RESEARCH HIGHLIGHTS

Resilient Futures Program Helps Imperial Beach Prepare for Sea-Level Rise

One of California's cities most vulnerable to sea-level rise avoided damage this winter thanks to an early-warning flood system engineered at Scripps. The City of Imperial Beach faced 15-foot waves from a king tide event in January, inundating streets and coastal property. Prior to that event, Scripps' Center for Climate Change Impacts and Adaptation had installed an experimental warning system kickstarted in November 2018 by a donation from the David C. Copley Foundation. The system flagged dangerous flood-threatening wave conditions in advance of when high tides were predicted so the city could close off streets and prepare crews to patrol seaside locations.

"We were all anticipating the flooding being on Monday or Sunday. Scripps really alerted us that this [Friday, January 18] was going to be the day," Imperial Beach Mayor Serge Dedina told *The San Diego Union-Tribune*, regarding the advance notice the city received. "It reinforced that we needed to be out here closing off the street, getting all hands on deck."

The warning system coordinates a network of instruments collecting data on ocean conditions, such as wave buoys deployed by the Coastal Data Information Program at Scripps, LIDAR (light detection and ranging) scanners, and groundwater and tide gauge sensors. It's part of the center's Resilient Futures program that could later customize warning systems for vulnerable cities along both U.S. coasts.

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Photo by the Center for Climate Change Impacts and Adaptation.

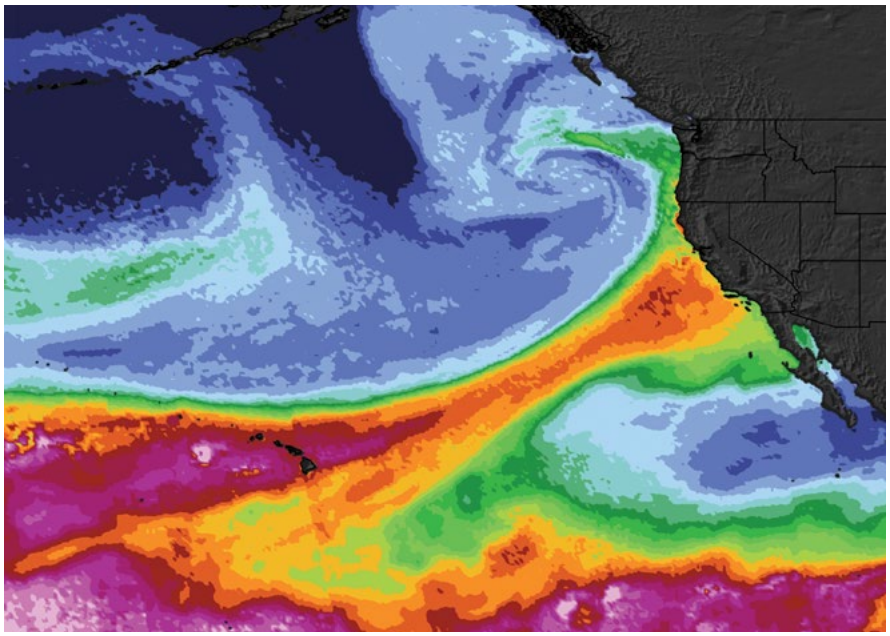
Drone-Mounted Tech Helps Keep Eyes on Erosion

As cliffs throughout California succumb to erosion and collapse due to rising sea levels, moisture from rain and urban runoff, and natural processes, Scripps Oceanography is using new technology to study and assess cliff erosion and retreat. A new LIDAR-equipped drone will supplement efforts to monitor coastal erosion, joining a truck-mounted system. LIDAR uses laser pulses to measure distances and make 3D records of the terrain.

"The drone will help with areas inaccessible to the truck and can be used during high tides when the beach is too narrow to drive," researcher Adam Young said. "It will be able to map features not visible from the beach providing a complete picture of cliffs, and also be used to monitor wave run-up."

The new drone purchase was funded via the U.S. Army Corps of Engineers. Young is also leading the first high-resolution statewide assessment of California coastal cliff erosion via a grant from California's Ocean Protection Council. The goal will be to detect erosion hot spots, map a coastal cliff stability and hazard index, and identify areas prone to future coastal erosion.

Photos by Erik Jepsen



New Scale Developed to Categorize Atmospheric Rivers as Economic Impacts of Storms Realized

The Center for Western Weather and Water Extremes at Scripps introduced a scale that helps weather forecasters evaluate the magnitude of precipitation-bearing bands of moisture known as atmospheric rivers. The scale assigns five categories to atmospheric rivers using as criteria the amount of water vapor they carry and their duration in a given location.

The intention of the scale is to describe a range of scenarios that can prove beneficial or hazardous based on the strength of atmospheric rivers. While Category 1 storms would be expected to bring light rain, Category 5 atmospheric rivers could bring flooding and substantial infrastructure damage to various areas. Atmospheric rivers are a crucial means by which the West Coast receives rain and snow. Scientists expect they will become even more significant as global warming trends increase their intensity.

In separate research, Scripps scientists estimated that atmospheric rivers pose a $1 billion-a-year flood risk in the West. The team led by Scripps postdoctoral researcher Tom Corringham found that flooding has caused nearly $51 billion in damages to western states in the last 40 years. More than 84 percent of these damages were caused by atmospheric rivers.

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A satellite view of the integrated water vapor from an atmospheric river that impacted California in April 2018. Image by the Center for Western Weather and Water Extremes at Scripps.

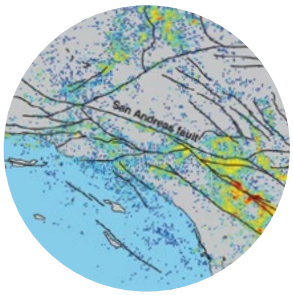
Keeping an Eye on Wildfire Threats, for Today and for the Future

Scripps research continues to aid in California's efforts to understand the causes of deadly wildfires and combat their spread. ALERTWildfire, a multi-hazard-detecting camera network developed by a consortium of academic centers including Scripps, grew significantly this year in high fire-risk areas in the West. The now 300-camera system covering five states is credited for early detection of hundreds of fires in the last two years and enhanced situational awareness for fire officials and first responders.

The need for such technology should only grow, as Scripps researchers helped clarify the link between wildfires and a warming climate. A study published in July showed summer forest fires in Northern California have a strong connection to dry ground conditions brought on by increasing heat. The researchers say forest fire increases are driven by a simple mechanism: when air heats up even modestly, it causes more moisture to evaporate from soils and vegetation. Thus fires start more easily, and can spread faster and farther.

The wildfire cameras are publicly available at www.alertwildfire.org.

Scientists Identify Almost 2 Million "Hidden" Earthquakes



After looking through 10 years' worth of Southern California seismic data, Scripps seismologist Peter Shearer and colleagues identified hundreds of thousands of previously unidentified tiny earthquakes that occurred between 2008 and 2017. The study expands the earthquake catalogue for that region—growing it from about 180,000 recorded earthquakes to more than 1.8 million. This tenfold increase represents the tracking of tiny temblors, between negative magnitude 2.0 (-2.0) and 1.7. The expanded earthquake catalogue, detected via a high-resolution approach, reveals previously undetected foreshocks that precede major earthquakes, as well as the evolution of swarms of earthquakes. The richer data set will provide a clearer picture of how seismic events affect and move through the region.

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scripps.ucsd.edu/hiddenearthquakes

Cal Fire Capt. Kevin Cox points to the screen as he and Capt. Ryan Silva demonstrate the use of wildfire surveillance cameras while in the emergency command center at the Cal Fire San Diego Unit Headquarters in October. Photo by Hayne Palmour IV/The San Diego Union-Tribune.

Arctic Sea Ice Minimum

Scripps researchers calculated that if all Arctic Ocean sea ice were to melt, it would make the same contribution to global warming as would adding one trillion tons of carbon dioxide to the atmosphere. It would consequently speed up the arrival of a global threshold of warming of 2°C greater than the temperatures the world experienced before the Industrial Revolution. Scientists believe exceeding that threshold will lead to catastrophic consequences across the planet.

"Losing the reflective power of Arctic sea ice will advance the 2°C threshold by 25 years. Any rational policy would make preventing this a top climate priority for world leaders," said Veerabhadran Ramanathan, a professor of atmospheric and climate sciences at Scripps and co-author of the report.

The research team noted that climate models have tended to underestimate the speed at which Arctic sea ice is melting, sometimes drastically. Research by other scientists has suggested the possibility of a seasonal ice-free Arctic as early as the 2020s.

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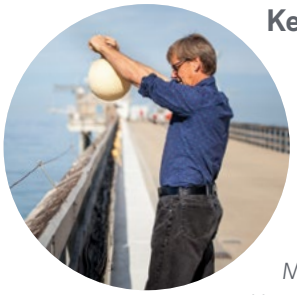
scripps.ucsd.edu/seaice25

Photo by Alex Hamel



Keeling Curve Hits 415 PPM

The Keeling Curve, a daily measurement of carbon dioxide concentration in the atmosphere and one of the founding tools in modern climate change science, passed a daily reading of 415 parts per million in May. This reading was the highest since the late Scripps scientist Charles David Keeling began tracking CO_2 concentration 61 years ago. Measurements are taken at the Mauna Loa Observatory in Hawaii, and are managed by the Scripps CO_2 Program.

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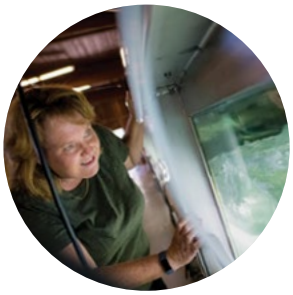
SeaSCAPE Experiment



A two-month-long experiment by the NSF Center for Aerosol Impacts on Chemistry of the Environment (CAICE) took place in the wave channel at Scripps Hydraulics Lab. Led by CAICE Director Kim Prather, the Sea Spray Chemistry And Particle Evolution project, or SeaSCAPE, was a novel experiment in which scientists unraveled complex ocean-atmosphere interactions. The focus of the project was to understand how human pollution interacts and reacts with ocean emissions of gases and aerosols—and ultimately affects cloud formation, air quality, and climate.

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scripps.ucsd.edu/seascape

Microplastics Found Throughout Water Column

Researchers at Scripps Institution of Oceanography, Monterey Bay Aquarium, and the Monterey Bay Aquarium Research Institute found that microplastics are common from the surface to the seafloor in Monterey Bay. Using underwater robots equipped with sampling devices, the researchers, including Scripps' Anela Choy, filtered plastic particles out of seawater and collected animal specimens. The most common plastics found are those that are used to manufacture consumer products. Additionally, the researchers found that marine animals are also consuming the microplastics, introducing the pollutants to the marine food web.

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SeaSCAPE photo by Erik Jepsen
Giant larvacean image courtesy Monterey Bay Aquarium Research Institute

Technology: Argo Captures Two Millionth Profile

The international Argo network of ocean-observing robots recorded its two millionth profile in December 2018, marking a major milestone for the 20-year-old observation program. During profiles, the floats collect data on temperature, salinity, and current speed and direction while diving to a depth of 6,500 feet and resurfacing. The collection of Argo data represents the most detailed observation of ocean physics in history.

As the 4,000 floats in the Argo network continue to collect data in all ocean basins, specialized types of Argo floats are being deployed. One of those is Deep Argo, which can dive three times deeper to the ocean bottom in depths up to 6,000 meters (3.7 miles), helping researchers understand the largely unobserved deep ocean. Biogeochemical Argo floats can measure a range of variables such as oxygen, nitrogen, and pH – critical for addressing pressing environmental issues, such as ocean acidification and low oxygen levels that have been detected in some parts of the ocean. Argo leaders hope to integrate as many as 1,250 Deep Argo and 1,000 biogeochemical Argo floats into the global array to bring its total size to 4,600 floats, starting with deployments being made next year.

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Deep Argo photo by Ben Reineman, Instrument Development Group.

Human Health: Climate Change Likely to Increase Human Exposure to Toxic Mercury

Researchers found that warming oceans are leading to an increase in the harmful neurotoxicant methylmercury. The study was led by Amina Schartup, a new Scripps faculty member. Mercury levels in fish are influenced by diet and how much they swim. Warming temperatures could affect all of these. While the regulation of mercury emissions has successfully reduced methylmercury levels in fish, spiking temperatures are driving those levels back up, which could increase human exposure to mercury through seafood.

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scripps.ucsd.edu/mercury

National Security: U.S. Naval Academy Internship

For six weeks in the summer of 2019, Scripps Oceanography hosted three midshipmen summer interns from the U.S. Naval Academy. Created with the goal of exposing Navy personnel to the latest ocean science and technology development, this was the first year of the program, which plans to continue next summer. Two of the interns worked with Drew Lucas, an assistant professor in the Marine Physical Laboratory, who develops technologies and equipment to observe the oceans. Specifically, they worked on the refitted custom-made sonar system for R/V *Roger Revelle*, the only ship in the U.S. academic fleet with this kind of custom technology. The third midshipman worked with Sean Wiggins and John Hildebrand of the Whale Acoustic Lab to help analyze a large quantity of underwater ambient sound data to identify trends in the presence of ships and ocean storms. This work will also facilitate the discovery of sounds produced by marine mammals. The midshipmen also participated in events alongside the Marine Physical Laboratory Summer Internship Program, a ten-week program for undergraduates interested in marine science and technology.

Climate Change: Low Oxygen Levels Could Temporarily Blind Marine Invertebrates

Former Scripps PhD student and now postdoctoral scholar Lillian McCormick published the first study to demonstrate that vision in marine invertebrates is highly sensitive to the amount of oxygen in the water. Studying four local California marine invertebrates—Market Squid, Two-spot Octopus, Tuna Crab, and a Brachyuran Crab—she found that vision was reduced by 60-100 percent under low-oxygen conditions. In the marine environment, oxygen levels change over daily, seasonal, and inter-annual time scales. However, these conditions are changing due to human-influenced climate change and pollution.

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