

Caltech

William G. Kerckhoff Marine Laboratory

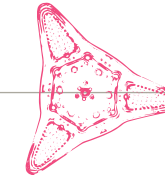


A NEW ERA
OF DISCOVERY



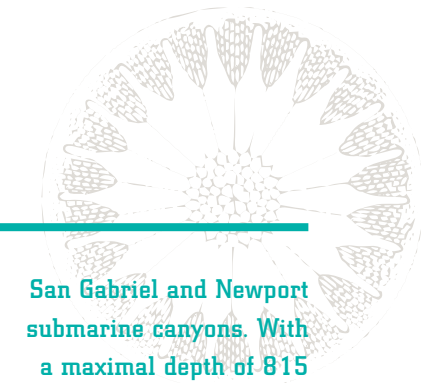
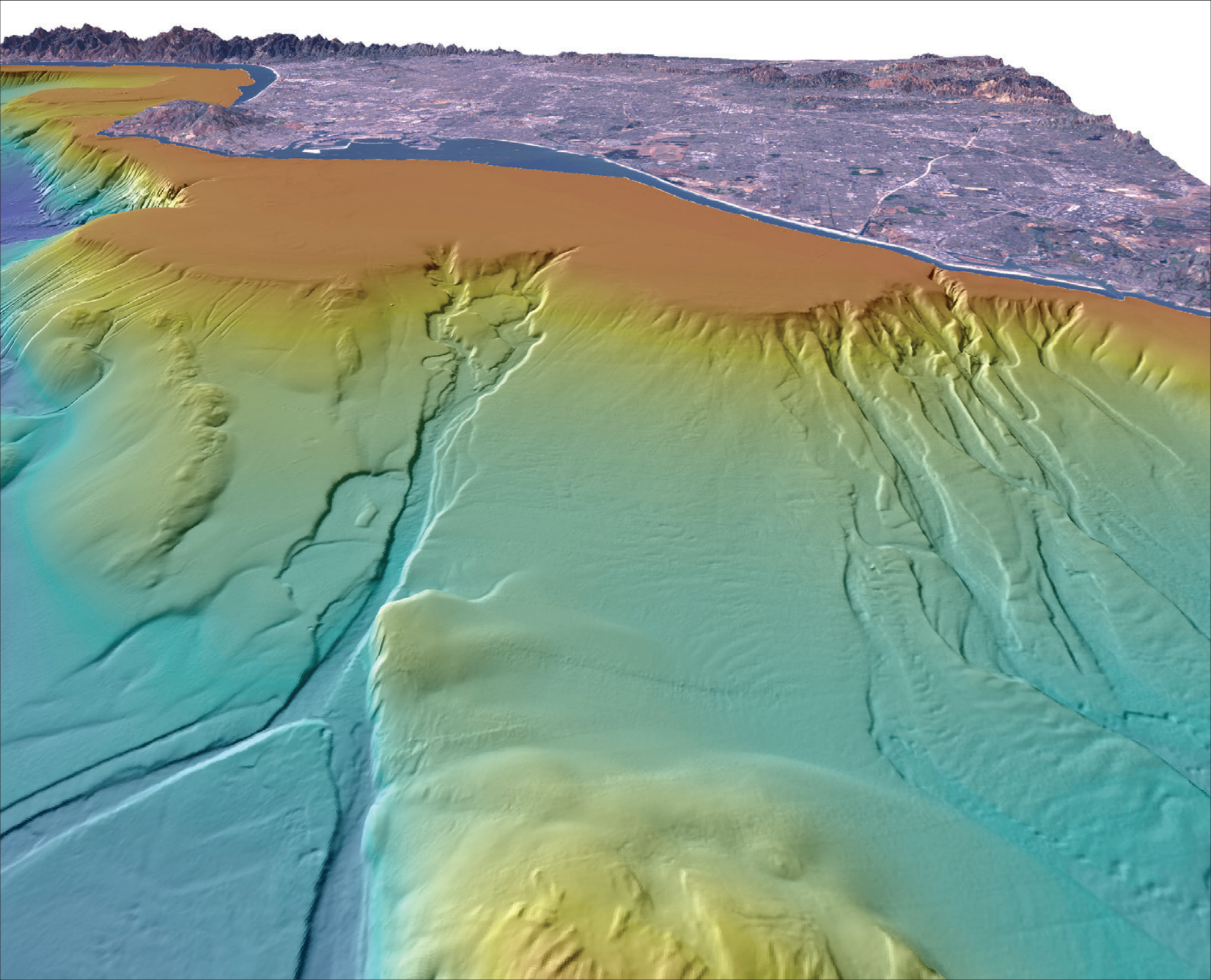
Prochlorococcus cells as seen through a colored transmission electron micrograph. These single-celled marine microorganisms are thought to be the most abundant photosynthetic organisms on Earth, playing an important role in regulating levels of carbon dioxide and oxygen in the atmosphere.

RESEARCH FROM ORANGE COUNTY, INSIGHT FOR THE WORLD



The William G. Kerckhoff Marine Laboratory in Corona del Mar—an iconic structure familiar to generations of Orange County residents—has provided Caltech faculty, postdoctoral scholars, and students a window into the natural world for nearly 90 years. Now Caltech aims to usher in a new era of marine-based research and exploration by revitalizing this gem by the ocean.



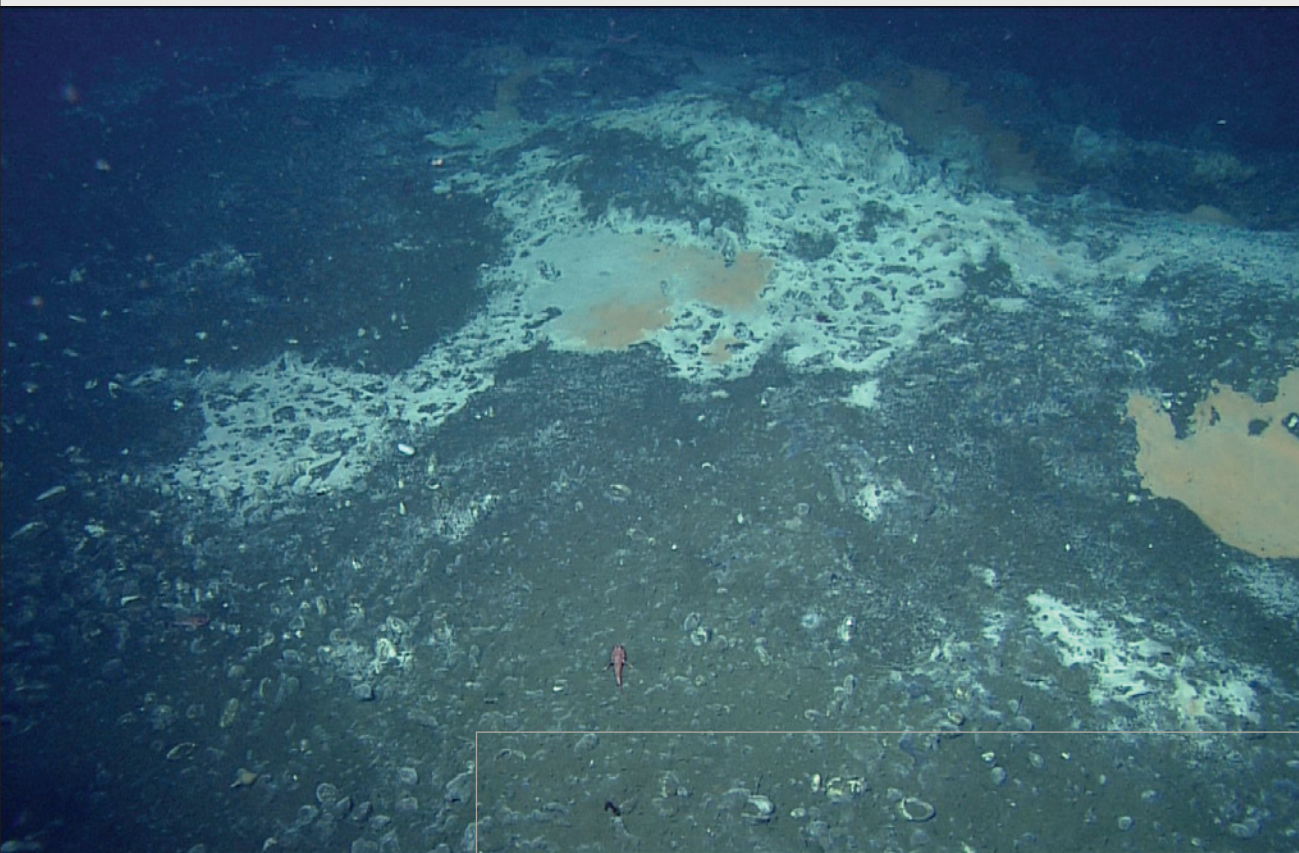


San Gabriel and Newport submarine canyons. With a maximal depth of 815 meters, these submarine canyons—just a stone's throw from the Kerckhoff Marine Laboratory—offer researchers unique opportunities to study deep-ocean processes close to the shore.



One of the oldest marine field stations on the West Coast, the Kerckhoff Marine Laboratory has enabled world-changing discoveries that have illuminated complex processes underlying human and ocean life.

Studying a rich set of marine organisms—including sea urchins, sponges, and mollusks—scientists have used the facility to help reveal the unique functions of the left and right sides of the brain, to decipher how cells interact with each other to make embryonic development possible, and to demonstrate the effects of pollution on ocean life.



Methane seep at the Santa Monica Basin. Methane-consuming microorganisms that live near methane seeps help sustain life for oases of chemically fueled animal life and multilayered microbial communities at the seabed.



Today, Caltech researchers are collaborating with colleagues at organizations such as JPL, Scripps Institution of Oceanography, the Monterey Bay Aquarium Research Institute, the USC Wrigley Marine Science Center, and the University of California, Irvine, to embark on an exciting new era of underwater exploration at the Kerckhoff Marine Laboratory. With its easy access to Newport Bay and Newport Submarine Canyon, the laboratory offers an ideal setting for ocean research and field-testing new technologies such as autonomous underwater vehicles to explore the oceans, floats that communicate with space-based satellites to gauge ocean temperatures, and other instruments for conducting cutting-edge environmental and engineering investigations off our coast.



To make this vision a reality, Caltech is looking to join with visionary philanthropic partners to undertake a significant rehabilitation of this historic facility. By transforming the lab into a modern hub for ocean science and engineering development, we will create new opportunities to forge foundational knowledge about our environment and about life itself.





Caltech alumnus and JPL robotics engineer John Leichty (BS '09) tests the Buoyant Rover for Under-Ice Exploration (BRUIE) at Kerckhoff Marine Laboratory's aquatic "Mars Yard." BRUIE is a prototype vehicle for NASA's future exploration of Europa.

Exploring Oceans— Here and on Other Worlds

You may know that rovers are probing Mars to determine whether the red planet supports microbial life. What you may not know is that leading up to these historic voyages, prototypes were tested in an area of rocky terrain known as the Mars Yard at JPL's campus in Pasadena.

As astronomers discover that our solar system contains more liquid and ice than previously imagined, scientists and engineers at Caltech and JPL are collaborating to invent tools to explore these ocean worlds. They envision the refurbished Kerckhoff Marine Laboratory as an aquatic "Mars Yard" where they can pursue and test their best ideas.

Collaboration at the Orange County facility has already begun using the Buoyant Rover for Under-Ice Exploration (BRUIE). Built to travel underneath the icy crusts of celestial objects and equipped with methane sensors, the two-wheeled BRUIE robot also can help us learn how methane forms on icy lakes here on Earth.

THE TOOLS OF TOMORROW: ENHANCING EQUIPMENT TO HELP ADVANCE DISCOVERY

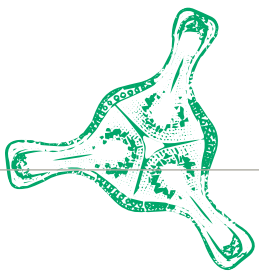
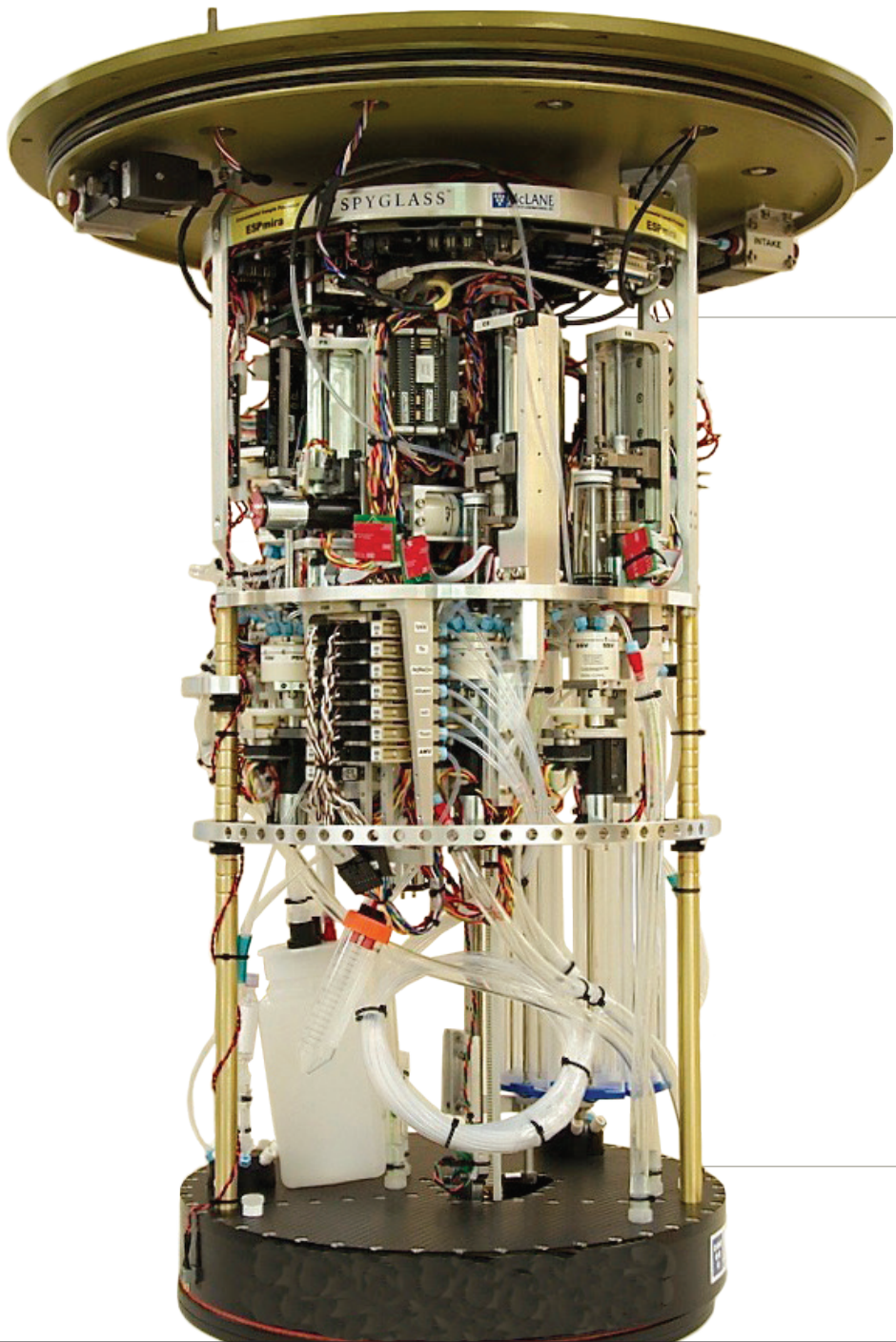


Elucidating the Global Carbon Cycle

The ocean, and its ability to take up and store carbon dioxide, plays a crucial role in stabilizing temperatures on Earth. To better understand whether the ocean will continue to take up carbon dioxide in a changing climate, scientists around the world are employing diverse types of robotic (floats, gliders, autonomous surface vehicles) and remote-sensing platforms, such as satellites, to gather information about ocean chemistry, biology and circulation. However, the ocean's size and diverse regional characteristics pose challenges for these platforms, which need to be piloted or assessed by humans on a daily basis.

Caltech researchers, working with partners at JPL and the Woods Hole Oceanographic Institution, envision a future where large networks of ocean robotics, with various engineering and scientific capabilities, communicate with each other as well as with satellite data and shore-based predictive models to autonomously determine and implement optimal sampling strategies based on prevailing ocean conditions.

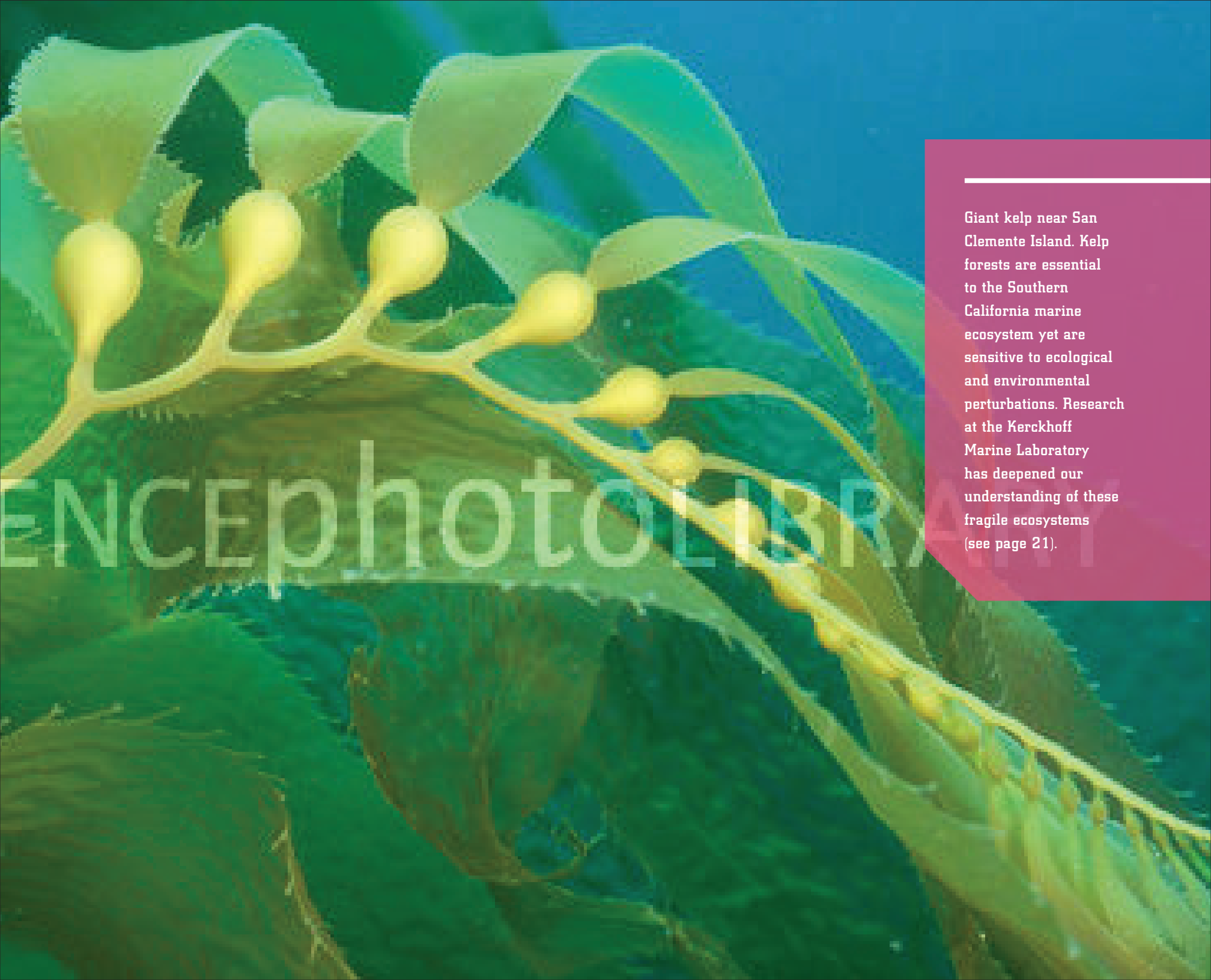
The Kerckhoff Marine Laboratory could serve as an important testing site for these new techniques.



Understanding Marine Microbial Life

Oceans cover 70 percent of Earth's surface and are teeming with life—from enormous aquatic mammals to organisms unseen by the human eye—yet we are just beginning to make strides in studying the deepest parts of our oceans.

Collaborating with colleagues from the Monterey Bay Aquarium Research Institute, Caltech scientists are harnessing the potential of the Deep Environmental Sample Processor (pictured left) to detect microbial marine life in situ. Functioning as a deep-sea laboratory, this instrument collects real-time data about the diversity and activity of microorganisms in situ. Access to the submarine canyon near the Kerckhoff Marine Laboratory will enable scientists to continue to enhance this instrument to detect dynamic microbial processes in unexplored deep-ocean regions off our coast.



Giant kelp near San Clemente Island. Kelp forests are essential to the Southern California marine ecosystem yet are sensitive to ecological and environmental perturbations. Research at the Kerckhoff Marine Laboratory has deepened our understanding of these fragile ecosystems (see page 21).

COLLABORATIVE AND CURIOUS: CALTECH SCHOLARS PURSUE MARINE-BASED INVESTIGATIONS

A renewed Kerckhoff Marine Laboratory will serve a variety of Caltech faculty, postdoctoral scholars, and graduate students who use marine organisms to further their investigations—from studying jellyfish to elucidate the evolutionary origins of sleep to observing Earth's climate history by dating sediments deep in the ocean floor. The laboratory also will host faculty who wish to make the ocean a living classroom for undergraduates studying geobiology and environmental science.



NEXT ARE SNAPSHOTS OF HOW SOME CALTECH SCHOLARS
PLAN TO USE THE REVITALIZED LABORATORY.





VICTORIA ORPHAN

Victoria Orphan, Caltech's James Irvine Professor of Environmental Science and Geobiology and a 2016 MacArthur Fellow, studies the important role marine microbes play in making Earth habitable for larger organisms—including us.

Microbes help produce most of the oxygen we breathe, consume methane deep in the ocean floor, and keep large amounts of carbon out of the atmosphere. Orphan wants to determine if marine microbial life will continue to function as a “first responder” in the carbon cycle as Earth's climate continues to change. She is pursuing this question in partnership with colleagues from JPL, the Monterey Bay Aquarium Research Institute, and Scripps Institute of Oceanography as well as from USC, the University of Queensland, and the Japan Agency for Marine-Earth Science and Technology. Access to the Kerckhoff Marine Laboratory will enable Orphan and her colleagues to engage in sustained and quantitative in situ and shore-based studies that are essential for understanding the links between marine microorganisms and the cycling of carbon and nutrients in the deep sea and coastal areas.

MORY GHARIB



Mory Gharib, Caltech's Hans W. Liepmann Professor of Aeronautics and Bioinspired Engineering, directs the newly established Center for Autonomous Systems and Technology (CAST). This science and engineering hub is dedicated to improving machines and robots so they can “think” better for themselves—such as adapting to physical changes in the environment and learning new tasks. Access to the Kerckhoff Marine Laboratory will offer Gharib and other members of CAST fruitful opportunities to test their autonomous systems for airborne and marine research.



Caltech professor of environmental science and engineering Andy Thompson (center) with (from left) JPL postdoctoral scholar Andrew Dellar, Caltech graduate students Giuliana Viglione and Xiaozhou Ruan, and Council for Scientific and Industrial Research technician Jean-Pierre Smit.

» ANDY THOMPSON

Andy Thompson, professor of environmental science and engineering, deploys autonomous robotic gliders in the most remote regions of the Southern Ocean, near Antarctica, to collect data on ocean currents and heat content. His research revealed the mechanism by which warmer waters were moving toward Antarctica and causing ice shelves to melt, a finding that may enable climate modelers to more accurately determine how quickly sea levels are rising.

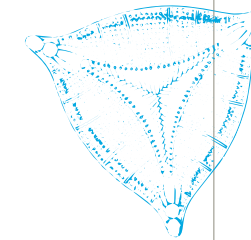
Yet even more valuable knowledge about the Southern Ocean is possible. Together with partners from JPL and the Woods Hole Oceanographic Institution, Thompson is creating a future in which a wide assortment of submersibles—augmented with artificial intelligence—plot their own courses in the deep ocean, searching for life and changes in water temperatures. With its nearby sea canyons and teeming aquatic life, the Kerckhoff Marine Laboratory will be a prime testing ground for these prototypes.



THE KERCKHOFF MARINE LABORATORY: A DISTINGUISHED LEGACY

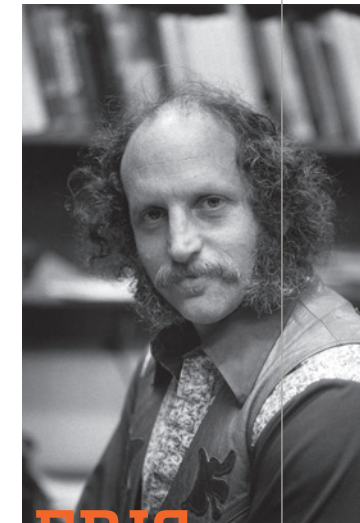
In the late 1920s, scientists Robert A. Millikan, Arthur A. Noyes, and George Ellery Hale were intent on building Caltech into a preeminent research institution. Hale had just recruited famed geneticist and future Nobel laureate Thomas Hunt Morgan to lead Caltech's newly established Division of Biology when Noyes saw an opportunity in the Corona del Mar neighborhood of China Cove. Noyes, who kept a summer home in the area, learned that the beach club he belonged to—the Balboa Palisades Club—was for sale. He envisioned transforming the club's boat and bath houses into a beachfront laboratory that would further amplify Caltech's commitment to the life sciences.

Using funds contributed by Caltech trustee and lumber and electricity tycoon William G. Kerckhoff, Caltech purchased the property. Since its opening as the Kerckhoff Marine Laboratory in 1929, the facility has been an important fixture in Orange County. The building, with its distinctive tower, has appeared in postcards and photographs to promote tourism. And Caltech scholars have invited researchers from Orange County and around the world to visit the laboratory and collaborate on wide-ranging scientific projects.



NEXT IS A SAMPLING OF INVESTIGATORS WHOSE HISTORIC CONTRIBUTIONS
TO SCIENCE BEGAN WITH BASIC RESEARCH AT THE LABORATORY. ➤

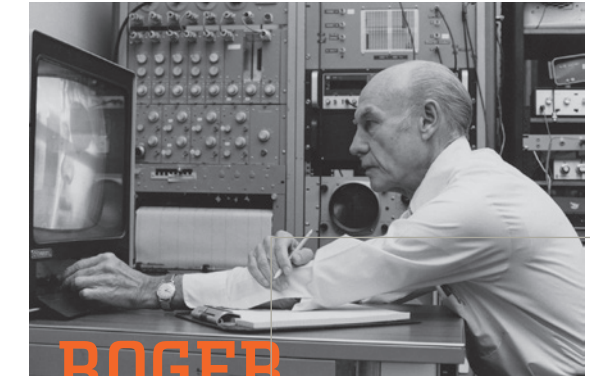
Immature spines of the purple sea urchin as seen through a colored scanning electron micrograph. The Kerckhoff Marine Laboratory has supplied purple sea urchins for many studies, including Caltech development biologist Eric Davidson's groundbreaking effort to sequence its genome (see page 21).



ERIC DAVIDSON

(1937–2015)

Eric Davidson, Caltech's Norman Chandler Professor of Cell Biology, had long been fascinated with how a single-celled egg could transform into a complex organism. At the Kerckhoff Marine Laboratory, he found an abundance of purple sea urchins—whose genetic makeup is remarkably similar to our own—and embarked on an ambitious effort to sequence its genome. His pioneering studies of how genes interact with each other to control specific cell functions open up new possibilities for replacing damaged or missing cells in humans.



ROGER SPERRY

(1913–1994)

Roger Sperry, Caltech's Hixon Professor of Psychobiology and later the Board of Trustees Professor of Psychobiology, made Nobel Prize-winning contributions to our understanding of the unique functions of the left and right sides of the brain. Part of Sperry's foundational research for this landmark discovery involved examining animals at various scales, including studying nerve regeneration in fish at the Kerckhoff Marine Laboratory.



WHEELER NORTH

(1922–2002)

Wheeler North, professor of environmental science and also a Caltech alumnus, explored the waters off the Southern California coast to elucidate the effects of pollution on the marine ecology. North's research created a new understanding of how sewage spurs growth in the sea urchin population, in turn depleting the beds of kelp that nourish and shelter other organisms. He established techniques for kelp bed restoration and monitored the effects of oil spills on marine life.

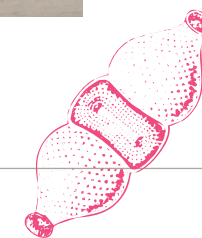


LOOKING AHEAD: A FACILITY FOR FUTURE- FOCUSED INQUIRIES



When renovations are complete, the exterior of the Kerckhoff Marine Laboratory will maintain its historic design as a visual tribute to Orange County's heritage. The interior of the 17,650-square-foot structure, however, will be as future-focused and innovative as the people who use it. Scientists and engineers will work in laboratories outfitted with state-of-the-art equipment, build and test underwater autonomous vehicles in a new mechanical yard, and teach students in a modern classroom space. A reconfigured pier will better account for sea level rise and storm surges, and the lifeblood of the laboratory—the seawater system that pumps water from the ocean to sustain a rich set of aquatic organisms—will be upgraded to ensure that it can continue supporting marine life under investigation inside the lab.

For the better part of a century, scientists have leveraged Caltech's Kerckhoff Marine Laboratory and Orange County's natural resources to advance our understanding of marine ecosystems and illuminate the biological mysteries of life. Now, with the support of visionary philanthropic partners, a reinvigorated facility will empower Caltech faculty researchers and their students—the scientists and engineers of tomorrow—to pursue scientific breakthroughs and generate new ideas, solutions, and technologies that will benefit Orange County and the world.



Caltech

William G. Kerckhoff Marine Laboratory

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