ANNUAL REPORT 2017

advancing sustainability and the oceans

SCRIPPS INSTITUTION OF OCEANOGRAPHY, UC SAN DIEGO

Researchers at Scripps Institution of Oceanography at UC San Diego perform an aerial Light Detection and Ranging (LIDAR) survey of the Southern California coastline to measure coastal response to the 2015-2016 El Niño.

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Cover image: *Scripps graduate student Isabella Arenzo is taking measurements of sand elevation at the Los Peñasquitos Lagoon using a high-precision GPS instrument. This particular survey was conducted during the 2015-16 El Niño in order to investigate the estuarine response to extreme water level events. Photo credit: Sarah Giddings*

FROM THE DIRECTOR

At Scripps Institution of Oceanography at UC San Diego, we work to better understand our planet so we can solve the world's most challenging environmental problems.

We chose Sustainability of the Oceans as a focus for this year's annual report as it is an issue of paramount international importance and an issue for which our work at Scripps Oceanography is critical. In June, Scripps had a major presence at the United Nations international conference on Sustainable Development Goal 14 – sustainability of the ocean – in New York (page 25).

We continued to make major discoveries in research this year, and you'll see a small selection of that work (pages 4-7) across Scripps' four focused research initiatives: climate change impacts and adaptation, human health and the oceans, resilience to hazards, and innovative technologies to observe the planet. All of these include work essential for ocean sustainability.

On the cover, we've highlighted coastal research being done by the Giddings Lab at the Los Peñasquitos Lagoon in Del Mar, Calif. More than just a beautiful image, it shows our work at the intersection of climate change impacts, human health, and technology. Scripps scientists study sand movement near the lagoon inlet and how waves transport sand into the intermittently open estuary. This research helps inform coastal managers how to maintain the health of estuaries, which when closed become a breeding ground for disease-carrying mosquitoes, and understand how they might be impacted during extreme water-level events.

As always, key elements of our research would not be possible without philanthropy. Thank you to our donors for their generosity during the past year.

An important grant we received from the National Science Foundation will allow us to continue the Scripps Undergraduate Research Fellowship (SURF) program for another five years. This summer program recruits diverse and talented students from colleges and universities across the country, many of which

have limited marine research opportunities. UC San Diego has made increasing the diversity of its student population a top priority and the SURF program successfully builds a pipeline for underrepresented students into graduate programs and careers in marine science. There are ten former SURF students now making a splash as Scripps graduate students!

I would also like to give special recognition to Walter Munk for his 78th year of service to Scripps. The science icon turned 100 years old on Oct. 19, 2017, and we have spent this year celebrating Walter and the science he helped shape. On behalf of the entire community, I thank Walter for his lifetime of work transforming how the world understands the ocean, and for inspiring our faculty, students, staff, and supporters to be daring.

Thank you, all, for making this a great year.

Margaret Leinen
Director, Scripps Institution of Oceanography
Vice Chancellor for Marine Sciences
UC San Diego

RESEARCH HIGHLIGHTS

SUSTAINABILITY AND THE OCEANS

Scripps scientists are always finding new ways to study human impact on our oceans and creating innovative tools for sustainable management of fisheries and ecosystems.

In the past year, professor Bradley Moore and researcher Abrahim El Gamal from the Scripps Center for Oceans and Human Health identified an enzyme in marine bacteria that could help break down hazardous industrial chemicals.

Fishermen in the Gulf of Mexico

In another study, Scripps grad student Timothy Rowell and Scripps marine ecologist Octavio Aburto-Oropeza partnered with local fishermen in the Gulf of Mexico to find a surprising new tool for fishery management: the fishes' own mating calls. The Gulf Corvina is a fish native to the Gulf of Mexico, and every year all 2 million of these fish come together for a mating frenzy, distinguished by the earsplitting sounds of the male mating calls. An underwater microphone that measures the mating calls found that if they were on land, the songs would be "louder than a rock concert."

The downside to the din is that it makes it easy for fishermen to scoop up huge amounts of corvina at once; the noise leads them right to the fish. Because the entire species spawns in one location, this makes the Gulf Corvina very vulnerable to overfishing, but monitoring the species population had been too difficult and expensive—until now. Rowell and Aburto-Oropeza along with co-authors from the University of Texas at Austin have found an upside to the fish noise: it can be used to estimate the population size, and thus used to design effective management practices to protect Gulf Corvina from overfishing.

The new technique relies on underwater microphones and is cheaper than most traditional methods. Local fishermen collaborated with the scientists on the project, and Aburto-Oropeza says he hopes they can be trained to use the hydrophones to monitor the Gulf Corvina themselves. After all, "they're the ones most interested in sustainability," he said.

Research Highlights *Scripps Oceanography is one of the most important centers for global science and education in the world. Hundreds of research programs covering a wide range of scientific areas are underway on every continent and in every ocean.*

CLIMATE CHANGE IMPACTS AND ADAPTATION

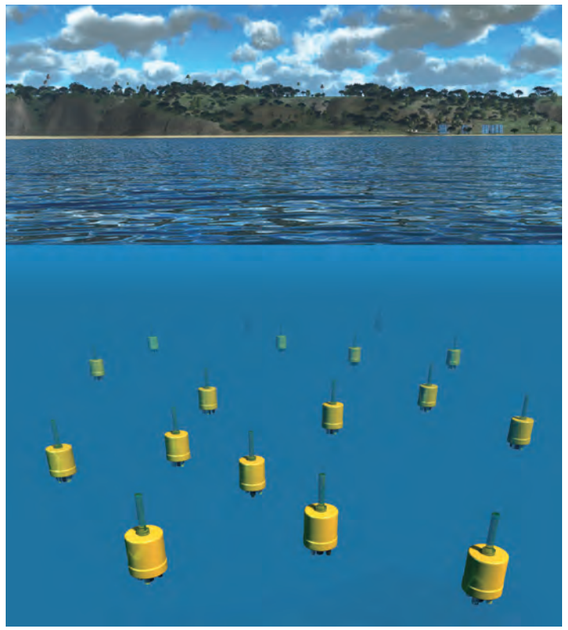
Researchers Capture Large-Scale Antarctic Melt Event

Scripps scientists had a hand in making the first comprehensive atmospheric measurements on the West Antarctic Ice Sheet since the 1960s. In 2016, Scripps scientists were on the frozen continent to document a melting episode on a landbound mass of ice larger than Mexico.

The West Antarctic Ice Sheet experienced substantial surface melt through the austral summer of 2015-16 during one of the largest El Niño events of the past 50 years. A science team conducting the ARM West Antarctic Radiation Experiment (AWARE) led by Scripps researchers reported that El Niño likely delivered warm air bearing moisture and extensive cloud cover over the ice sheet, causing the melt. Melted snow was spotted over most of the Ross Ice Shelf, a thick platform of floating ice that channels about a third of the ice flowing from the West Antarctic Ice Sheet into the ocean.

"We were extraordinarily fortunate to be able to deploy state-of-the art equipment to West Antarctica just before this large melt event occurred," said AWARE principal investigator Dan Lubin, a research physicist at Scripps Oceanography. "These atmospheric measurements will help geophysical scientists develop better physical models for projecting how the Antarctic ice sheet might respond to a changing climate and influence sea-level rise."

INNOVATIVE TECHNOLOGY: ROBOTIC PLANKTON MIMIC OCEAN LIFE



This year, Scripps researchers developed underwater robots that mimic plankton to study ocean currents and the microscopic organisms that drift with them.

Scripps research oceanographer Jules Jaffe designed and built miniature autonomous underwater explorers to study small-scale environmental processes taking place in the ocean. The ocean-probing instruments are equipped with temperature and other sensors to measure surrounding ocean conditions while the robots "swim" up and down to maintain a constant depth by adjusting their buoyancy.

The robotic plankton were tested by Jaffe and Scripps biological oceanographer Peter Franks during an experiment in which a swarm of 16 grapefruit-sized underwater robots were deployed off the coast north of Scripps. The robotic swarm was programmed to stay 10 meters (33 feet) deep, and three-dimensional location information was collected every 12 seconds revealing where the swarm moved.

The experiment helped researchers confirm that free-floating plankton can use physical dynamics of the ocean—in this case internal waves—to increase their concentrations to congregate into swarms to fulfill their fundamental life needs. The research team hopes to build more to study the movement of larvae, monitor harmful red tide blooms, and track oil spills.

This technology builds on Scripps' history of innovative ocean observation, including the Argo free-drifting profile floats, the Coastal Data Information Program (CDIP), and High Frequency Radar surface current measurements.

RESILIENCE TO HAZARDS: WILDFIRE WARNING

In California, a longer fire season is becoming the new norm and wildfires are a growing hazard facing the entire state.

Over the last decade, a collaborative team of researchers at UC San Diego built a network across areas most prone to wildfires in San Diego's back country, creating a multi-hazard detection system with a microwave communications network, seismic sensors, wildfire monitoring, meteorological capabilities, and more.

In Oct. 2017, San Diego Gas & Electric (SDG&E) partnered with UC San Diego to install 15 high-definition cameras that offer a live-streaming view of San Diego's biggest fire threat areas. The new Alert SDG&E Cameras have live and time-lapse video, can pan-tilt-zoom, use near-infrared capabilities for night vision, and link to incident command centers to notify fire officials when smoke appears.

The cameras are controlled by San Diego fire agencies, SDG&E, and UC San Diego. The public can access the cameras at alertwildfire.org/sdge.

HUMAN HEALTH & THE OCEANS

Toxic Sea Sponges and Pollutants in Yellowfin Tuna

Researchers at Scripps continued to unravel complex connections between human health and the oceans. Scripps postdoctoral researcher Vinayak Agarwal and graduate student Jessica Blanton led a team of collaborators from several universities in a study that discovered that microbes in sea sponges produce chemicals very similar to polybrominated diphenyl ethers (PBDEs). PBDEs are a type of flame-retardant that are added to foam, textiles, and electronics. These human-made industrial chemicals are powerful endocrine disruptors that mimic the activity of the human body's most active thyroid hormone.

"For many years scientists were finding clues that suggested nature was making these compounds," said study author Bradley Moore, a professor at the Scripps Center for Marine Biotechnology and Biomedicine and the Skaggs School of Pharmacy and Pharmaceutical Sciences at UC San Diego. "Now that we understand how they are produced in the marine environment, we are exploring why they exist, and the human health concerns associated with them."

Human-made PBDEs are part of a class of compounds known as persistent organic pollutants (POPs) that includes pesticides and other industrial chemicals that accumulate in organisms—including fish and humans—and lead to negative health impacts.

In a separate study, a team led by Scripps postdoctoral researcher Sascha Nicklisch found that levels of POPs in the muscle tissue of yellowfin tuna vary widely depending on where they are caught. Levels were as much as 36 times higher in tuna caught in the more industrialized areas of the northeast Pacific Ocean and northeast Atlantic Ocean than in tuna caught in the west Pacific Ocean and Indian Ocean. This new information suggests that catch location could be used to guide consumer choices and to help reduce exposure to these pollutants.

Scripps Center for Marine Archaeology Debuts

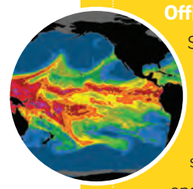
Scripps Oceanography and the Department of Anthropology at UC San Diego launched the Scripps Center for Marine Archaeology (SCMA). SCMA researchers will conduct fieldwork at key underwater and coastal archaeological sites around the world, studying the influence of marine environments on human cultures.

First Glimpse of Ruby Seadragon Caught in the Wild

In April 2016, Scripps marine biologists Josefin Stiller and Greg Rouse were part of the scientific team that made the first-ever field sighting of the Ruby Seadragon, spotted near Western Australia's Recherche Archipelago. This rare glimpse of the third species of seadragon was captured on a video that now has more than 1.8 million views on YouTube.

Scripps Science Informs SUPER Act Bill

Driven by research on short-lived climate pollutants conducted at Scripps by atmospheric scientist Veerabhadran Ramanathan, in June 2017 Rep. Scott Peters (CA-52) and Rep. Carlos Curbelo (FL-26) introduced the bipartisan Super Pollutant Emissions Reduction (SUPER) Act, to help reduce the emission of climate pollutants including black carbon, hydrofluorocarbons, and methane.



'Atmospheric River' Becomes an Official Meteorology Term

Scripps research meteorologist F. Martin Ralph led an American Meteorological Society (AMS) effort to define atmospheric rivers, the study of which Ralph has pioneered, and add it to the AMS glossary in 2017. The definition of the phenomenon vital to the water supply of California is "a long, narrow, and transient corridor of strong horizontal water vapor transport that is typically associated with a low-level jet stream ahead of the cold front of an extratropical cyclone."

EDUCATION **GROWTH** IN 2017

Scripps Oceanography remains a world-class institution thanks to the instruction and mentorship provided by its stellar faculty. Scripps welcomed four new faculty this year, including several with joint appointments in other UC San Diego departments, bridging Scripps science with humanities, health sciences, engineering, and more.

NEW MAJOR OFFERED TO UNDERGRADUATES

This year, Scripps Oceanography began offering an undergraduate degree in oceanic and atmospheric sciences, the fourth undergraduate degree administered through Scripps. Students pursuing a bachelor's degree in the new major will develop an understanding of the fundamental physics and chemistry governing the ocean and atmosphere.

The major is distinctive because of its breadth and the ways it gives undergraduate students unprecedented access to resources at Scripps.

"With the launch of this major, Scripps hopes to forge a new path for undergraduate oceanographic education," said oceanographer Daniel Rudnick, one of the professors who led the effort to implement the new major.

In total, Scripps serves more than 4,000 undergraduates in 74 courses taught across UC San Diego.

EDUCATION

***Education** offerings at Scripps Oceanography continued to expand throughout the 2016-17 academic year to meet the needs of a growing student population. Scripps students, whether enrolled in a doctoral, master's, or undergraduate program, are among the best and brightest and represent the future of earth, ocean, and atmospheric science.*

SCRIPPS STUDENT RECEIVES SWITZER ENVIRONMENTAL FELLOWSHIP

Scripps Oceanography PhD student Natalya Gallo was selected as a 2017 recipient of the Switzer Environmental Fellowship, a program of the Robert and Patricia Switzer Foundation providing support to emerging leaders committed to solving real-world environmental problems.

Gallo's research focuses on how climate change impacts marine communities, and particularly climate-driven oxygen decline in the ocean. She has participated in four international climate negotiation conferences held by the United Nations, as well as the Ocean Conference and World Oceans Day.

"The fellowship provides financial support to allow me to continue my scientific and policy outreach efforts on ocean and climate change issues, and provides critical leadership training," said Gallo.

SCRIPPS STUDENT RECOGNIZED FOR INNOVATIVE RESEARCH ON WHALE BEHAVIOR

Eric Keen, a recent graduate student at Scripps Oceanography, was selected as the 22nd recipient of the Edward A. Frieman Prize for Excellence in Graduate Student Research. The Frieman Prize is awarded annually to a Scripps graduate student who has excelled in his or her research field, as measured by a recent publication.

Keen's winning study examined how mobile predators such as rorqual whales, the largest group of baleen whales, deal with mobile prey in a marine ecosystem. Keen and a small team of researchers conducted visual and acoustic transect surveys and behavioral observations of fin and humpback whales in the northern fjords of British Columbia during the summers of 2014 and 2015.

To execute the research on a limited budget, Keen purchased a small sailing vessel, R/V *Bangarang*, and selected the three-person research crew from among his network of friends and scientists. He also coordinated with the Gitga'at First Nation, one of the 14 tribes of the Tsimshian Nation in British Columbia, which helped facilitate the research.

WEATHER ON STEROIDS EXHIBIT MERGES SCRIPPS CLIMATE SCIENCE WITH ART

Creativity met climate change in a compelling exhibition titled, "Weather on Steroids: The Art of Climate Change Science." The exhibition debuted at the La Jolla Historical Society in the spring, and is the result of a collaboration between climate scientists at Scripps Oceanography and eleven renowned artists. Through artwork ranging from sculpture and photography to mosaic and sound, the science-inspired showcase creates a visual dialogue about the vexing problem of climate change.

Following its initial run, "Weather on Steroids" moved to the San Diego Central Library Gallery, and the Aquarium of the Pacific in Long Beach.

PUTTING SCIENCE IN YOUR COMIC-CON

Researchers from Scripps Oceanography suited up for San Diego Comic-Con International this summer, reaching a pop culture audience during a panel focused on putting "More Science in Your Fiction." The panel was led by the League of Extraordinary Scientists and Engineers and included Scripps participants Ben Frable, marine vertebrate collection manager; Andrew Allen, associate professor of microbial oceanography, ecology and genomics; and marine biology graduate student Angela Zoumplis.

Panelists took questions from an audience of nearly 200 on topics ranging from the best and worst science they've seen in fiction to how their fields would be affected by global warming. Audience members asked Frable about his favorite fishes and what he considered to be the collection's weirdest specimens. His answer: the stargazer, a fish with eye muscles that evolved to transmit electric shocks.

OUTREACH

Outreach *Educators, students, staff, and volunteers at Scripps made waves through outreach to the public in 2017. From classrooms to Comic-Con, Scripps brought science to the community in new and creative ways.*

SALLY RIDE SCIENCE PROGRAMS INSPIRE YOUTH

Summer 2017 marked the second year that the Sally Ride Science Junior Academy offered innovative science, technology, engineering, arts, and math (STEAM) workshops for middle to high school-age students. These hands-on learning experiences are taught by top-notch instructors, the majority of whom are affiliated with Scripps Oceanography, including seismologist Debi Kilb, science outreach director of the Junior Academy.

Sally Ride Science is an education company that Ride, the first American woman in space, co-founded in 2001 to ignite student enthusiasm for science. Students assume the roles of space explorer, ocean engineer, computer scientist, and more as they immerse themselves in hands-on projects. Non-traditional class offerings such as "Pirate Science," "Slimy Sea Creatures," and "Music of Earthquakes" were designed to entice students who might shy away from the sciences.

SMARTFIN/SURFRIDER CITIZEN SCIENCE COLLABORATION FOSTERED BY SCRIPPS SCIENTISTS

A summer Surfrider meeting at Karl Strauss Brewery offered a taste of science paired with brews on tap. The quarterly meeting of surfers featured an unprecedented prize giveaway: some would go home with a new Smartfin, a surfboard fin equipped with sensors to record ocean data.

Smartfin is a collaboration among researchers at Scripps Oceanography, the Surfrider Foundation, and the nonprofit Lost Bird Project. The Smartfin records ocean temperature and location data, which can be uploaded and shared with scientists via a smartphone app. Scripps scientists Phil Bresnahan and Tyler Cyronak, members of the Smartfin team, helped develop the high-tech fin.

More than 20 happy surfers, now citizen scientists, went home with a new Smartfin, and are now sharing important coastal zone data.

R/V SALLY RIDE

R/V *Sally Ride*'s historic arrival in home port at the Nimitz Marine Facility in Point Loma in August 2016 marked a major milestone for Scripps, but not the end of our effort to develop the vessel into a world-class research machine.

SCRIPPS FLEET

Scripps Fleet *Scripps operates oceanographic research vessels recognized worldwide for their outstanding capabilities. Equipped with innovative instruments, these ships are mobile laboratories and observatories serving students and researchers throughout the world.*

Scientific Verification

Our commitment to the U.S. Office of Naval Research involved a year-long period of configuring, testing, and proving R/V *Sally Ride*'s systems and instruments. To accomplish this, we organized a series of science verification cruises under the leadership of scientists from Scripps and across the country who are experts in expeditionary oceanography. Missions were organized to test the vessel's capabilities, including dynamic positioning, seafloor sampling, deep- and shallow-water mooring installation, biological net sampling, water column profiling, heavy instrument overboarding using the starboard side handling systems (robot arms), autonomous underwater vehicle operations, midwater imaging for fisheries research, seafloor imaging, and dozens of other capabilities.

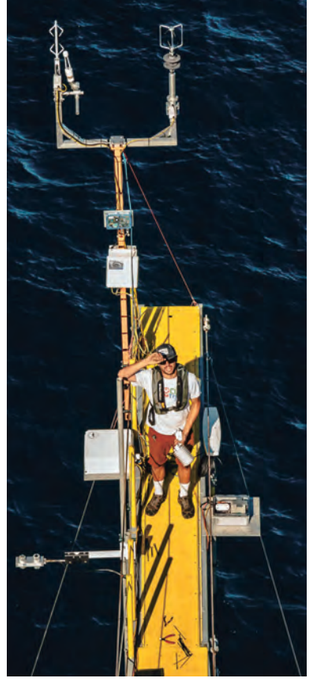
Additional scientific instruments were also installed, including a scientific wave radar, a flow-through CO_2 system to continuously monitor CO_2 in the surface water, an upgrade to the shallow-water seafloor imaging system, and enterprise-level computing infrastructure.

Research Missions

With the testing completed and modifications made, the long journey to bring a new Ocean Class vessel into operation is now complete. R/V *Sally Ride* has embarked on regularly scheduled scientific research missions and successfully carried out major funded research programs in the California Current, the Channel Islands, the California Borderlands, Ocean Station Papa (Gulf of Alaska), and an ambitious multi-ship program off Point Sal.

R/V ROGER REVELLE

R/V Roger Revelle completed a series of significant research programs during the past year that fully capitalized on the capabilities of this flagship vessel. The NASA-supported EXPORTS program was a 42-day expedition that traveled 2,100 nautical miles southeast of Hawaii to characterize small-scale upper ocean variability during heavy rain events. This mission was followed by projects in the western Pacific near Palau, Micronesia, and Taiwan before heading back to the West Coast. Research missions conducted closer to home included a California Current research program led by Scripps professor Mark Ohman, and deep-diving research programs off the coast of Oregon and Washington supported by the National Science Foundation.



R/P FLIP

Research Platform FLIP was recently outfitted with a host of upgrades including a robust face boom, new sensors, upgraded networking infrastructure, and improved satellite broadband communications systems for internet coverage while deployed at sea. These upgrades have been put into productive use over the past year, with FLIP involved in three major programs off Southern California. Scripps scientist Luc Lenain used FLIP in an experiment to observe how ocean surface waves interact with the upper ocean boundary layer, which has implications for the physical, chemical, biological, optical, and acoustic properties of the upper ocean. This ambitious program involved research vessels *Sally Ride* and *Robert Gordon Sproul*, plus research aircraft, working together.

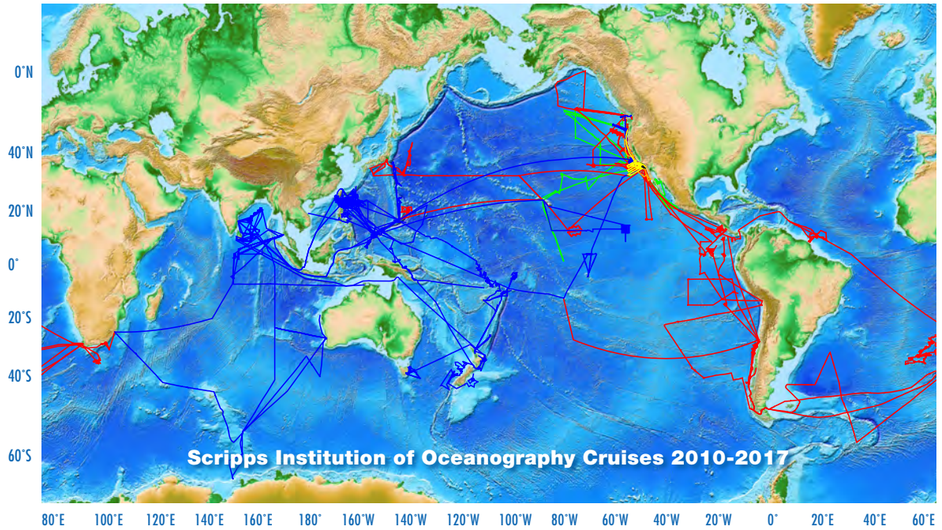
R/V ROBERT GORDON SPROUL

R/V Robert Gordon Sproul is the institution's stalwart local research vessel, conducting regional and nearshore scientific projects vital to our teaching, research, and development activities. This year was our busiest in a decade, involving several major expeditions ranging southward off Mexico and into California's central coast. R/V *Robert Gordon Sproul* continued its important service to students by conducting trips offshore for graduate and undergraduate classes to learn methods and acquire samples and data. Another vital service to students is the UC Ship Funds Program for students to conceive, propose, and (if selected by competitive peer review) conduct their own research at sea. This year, 247 Scripps students participated in seagoing research aboard R/V *Robert Gordon Sproul*.

RESEARCH VESSEL

TRACKLINES

2010-2017



Over the past year, Scripps vessels served a large and diverse group of scientists, students, and educators. During calendar year 2016, Scripps vessels took 752 people to sea on 56 separate research missions, and collectively spent 463 days at sea conducting scientific research and instruction. Of the people who sailed aboard, 580 were affiliated with Scripps, and 172 were from a total of 62 different institutions representing five different countries. This is indicative of robust utilization of the Scripps fleet in support of research and education sponsored by the National Science Foundation, the Office of Naval Research, NOAA, NASA, and other agencies.

Infinity CUBE

Three New Exhibits

Birch Aquarium at Scripps opened three exhibits that highlight Scripps science in the last year, providing guests with new opportunities for interactive learning including *Expedition at Sea: R/V* Sally Ride *Gallery, Infinity Cube*, and *Research in Action: 100 Island Challenge*.

BIRCH AQUARIUM

BIRCH AQUARIUM

***For more than a century**, Birch Aquarium has served as the public outreach arm of Scripps Institution of Oceanography. In September, the aquarium celebrated its 25th anniversary in its current location "on the hill," and is more committed than ever to helping the public understand and protect the planet.*

Supported by Philanthropy

Birch Aquarium is grateful to the friends and donors who support its mission of ocean conservation and outreach. As a self-sustaining organization, the aquarium relies upon philanthropy to fulfill this mission.

Research in Action: 100 Island Challenge

The newest exhibit in the *Hall of Fishes* is different from anything in the history of Birch Aquarium. More than a display, it is also a working laboratory for Scripps Institution of Oceanography scientists. *Research in Action: 100 Island Challenge* serves as an experimental reef that allows Scripps scientists to develop coral research techniques and test equipment and ideas before traveling to remote locations.

Guests can meet scientists and see prototype digital cameras and underwater robotics before they are deployed in the field. The exhibit is designed to assist Scripps scientists as they take on a gargantuan task: collecting coral reef data from 100 tropical islands around the world.

By the Numbers

465,744 GUESTS

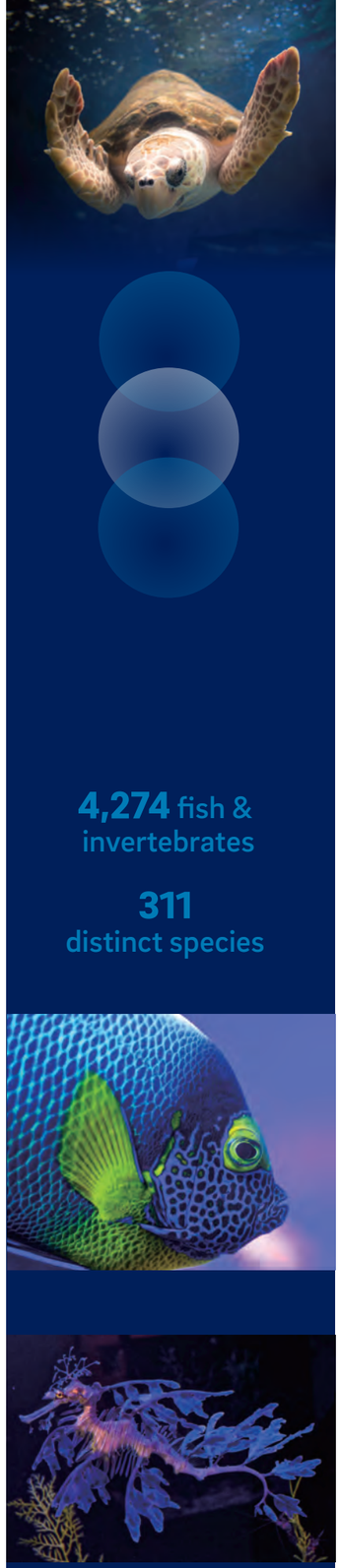
10,000 ANNUAL MEMBERS- A NEW RECORD!

56,449 Pre-K-12 students, a record (and a huge leap from last year's record of 50,383).

18,752 people attended programs in the field including Whale Watching, Grunion Runs, Shark Snorkels, Tidepooling, and Pier Walks.

33,243 hours donated by a record **532 volunteers**

115 teachers served in professional development workshops, connecting their classroom lessons with current research from Scripps Institution of Oceanography.



4,274 fish & invertebrates

311 distinct species

K-12 Education

Birch Aquarium continues to be the largest provider of K-12 ocean science education in San Diego County. During fiscal year 2016-17, Birch Aquarium served 23,023 students through $216,469 in financial aid. That includes 12,045 students served through the Price Philanthropies Ocean Science Education Fund.

The aquarium also purchased a new van through the generosity of the Las Patronas Foundation which will bring live organisms and programs to students throughout San Diego.

Alumni On Deck

Scripps is honored to have more than 2,100 alumni around the world, distinguished by their accomplishments in education, research, industry, government, and social impact. Their success is our success, and we watch with pride, awe, and gratitude as they make indelible marks on the world.

ALUMNI CONNECTIONS

Our active community of alumni return to campus each year to meet and mentor current students, pursue professional goals, and develop partnerships with faculty and researchers. They also enjoy meeting each other wherever their professional and personal paths take them. In 2017, Scripps gathered alumni around the United States and beyond –from San Francisco, Honolulu, and Atlanta to Chile, Japan, and the U.K.–to capture their stories and connect them to our institution and each other.

We also reached a milestone, celebrating our "oldest living alumnus" when **Walter Munk**, PhD '47, reached 100 years of age on Oct. 19, 2017.

Above: **Loren Shure**, PhD '82, visited Scripps in Sept. 2017 to deliver a talk about career opportunities outside of academia. For the past three decades, Shure has worked at mathematical computing software company MathWorks and has co-authored or contributed to the design of several of its products, including MATLAB.

Rear Admiral Brian Brown, MS '87, was promoted to Director, Warfare Integration for Information Warfare for the U.S. Navy. As a flag officer, Brown commanded the Naval Meteorology and Oceanography Command and most recently served as deputy commander, Joint Functional Component Command for Space, U.S. Strategic Command. In 2014, he was appointed as the head of the Navy's Space Cadre.

Alumni at Home

Mark Merrifield, PhD '89, returned to Scripps Oceanography to serve as the inaugural director of the Center for Climate Change Impacts and Adaptation. A renowned specialist in sea-level rise, he will coordinate Scripps' efforts to provide practical strategies for helping society cope with increasing climate instability.

Assistant Professor of marine biology **Octavio Aburto**, PhD '09, was named by the Explorers Club as the 2017 Rolex Artist-in-Exploration for his photography depicting marine life. The $25,000 grant will support four expeditions to document four different mangrove forests in the Tropical Eastern Pacific Ocean.

ALUMNI

Alumni *of Scripps Oceanography represent academics, professionals, experts, and entrepreneurs. Their accomplishments are felt widely, from education and environment to industry and innovation, and their impact spans the expanse of our planet, from deep oceans to deep space.*

Alumni career panelists (from left) ***Jerry Mullison****, MS '94, senior scientist at Teledyne RD Instruments;* ***Gabriela Tobal****, MS '93, life sciences corporate partnership professional (previously with The Scripps Research Institute);* ***David Myer****, PhD '12, geophysicist/founder BlueGreen Geophysics.*

Scripps Director Margaret Leinen *(far right) brings Scripps alumni together in Chiba, Japan in May 2017. Pictured from left:* ***Professor Guy Masters****, Scripps Oceanography;* ***Takuro Kobashi****, PhD '07;* ***Ben Chao****, PhD '81;* ***Christine Hernlund****, PhD '05;* ***Keir Becker****, PhD '82;* ***Aneesh Subramanian****, PhD '12;* ***Michael Gregg****, PhD '71;* ***Valerie Sahakian****, MS '10, PhD '15;* ***Diego Melgar****, PhD '14;* ***Rebecca Asch****, PhD '13; and* ***Michael Peto****;* ***Xiaowei Chen****, PhD '13;* ***Leinen****;* ***Shingo Watada*** *(former Scripps postdoc).*

Welcome, Class of 2017 Graduates: Our Newest Alumni

In June, 127 scholars earned degrees from Scripps Oceanography and have since become the newest alumni in our global network of change makers, leaders, academics, and educators.

TOTAL SCRIPPS CLASS OF 2017

127 graduates

Female – 81 (64%)
Male – 46 (36%)

UNDERGRADUATE

Total BS degrees: 60 (47%)
Marine Biology – 39
Earth Sciences – 21
Gender:
Female – 39
Male – 21

MASTER OF ADVANCED STUDIES

Total MAS degrees: 28 (22%)
Gender:
Female: 22
Male: 6
Photo: CSP Class of 2017

MAS-MBC

Total MAS - MBC: 20 graduates
Gender:
Female – 15
Male – 5

MAS - CSP

Total MAS - CSP: 8 graduates
Gender:
Female – 7
Male – 1

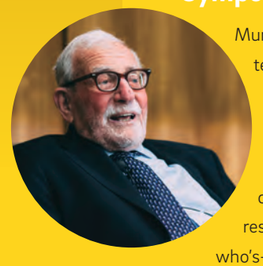
MASTER'S

Total MS degrees: 5 (4%)
Earth Science – 3
Marine Biology – 2
Gender:
Female – 3
Male – 2

PHD

Total PhD degrees: 34 (27%)
Earth Science – 6
Marine Biology – 13
Oceanography – 15
Gender:
Female – 17
Male – 17

Walter Munk joined Scripps Oceanography as a young doctoral student in 1939, and in nearly eight decades here transformed how the world understands the oceans through pioneering research on wave prediction, tide prediction, ocean acoustics, ocean circulation, deep-sea tides, and more. Scripps honored Munk with a nearly year-long celebration of his 100th birthday, which fell on Oct. 19, 2017.



Royal Centennial Conversation

His Serene Highness (H.S.H.) Prince Albert II of Monaco made a special visit to UC San Diego on Oct. 26, 2017 to join the renowned oceanographer in a Centennial Conversation where the two discussed their shared passion for ocean exploration, the importance of investing in scientific research, and hope for collaborating to solve climate change in the future.

On climate change, Munk looked back to history he influenced, comparing the military and scientific collaboration and cooperation required to defeat German submarines and learn the science of ocean acoustics during World War II "a miracle."

"I think now the problem [of climate change] is somewhat comparable and I'm looking for another miracle," said Munk. "I'm fully convinced that under such cooperation we could find an answer to replace fossil energy with renewable energy in time to prevent a catastrophic level to our oceans and sea level change. I'm hoping that is coming."

Symposia

Munk's centennial celebrations began in February when the world's largest ocean technology trade show devoted its final day to Munk. Events at Oceanology International centered on the theme of celebrating of the past to awaken the future.

The year also saw Munk's colleagues and current and former students give credit to his outsized influence on the fields of ocean wave and ocean acoustics research in two symposia. Events in May and August on these topics attracted a who's-who of leading international researchers in ocean physics, sound propagation, and national security to honor Munk's own research history and an ever-forward-looking perspective on scientific inquiry.

WALTER MUNK

100

Walter Munk Way Dedication

The City of San Diego recognized science icon Walter Munk on the eve of his 100th birthday by officially naming the La Jolla Shores boardwalk in his honor. Three honorary "Walter Munk Way" street signs were installed along the length of the boardwalk.

COP22 | MARRAKECH

Scripps graduate students and colleagues explore Morocco.

Scripps Informs Science Policy at International Climate Conference

The largest-ever delegation of Scripps Oceanography and UC students and researchers brought scientific knowledge to the 22nd Conference of the Parties (COP22) in Marrakech, Morocco. The November 2016 conference was the latest in a series of global climate change policy negotiations led by the United Nations Framework Convention on Climate Change.

At COP22, Scripps hosted its first-ever solo exhibit showcasing critical programs and new observational technology used by Scripps and other scientific organizations to monitor and understand the effects of climate change on the environment. Scripps delegates, including ten graduate students, led a record number of press conferences and panels and were able to convey to policymakers and delegates the important role the ocean plays in absorbing and regulating the impacts of climate change.

"It was amazing to see so many countries and cultures come together to combat worldwide climate change," said Scripps postdoctoral scholar Maya deVries, a member of the Scripps delegation. "Many countries are working towards a common goal and that will continue to move forward."

INTERNATIONAL RELATIONS

International Relations *As a world leader in research and education, Scripps Oceanography builds and maintains connections with other top universities and organizations around the world. Scripps traveled near and far in 2017 to enhance international collaborations.*

United Nations Ocean Conference

In June 2017, the United Nations in New York hosted the Ocean Conference, the first event convened to consider ocean protections as one of the 17 sustainable development goals identified by the U.N. in recent years. U.N. members pledged to conserve and sustainably use the ocean, seas, and marine resources, and more than 1,000 individual national commitments were made.

Students, researchers, and leaders from Scripps traveled to the conference to participate, learn, and network with key decisionmakers from around the world. Representatives from Scripps and UC San Diego's School of Global Policy and Strategy (GPS) took part in a range of science panel discussions, and Director Margaret Leinen participated in talks on ocean acidification and the blue economy.

Scripps Leaders Discuss Climate Change with the Dalai Lama

When His Holiness the 14th Dalai Lama visited UC San Diego in June, he shared a public address on campus June 16, and a keynote speech June 17 at the all-campus commencement. He also made time to meet with leaders and researchers from Scripps Oceanography including Director Margaret Leinen, Scripps climate and atmospheric scientist Veerabhadran Ramanathan, and legendary geophysicist Walter Munk.

Ramanathan, in what marked his fourth meeting with His Holiness, said he utilized his time with the Dalai Lama to discuss climate change, and what he deems a moral problem in which the worst consequences of climate change will be experienced by three billion of the world's poorest people. Munk also rubbed elbows with the Dalai Lama at a leadership luncheon on the UC San Diego campus.

Scripps Director Continues Work as Science Envoy

Vice Chancellor Leinen was appointed the 13th U.S. Department of State Science Envoy in 2016, and her term was renewed in 2017. With the renewal, Leinen continues her work in Latin America and the Pacific Islands on the monitoring of marine protected areas, detecting illegal and unregulated fishing, and mitigating ocean acidification and sea-level rise.

In September, she traveled to Vina del Mar, Chile, where she participated in the fourth International Marine Protected Areas Congress (IMPAC4), including a discussion with government leaders on how climate change is going to affect marine protected areas.

DEVELOPMENT

At Scripps Institution of Oceanography, a legacy of philanthropy has allowed us to expand our capabilities in the most innovative ways. Our philanthropic partners have always been essential to fulfilling our aspirations, and together as part of the Campaign for UC San Diego, we are empowering the next generation of Scripps and UC San Diego innovators to blaze new paths toward revolutionary ideas, unexpected answers, lifesaving discoveries, and planet-changing impact.

We're already changing the world and on the cusp of tremendous breakthroughs. This is a glimpse into how Scripps donors are contributing to the success of the Campaign for UC San Diego and continuing Scripps' history of paradigm-defining discovery.

BY THE NUMBERS

FY17 CAMPAIGN SUPPORT FOR SCRIPPS INSTITUTION OF OCEANOGRAPHY

$17,000,000

In addition, Scripps has received bequest intentions this fiscal year totaling $4,707,000

THE CAMPAIGN FOR UC SAN DIEGO: PROGRESS AS OF SEPTEMBER 30, 2017

104,303+ UNIQUE DONORS

72%

404+ DIVISIONS / DEPARTMENTS / PROGRAMS IMPACTED

$1.43 RAISED OF $2 BILLION

MEMBERSHIPS

E.W. SCRIPPS ASSOCIATES
135 members
(26 new members)
7% growth
$189,450 raised

FRIENDS OF THE COLLECTIONS
44 members
$78,368 raised

FRIENDS OF BIRCH AQUARIUM
55 members
(20 new members)
$102,748 raised

For a full list of our generous supporters this past year, visit: https://scripps.ucsd.edu/giving/donors2017

Development *Philanthropy plays a vital role in helping Scripps Oceanography address some of the most important environmental challenges we face today. We are incredibly grateful to all our donors for supporting our world-class research initiatives, and helping us educate the next generation of scientists.*

SELECT HIGHLIGHTS

$2.6 million gift to fully fund revitalization of the Ellen Browning Scripps Memorial Pier

$2 million gift to name the Scripps Center for Coastal Studies building

$1.4 million gift to support new sensor technology development

$1 million gift to support the Director's highest priorities

$500,000 gift to help create a new Makerspace at Scripps for UC San Diego students and faculty

Major gift to fund new seadragon habitat at Birch Aquarium

Major gift to support development of a marine compound library in collaboration with UC San Diego Skaggs School of Pharmacy and Pharmaceutical Sciences

Scripps Supporters Dive into Adventure in Palau

Scripps scientists Jennifer Smith, Stuart Sandin, and colleagues led a group of adventurous Scripps supporters on a week-long diving and learning experience in Palau, an island country located in the western Pacific Ocean. The scientists were there to conduct research for the 100 Island Challenge, a Scripps-led project that aims to collect coral reef data from 100 islands across the globe to gain a better understanding of how reefs are adapting to our rapidly changing planet.

Thanks to the support of nine generous donors, the Scripps team was able to charter a boat and study the coral reefs of Palau's southwest islands, which are extremely remote, and donors were able to experience some of the best diving in the world. Donors were also thrilled to meet Palau's President Tommy Remengesau, who is leading conservation efforts across the island. "It speaks to the prestige of the Scripps scientists that the president wanted to come aboard and thank them for their work and for their collaboration," said supporter Elizabeth Oliver, who described the overall trip as "amazing."

Learn more about supporting Scripps science at: scripps.ucsd.edu/giving.

DEVELOPMENT

MULTI-YEAR

Statement of Activity

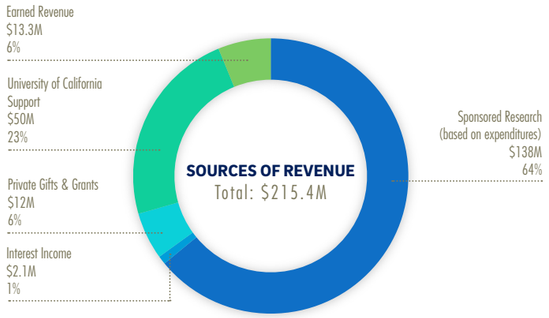
REVENUE	FY 15/16 (expensed this period)	FY 16/17	FY 16/17 (awarded this period)
Sponsored Research	**119,433,501**	**137,925,597**	**143,065,172**
Federal Government	109,533,326	124,584,325	128,099,428
National Science Foundation	35,721,011	36,457,382	38,004,502
Department of the Navy	30,417,326	45,454,020	44,478,861
National Aeronautics and Space Administration	6,471,379	6,975,035	8,977,774
National Oceanic and Atmospheric Administration	23,478,529	21,499,590	12,176,200
Department of Energy	2,052,420	1,862,443	1,382,025
Other Department of Defense Agencies	7,227,225	8,544,011	18,075,592
Other Federal Departments	893,568	1,185,694	3,525,431
National Institutes of Health	3,271,869	2,606,150	1,479,043
State Government	5,436,964	8,321,462	8,724,138
Local Government	706,977	793,804	720,795
Private Contracts	3,748,701	3,914,730	5,508,885
UC Sponsored Research	7,532	311,277	11,925
University of California Support	**43,356,222**	**50,034,159**	
Earned Revenue	**13,928,539**	**13,345,076**	
Birch Aquarium at Scripps (BAS)	6,847,838	6,605,041	
Recharge Unit Revenues	5,699,357	5,628,081	
Intellectual Property and Royalty Income	25,095	115,688	
Other Revenue	1,356,250	996,265	
Private Giving	**12,869,432**	**11,960,480**	
1 Birch Aquarium at Scripps (BAS)	1,033,289	1,992,566	
1 Private Gifts	8,684,397	7,437,937	
2 Private Grants	3,151,746	2,529,978	
Interest Income	**2,097,411**	**2,117,701**	
Interest Earned	87,139	(5,588)	
Endowment Yield	2,010,272	2,123,290	
Total Revenue	**191,685,105**	**215,383,013**	
EXPENSES			
Research Programs - SEEK	**(165,672,857)**	**(174,040,825)**	
Sponsored Research	(135,865,759)	(138,233,754)	
Ships	(25,310,805)	(31,259,537)	
Oceanographic Collections	(447,479)	(485,408)	
Contract & Grant Administration	(1,208,506)	(1,302,118)	
Research Development & Planning	(750,353)	(740,503)	
Research Infrastructure & EH&S	(717,106)	(667,327)	
OP Tax on Research Expenditures	(1,372,848)	(1,352,180)	
Instruction Programs - TEACH	**(11,481,638)**	**(12,793,598)**	
Outreach - COMMUNICATE	**(10,022,379)**	**(11,774,134)**	
Birch Aquarium at Scripps	(7,722,192)	(8,858,679)	
Business Development		(153,276)	
Communications (Scripps share) & Web Group	(957,068)	(1,136,243)	
Development (Scripps share)	(303,073)	(350,674)	
Diversity	(60,615)	(152,994)	
Special Events (including lectures, awards, conferences)	(241,093)	(274,717)	
Conference Facilities (Forum debt service, staff, maintenance)	(738,338)	(847,551)	
Institutional Support	**(6,518,380)**	**(7,478,881)**	
Scripps Administration	(2,734,670)	(2,827,154)	
IT Services	(1,534,893)	(1,483,255)	
3Facilites Maintenance & Capital Improvements	(1,991,813)	(2,915,473)	
OP Tax on non-core Expenditures	(257,004)	(253,000)	
Total Expenses[4]	**(193,695,254)**	**(206,087,439)**	
Annual Balance/(Deficit) from Current Activities	**(2,010,149)**	**9,295,574**	

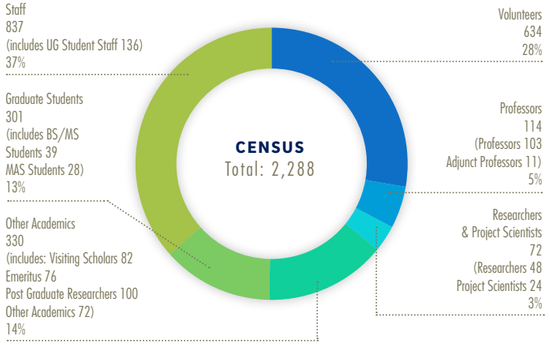
1. Amounts include only gifts received and available for spending in UC Regents funds in the current year. With bequests, pledges, contributions to endowments, and gifts booked with the UC San Diego Foundation, total Scripps Development fundraising was $17M in FY 16-17.

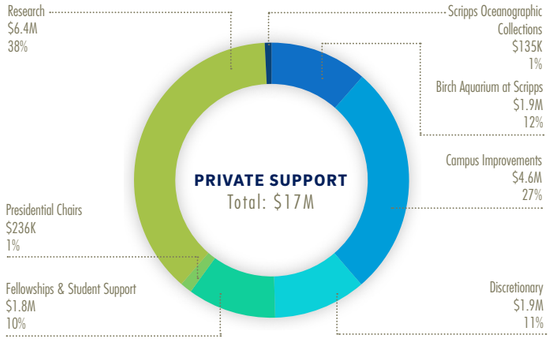
2. Private grants are typically restricted funds and considered Sponsored Research; however UC San Diego counts them as Private Giving.

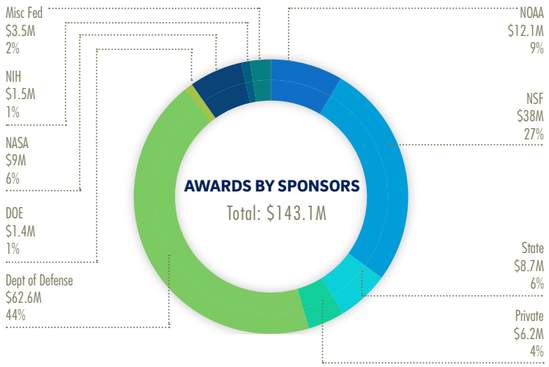
3. Does not include funds transferred to UC San Diego Facilities Design and Construction or Facilities Management and spent by those units on Scripps projects which causes variability in the year-to-year totals. FY 16-17 total facility/capital improvement expenses paid by Scripps were approximately $5M.

4. This statement does not reflect all annual expenditures associated with operating Scripps. Services provided by campus departments are captured in UC San Diego financial reports, e.g. utilities, custodians, central administrative services such as payroll, purchasing, and general accounting, transportation, deferred maintenance costs, etc.









EXTRAMURAL FUNDING

FEDERAL

Department of Agriculture
U.S. Department of Agriculture Forest Service

Department of Commerce
National Oceanic and Atmospheric Administration
National Institute of Standards and Technology

Department of Defense
Air Force Office of Scientific Research
Army Engineer Research and Development Center
Defense Advanced Research Projects Agency
Department of Army Engineers
Department of Defense Strategic Environmental Research Development
Pacific Fleet Commander
Space & Naval Warfare Systems Command

Department of Education

Department of Energy
DOE Office of Science
DOE National Energy Technology Laboratory

Department of Health and Human Services
National Institute of Allergy and Infectious Diseases
National Institute of Environmental Health Sciences
National Institute of General Medicine Science

Department of the Interior
Bureau of Reclamation
Fish and Wildlife Service
Bureau of Safety and Environmental Enforcement
United States Geological Survey

Department of Navy
Naval Air Systems Command
Naval Facilities Engineering Command
Naval Research Laboratory
Naval Surface Warfare Center
Office of Naval Research
Space and Naval Warfare Systems Command

Department of State

Department of Transportation
Federal Railroad Administration

National Aeronautics and Space Administration

National Science Foundation

STATE OF CALIFORNIA
Coastal Commission
Delta Stewardship Council
Department of Fish and Wildlife
Department of Parks and Recreation
Department of Water Resources
Energy Commission
Natural Resources Agency
Ocean Protection Council
State Coastal Conservancy
State Lands Commission
State Water Resources Control Board
Wildlife Conservation Board

CITIES AND COUNTIES
City of San Diego
County of Sonoma
Sonoma County Water Agency
Southern California Coastal Water Research Project
Southern Valley Water Authority
State and Federal Contractors Water Agency

EXTRAMURAL SUPPORT
BGP Inc., CNPC
BP Group
California Ocean Science Trust
Center for Scientific Research and Higher Education at Ensenada
CH2M Hill
Chevron Corporation
Earth Networks, Inc.
Electromagnetic Geoservices SA, Seabed Logging Company
Environment Canada
Exxon Upstream Research Company
Geophysical Resources & Services PTY Ltd.
Geothermal Energy Research and Development Co., LTD.
Greenridge Sciences, Inc.
Gulf of Mexico Research Initiative
Henningson, Durham & Richardson, Inc.
Inter-American Institute for Global Change Research
King Abdullah University of Science and Technology
Ocean Floor Geophysics, Inc.
Royal Dutch Shell PLC
Shandong Jiejing Group Corporation
State Government and Federal Contractors Water Agency
Total E&P Research Development
Vertex Pharmaceuticals Incorporated

INTERNATIONAL GOVERNMENT
European Union/European Commission
Japan Aerospace Exploration Agency
Government of Singapore
The Research Council of Norway

FINANCE


UC San Diego
SCRIPPS INSTITUTION OF OCEANOGRAPHY