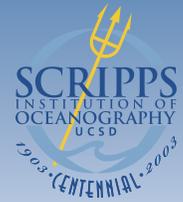


Special Issue—Scripps Centennial

Scientific Diving at Scripps



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Scripps Institution of Oceanography has been at the forefront of underwater exploration for a hundred years. Even before the development of scuba, a few pioneering Scripps scientists were going underwater with snorkels and hardhat gear.

Scripps's first scientific diver was Cheng Kwai Tseng, a biologist from China who was a graduate student during World War II (Figure 1). In 1944 he used surface-supplied abalone gear, made in Japan, to collect algae off San Diego's coast. Now in his 90s, Tseng is still on the faculty at China's Institute of Oceanology, Chinese Academy of Sciences.¹

In 1947, Frank Haymaker, a diver working for Scripps zoologist Francis Shepard, made dives in the Scripps Submarine Canyon using hardhat gear.

The institution's first dive master, Conrad Limbaugh, and graduate student Andreas Rechnitzer, helped begin the research diving program at Scripps in the early 1950s and helped establish the first scientific diving standards. They exchanged ideas and techniques with the U.S. Navy, which eventually filtered down to the public.

Limbaugh and Rechnitzer also began the nation's first civilian diving course. The two volunteered their time to teach anyone interested in learning scuba. Many researchers and divers at Scripps contributed to new diving techniques, including the second diving officer at Scripps, Jim Stewart, who was responsible for the first formal diving safety manual. Utilizing this manual, he trained divers on safety procedures both nationwide and worldwide.

University of California, Berkeley physicist Hugh Bradner is credited with invention of the wet suit, in 1951–52. He was helped along the way by colleagues at UCB and Scripps, as well as by the U.S. Navy. The wet suit brought more people into diving than even the invention of the regulator, because cold temperatures were no longer a limiting factor in staying underwater.

Chuck Mitchell was just 15 years old when he began diving with Scripps researchers. He went on to found a company that provided commercial assessments of marine environments and also served as president of the American Academy of Underwater Sciences.

The early days of diving at Scripps can best be told through the recollections of some of the pioneers who were there.

Conrad Limbaugh

An early freediver and spearfisherman, Conrad Limbaugh was a graduate student in marine biology at University of California, Los Angeles when he convinced his major professor, Boyd W. Walker—who had himself received a Ph.D. from Scripps—that this new gadget had a place as a tool for marine scientists of the future (Figure 2). Walker purchased one of the first Aqua-Lungs ever sold in the United States. Limbaugh and Rechnitzer, also at UCLA at the time, took turns on the scuba gear while the other snorkeled on the surface.

When a UC Berkeley graduate student died in a diving accident off the coast of La Jolla, Scripps Director Roger Revelle asked Limbaugh to develop a training program in scuba. The first official course was held at Scripps in 1951. The curriculum was heavily influenced by the U.S. Navy's training as Underwater Demolition Teams (UDT) Commander Doug Fane often invited Limbaugh and other Scripps divers to participate with his men. This "boot camp" aspect continued as part of dive training for more than 20 years. Limbaugh's training course became the basis of the first public scuba certification, founded in Los Angeles County by Bev Morgan, Ramsey Parks, and Al Tillman after they studied under Limbaugh.

Chuck Mitchell, who also trained under Limbaugh, reflected on Limbaugh's methodical techniques. "I used to marvel at how we would dive an hour someplace rather unexciting, usually the sand dollar beds at the end of Scripps Pier," Mitchell said.

"He would come back, sit down at the typewriter, and it would be almost like he had a videotape running the whole time. He would fill 15 or 20 typewritten pages with notes of incredible detail. Nothing was taken for granted, everything was recorded."

In such dive reports, Limbaugh would record everything from the technical to the peculiar. In an undated report of a 64-m dive in La Jolla Canyon, he wrote the following:

¹See <http://www.qdio.ac.cn/english/History.asp>

"The reference points were the Cove Park flag pole, lined up on the La Valencia Hotel tower, and the north end of the Marine Room of the Beach and Tennis Club on the white house with the rounded dome, known as the 'monstrosity' by the SIO geology department...As we neared the 200 foot [61 m] depth, we found a few cobbles to which were attached gorgonians. One cream-colored gorgonian was attached only in the mud and lay flat on the substrate. I noted several crook-shaped sea pens.

*"Nitrogen narcosis was evident in a subtle way. On several occasions, I saw objects I wanted to pick up while I was collecting something else, but would forget to pick them up...I noted we had used up 11 minutes and motioned the others to ascend...At about 190 feet [58 m] noted a dense patch of the sea urchin *Litichinus* [sic] approximately 100–300 per square meter...We had no noticeable aftereffects, except the feeling of being extremely tired."*

Rechnitzer says that Limbaugh's techniques continue to influence divers.

"Today, diving operations for universities and scientific organizations are governed by a diving control board," Rechnitzer said. "This originated when Limbaugh refused to certify a student on the grounds that he was not psychologically balanced enough to be a diver. He proved our point when he threatened to kill Limbaugh. He really meant it. We said, 'We've got to take that burden off you and set up a committee, so he will have to pick on five or six people.'"

"At that time no one was overseeing us except Carl Hubbs. We got him to go diving when he was 55. He used to be a great swimmer, but that's the only dive he ever made. Mrs. Hubbs once got furious with me. 'When are Connie and you going to get to work? You are out diving all the time.' But old Wesley Coe, a Scripps professor, said, 'Son, you go on out there. You will learn more in an hour [underwater] than you'll learn in ten hours with books.'"

Limbaugh died in a cave-diving accident in France in 1960, at age 35. His death sent shockwaves through the diving community because he was recognized as one of the top authorities on all aspects of the underwater world.

In a report about the accident, Scripps scientist Wheeler North, who had worked closely with Limbaugh, wrote the following:

"On 20 March 1960, Conrad Limbaugh, one of the most experienced, cool-headed, and safety-conscious divers in the world, lost his life while diving in a submarine cave at the tiny harbor of Port Miou, near the Mediterranean resort town of Cassis, France, about 10 miles [16 km] east of Marseilles."

Limbaugh had become separated from his buddy, lost his light, and took a wrong turn that led him deeper into the cave. His body was found a week later.



Figure 1. Cheng Kwai Tseng, Scripps's first scientific diver.



Figure 2. First scientific diving program. Left to right: Early Murray, Scripps; Tom Theise, UDT; John Carter, VOL; Chuck Fleming, Scripps; Andy Rechnitzer, Scripps; and Jim Stewart, Scripps. November 1954 in Mexico.

"That was really a shocker when he went," Rechnitzer said. "I figured Limbaugh was sitting on a ledge somewhere in that cave, twiddling his thumbs, trying to figure a way to get out, because we had gotten out of some pickles before. He was cool...He'd figure a way out. Whenever we had problems in the canyon, whatever it might be he, would always coolly, calmly figure out what to do."

"According to the wishes of Mrs. Limbaugh," North's report said, "the body was interred in the Cassis cemetery. The marine biologist now lies interred with plain fisherfolk of the Mediterranean, a fitting place for a scientist who devoted his life to studies of the sea."

Andreas B. Rechnitzer

Limbaugh's associate and later a leader in the U.S. Navy's manned submersible program, Andy Rechnitzer was head scientist on the Trieste project,

which resulted in humanity's only excursion to the Marianas Trench, the deepest point in the ocean.

Limbaugh met Rechnitzer when they were both graduate students in marine biology under UCLA Professor Boyd Walker. Rechnitzer was an avid freediver and spearfisherman, and had served in the U.S. Navy in Hawaii at the end of World War II. Like Limbaugh, he was attending school on the G.I. Bill with the ultimate goal of earning a Ph.D. in marine biology at Scripps. At that time Scripps was a branch of UCLA, and all graduate students first had to take a year of coursework at the "mother" institution.

When the Aqua-Lung was purchased, the two graduate students set out to master its use. There were no courses or instruction books, so like all early divers they learned through trial and error. Because there was only one unit, one of them would dive while the other followed with a snorkel.

"We dived out of the back end of [Limbaugh's] car. We had bathing suits, Aqua-Lung, faceplate, and fins, that's all."

By the time Rechnitzer and Limbaugh arrived at Scripps in the summer of 1950, they had obtained a second Aqua-Lung. There was no compressor in San Diego, so refills were made from a storage system of six tanks. When those ran out, the tanks were shipped to Los Angeles for refilling, causing a temporary hiatus in diving activity.

This was the beginning of the Scripps scuba diving program. Procedures such as the buddy system, buddy breathing, and ditch and recovery were introduced and developed by Limbaugh and Rechnitzer.

"Limbaugh, [Scripps diver Jim] Stewart, and I wanted others to enjoy what we were enjoying, and show them what it could do for their scientific work," Rechnitzer said. "So it wasn't long before we started a training program. Interest was slow to build, and those first courses were almost private lessons. We didn't really teach the first divers, we just demonstrated and told them, 'This is how you do it.' But they were divers or snorkelers to start with. It wasn't until 1952 that we finally organized it into a written syllabus. By that time there were no more than four or five divers."

When Limbaugh and Rechnitzer were recruited by Roger Revelle to formalize diving procedures at Scripps, they began with trying to solve the most basic problems.

"We asked, 'What problems might someone have down there?'" Rechnitzer said. "'If someone kicks my faceplate off, what do I do?' So you've got to breathe without a faceplate on. 'What else?' We've got to swim, so there has to be some endurance swimming."

Ditching equipment and recovering it from the bottom were done for psychological preparation. Harassment was also part of the program, consisting of kicking off divers' faceplates and turning off their air by pinching the hoses.

Rechnitzer said to Limbaugh one day, *"I feel comfortable when we are diving together. We ought to have a*



Figure 3. Conrad Limbaugh.

buddy system." Limbaugh agreed that it was a good idea, then asked, *"What do we do as buddies?"* One thing was sharing air. They swallowed a lot of saltwater while developing diving techniques, because early regulators lacked nonreturn valves, causing the hoses to fill with water. *"Psychologically, in anything that has a side of danger, you assume the other guy has the answer. You just do better when there are two. So that's how the buddy thing got started,"* Rechnitzer said.

Early on, these pioneers recognized the need for self-regulation of diving. In an article written for the second issue of *Skin Diver* magazine in 1951, Rechnitzer wrote that *"we should license ourselves and keep the bureaucrats out of our business."*

Rechnitzer recently recalled, *"This is one of my proudest things. We have good training, cross certification—and it derived from what Limbaugh and I put together years ago."*

James R. Stewart

In 1952, Limbaugh recruited Jim Stewart as a volunteer to assist with kelp research and diver training (Figure 3). Stewart had earned a degree in botany from Pomona College and had studied marine botany at the graduate level at the University of Southern California and the University of Hawaii. His volunteer work at Scripps was soon upgraded to a part-time job assisting Limbaugh and Wheeler North with kelp studies. Adapting topside surveying techniques, the research team performed the first underwater transects, a method that is now a cornerstone of underwater science.

Fish collecting was among Stewart's duties, both for research and for display at Scripps Aquarium. A major problem at the time was keeping deepwater fish alive because they often died when brought to the surface as a result of pressure changes that ruptured their swim bladders. Stewart helped develop the technique of removing gas underwater with a hypodermic needle, which is still used today.

After Limbaugh died in 1960, Stewart was named to succeed him. His job title was principal health and



Figure 4. Hugh Bradner in 1953.

safety technologist, but he soon changed that.

"The only recompression facilities available to us at the time belonged to the Navy. I thought that if I had a pressure-related problem...and identified myself by that job title, they would pass me around the ship to whomever would talk to me, but certainly not to the medical officer or the master diver. Hence, I chose the 'operating title' of diving safety officer on the premise that I could probably speak to someone who knew what I was talking about."

Stewart participated in some of the pioneering efforts of diving science, including the first diving research cruise in the Channel Islands, aboard the 30-m vessel Orca. It was on this trip that he and Rechnitzer first recorded the sounds of humpback whales.

Stewart also traveled to the Enewetak and Bikini atolls in the Marshall Islands, sites of atomic and hydrogen bomb tests. His assignment was to study the effects of the bombs on marine algae. *"We were diving in those craters three days after the bombs went off,"* Stewart said. *"Our radiation protection consisted of a pair of Speedos."*

From 1952 to 1960, Scripps was the epicenter of diving for the University of California, conducting all the training for the other campuses, certifying divers, and maintaining all the records. By the mid-1960s the university started to decentralize, and Stewart was asked to create a systemwide program that could be used by all divers. The original diving safety manual had been put together by a statewide committee chaired by the director of the University of California Institute of Marine Resources, Admiral Charles Wheelock.

"Because I didn't want to reinvent the wheel, I looked for something that was already a university-wide manual that would lend itself to diving...What I found was the radiation safety manual. So I took it and simply changed the wording to diving. There was a radiation safety officer, so it was a comparable position to the one I had as diving officer."

Stewart's updated rules struck a delicate balance between strong safety standards and enabling scientists to do their jobs. At other institutions, according to Scripps biologist Paul Dayton, *"bureaucrats got scared*

about liability, and hired ex-military people to run dive programs. [They were] elitist, macho types. Many scientists couldn't qualify. So they got Jim to come to their institutions in the late '60s to explain the Scripps program...Everywhere I've been I've seen the effects of Jim Stewart selling diving as a scientific tool...Many of us owe our careers to him."

In 1971 Stewart was asked by California Sea Grant to put the Scripps manual in a format that could be published and sent around the nation as well as around the world. *"I became an expert in the blink of an eye. But, it's not hard to be an expert when there's only one of you."*

Stewart recalled,

"I inherited a program. In his 1953 letter, Roger Revelle wrote UC President Robert Gordon Sproul that scuba should be accepted as a legitimate means of conducting research. I just brought it out of the dark ages. Lots of Revelle's words are still in our regulations. The people that started scuba were water people. We trained the rest."

As colleges and consulting firms around the country became involved in scientific diving, they too adopted the Scripps guidelines. Today, the guidelines form the basis of the American Academy of Underwater Sciences (AAUS) diving manual, the "bible" for the scientific diving community. Stewart was a founder of AAUS, an organization originally formed to combat the federal Occupational Safety and Health Administration's regulation of scientific diving. Today, AAUS is the voice of scientific diving.

Hugh Bradner

A physicist at UCB, Hugh Bradner was an active diver in San Diego throughout the development of diving at Scripps in the 1950s (Figure 4). He served as an adviser to Scripps and the Navy in areas ranging from safety to equipment. It was in this capacity that he invented the wet suit in 1951–52. Before then, divers tried to stay warm with thin, latex dry suits. A single puncture would render the suits useless in a flood of cold water.

"If you'd ever used any of the so-called dry suits that the navy had at that time, there'd be no question about the need for improvement," Bradner said. *"It was pretty self-evident that heat insulation through the suit came from the dead air that's trapped there, and that you don't have to stay dry to stay warm."*

Bradner realized that adding insulation to a suit could restrict water flow next to the skin, allowing body heat to warm the water. He sought a material that would be unicellular, could be cemented, and would stretch. Neoprene foam met the criteria. It was being used at the time in seat cushions and insulation for homes. In his spare time, he made some suits, tested them, and offered them to the U.S. Navy's UDT for testing (Figure 5).

"[UDT Commander Doug] Fane felt that the suits were far from optimum; they were too fragile, and he did his damndest to get his guys to tear them every time they used



Figure 5. John S. Foster, a physicist and colleague of Hugh Bradner, modeling an early design of the Bradner wet suit in 1953.

them,” Bradner said. Apparently they eventually passed muster, and Fane asked for more. But the Navy brass wasn’t interested.

“Initially, we treated it as a classified project and turned it over to the government for trying for a patent, but they felt that they didn’t need any patent protection,” Bradner said. “The morality in those days was that one was not supposed to profit by anything that he did under government auspices... So they gave it back to me to turn over to the university. The university asked, ‘Did I see any significant commercial aspect to it? In my wisdom I said no, maybe 50 people in the country might buy one.’”

“After that, the UDT wanted them. Even Doug Fane was much in favor of it, but the Navy couldn’t put out contracts and issue them and run all the acceptance tests in less than about seven years at that time. So, having gotten it declassified, we arranged to have a couple of outfits build them commercially. Fane got a discretionary fund, which he could then use to allow his swimmers to go out and buy the things.”

Bradner and his friends at the Berkeley Radiation Lab started the Engineering Development Company (EDCO), which began producing wet suits. Busy with his research, Bradner soon phased out of the company—in 1961 he became a professor at Scripps Institution’s Institute of Geophysics and Planetary Physics—but it wasn’t long before divers around the world picked up on the new concept and deserted their primitive, fragile dry suits for the new wet suits.

Chuck Mitchell

In 1955, Chuck Mitchell heard that Scripps Institution of Oceanography was looking for a part-time technician of at least 16 years old. Chuck was a year too

young and had just graduated from junior high, but he kept badgering folks at Scripps, stressing his experience in and around the water, and finally got hired. That part-time job set the course for the rest of his life.

Hired on a National Science Foundation grant, Mitchell was assigned to the biochemistry department. He took the Scripps diving course, with Rechnitzer as head instructor, and was awarded Diving Card No. 103. Mitchell also worked and dove with Limbaugh in those early years.

“I was the kid, and was subjected to a lot of testing and scrutiny,” Mitchell said. “That’s something lacking in diving today. I remember making whole dives with no faceplate, my air being turned off constantly. For a 100-foot [30-m] card, you had to go to 160 feet [48 m] on air in a chamber and 60 feet on pure oxygen. If you convulsed, you failed.

“The test was done on the *Nereis*, a submarine repair ship anchored in San Diego Bay. I went in with two women that day, Nan Limbaugh and Marge Reidell, both excellent divers. They were the first two women who had ever been in there. That old Navy chief who was with us did nothing but grouse about women in his chamber. He did everything he could to stress them out. We made the descent to 48 m in less than a minute.”

Diving in those days was cold, with only a navy watch sweater belted around the waist to keep the cold water from circulating. When diver Bill Batzloff was hired to manage the Scripps diving locker, he brought his expertise in making the new wet suits. Shortly thereafter, all of the Scripps research divers had them.

At the end of that first summer, a project was funded to study kelp forests along the West Coast. This meant Mitchell could stay on, working weekends, after school, and during vacations.

When the tanker *Tampico* ran aground south of Ensenada in the late 1950s, Wheeler North began a long-term study of the effects of the massive diesel spill. Several of the Scripps divers joined the effort, observing the underwater effects of the spill.

“We used to load everything in three-ton stakebed trucks, fill the back with 50 to 60 tanks and food, and drive on down the road. Nobody had four-wheel drives. We would drive into all these god-awful areas and spend the week diving. Jim Stewart, Pat Cunnison, Earl Murray, Ray Ghelardi... a whole bunch of people contributed their time just to dive.”

Mitchell went on to establish MBC Applied Environmental Sciences in 1969, and continues to dive, 50 years after learning from the Scripps diving pioneers.

From these beginnings, Scripps divers have traveled the world over the past half century, from the Antarctic to the tropics and points between. Their experiences, adventures, and contributions to science are far too numerous to recount here. Although modern technology provides new, automated methods to study the oceans, there will always be a place for human eyes and hands and direct observation through diving. 