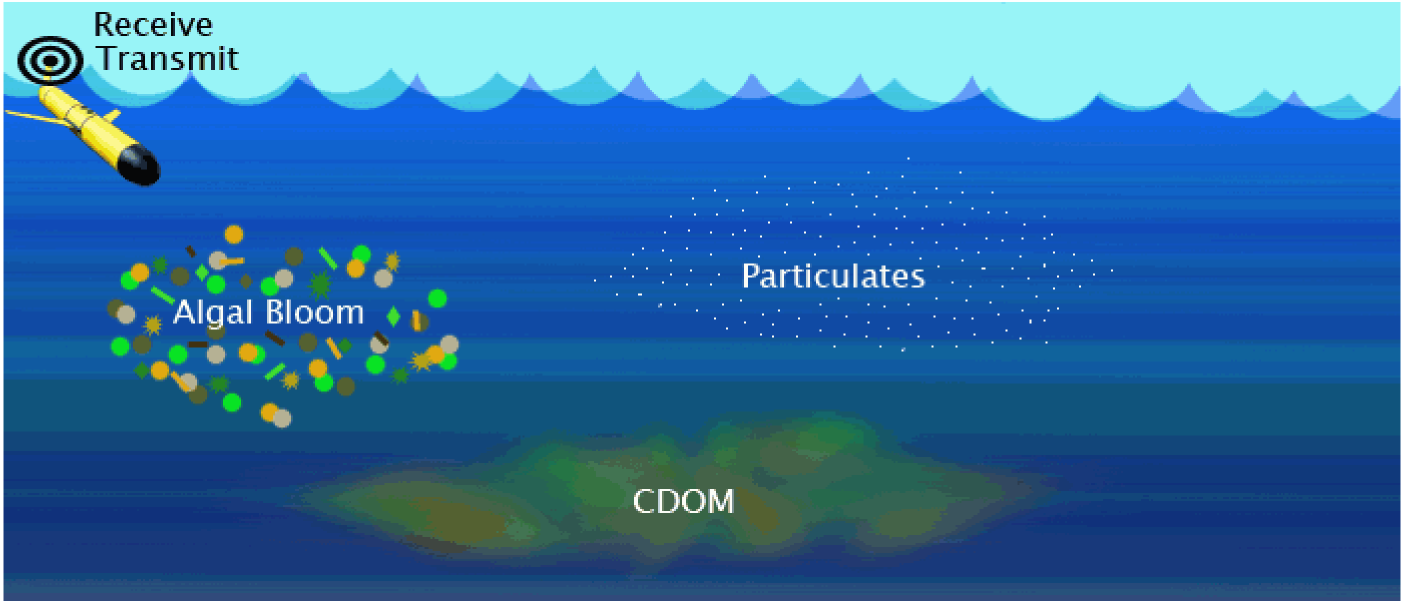


The alga, *Alexandrium catenella*, can release saxitoxin, which can accumulate up the marine food chain, causing severe illness and death in marine mammals, birds, and even humans. (Image courtesy of Caron Lab and photo credit: C. Thomas, UNCW)

Dr. Burt Jones and his research team study a variety of issues related to coastal oceanographic processes and use a variety of high-tech equipment to do so. One of the most important types of measurements Dr. Jones obtains is the optical properties of the water. The optical properties provide information about particle content, plant pigments, and dissolved organic matter. Like terrestrial plants, marine algae contain different pigment systems that capture certain wavelengths of light in order to photosynthesize, while simultaneously reflecting other wavelengths of light visible to our eyes.

One of the most common colors of light that both terrestrial plants and marine algae reflect is the color green. The fact that they reflect green light more than other colors indicates that they absorb many of those other wavelengths of light. It follows then that the optical properties of coastal water—the degree to which various wavelengths/colors of light penetrate or scatter—affect the growth of phytoplankton and algae floating in the water column or living on the ocean floor.

Bio-optical sensors are able to measure the optical properties of the water (the way light is penetrating and behaving), and methods have been developed from this data to characterize phytoplankton abundance, to estimate the amount of primary productivity (how large a bloom is), to discriminate between major types of phytoplankton, and to study physical processes expressed through these optical signals. For example, Dr. Jones and his team have been able to use a combination of physical signals (temperature, salinity) and bio-optical signals (beam attenuation at 660 nm, and the fluorescence from chlorophyll and colored dissolved organic matter) to differentiate an urban outfall plume of stormwater from the normal coastal water and to follow it over the course of several days to see how long it takes to dissipate.



This cartoon depicts a glider diving through the water column where it may encounter a number of physical and/or biological phenomena such as thermal and density gradients, patches of algae, colored dissolved organic matter (CDOM), suspended particulates, etc. (To see an animation of this sampling process and to see where the gliders are now, go to http://usclab.usc.edu/gliders.html)

In Depth: About the Research

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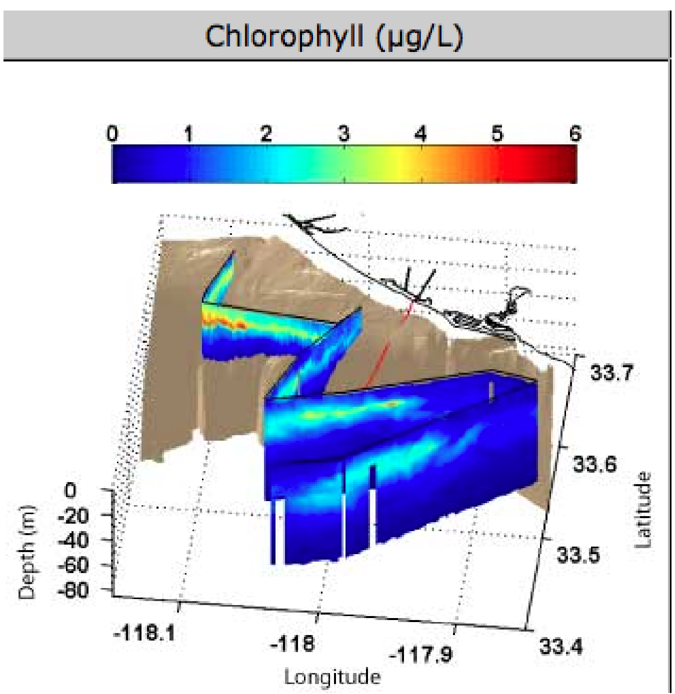
A stormwater plume will be filled with more dissolved organic matter and inorganic nutrients than the natural coastal water, which drastically effects the behavior of light moving through it, resulting in a distinct 'optical signature' in the data coming from the bio-optical sensors. Bio-optical sensors are used in conjunction with physical sensors and can be deployed on moorings or buoys, tow vehicles, and autonomous vehicles. Using autonomous underwater vehicles, or 'gliders,' Dr. Jones is able to gather real-time data on the depth, temperature, salinity, turbidity, chlorophyll-a fluorescence (an indicator of photosynthesis and therefore, a phytoplankton bloom), optical-backscatter, and dissolved organic matter.

A glider may be deployed for a couple months, during which time it dives and resurfaces continuously, using buoyancy-based propulsion, gathering data on designated intervals and relaying the data via satellite signal each time it surfaces. Coupling these high temporal and spatial resolution in situ glider measurements with shipboard grab samples (water samples, net tows, etc.), and then correlating them with satellite data and regional ocean models, enables Dr. Jones and his colleagues to find relationships in this data with oceanographic and anthropogenic processes occurring in the region.

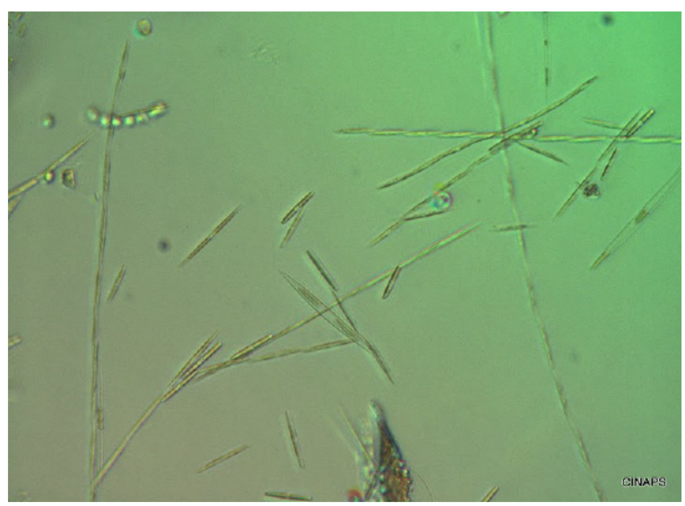


Example of 3D imagery from the track of one glider depicting chlorophyll (i.e. a phytoplankton bloom) present along the Orange County coast. (Photo courtesy of usclab.usc.edu)

Analyzing water samples in the lab. (Photo courtesy of CINAPS)

This type of data is invaluable for understanding and predicting the movement of bacteria and virus-laden urban run-off and the development and movement of harmful algal blooms, both of which are unsafe for humans. The data contributes directly to a better understanding of how to minimize and manage anthropogenic impacts on such an urban coastline.

> *"Subsurface mapping using gliders, fixed sensor platforms, remote sensing, and mapping of surface currents are just part of the tool set that we actively use to monitor the ocean and make the data available in real-time."*
>
> – Dr. Burton Jones

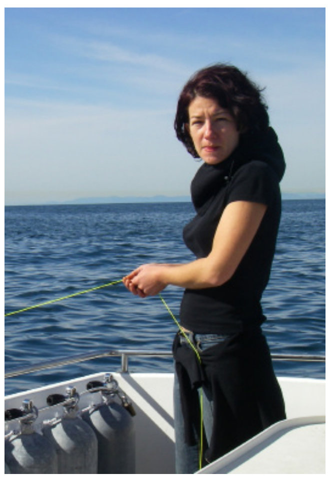


Like *Alexandrium catenella*, the alga *Pseudo-nitzshia* can release a toxin, domoic acid, which also can cause adverse effects as it accumulates up the marine food chain. Both are of concern and are the two target toxins for which the California Department of Public Health monitors. (Photo courtesy of CINAPS)

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 one of Dr. Jones' students, Dr. Ivona Cetinic, who was influenced by the opportunities for collaboration and policy applications of the Sea Grant funded research in Dr. Jones' lab.

Ivona Cetinic, Ph.D.
Postdoctoral Fellow, University of Maine, Darling Marine Center



Dr. Ivona Cetinic.

Dr. Ivona Cetinic received her Ph.D. at the University of Southern California working with Dr. Burton Jones. Dr. Cetinic's thesis focused mostly on how optical tools and various deployment platforms, such as the autonomous gliders, could benefit harmful algal bloom research off Southern California's coast. She also helped to develop ways to use the gliders with optical instruments to track different water masses with potential pollutants (stormwater plumes) in the coastal ocean in real time.

In 2009, Dr. Cetinic began a postdoctoral fellowship with Dr. Mary Jane Perry at the Darling Marine Center of the University of Maine. Dr. Cetinic is currently working on two projects. The first, the North Atlantic Bloom project, is focusing on an enormous phytoplankton bloom, which occurs off the east coast and is known to be the largest natural carbon drawdown—phytoplankton remove carbon dioxide from the atmosphere and use it to photosynthesize. Dr. Cetinic is using modern oceanographic tools to calculate carbon flux numbers and examine the processes governing those fluxes. Her second project is looking further into the usage of autonomous under water vehicles in studying marine biogeochemistry.

Dr. Cetinic retrieving a glider. (Image courtesy of CINAPS)

She focuses on whether these gliders can be a useful tool in monitoring the primary production in the coastal ocean as they are being shown to do in Southern California.

Dr. Cetinic is fascinated with studying the human-impacted coastal ocean and feels that better understanding coastal ocean processes—either physical or biogeochemical—will allow us to better see human impacts and how to minimize those impacts. According to Dr. Cetinic,"The skills and lessons I learned while working in the heavily populated Southern California bight were invaluable for my future work. Applied science—the science where scientific tools and results can be used right away for the benefit of the humanity or nature—is the type of work that Sea Grant funds and that I want to pursue in my career."

Dr. Cetinic received her B.S. in Biology and Ecology in 2001 at the University of Zagreb, Croatia.

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