

# OCEANOGRAPHY IN A CHANGING WORLD

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In 2003, Scripps Institution of Oceanography will celebrate its first century of oceanographic exploration, research, and discovery. This feature is the eighth in a series of articles that will present special features about the history of Scripps Institution and the science, people, ideas, and technology that have played major roles in its century of leadership.

Edward A. Frieman's tenure at Scripps was marked by campus expansion and scientific globalization. **Far left**, Frieman (left) and his predecessor William A. Nierenberg (right) consult with French undersea explorer Jacques Cousteau. **Left**, The Ellen Browning Scripps Memorial Pier was dedicated in 1988. **Below**, R/V Roger Revelle prior to its launch (middle) and Frieman at the occasion (bottom).



## Scripps Institution of Oceanography 1986 to 1996

At the end of the '80s and the beginning of the '90s, change was in the air. Global power shifts continued to shake up the Old World order, affecting the political as well as the scientific communities. Greater demands were placed on research-intensive institutions such as Scripps as the national agenda shifted.

"Scripps was an honest broker of information on the scientific issues of the day," said Edward A. Frieman, the eighth director of Scripps, who succeeded William A. Nierenberg in 1986. "Global scientific problems were increasingly coming to the fore, creating new opportunities for Scripps to solve major problems facing our planet."

Environmental concerns and global climate change were among the most urgent of these issues. Frieman brought to Scripps extensive experience as a research administrator at Princeton University and as a public policy advisor for two administrations in Washington, D.C. Thus, he was just the sort of leader that Scripps needed at the time: Frieman was well versed in working with fellow scientists and policy makers to evaluate global monitoring strategies and to help establish sound environmental standards for industry and government.



## CLOUDS, CHEMISTRY, AND CLIMATE

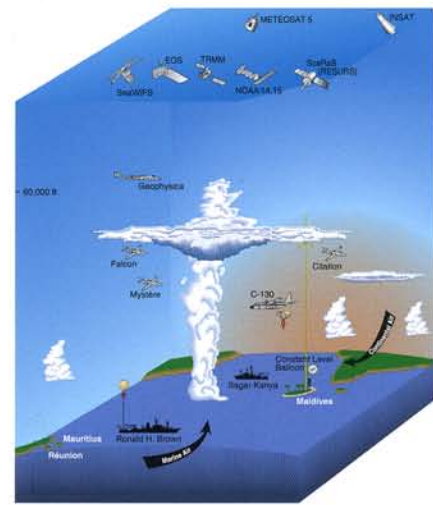
In response to the changing needs of the U.S. government, Frieman launched Scripps on a course centered on global environmental science. He initiated strategic planning and made critical faculty and research appointments, working to establish a new center for atmospheric research and strengthening Scripps's programs in global monitoring.

Frieman recruited atmospheric chemist Veerabhadran Ramanathan, the first scientist to demonstrate that chlorofluorocarbons in the atmosphere were major contributors to global climate change. Ramanathan also developed a method using solar radiation data to learn how clouds modulate energy and the greenhouse effect.

"Clouds are one of the most poorly understood phenomena in earth science. One of the major sources of uncertainty in our ability to predict the climate is that we don't know how clouds respond to global warming," Ramanathan said.

Ramanathan founded the Center for Atmospheric Sciences at Scripps and received funding from the National Science Foundation (NSF) to operate a Scripps branch of the Center for Clouds, Chemistry, and Climate (C<sup>4</sup>), which he had established at the University of Chicago.

"Some of the foremost research groups in the world in the areas of atmospheric chemistry, climate, and global change have been brought



*Using satellites, ships, and aircraft, scientists measured solar radiation, atmospheric chemistry, and cloud properties in an effort to better understand cloud-pollution interactions as part of the Indian Ocean Experiment (INDOEX).*

programs also increased resources to such studies. In 1991 Frieman chaired the NASA Earth Observing System (EOS) Engineering Review



*Researchers stationed at INDOEX observatories in the Maldives, southwest of India, included John Wieland and Greg Mitchell (left), Jens Merick (middle), and Jürgen Lobert (right).*

together at C<sup>4</sup>," Frieman said. "The research to be conducted is among the most important scientific work today because the chemistry of the atmosphere is undergoing significant changes, both as the result of natural causes and human activities."

In 1993 Ramanathan led the multi-institutional Central Equatorial Pacific Experiment (CEPEX), which confirmed his theory that clouds regulate the upward limits of ocean warming in that region. The Indian Ocean Experiment (INDOEX) in 1999 was a \$25-million international effort in which scientists discovered a massive layer of air pollution affecting the solar heating of the sea surface, climate, and rain in southern Asia.

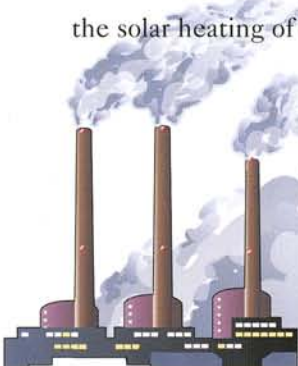
"The links between the emission of pollutants and the climate can have a major impact on future energy policies in both industrialized nations and emerging third-world countries," Ramanathan said.

## SCIENCE AND SOCIETY

As Scripps further focused on the science of climate and global change, national science and space

Committee of the U.S. Global Change Research Program, a key component of NASA's Mission to Planet Earth, which addressed fundamental scientific issues in climate change and global warming.

In 1992 Scripps joined with the National Oceanic and Atmospheric Administration (NOAA) to create the Joint Institute for Marine Observations (JIMO), a consortium established to study long-term global environmental processes. One goal was to improve the understanding of past climate by examining geological and geochemical records such as the structure of corals, ocean sediments,







**Above,** Deployment of conductivity temperature density (CTD) casts containing water-sampling bottles used for measuring temperature and salinity at various ocean depths. **Left,** Physical oceanographer Lynn Talley draws a water sample from a CTD rosette during the World Ocean Circulation Experiment.

and gases dissolved in ice sheets. The scientists were also interested in “how the climate is functioning today so we can assess the likelihood of significant changes in the future,” said Russ Davis, a physical oceanographer at Scripps.

To help Scripps study the role of the ocean in global climate systems, NOAA awarded the institution a \$3.27-million grant in 1993. As a result, Davis and other oceanographers at Scripps participated in large-scale, multi-institution programs, including the World Ocean Circulation Experiment (WOCE) and the Tropical Ocean Global Atmospheres/Coupled Ocean Atmosphere Response Experiment (TOGA/COARE).

Frieman advocated that studying the long-term effects of

climate change would also mean gaining a greater understanding of global warming.

“Government efforts have focused increasingly on understanding the impacts of global warming in terms of agriculture, sea-level rise, disease transmission, ecosystem damage, and other economic and environmental issues. We must understand the consequences of global warming to be able to formulate wise public policies.”

**THE SOUND HEARD 'ROUND THE WORLD**

Concurrent with these atmospheric and upper-ocean programs, a deep-sea search for signs of global climate change was launched—amid controversy. The Defense Advanced Research Projects Agency awarded

Scripps a \$35-million contract in 1993 to develop and initiate the Acoustic Thermometry of Ocean Climate (ATOC) project.

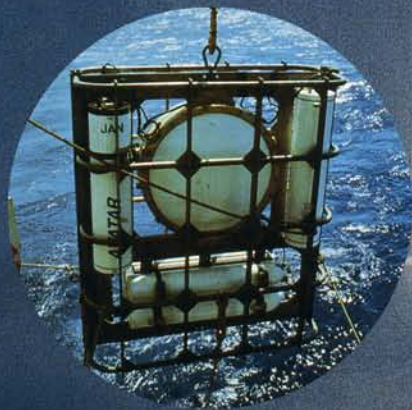
Using amplified low-frequency sound waves to measure the temperature of the Pacific Ocean, Scripps oceanographers Walter Munk and Peter Worcester, along with several colleagues from various institutions, proposed that long-term data could help prove that global climate change was occurring.







**Above,** Physiologist Gerald Kooyman has studied the diving physiology of Antarctic penguins and seals for more than 30 years. **Below,** A sound source is deployed in the Pacific Ocean during the Acoustic Thermometry of Ocean Climate experiment.



**Opposite page, Left,** Marine chemist William Fenical examines a drug source at the Center for Biotechnology and Biomedicine. **Middle,** IDA Project researchers install a seismometer in Azores, Portugal. **Right,** Seismologist Jon Berger greets a Soviet colleague.





**Above,** A Scripps diver collects reef organisms for potential use as a drug for the treatment of human diseases.

The principle behind this experiment was fairly simple. Sound waves can be transmitted through water with far less deterioration than through air; thus, it would be theoretically possible to send and receive sound waves throughout entire ocean basins in a

even blue whales made more noise.

After a few delays and an agreement to conduct the experiment farther off the coast of central California, the first broadcasts were transmitted in late 1995. Throughout the months and years that followed, ATOC transmissions safely produced a wealth of data indicating a warming trend in the Pacific.

#### DRUGS FROM THE SEA

In the early 1990s, marine pharmacology and biotechnology programs evolved from marine biology and chemistry disciplines at Scripps.

from a rare soft coral discovered by Fenical during a dive off the coast of Australia. Eleutherobin proved very promising as an alternative drug in the treatment of breast cancer. Another, pseudopterosin, was discovered in a Caribbean gorgonian coral, and showed promise as an anti-inflammatory agent for skin conditions such as psoriasis and contact dermatitis.

#### THE WHOLE EARTH

Facilities and research at the Cecil H. and Ida M. Green Institute of Geophysics and Planetary Physics (IGPP) both expanded under Frieman's leadership. A dynamic laboratory complex was added and named in honor of former director Roger Revelle and his wife, Ellen.



time span of mere hours. The speed of the sound waves would be influenced by the density of the water through which they passed. Because density changes as water warms or cools, it would effectively be possible to take the ocean's temperature with sound.

ATOC faced opposition at acrimonious public hearings and protests from those who claimed that the experiment's sound transmissions would harm marine life. The researchers defended the project, with Munk pointing out that the noise levels produced by ATOC sound sources would not exceed those emitted by ships and that

Marine chemists William Fenical and John Faulkner joined forces with bacteriologist Margo Haygood and others to form the Center for Marine Biotechnology and Biomedicine (CMBB). Integrating the knowledge of marine science with resources at the UCSD Medical School, CMBB scientists isolated natural substances in marine organisms that had potential for a variety of pharmaceuticals.

Many of the compounds discovered in the ocean and developed in the laboratory were found to be remarkably effective in combating specific human diseases. One was eleutherobin, isolated

The 17,000-square-foot redwood complex was joined to Scripps facilities on the east side of La Jolla Shores Drive by Scripps Crossing—an award-winning, single-span pedestrian bridge designed by Frieder Seible, a structural engineer at UCSD.

IGPP was the headquarters of







*Above, The 275-foot R/V Roger Revelle being launched on the Mississippi River in 1996. It is among the largest and most capable of modern oceanographic research vessels.*

Project IDA, the International Deployment of Accelerometers. This global seismic monitoring network received substantial support from longtime Scripps benefactors Cecil and Ida Green, and was administered by a team of seismologists led by Jon Berger. Project IDA was part of the Incorporated Research Institutions for Seismology (IRIS), a scientific consortium of more than 60 U.S. institutions.

“The program provided an opportunity to study the Eurasian continent in a way never before possible,” Berger said, “putting both countries in a better position to assess the effectiveness of seismic data in monitoring nuclear tests.”

Berger led a team of IRIS scientists on a tour of seismic mon-

itoring stations in the Soviet Union, and agreements were made to set up stations there. In return, a contingent of Soviet scientists visited Scripps, and the two nations agreed to share seismic data openly in order to support a comprehensive nuclear test ban treaty.

With the subsequent fall of the Soviet Union, the U.S. government also became more open with its science. Of significant interest to oceanographers was global seafloor imagery that had secretly been gathered in the midst of the Cold War era. At the urging of Frieman and members of the Environmental Task Force, which included IGPP Director John Orcutt, the U.S. Navy declassified all of the data obtained by its GEOSAT satellite. This enormous

body of data greatly enhanced research in the study of changes to ocean water mass and the composition and shape of the seafloor.

“Now,” Frieman told the press, “the world is our oyster.”

#### **ALL ECOLOGY IS LOCAL**

At the time of Frieman’s arrival at Scripps, alarming trends were becoming evident in southern California’s marine ecosystems. The kelp beds off the coast of San Diego near Point Loma had fallen victim to the effects of overfishing and pollution. By the 1990s, Scripps ecologist Paul Dayton, who has studied these once-extensive kelp beds for more than 30 years, was describing them as “ghost forests.” As a result of witnessing this devastation of marine life,





**Left,** Kelp forest ecologist Mia Tegner studies giant kelp off the coast of San Diego. **Right,** The Stephen Birch Aquarium-Museum opened in 1992.

Dayton became an advocate for scientifically informed stewardship of coastal habitats.

While depletion of local marine species alarmed Scripps ecologists, not all human-caused environmental impacts proved negative. In 1992 ecologist Mia Tegner showed that sewage from the San Diego wastewater treatment plant

grams to the institution, creating new outreach efforts, expanding the Scripps fleet, and enhancing academic resources.

“It is critical to several research programs in global environment change for the oceanographic community to maintain state-of-the-art research vessels,” Frieman said. In turn, he oversaw the “midlife

science as well as an educational resource for the community. The Birch Aquarium was a major achievement for Frieman and the institution and has become an important part of the La Jolla and San Diego communities, visited by more than 350,000 people each year, including tens of thousands of children on school field trips.

In 1995, at the end of Frieman’s years of dedicated service to the institution, the National Research Council ranked Scripps first in faculty quality among all graduate oceanography programs in the United States. “We’re Number One!” became a

**Left,** Ecologist Paul Dayton and Scripps graduate student Arja McCray measure growth in the Kendall-Frost Marsh Reserve on Mission Bay. **Right,** R/V Melville is lifted from its drydock prior to lengthening and extensive refitting.



being discharged close to the San Diego kelp beds had negligible effects on marine life. Her research supported the city of San Diego’s position that secondary treatment of sewage was unnecessary, contrary to assertions made by the Environmental Protection Agency, thus saving taxpayers \$3 billion on construction of a new treatment facility.

**“WE’RE NUMBER ONE!”**

Throughout his tenure, Frieman further secured Scripps’s reputation as a first-rate ocean and earth sciences research center by continuing to introduce new research pro-

grams to the institution, creating new outreach efforts, expanding the Scripps fleet, and enhancing academic resources. “It is critical to several research programs in global environment change for the oceanographic community to maintain state-of-the-art research vessels,” Frieman said. In turn, he oversaw the “midlife refit” of R/V *Melville*, including a substantial lengthening and full-scale refitting, increased berthing and laboratory space, new engines, and various electrical and operating system upgrades. Frieman also secured government funding for the construction of the 275-foot R/V *Roger Revelle*. In 1996, this ship was launched as one of the most scientifically advanced research vessels operating in the world.

Overlooking the Pacific Ocean and the Scripps campus, the Stephen Birch Aquarium-Museum opened its doors in 1992 as the new interpretive center for Scripps

resounding catchphrase on the Scripps campus.

“I believe this designation reflects the fundamental greatness of this institution and our faculty, our place in the world as a teaching center, and our positive contributions to society,” Frieman said. 🌐

