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Scripps Before World War II: The Men, the Science, and the Instruments

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A century ago, University of California zoologist William E. Ritter dreamed of establishing a marine station on the West Coast of the United States. Beginning in 1892, he and a few of his graduate students pitched a tent each summer at a different town along the Pacific coast and studied marine specimens. In 1903, he was in San Diego and met the Scripps family, who would fund his dream laboratory. Ritter, E. W. Scripps, and Ellen Browning Scripps wrote the bylaws of the newly established Marine Biological Association of San Diego on September 26, 1903. The marine station in San Diego, they wrote, was to conduct, "a biological and hydrographic survey of the waters of the Pacific Ocean adjacent to the coast of Southern California; to build and maintain a public aquarium and museum."

Historians of science have long discussed this wording to determine Ritter's intention. Was the San Diego station to be just another summer shore station for biologists or was it really a proto-oceanographic institution?

These historians have generally studied Ritter's lectures and publications to answer this question. But a study of the instruments acquired by scientists at Scripps before 1940 may offer better evidence of their scientific intentions. Oceanography has been called an instrument-driven science. Instruments have defined ocean science as a discipline and have influenced the way Scripps Institution was organized. That was true in 1903 and it is true today.

Before Scripps

In 1903 both Ritter and his Berkeley colleague Charles A. Kofoid described themselves as zoologists, not oceanographers. Ritter was born in Wisconsin in 1856 and Kofoid in Illinois in 1865. Ritter studied at Oshkosh and the University of California, and Kofoid's undergraduate degree was from Oberlin. Both men went to Harvard as graduate students of E. L. Mark at the Museum of Comparative Zoology. At Harvard they undertook original scientific research leading to a doctorate, which was considered appropriate training for university faculty. Along the way, they both acquired a little East Coast polish and some important connections.

Graduate education has changed substantially over the last century. Science at Harvard was taught at the bench, not in the classroom. Kofoid describes this environment as follows:

> *The men have each an appointed seat, microscope & lens, and everything is furnished [for] them to do. He is told to draw what is given him and the assistant criticizes and corrects his work-questions him on it and make any suggestions which are best in his mind….There is little spontaneity and freedom.*[1]

Ritter and Kofoid each spent summers at the private marine laboratory established in Newport, Rhode Island by Alexander Agassiz, the leading American marine scientist of his generation. Agassiz was the son of Louis Agassiz, a famous Harvard naturalist. Alexander Agassiz became enormously wealthy through investments in the Calumet copper mine. He used his personal wealth to support science at Harvard and to fund his own research. Agassiz was a seagoing scientist with experience and a wide acquaintance among oceanographers around the world.

Ritter and Kofoid, like many of their contemporaries, worked largely with preserved specimens at Harvard. In Newport, they learned to use dip nets and dredges to collect living specimens from small launches and rowboats. Both had a roaring good time in Newport, loved the fieldwork, and began to think about starting a little seaside laboratory of their own when they went back West.

Outfitting Scripps Institution

Scripps Institution of Oceanography began as a small marine biological laboratory set up by Ritter in the boathouse of the Hotel del Coronado during the summer of 1903 (Figures 1 and 2). It was poorly equipped with a couple of Zeiss-Greenough binocular microscopes, a dredge, a trawl, and some glassware borrowed from the University of California, Berkeley. Ritter hired a local fisherman to collect specimens and sample plankton. The scientists apparently made nets

[1]C.A. Kofoid to Prudence Winter, December 25, 1891. Kofoid Papers, Box 2, Folder 33, Scripps Institution of Oceanography Archives UCSD.

Figure 1. *Boat House of the Hotel del Coronado, summer 1904.*

Figure 2. *Staff and students of the Marine Biological Station at Coronado, 1904.* ***Seated left to right:*** *John F. Bovard, Effie Rigden Michener, Alice Robertson, and Calvin O. Esterly. Standing: Robert Day Williams, B.D. Billinghurst, William E. Ritter, Loye H. Miller, Charles A. Kofoid and Harry Beal Torrey.*

themselves from bolts of silk and gauze purchased from a department store in Chicago.

If the little marine station in Coronado wasn't rich in instruments, it was rich in connections. The Scripps family provided funds for its operation, and Alexander Agassiz himself came to visit in the summer of 1905. Agassiz was so distinguished and so wealthy that he was allowed to periodically borrow a ship from the U.S. Fish Commission for oceanographic expeditions with the understanding that he would pay for the coal himself. Agassiz and Kofoid took the commission's steamer *Albatross* from San Diego to the South Pacific in 1905, on the final leg of the *Albatross* Expedition (Figure 3).

When Kofoid returned from the *Albatross* Expedition, Ritter entrusted him with the work of acquiring instruments and supplying the laboratories for the marine station. The first instrument acquired by the institution was a Pettersson vertical closing net, a gift of Agassiz (Ritter, 1912). By 1912, a quarter of the instruments acquired by the institution were purchased from commercial sources, another quarter were designed and constructed by scientists themselves, and the remaining half were purchased in Europe. Ritter noted that biological apparatuses were generally available in the United States, while hydrographic instruments were not (Ritter, 1912).

On Ritter's instructions, Kofoid purchased a Thomson sounding machine around 1905.[2] This was a significant choice. The Thomson sounding machine was best for work in shallow water, while the Sigsbee sounder was more appropriate for deep-ocean work. Ritter expected to be working close to shore.

The marine scientists in La Jolla used piano wire with the Thomson device. The Bureau of Fisheries turned down Kofoid's request for a loan of sounding wire from *Albatross*.[3] Good cable was hard to find. The best cable wire was manufactured in Germany but shipping was costly and unreliable. Ritter advised Kofoid and the other young scientists at La Jolla to make do with what they had in hand or content themselves with American wire. Kofoid found this unsatisfactory:

> *"To my mind it is both useless and a waste of time and money to attempt to do oceanographical work without an adequate equipment."*[4]

Like many scientists of his generation, Kofoid designed some instruments himself. He worked with Valdemar Arntzen, an instrument designer and mechanic from Berkeley. Arntzen prepared detailed plans from Kofoid's sketches of nets and plankton samplers and then built them.[5] At the time, the best oceanographic instruments in the world came from the North Sea nations in Europe, especially

[2]Accounts in Box 11, Folder 45, Scripps Institution of Oceanography Archives UCSD.
[3]G.M. Bowers to C.A. Kofoid, June 4, 1907. Kofoid Papers, 82–71, Box 1, Folder 3, Scripps Institution of of Oceanography Archives UCSD.
[4]C.A. Kofoid to W.E. Ritter, August 12, 1908, p. 12. Kofoid Papers 82–71, Box 1, Folder 4, Scripps Institution of Oceanography Archives UCSD.
[5]V. Arntzen to C.A. Kofoid, May 29, 1907. Kofoid Papers, 82–71 Box 1, Folder 3, Scripps Institution of Oceanography Archives UCSD.

Figure 3. *Deck of U.S. Fisheries steamer* Albatross *in San Diego (ca. 1905).*

Figure 4. *University of California President William W. Campbell and Scripps Director Thomas Wayland Vaughan looking at Ekman current meter in Scripps Museum, 1927.*

Germany and Norway. They were expensive, but the financial prospects of the marine station in San Diego were about to improve.

Ellen Browning Scripps provided an endowment in 1906, and the Marine Biological Association purchased land in La Jolla on which to build a permanent marine biological station. E. W. Scripps promised to build a research vessel for the institution. Kofoid got a small grant from the U.S. Bureau of Education to tour the biological stations of Europe and write a report on their organization, equipment, and work. His purpose was to investigate the facilities, staff, and research methods of the European nations in order to assist Ritter in designing and equipping the marine station in La Jolla. He also planned to purchase oceanographic instruments.

His timing was perfect. For in 1908, the Central Laboratory for the International Council for the Exploration of the Sea (ICES) in Cristiania (now Oslo, Norway) was closing. ICES was the first effective international oceanographic organization. The Cristiania laboratory had been established in 1903 to design, standardize, and calibrate the instruments used for ICES cruises, and Walfried Ekman had developed the first standardized hydrographic instruments. Ekman was willing to sell instruments to Kofoid. Kofoid sent Ritter an inventory of what was available and asked for authority to purchase the lot on behalf of the La Jolla marine station. The instruments had been made at the laboratory by the scientists themselves or by various instrument makers. Kofoid wrote the following: *"The present instruments are tested and approved whenever necessary. It will be difficult to get any one to do this in the future."*[6]

Kofoid had a remarkable opportunity to acquire the latest hydrographic instrumentation. Ritter had the funds for the purchase, but he authorized Kofoid to spend only $700 and to concentrate on equipment necessary for plankton and biological work. "As to general policy," Ritter wrote Kofoid,[7] "*while we are greatly interested in oceanographic problems as such, we must not, as I see it, ever let these rise to the place of primary importance. Biology is our main interest.*"

Ritter specifically advised Kofoid not to purchase the Christiania bottom sampler, a coring device. "*Since with our present working force it is impossible to take up this work seriously it will not be wise to put much money in apparatus for it*," Ritter said.[8]

This clearly shows that Ritter wanted a marine biological station focused on nearshore biology and was not yet willing to undertake deep-sea hydrography or even collect nearshore cores.

Kofoid purchased a Petterssen trawl, a Fox gas analysis apparatus (Fox, 1905), steel sounding wire, four fish baskets, a plankton bucket, two Nansen closing nets, Richter deep-sea thermometers, an Ekman reversing water bottle, an Ekman current meter (Figure 4), and standardized water.[9] These were added to the equipment of the marine biological station's new ship R/V *Alexander Agassiz*.

The equipment was shipped from Norway to the Isthmus of Tehultepec, and then by rail to San Diego. It took five months to arrive, and some pieces were found to be missing or broken. Kofoid wrote Ritter the following:

> *Long delays are inevitable in ordering from Richter as he is an artist in thermometers and exceedingly careful and lets none go but perfect instruments. Ekman says*

[6]C.A. Kofoid to W.E. Ritter, August 12, 1908, p. 13. Kofoid Papers, 82–71, Box 1, Folder 4, Scripps Institution of Oceanography Archives UCSD.
[7]W.E. Ritter to C.A. Kofoid, October 18, 1908. Ritter Papers, Box 1, Folder 13, Scripps Institution of Oceanography Archives UCSD.
[8]W.E. Ritter to C.A. Kofoid, September 2, 1908. Ritter Papers, Box 1, Folder 13, Scripps Institution of Oceanography Archives UCSD.
[9]C.A. Kofoid to W. Ekman, September 20, 1908. Kofoid Papers, 82–71, Box 1, Folder 5, Scripps Institution of Oceanography Archives UCSD; Rohlfsen & Frien to W.E. Ritter, December 21, 1908. Ritter Papers, Box 1, Folder 13, Scripps Institution of Oceanography Archives UCSD.

we must allow from 6 mos. to a year on all orders from him and he is overcrowded with orders even now….Breakage in shipment or in handling might seriously or completely disarrange a summer's program at a critical point.[10]

Hardy Instruments, Hardy Scientists

All of this had a profound effect on the culture of the La Jolla marine station. Instruments were precious but had to be risked at sea. Scientists had to be physically strong and skillful with their hands. Scientists needed to maintain relationships with instrument designers and mechanics. Many scientists owned, shipped, and handled their instruments personally, rather than entrusting them to others. Instrument losses could be catastrophic, but they were common. Marine scientists became adaptive by necessity.

Some of these characteristics persist among seagoing oceanographers today. Oceanographers tend to be physically strong and good with their hands. They value old shipmates and experienced technicians over laboratory-based theoreticians. They test instruments themselves and often design and build them. They interact closely with companies that design and manufacture scientific equipment. They prepare meticulously in advance for their work at sea. They are particular about the research vessels they sail on and the vessels' equipment. They want a cordial relationship with the captain and crew, though they are focused on instruments, collections, and data. But their defining characteristic is their adaptability. Successful oceanographers learn to triumph over disaster when critical instruments fail and research programs falter.

The peril of work at sea combined with the risks necessary for success in oceanography spawned a hero culture. This is evident in the obituaries of oceanographers and polar scientists of the nineteenth century. In 1872, the British ship HMS *Challenger* returned from a four-year circumnavigating oceanographic expedition. Twelve men died on the cruise. This represented a loss of five percent of the ship's company, if you don't count two additional men murdered in ports of call. The chief scientist did not even mention these deaths in the scientific report of the expedition, but he praised the dead scientists as heroes in their obituaries. By 1950, oceanography was safer and the term hero began to be used with irony. For instance, the bucket in which scientists stand while deploying instruments over the side of a research vessel is called the "hero platform." The word *hero* is applied today to scientists who sacrifice their own research in order to write proposals, gather support, and administer large cooperative oceanographic projects. The hero culture has changed, but as long as scientists risk their lives at sea, it will continue to be in the culture of the discipline.

Oceanography has long been called an international science. When scientists say this, they are often referring to the literature and the global scale of research, but it also has a literal meaning. Western oceanography began in the North Sea nations. Many of the great American oceanographers of the early twentieth century were North Sea born. At Scripps, many scientists had North Sea connections. The families of Martin Johnson and Kofoid came from the Danish island of Bornholm. Eric Moberg, the Scripps chemist who was also in charge of ships, was Swedish born. German was the second language on the Scripps campus, and this was true both for the oceanographers and technicians.

It's easy to see European influences at Scripps. For instance, during the early twentieth century, the instruments that were not at sea were kept in the museum, which was operated by the aquarium. Scripps Aquarium was not merely a place for the public to observe marine life; it functioned after the European model, as a storehouse for living specimens and instruments for the use of scientists.

World War I significantly changed the instrument-making centers of Europe. The instruments up until that time were primarily mechanical—springs and gears, clockwork, lead weights, and messengers operated them. If a Nansen reversing water bottle closed too quickly, you could lose a thumb. If instruments were not properly attached to the wire, a kink in the wire could endanger a whole string of apparatuses, the winch, and even the ship. Instruments had to be recovered from sea in order to read their data or obtain their samples, and what went down didn't always come up. Data was stored the old-fashioned way: on paper. Computations, reductions, and averages were made by computers, which were people, not machines. At Scripps, scientists initially performed these mathematical computations, but often the daughters of scientists were drafted for this task.

Most of the instruments used at Scripps before 1916 were handmade and meant to be deployed at anchor on station. The post-World War I generation of instruments were designed to be deployed while a ship was under way. Instruments that automatically recorded data and were expendable were preferred. Instruments began to be mass-produced. They were designed to be maintained and deployed by technicians rather than oceanographers. Oceanographic instruments designed and fabricated in the United States became more common, while American glassware, marine cable, laboratory benches, and adding machines were as good or better than anything that could be purchased in Europe.

These developments affected the structure of Scripps. By 1916, Scripps began to employ a new class of scientific worker, the associate. Associates were paid

[10]C.A. Kofoid to W.E. Ritter, 20 September 1908. Kofoid Papers, 82–71. Box 1, Folder 5. Scripps Institution of Oceanography UCSD.

less than the faculty and their job was to maintain instruments on the pier and on ships and record their readings for the scientists. This class of worker eventually included laboratory technicians, draftsmen, computers, aquarists, and collectors. Many of these people were college educated and could speak foreign languages. That inflamed nativists during the World Wars who found the multinational workforce at Scripps suspicious.

The associates were also the locus of many administrative problems for the director. The home campus, UC Berkeley, never understood their job descriptions and wanted to pay them as clerks. While Scripps purchased instruments centrally, the technicians who knew how they worked and how to fix them reported to individual faculty. Individual faculty controlled data; some shared it while others did not. Some of the associates were women, who, under the nepotism rules of the University of California, could not keep their jobs if they married fellow Scripps employees. The director of Scripps had his hands full trying to maintain harmony on campus.

Oceanography in 1936: Introduction of Electronic Instruments

Up to the 1930s, instruments were precious and expensive. When Sverdrup came to Scripps Institution in 1936, he brought several instruments with him from Norway. There was still nothing manufactured in America that could match them. $1,500 worth of uninsured instruments were lost in 1936 when the institution's research vessel *Scripps* burned and sank. The Nansen bottles were recovered when Scripps offered a reward for any that washed up on the beach (Sargent, 1979). In 1937, Athelstan Spilhaus, an American oceanographer, took out a patent on an instrument we now call the bathythermograph. It plots the temperature of the ocean against depth and is a critical instrument for oceanography. In 1937, copper tubing filled with xylene inside the bathythermograph expanded or contracted depending on the temperature. This pushed a stylus inside the instrument that scratched across a smoked slide, leaving a trail. The bathythermograph was born as a mechanical instrument, but was modified over the years to become an electronic instrument, and is now a digital instrument. I consider it the last mechanical instrument in the field (Figure 5).

The early mechanical instruments were replaced after World War II by electronic instruments that used slow-speed tape recorders and direct-wiring plotters to record data (Figure 6). Oceanographers of that generation described the difficulty of deploying instruments with vacuum tubes at sea.

The associates as a work force faded away when electronic instruments replaced mechanical instruments. A unit called Special Developments was created at Scripps to design and maintain instruments. IBM

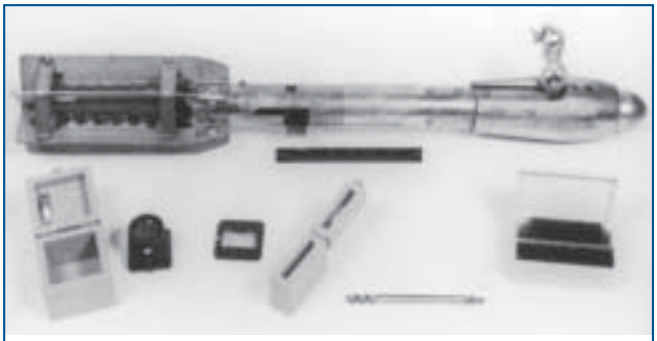

Figure 5. *Bathythermograph, Spilhaus Model, 1938.*

Figure 6. *James Snodgrass* ***(right)*** *with BT Mech-I-Tron HY-Tech Recorder on R/V* Crest, *1959.*

computers enabled Scripps to automate and centralize the collection of data into data centers. While some data continued to be controlled by individual scientists, the data centers took a more collective approach. A new group of scientific workers, the Marine Technician series, was created under Ship Operations to recruit and train technicians for sea duty.

Instruments shaped Scripps Institution. We are now in the digital age and the next generation of oceanographic instruments will again change how oceanography is done. That generation of instruments will shape what Scripps Institution becomes in the twenty-first century.

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