Roger Revelle and the Great Age of Exploration

BY JOE HLEBICA

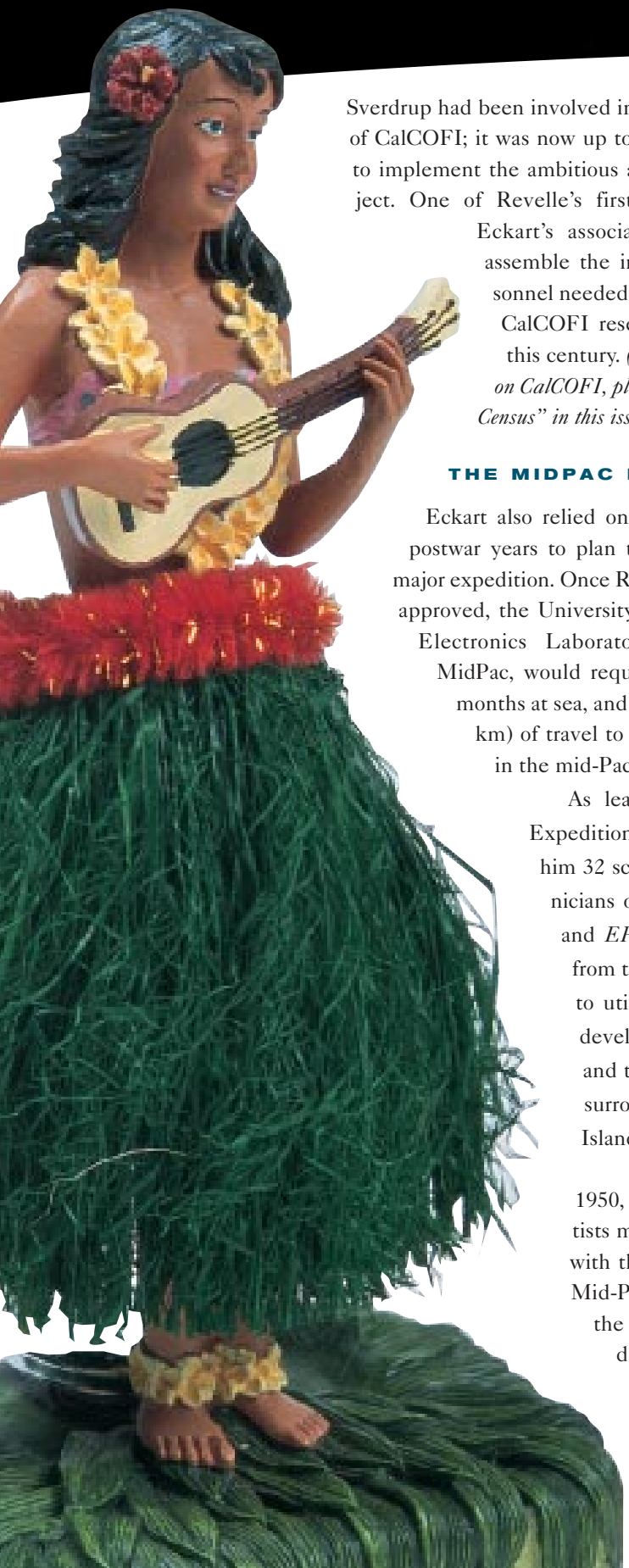
In 2003, Scripps Institution of Oceanography will celebrate its first century of oceanographic exploration, research, and discovery. This feature is the fifth in a continuing series of articles that will present special features about the history of Scripps Institution and the science, people, ideas,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

Scripps Institution of

THE YEARS AT SCRIPPS following the Allied victory in World War II were optimistic and rich with the possibilities that lay ahead. It was an ideal climate for Roger Revelle, who returned to Scripps in 1948 after the war and a brief tenure at the Office of Research and Inventions in Washington, D.C.

This was also the year Harald Sverdrup resigned as director. Sverdrup had hoped Revelle would become his successor and "lead Scripps out of the lab and into ocean exploration," according to Revelle biographers Judith and Neil Morgan. Some faculty members, however, considered Revelle too young and inexperienced, and Carl Henry Eckart, head of the Marine Physical Laboratory at the institution, was appointed interim director.

It was during Eckart's directorship that the California Cooperative Oceanic Fisheries Investigations (CalCOFI) program was formed in an attempt to explain the dramatic decline of the California sardine population.



Sverdrup had been involved in the planning stages of CalCOFI; it was now up to Eckart and Revelle to implement the ambitious and challenging project. One of Revelle's first responsibilities as Eckart's associate director was to assemble the instruments and personnel needed to support the ships. CalCOFI research continues into this century. *(For more information on CalCOFI, please refer to "Undersea Census" in this issue.)*

THE MIDPAC EXPEDITION

Eckart also relied on Revelle during the postwar years to plan the institution's first major expedition. Once Revelle's proposal was approved, the University of California–Navy Electronics Laboratory Expedition, or MidPac, would require two ships, three months at sea, and 25,000 miles (40,000 km) of travel to the Marshall Islands in the mid-Pacific Ocean.

As leader of the MidPac Expedition, Revelle took with him 32 scientists and 85 technicians on the ships *Horizon* and *EPCE(R)–857*, on loan from the navy. He planned to utilize new technology developed during the war and to explore the waters surrounding the Marshall Islands.

On September 9, 1950, the Scripps scientists made world headlines with their discovery of the Mid-Pacific Mountains on the ocean floor. Revelle described it as "a great elongated mountain range, perhaps thousands of miles long and more than sixty miles wide."

A Scripps postwar field station on Bikini Atoll.

The Mid-Pacific Mountains would prove to be part of a 40,000-mile-long (64,000-km) global seafloor mountain range now known as the Mid-Ocean Ridge.

Many of the discoveries made during the MidPac Expedition toppled firmly held scientific beliefs concerning the seafloor: it proved to be geologically young, not old, and mountainous, not a featureless plain. Arthur E. Maxwell, a Scripps graduate student, found evidence of the flow of heat through the ocean floor, which suggested to him—as well as to Revelle and Sir Edward C. Bullard, visiting from the National Physical Laboratory in England—that slow, convective movements were occurring in Earth's mantle.

Other scientists participating in the expedition also made notable observations. Russell W. Raitt of the Marine Physical Laboratory discovered that only a thin layer of sediment overlies the solid rock of the seafloor, and Edwin L. Hamilton of the Navy Electronics Laboratory found that the flat-topped seamounts at depths of about 6,000 feet (1,800 m) had been volcanic islands less than 100 million years before.

THE CAPRICORN EXPEDITION

After serving Scripps as acting director for a little more than a year, Revelle was appointed director in 1951. Ready to return to sea, Revelle set off on the five-month Capricorn Expedition. He was accompanied by most of the geologists and geophysicists at Scripps and hoped to replicate the success of the MidPac Expedition. On this expedition, however, Revelle chose the waters of the central South Pacific for the team's research.

At the time, Scripps was still dedicated to naval oceanography, and the expedition's first objective was classified. Scientists aboard the *Horizon* and the *Spencer F. Baird*, both former navy ships converted for research by Scripps, were to observe Operation Ivy, the first thermonuclear bomb test.

But as with Operation Crossroads in 1946, Revelle was primarily motivated by the opportunity to do basic research. In Helen Raitt's *Exploring the Deep Pacific*, Revelle was quoted as saying, "Most of us were marine geologists and geophysicists, and our ultimate objective was nothing less than to write a history of the [Pacific] ocean, extending back through the long reaches of geologic time."

While this monumental objective continues to challenge researchers, the Capricorn Expedition, as well as the MidPac, made a number of important contributions to modern oceanography, including some remarkable early achievements.

Using the recent innovation known as scuba, Scripps divers observed corals colonizing newly formed volcanic seamounts (undersea mountains formed by volcanic activity). "We were a little awed to be present at the birth of a coral atoll," wrote Willard Bascom, a Scripps instrument engineer. "It is the greatest structure ever built by any animal, including man."

When they tried to core and dredge the 35,000-foot-deep (11,000-m) Tonga Trench in the equatorial South Pacific, the instruments came up damaged—and empty, indicating that if any sediments

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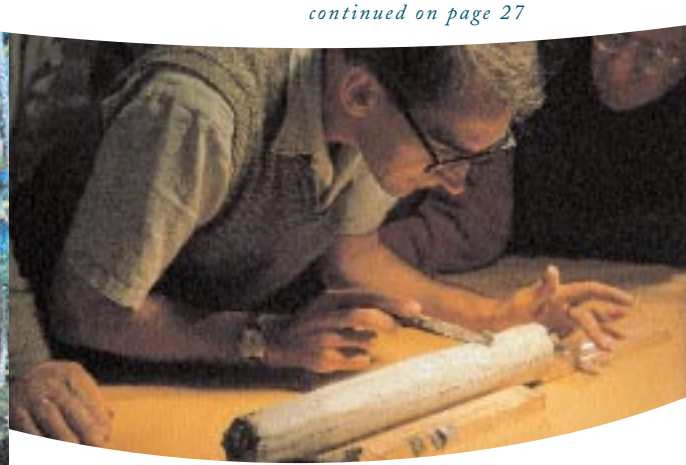

Above, *Scripps geologist Bill Riedel examines a seafloor sediment core during the Mohole drilling project.* **Left,** *Scientists in Tahiti during Capricorn Expedition.*

REVELLE: IN HIS OWN WORDS

"Oceanography is fun."

—Roger Revelle

THE OCEAN HOLDS ME IN AN ENDURING SPELL.

Part of the spell comes from mystery—the fourfold mystery of the shoreline, the surface, the horizon, and the timeless motion of the sea.

At the horizon, where my line of sight touches the edge of the great globe itself, I watch ships slowly disappear, first the hulls then the tall masts, bound on voyages to unknown ports 10,000 miles away. From beyond the horizon come the waves that break rhythmically on the beach, sounding now loud, now soft, as they did long before I was born and as they will in the far future. The restless, ever-changing ocean is timeless on the scale of my life, and this also is a mystery.

Being an oceanographer is not quite the same as being a professional sailor. Oceanographers have the best of two worlds—both the sea and the land. Yet many of them, like many sailors, find it extraordinarily satisfying to be far from the nearest coast on one of the small, oily, and uncomfortable ships of their trade, even in the midst of a vicious storm, let alone on one of those wonderful days in the Tropics when the sea and the air are smiling and calm. I think the chief reason is that on shipboard both the past and the future disappear. Little can be done to remedy the mistakes of yesterday; no planning for tomorrow can reckon with the unpredictability of ships and the sea. To live in the present is the essence of being a seaman.

The work of an oceanographer, however, is inextricably related to time. To understand the present ocean he must reconstruct its history, and to test and use his understanding he needs to be able to predict—both what he will find by new observations and future events in the sea.

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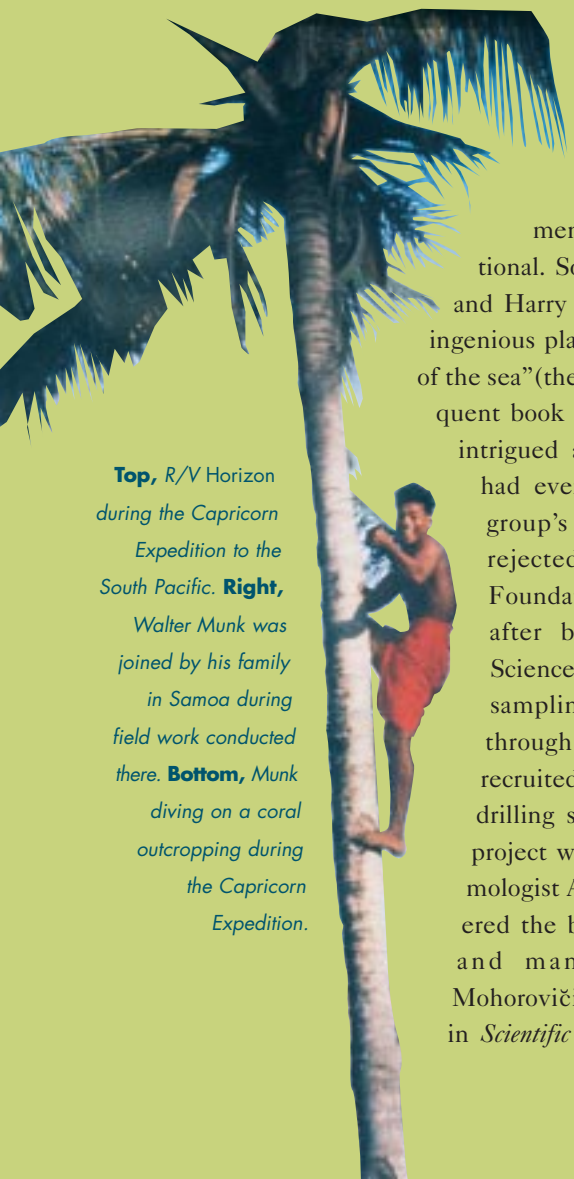
did lie at the bottom of the trench, they were sparse. It appeared as though seafloor sediments were disappearing into Earth along the axis of the trench. Later research showed that this was indeed the case, through the process now known as subduction.

"In hindsight, the evidence was all there for proclaiming the doctrine of plate tectonics, but it was a decade before others pieced the puzzle together," said Revelle's colleague and close friend Walter Munk.

Revelle recalled that the MidPac and Capricorn expeditions were "the beginning of our great age of exploration. I think it was one of the greatest periods of exploration of the earth; not just for Scripps, but for oceanographers in general."

Some of the expeditions during the mid-1950s have become familiar words in the oceanographic literature. Northern Holiday, Shellback, Transpac, Norpax, Eastropic, Downwind, and others. Munk recalls, "A generation of expedition leaders rose through the ranks, among them Bill Menard, Warren Wooster, Bob Fisher, Fred Spiess, and George Shor."



A HOLE IN THE BOTTOM OF THE SEA

Always ready for an adventure, Revelle was in his element when pursuing the unconventional. So in the late 1950s when Munk and Harry Hess of Princeton proposed an ingenious plan to "drill a hole in the bottom of the sea"(the title of Willard Bascom's subsequent book about the project), Revelle was intrigued and excited. Nothing like this had ever been attempted before. The group's daring proposal was bluntly rejected by the National Science Foundation, but accepted shortly thereafter by the National Academy of Sciences. Munk and Hess envisioned sampling Earth's mantle by drilling through the deep seafloor, and later recruited Willard Bascom to develop a drilling system to accomplish this. The project was named for the Croatian seismologist Andrija Mohorovičić who discovered the boundary between Earth's crust and mantle, later known as the Mohorovičić discontinuity. In a 1959 article in *Scientific American*, Bascom dubbed the

Top, *R/V* Horizon *during the Capricorn Expedition to the South Pacific.* **Right,** *Walter Munk was joined by his family in Samoa during field work conducted there.* **Bottom,** *Munk diving on a coral outcropping during the Capricorn Expedition.*

Left, *A luau was held in honor of Scripps scientists during the Capricorn Expedition.* **Below left,** *Willard Bascom aboard CUSS I during the Mohole project.* **Below,** *Scripps pioneered the scientific use of scuba during the early 1950s.*

new project Mohole.

Bascom's revolutionary "dynamic positioning" system allowed the drill vessel to remain in a stationary position for long periods of time while drilling. It was first put to test on *CUSS I* in March 1961 off the coast of La Jolla. This vessel was based out of Los Angeles and named for the oil companies that owned it: Continental, Union, Shell, and Superior.

After this initial experiment, the drilling system was further tested in waters near Guadalupe Island, Baja California, Mexico, under more rigorous ocean conditions. Scientists and engineers aboard *CUSS I* broke drilling records on that expedition while going down approximately 600 feet (180 m) into the sediment; the system was a success and ready for Phase II of the Mohole project.

But because of bureaucratic haggling and budget overruns, Congress halted the project. Much to Revelle's disappointment, Mohole was abandoned, although its successes led to the Deep Sea Drilling Project, now known as the Ocean Drilling Program, which has been in existence for more than 40 years.

GLOBAL WARMING RESEARCH BEGINS

With the knowledge that the ocean's carbon dioxide content might be more than 50 times greater than the atmosphere's, Revelle recruited atmospheric chemist Charles David Keeling in 1956 to monitor this gas. Scripps research in this area contributed to the international Atmospheric Carbon Dioxide Program, which was a major project for the International Geophysical Year of 1957–58. During this time as well, Revelle and geochemist Hans E. Suess warned the academic community and society that the burning of fossil fuels increased carbon dioxide in the atmosphere.

To prove this theory,

Keeling took continuous measurements of carbon dioxide at the South Pole and Hawaii over a long period of time, beginning in 1958. More than 20 years later, he was able to show a five percent increase in carbon dioxide levels. Now in its 45th year, the Scripps atmospheric program is recognized as the cornerstone of global warming studies.

Revelle's insatiable curiosity once again led Scripps into uncharted frontiers and science firsts. He was able not only to take the institution to sea but also beyond it.

A rare moment ashore: Roger Revelle with island children at a Capricorn Expedition port of call. **Below,** *Edward S. Barr (left), Warren Beckwith (center), and Willard Bascom (right) approaching Bikini Island.* **Inset,** *John D. Isaacs joined Revelle and others during postwar atomic bomb tests conducted on Bikini Atoll.*

Revelle helped society begin to understand the interrelatedness of the oceans, atmosphere, and Earth, and humankind's affect upon all three.

It was a remarkable time for Scripps under Revelle's tutelage. His spirit, imagination, and daring personality were what Scripps needed during the postwar years. And through it all, he never missed an opportunity to remind everyone what great fun he was having while exploring the mysteries of the sea.

UCSD Visionary

IN 1956, THE REGENTS OF THE UNIVERSITY OF CALIFORNIA voted to build a UC campus in the San Diego vicinity. University president Robert Gordon Sproul named Roger Revelle to head the campus planning committee. While influential opponents wanted to see the campus located elsewhere, Revelle championed the La Jolla location next to Scripps campus. To recruit faculty for what he envisioned as a new polytechnic institute by the Pacific, Revelle traveled the country seeking the best and the brightest. He sought an eclectic mix of art, culture, and science. When Jewish faculty members were excluded from buying homes in La Jolla, Revelle fought successfully against anti-Semitism in the community.

Despite his vision and significant contributions in planning the university, he was passed over for appointment as chancellor of the new university. This honor was awarded instead to Herbert York, formerly of UC Berkeley.

Statesman of Science

ROGER REVELLE'S INFLUENCE as director in the early 1960s extended well beyond the Scripps campus and continued even after his resignation in 1964. During this time, Revelle became the nation's recognized expert on global environmental issues and, as a result, testified frequently before Congress. He also made numerous television appearances.

In 1961, President Kennedy asked Revelle to become America's first scientific advisor to the Secretary of the Interior Stewart Udall. By 1963, Revelle was a renowned expert on global resources, and had accepted an endowed chair at Harvard and the directorship of its new Center for Population Studies. In 1975, Revelle returned from Harvard to become Professor of Science and Public Policy at UCSD.

When Revelle accepted the National Medal of Science from President George H. Bush in November 1990, he told a reporter, "I'm not a very good scientist, but I've got a lot of imagination. The age of exploration of the sea was just right for me."

Roger Revelle's legacy is extraordinary—nothing less than a university, born of a vision nurtured during a 50-year career. Graduate student, faculty member, naval officer, expedition leader, director, and public servant, Revelle dedicated his life to science, society, and Scripps.