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Oceanography and Fieldwork
Geopolitics and Research at The Scripps Institution

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In 1933 W.E. Allen, a phytoplankton specialist at the Scripps Institution of Oceanography in La Jolla, California, published a newspaper article entitled "Caged Animal not Natural." Allen defined himself as a naturalist and throughout the 1920s and 1930s wrote a weekly column on natural history topics distributed through the news corporation Science Service. That particular essay, however, was different: it was a thinly veiled attack on the policies and priorities of Scripps' director Thomas Wayland Vaughan. Allen charged that Vaughan was de-emphasizing fieldwork in favor of laboratory-based research. In Allen's words, Vaughan had shifted Scripps' mission from outdoors to indoors, from sea to land.[1]

Allen's statement applied to oceanography but also related to larger issues. Beginning in the late nineteenth century experimental laboratory-based research became dominant in the biological sciences in the United States. Although natural history and fieldwork were not eliminated, scientists touted new experimental methods in genetics and physiology as the best means for doing productive research. As experimental biology outstripped natural history in financial support, journals, and university positions, natural history institutions became more and more marginal. Such changes seriously threatened naturalists and they frequently struck back, condemning experimentalists and highlighting the importance of fieldwork.[2] At Scripps fieldwork pertained to research at sea and Allen condemned Vaughan's interest in constructing a new experimental research laboratory while use of the institution's ship, the *Scripps*, declined.[3]

The claim that there was a vacillating commitment to fieldwork at Scripps may seem odd. Scripps is situated right at the edge of the Pacific Ocean, which suggests that it would naturally be an ideal location for seagoing research. But as Allen's criticisms indicate, work at sea was not always the top priority at the institution. This paper will explore Scripps' changing commitment to ocean research during that institution's first half century, from 1903 to the mid 1950s. Intermittent sea studies coincided with the availability of resources, namely ships. However, different directors also held distinctive ideas about oceanography and had different priorities. This paper will claim that the changing political economy of oceanography, especially during wartime when the government became a major patron for the science, had significant consequences for research at Scripps.

The Scripps Institution for Biological Research

Although this paper concentrates on the Scripps Institution of Oceanography, that organization cannot be fully understood without knowledge of its predecessor, the Scripps Institution for Biological Research. Established in 1903, that institution was the brainchild of William Emerson Ritter (Fig. 1). A marine biologist who received his Ph.D. from Harvard University, Ritter became professor and head of the Zoology Department at the University of California, Berkeley in 1892.

Over the next several years Ritter and his students conducted research while looking for a suitable, off campus biological laboratory. Ritter and his University of California colleague Charles Kofoid were impressed by the abundance of marine organisms and opportunities for year-round research in the San Diego area. In 1903, with enthusiastic support from local naturalists and financial commitments from business leaders, most notably E.W. Scripps and his sister Ellen Browning Scripps, Ritter agreed to establish a marine biological station in San Diego. Originally located in the boathouse of the Coronado Hotel, it moved the following year to a small facility in nearby La Jolla. In 1907 E. W. Scripps purchased a lot north of the village that became the new, permanent site for the laboratory two years later. With a $50,000 endowment from Ellen Browning Scripps, Ritter had the financial support that enabled him to move ahead with a scientific research program.[4]

FIGURE 1. William Emerson Ritter

The new station differed in important respects from other biological institutions. In contrast to the Marine Biological Laboratory at Woods Hole, Massachusetts or the Naples Zoological Station, Ritter stressed that his scientists would conduct investigations in marine biology rather than "general biology prosecuted on marine organisms."[5] Scientists elsewhere, he claimed, examined evolutionary or physiological problems and used specimens that just happened to be marine organisms. Scripps' scientists were dedicated "to finding out what marine organisms are as such." In addition they maintained that hydrographical research, the study of the temperature, salinity, and oxygen content of seawater, was "as indispensable as any recognized field of biology." Only through analysis of physical and chemical conditions could scientists begin to understand how environment affected the distribution, migration, and physiological processes of marine organisms.[6]

Given those objectives, studies at sea were a crucial feature of the institution's research program. Ritter called for repeated investigations in a localized area, and as early as 1901 he and his students were conducting dredging and trawling operations in southern California. By 1905 he had identified an area between Point Conception on the north and west, and Point Loma on the south and east, as the region he and his colleagues would survey (Fig. 2). After acquiring their own ship, the *Alexander Agassiz*, in 1908, Scripps' scientists launched a more systematic program of collecting plankton samples, hydrographic data, and ocean bottom sediments. In addition to developing improved instruments for gathering data, they instituted precise recording methods. The system that they developed for identifying the location, time and date, and data collected was not new; scientists had employed such techniques for decades. But the emphasis on accuracy and amassing large numbers of observations reflected the institution's commitment to fieldwork.[7]

Over the next ten years the marine biological station grew. In 1910, the institution obtained its

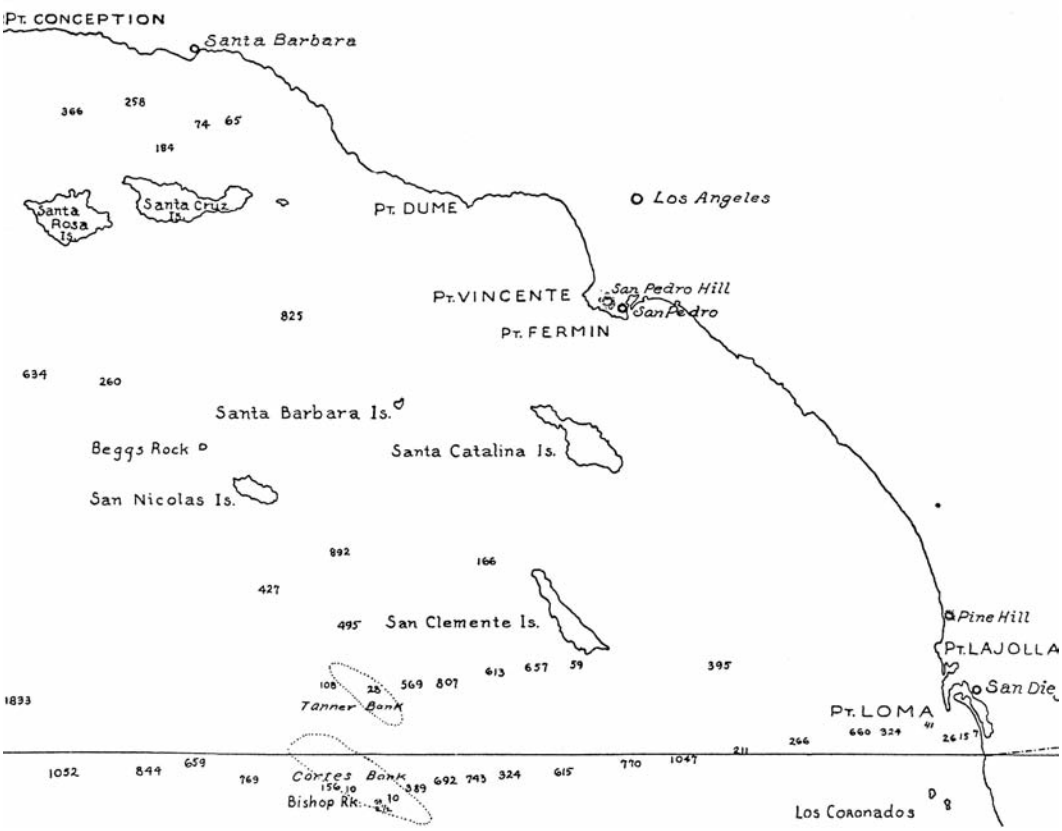

FIGURE 2. Scripps survey map. Area to be surveyed by the Scripps Institution for Biological Research. William E. Ritter, The Marine Biological Station.

first building, the George H. Scripps Memorial Marine Biological Laboratory, which, in addition to housing offices, laboratories, the aquarium, and library also served as the residence for the director and his wife. In 1912, it officially became part of the University of California. More important, it emerged as a productive center for fieldwork and research. In addition to Ritter, early staff members included E.L. Michael, who studied worms, Calvin O. Esterly, a zooplankton specialist, and George F. McEwen, a physical oceanographer. Each pursued their own investigations but they embraced Ritter's larger agenda. That included combining fieldwork and laboratory research. They were also committed to employing quantitative methods, but not for economic or strictly empirical purposes. Instead Ritter emphasized collecting massive amounts of data, and developing precise methods for organizing that data, as the basis for establishing the relationship between organisms and their environment. By organizing their data according to a specific environmental factor, such as temperature, Scripps scientists could calculate the frequency of a species within a particular temperature interval. Comparing that to the frequency of the species under different temperature conditions then enabled them to establish a correlation between environment and organism. Using that approach Michael sought to explain how water temperature, depth, and density influenced the migration of worms. Esterly examined similar factors in his studies of the habits of copepods.[8]

Extensive field data were also necessary for McEwen's research. He had an interest in the phenomenon of upwelling, the process by which the impact of winds on surface waters results in the

upward flow of deep, cold waters near a coastline. Through the study of hydrographic and biological data collected by Scripps scientists, including himself, McEwen developed a sophisticated interpretation of upwelling off the California coast.[9]

But not everyone at Scripps was fully committed to work at sea. Francis B. Sumner, who had previously established a reputation for his studies of fish, took up an entirely different line of research when he came to La Jolla. Interested in the problem of the inheritance of acquired characters, Sumner devoted his attention to studying the evolution and distribution of deer mice. His project entailed fieldwork but was unrelated to the activities of a marine biological station and later an oceanographic institution.[10] Nor was McEwen an ardent proponent of fieldwork. Certainly he participated in cruises and collected field data, but in the mid 1910s he noted that data on hydrobiological relations had become too complex, and as a result Scripps discontinued its plankton investigations and limited data collecting to temperature and salinity samples. Rather than gathering more information McEwen wanted to use the data at hand to establish agreements with or deviations from average conditions. In other words he was now primarily interested in applying the principles of mathematical physics to data already accumulated in order to derive formulas.[11]

Ritter also moved away from fieldwork, largely as a result of his close association with E.W. Scripps. A newspaper magnate who had built a winter home in San Diego, Scripps originally had little interest in the scientific work being done at the marine station. As a businessman his priorities were "management, capitalization, and the creation of new enterprises," one of which was the marine station.[12] Gradually, however, he became interested in Ritter's science and began to press the director and his colleagues to "explain what kind of a thing this damned human animal is, anyway." Scripps wanted the scientists he supported to account for human customs, ethics, religion, and especially democracy. He and Ritter frequently engaged in extended discussions on those topics and gradually Ritter, who had studied development and evolution, abandoned field research. He devoted himself to developing a philosophical biology, most fully embodied in his 1919 book *The Unity of the Organism or the Organismal Conception of Life*. Ritter developed a form of non-vitalistic mysticism in which unity, cooperation, and interdependence constituted the basic principles of biology and democracy. The close personal relationship between Scripps and Ritter, patron and client, had a profound impact on the laboratory director, and it is likely that Ritter changed his priorities to address E.W. Scripps' "enormous belief in science as an instrument for human welfare."[13]

The emphasis on science as a means for promoting human welfare had additional consequences for the institution. When the United States entered World War I in 1917, the Scripps Institution took part in two large-scale government projects: kelp harvesting and fisheries. The latter was especially important, and when Ritter became director of operations for the U.S. Bureau of Fisheries for southern California, Scripps scientists began investigating the distribution and habits of tuna. With support from the National Food Administration and the Council of Defense of California, Scripps scientists also conducted biological and hydrographic studies in support of the fishing industry. As a result of those new initiatives in pelagic research, the institution in 1917 sold the *Alexander Agassiz* since it was "too large and expensive to operate for the particular phase of the marine investigations we are now entering upon." Virtually all investigations, including plankton studies, were "now subordinated, in one way and another, to fisheries problems, . . ."[14]

Wartime developments and fisheries research also influenced Ritter's changing ideas on the role of science. In earlier years Ritter had recognized a role for applied science but was intent on making "research primary and loaves and fishes secondary."[15] Now, however, he highlighted fisheries as a means for achieving scientific and social objectives. Through fisheries research the Scripps Institution could play a leading role in studying problems of the North Pacific. For Ritter, influenced by his interactions with E.W. Scripps, fisheries was more than just a scientific or eco-

nomic issue; it concerned international relations. Rather than freedom of the sea Ritter emphasized the uses of the sea. For Asians as well as Americans the Pacific represented travel, adventure, and economic gain, resources that had profound social and economic consequences for humanity. The Pacific was "an interpeoples" problem that required an "interracial consciousness," he stated. By the late 1910s Ritter was convinced that fisheries research in the North Pacific provided a means to address the problems of civilization, democratization, and improved social and economic relations among nations that he and E.W. Scripps considered so important.[16]

As Ritter outlined an enlarged view of science, he began to advocate changes in the institution's research program. Inshore studies remained important, but now Ritter called for research on diatoms and bacteria in the open ocean. Plankton, long a staple of Scripps hydrobiological research, should now be studied as a source of fish food. And he increasingly touted the importance of oceanography. In 1908 he had told Charles Kofoid that

> 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 and we must in general keep all other interests secondary to that.[17]

Within a decade he was attempting to move the Scripps Institution beyond a narrow adherence to marine biology. Analysis of oceanographic conditions and their impact on spawning had become a top priority. The importance of currents off California and Japan and the relationship between oceanography and meteorology, especially the consequences for agriculture, were a major reason for studying the North Pacific.[18] But Ritter's growing commitment to oceanography did not result in increased fieldwork. Since Scripps no longer had its own ship he called for new vessels to undertake oceanic research, but none were purchased. On occasion the institution rented boats and scientists did some work onboard government ships. Ritter suggested that federal government agencies begin supplying Scripps with information on seawater temperature, pressure, and salinity, but that was not immediately put into practice. Without a ship Scripps scientists now relied primarily on collecting from the pier, which was constructed in 1915–1916. Nevertheless, Ritter, influenced by E.W. Scripps, had taken advantage of the changed political economy of science during WWI to redefine the institution's mission.[19]

Scholars have identified several factors in explaining Scripps' change from a marine station to an oceanographic institution. E.W. Scripps' increased interest in population studies and Science Service, Ritter's impending retirement, and the institution's need for greater financial support all played a role.[20] Yet Ritter's changing ideas about the institution's priorities, specifically his commitment to oceanography, must also be considered. From 1917 to the mid 1920s he frequently expressed his views in publications, presentations, and meetings with E.W. Scripps and John C. Merriam, director of the Carnegie Institution of Washington (CIW). Merriam and Ritter, both faculty members at the University of California, were old friends. They were also members of the National Research Council (NRC) Division of Foreign Relations, a committee originally devoted to problems of the Pacific. Merriam knew that Ritter had addressed that committee on the importance of oceanography, just as he was aware of other proposals to promote oceanography currently circulating in Washington, D.C. As Deborah Day has indicated, Merriam played a crucial role in determining the future of the Scripps Institution. It was not coincidental that the person selected to succeed Ritter, Thomas Wayland Vaughan, had spent several years doing ocean related research at the CIW. Nevertheless, it was Ritter, an advocate of science as a means for promoting human welfare, who had championed the shift from marine biology to oceanography.[21]

Vaughan and Scripps Institution of Oceanography

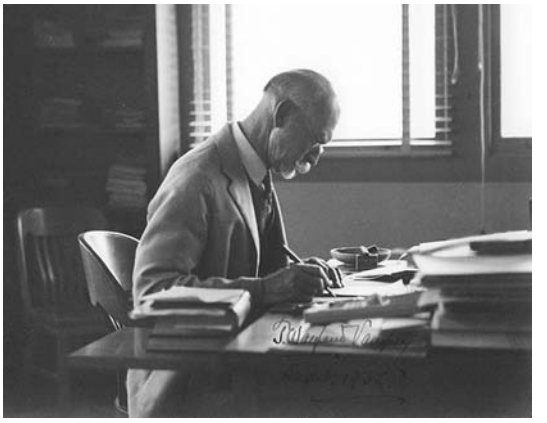

FIGURE 3. Thomas Wayland Vaughan at his desk, ca. 1932.

Selecting Vaughan (Fig. 3), a geologist, to head an oceanographic institution was in some respects peculiar. At the time, however, there were no other oceanographic centers or trained oceanographers in the United States. In addition Vaughan had certain strengths. He had considerable administrative experience at the U.S. Geological Survey and the United States National Museum. He was well known within the scientific community and actively promoted oceanography through the NRC. Following World War I Vaughan and other Washington scientists made a concerted effort to establish a federal agency for oceanography. That venture failed but Vaughan, as chair of NRC committees on seafloor topography, sedimentology, and shoreline processes, encouraged oceanographic research. Even before he moved to La Jolla, Vaughan, relying on his ties to leading scientists and government officials, had arranged for the Navy, the Coast and Geodetic Survey, and the Bureau of Lighthouses to provide the institution with oceanographic data.[22]

Vaughan's scientific interests influenced developments at Scripps. His research focused on coral reef formation, and he approached that problem from an interdisciplinary, ecological perspective. At the CIW's biological laboratory at Dry Tortugas, Florida, he had investigated the physiology of corals and the chemistry of seawater. In order to understand the effects of ocean bottom sediments on reef formation he studied the latest developments in sedimentology.[23] As director Vaughan saw the need to add marine geology and marine chemistry to the institution's traditional emphasis on marine biology and physical oceanography. He added Erik Moberg, a recent Ph.D. in chemical oceanography, to the staff, and arranged for Parker D. Trask, a geologist sponsored by the NRC and the American Petroleum Institute, to use Scripps' facilities for his investigations on the origins of oil. Vaughan's efforts to make Trask a staff member failed, but in 1929 he hired A. Haldane Gee whose work in marine bacteriology included the study of petroleum sources.[24] Vaughan also began the *Bulletin of the Scripps Institution of Oceanography*, an important vehicle for publishing the research done by the institution's scientists.

Although well aware that oceanography was a field science, Vaughan did not always give top priority to research at sea. At the time of his appointment the institution had no ship and was receiving plenty of data from government agencies. Vaughan, in addition, was impressed with the increasing significance of experimental laboratory research. His work on coral reef formation relied heavily on field observations, but experimentation was also important. He exposed corals to varying degrees of temperature, salinity, air, and light. He cemented colonies to terra cotta tiles in an effort to determine the best surfaces for coral larvae attachment. By 1929 Vaughan was convinced that

> As scientific research advances, emphasis changes. This is as true of marine biology as of any other field of investigation. In order to understand the relation of marine organisms to their environment, the shift has been to methods of attack through the medium of experiment and physiology.

In contrast to Michael and Ritter, who stressed the importance of field observations, Vaughan

was convinced of the value of laboratory research and made it a priority for his students in geological oceanography.[25]

Vaughan's preference for laboratory research had institutional implications for Scripps. In the late 1920s Vaughan, Henry Bryant Bigelow, and Frank Lillie headed up a National Academy of Sciences committee that convinced the Rockefeller Foundation to provide much needed support for oceanography. Most of the Rockefeller money went toward creating the Woods Hole Oceanographic Institution, but Scripps received $40,000 along with matching gifts from Ellen Browning Scripps and the State of California. Vaughan dedicated the money to building an experimental research laboratory and planned for Ancel B. Keys, a graduate student working on marine physiology, to have a prominent role in designing and running that facility. Vaughan's plans to hire Keys ran into problems, but the new laboratory, named Ritter Hall, was completed in 1931. The next year Vaughan hired Denis Fox, a marine biochemist, and Claude Zobell, a marine microbiologist. Both men were primarily laboratory scientists.[26]

W.E. Allen vigorously objected to Vaughan's initiative. Physiological research, he claimed, was too expensive and "does not fit naturally into our oceanographic program of observations." Allen had worked closely with Esterly and it was not surprising that he considered Vaughan's decision to drop zooplankton studies shortly after Esterly's death as "unfortunate." He was equally put out by what he perceived as a lack of work at sea. Although shipboard work had been on the decline since the sale of the *Alexander Agassiz*, the Scripps family purchased another vessel in 1925, renamed it the *Scripps*, and Allen and Moberg were soon using it for short cruises (Fig. 4). Allen, however, claimed that Vaughan placed obstacles in their way and over the years the number of cruises declined.[27]

FIGURE 4. Roger Revelle collecting onboard the R/V *Scripps*, ca. 1936

Nor was Allen alone. W.C. Crandall, the former captain of the *Alexander Agassiz* and longtime business manager of the biological research institution, seconded Allen's claims. According to Crandall, Vaughan's emphasis on "physiological experimental work" threatened to "defeat the purposes for which the institution was founded, and which the people of California believe it is doing . . . research upon the ocean." J.C. Harper, attorney for Ellen Browning Scripps, declared that the oceanographic laboratory had become "a desk institution."[28]

Although there was merit to those criticisms, they were not unvarnished. In the first place, each of those individuals had an axe to grind. Allen was disturbed that Vaughan's allocation of resources to other fields would adversely affect his research. Crandall, who had hoped to succeed Ritter as Scripps director, was sent packing when Vaughan arrived. In addition, the relationship between Vaughan and the Scripps family was awkward; in their view he did not adequately consult with them about the institution's affairs. Crandall, now Ellen Browning Scripps' business agent, continued to stir up ill will toward the director, perhaps explaining Harper's attitude and the unwillingness of the Scripps family to fully support Vaughan's actions.[29] The criticisms of Vaughan's

research program also did not take into account all of his efforts. It was not entirely coincidental that the institution acquired a new ship shortly after Vaughan's appointment. Although use of the *Scripps* may have declined between 1926 and 1930, work at sea was still greater than it had been since 1917, when the institution sold the *Alexander Agassiz*. Vaughan also had other research plans in mind. He had arranged with the CIW for Scripps to obtain the non-magnetic ship *Carnegie* after completing its round the world voyage in 1929. In anticipation of acquiring the vessel, Vaughan began planning a major expedition in the Pacific. But an explosion destroyed the *Carnegie* and with it Vaughan's hopes for an ocean-based research program. Since Moberg, the only Scripps faculty member capable of operating the ship had sailed on the *Carnegie*, albeit prior to the explosion, the *Scripps* went unused in 1929.[30] Vaughan was interested in expanding studies at sea, but by devoting so much money and attention to laboratory research he had created personnel problems and raised questions about the status of fieldwork at Scripps.

Those difficulties became the source of personal and professional frustration for Vaughan. Bitter animosity and rancorous confrontations characterized the relationship between Allen and Vaughan over the next several years.[31] Criticisms of the institution's research program influenced Vaughan to devote greater attention to the institution's work at sea, but with mixed results. Following the loss of the *Carnegie*, Vaughan pressed the Scripps family to purchase another vessel but because of economic hardship they did not do so. However, Robert P. Scripps, E.W.'s son, did pay for modifications to the vessel, including a diesel engine, a mast, and sails. In his annual reports, Vaughan now devoted more attention to work at sea and noted that an increase in the number of people able to handle the *Scripps* allowed for greater use.[32] Vaughan also arranged for Scripps students to go to sea. In 1933 Richard H. Fleming worked onboard the Coast and Geodetic Survey ship *Hannibal*, and Roger Revelle gained similar experience on the *Pioneer*. The following year he spent three months onboard the U.S.S. *Bushnell*, a Navy submarine tender operating between Alaska and Hawaii.[33] Increasingly Vaughan emphasized the importance of what he called the "big problems" of the Pacific. By that he meant studies of circulation as well as temperature, salinity, and oxygen distribution, in short, the data needed to study the ocean as a fluid in dynamic equilibrium. Although dynamical oceanography was cutting edge science in Europe by the early 1930s, it was still not fully understood or studied at Scripps. By emphasizing the need for students to learn dynamical oceanography and gain greater experience at sea, Vaughan was attempting to shift the focus of his research program, although the new emphasis was not all that different from what Ritter had advocated fifteen years before.[34]

Vaughan's overtures were not solely a response to Scripps' internal controversies. Throughout his career he was in close contact with European and American scientists and had worked to keep up with new developments in oceanography. He had known of dynamical oceanography for some time, even if he didn't fully understand it. Vaughan also had a longstanding interest in Pacific science. Since the early 1920s he had participated in the Pacific Science Congresses, and from 1926 to 1936 served as chair of the International Committee on the Oceanography of the Pacific.[35] Still it was only after 1929, the year when the controversy with Allen erupted, that Vaughan truly began to emphasize fieldwork and the importance of studying the oceanographic problems of the Pacific. Even then he was not entirely successful. With the acquisition of the *Scripps*, Vaughan was able to promote oceanographic field observations, but he did not succeed in establishing a coordinated research program or taking Scripps to sea. He did, however, have a hand in selecting a successor who would.[36]

Harald U. Sverdrup

That man was Harald U. Sverdrup (Fig. 5), a Norwegian scientist considered one of the world's leading oceanographers. Trained in a tradition of dynamical meteorology, Sverdrup applied those principles to the study of the oceans. He likewise had extensive experience at sea. In the 1910s and early 1920s he participated in the *Maud* expedition, a study of Arctic waters designed to take three years; it ended up lasting seven. In later years, he participated in a venture to take a submarine to the Arctic and conducted research expeditions in Greenland and Spitzbergen. As the new Scripps director, Sverdrup was committed to fieldwork.[37]

FIGURE 5. Harald U. Sverdrup checking current meter, ca. 1940.

When Sverdrup arrived at Scripps in the summer of 1936 he quickly devised a new curriculum for the graduate program. Developing a research program at sea took considerably longer. Sverdrup came from a background in the geophysical sciences and studied oceanic and atmospheric phenomena in terms of fluids in dynamic equilibrium. As a Norwegian he also knew the importance of fisheries research. But he was completely unprepared for the wide range of activities being pursued at Scripps. As Richard Fleming stated, Sverdrup was "shocked by the fact that we felt oceanography had a much broader content than he had ever imagined." Rather than a coordinated team of scientists pursuing a coherent program of research, he found a diverse, even eclectic group of individuals pursuing a wide range of specialized studies, some unrelated to oceanography. From Sverdrup's perspective the institution seemed to possess no explicit mission. He complained that Scripps was not an oceanographic laboratory but merely an "institution of marine sciences," and its ship nothing more than a "filthy, cramped washtub." Although Sverdrup was hired with a mandate to develop a coordinated, seagoing research program, for the first year he had no clear idea how to do so.[38]

Two developments changed the situation. In November 1936, the *Scripps* blew up, killing one crewmember and permanently injuring another. That was a tragic loss but it gave Sverdrup the opportunity to lobby the Scripps family for a new and better ship. It took about a year but by December 1937 the new *E.W. Scripps* (Fig. 6) was outfitted and ready to go. Capable of carrying over a dozen people and going farther offshore than the *Scripps*, it symbolized the possibility of a research program at sea.[39]

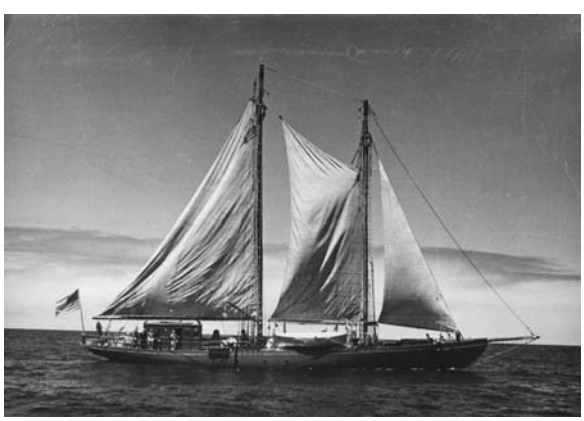

FIGURE 6. RV/*E.W. Scripps*, ca. 1938.

Even more important was a request in January 1937 from the California Division of Fish and Game. Concerned about declines in the annual catch of the California sardine, fisheries scientists approached Sverdrup with a proposal to study currents and their relation to spawning conditions. Work done that spring

onboard the Fish and Game ship, the *Bluefin*, had significant consequences for Scripps oceanography. Originally Sverdrup had anticipated that the institution would undertake large regional investigations, but the sardine project convinced him of the importance of intensive, localized area studies.[40] Those would become the model for Scripps' future research. Onboard the *Bluefin* Scripps scientists concentrated on upwelling, a process that required analysis of organisms and biological processes, subjects in which Sverdrup was not an expert. He now saw an opportunity to provide a greater role for Scripps' biologists, and in addition to collaborating with Allen, immersed himself in the study of marine and fisheries biology. Most important, that project enabled him to envision a cooperative research program at sea, one in which the investigations of individual scientists would "mutually reinforce one another."[41]

Drawing on the Fish and Game project Sverdrup now launched a program of fieldwork. With the new *E.W. Scripps* he and colleagues planned a systematic series of investigations, and between 1938 and 1941 Scripps scientists participated in more than thirty expeditions. But the fisheries project was more than a model for research; it also provided much needed financial resources. In the late 1930s the Scripps family was hit hard by the depression and its support for the oceanographic institution declined. Contracts with the U.S. Fish and Wildlife Service for studies of the sardine problem were crucial for sponsoring research at sea. In addition, the Geological Society of America supported a Scripps expedition to the Gulf of California (Fig. 7), largely because Revelle had suggested that the region could be a source of oil.[42] Sverdrup had created a research program based on fieldwork at sea, but in certain important respects his understanding of oceanography had evolved. The fisheries project led him to incorporate biological research. Previously he had defined Revelle and other marine geologists as "independent workers" who were marginal to the main research program. Now, however, they were an important component of the institution's activities. Sverdrup was an outstanding scientist and inspirational director whose commitment to dynamical oceanography had influenced his new colleagues. From a diverse group of specialists he had created a research school committed to fieldwork at sea. Under his leadership Scripps scientists produced a new textbook, *The Oceans*, which became the "bible" for the next two generations of oceanographers. Yet the changing political economy of science had also shaped oceanography at Scripps. Support from outside agencies helped bring certain scientists and their fields of investigation to the forefront. In short, patronage had an important impact in defining what work was done, by whom, and where.[43]

FIGURE 7. Scripps Gulf of California expedition, 1939.

World War II and Scripps Oceanography

World War II profoundly changed the tiny community of oceanographers. Like scientists throughout the country, Scripps oceanographers joined the war effort. Some enlisted in the military, others went to work at a new civilian laboratory in San Diego: the University of California Division of War Research (UCDWR). There they worked closely with physicists, engineers, and Navy personnel. The war also emphasized a new field of investigation: research on underwater

sound in support of anti-submarine warfare. In short, Scripps oceanographers were now pursuing new studies with new instruments for a new patron, the Navy, which was interested in developing weapons for operational, mission-oriented objectives. For a time Sverdrup worked at UCDWR, but in March 1942 he ran up against another feature of the new context for science: he was denied security clearance. Sverdrup returned to Scripps, but since the University of California had turned over the *E.W. Scripps* to the government for war work, he was isolated in La Jolla with no ship, few colleagues, and no opportunity to do research at sea.[44] When he received partial security clearance in the summer of 1943, he too went to work on military projects. In addition to training weather officers, Sverdrup and Scripps scientist Walter Munk developed a new system of sea, swell, and surf forecasting in support of amphibious warfare. In conjunction with scientists at UCDWR he developed manuals to aid submariners in locating and evading enemy ships.[45]

The changes that came with WWII continued to influence Scripps oceanography in the postwar period. Although Sverdrup and others claimed that they were returning to the basics of prewar oceanography, the science had changed in terms of patrons, instruments, and fields of research. The institution would expand its prewar studies of the sardine problem, leading to the development of the CALCOFI project, but the Navy became the major patron of oceanography (see Appendix). Scripps' educational program tripled in size, and throughout the 1940s military personnel comprised at least half of each new class. The institution also obtained a new fleet, mostly former naval vessels. Scripps now housed its ships at Point Loma, fifteen miles south of La Jolla, at a new location eventually named the Nimitz Marine Facility. Point Loma also became the site for two additional institutions, both of which soon became part of Scripps: the Marine Physical Laboratory, a facility supported by the Navy Bureau of Ships and the University of California, and the Visibility Laboratory supported by the Air Force.[46] And mission-oriented objectives influenced the trajectory of oceanographic research. According to Scripps oceanographer Revelle (Fig. 8), who remained in the Navy until 1948, "with the exception of some fields of marine biology, the entire program in oceanography is of particular military interest." During the next two decades research in physical, chemical, and geological oceanography, crucial for anti-submarine warfare, dominated over the biological sciences. The use of military vessels and instruments, including sonar, radar, and magnetometers, was equally important for postwar oceanography.[47]

FIGURE 8. Admiral Paul Lee presenting Roger Revelle with Commendation.

With substantial military support Scripps oceanographers gained access to an entire new world of research. Throughout the 1950s Scripps, largely through the efforts of its new director, Revelle, became a leader in worldwide, deep-sea expeditions. In contrast to previous intensive areas studies off the coast of California, Scripps scientists now participated in expeditions to the Marshall Islands in the western Pacific, the Arctic and Antarctic, and in later years the Indian Ocean. Those voyages provided extensive new information on waves, currents, and seawater tem-

perature, pressure, and salinity worldwide. Relying on new techniques in explosive seismology, scientists gained a much greater understanding of the ocean floor and the earth's interior. The Scripps Mid-Pacific (1950) and Capricorn (1952) expeditions yielded important discoveries of underwater mountain chains, trenches, and heat flow through the ocean floor. Such work was crucial for basic ocean science; it also contributed to the plate tectonics revolution of the 1960s.[48]

But it is equally important to emphasize that that work also served military objectives. Fundamental research on seawater temperature and pressure contributed to greater understanding of underwater sound transmission and anti-submarine warfare. Improved techniques in deep-sea dredging, bathymetry, and mapping of the seafloor provided valuable new data on underwater conditions that could affect war fighting in the ocean environment. Seismological projects, work on the earth's gravitational field, and studies of terrestrial magnetism yielded new geophysical data; they also served as means for tracking underwater guided missiles and atomic bomb explosions.[49]

Fieldwork in oceanography also supported America's geopolitical interests in the postwar era. Even before WWII had ended civilian and military leaders were defining a global role for the United States. The wartime allies agreed that the United States, Great Britain, China, and the Soviet Union would each have their own spheres of influence, but America would be the "prime guardian" of a new international order. Concerned about the threats of economic depressions and authoritarian rulers that had given rise to the war, the United States now called for an open economic and political world based on free trade, freedom of the seas, and self-determination. Foreign trade would stimulate the emergence of stable, democratic governments. It also had important strategic value. "America's security needs," stated Thomas G. Paterson, "demanded not only economic expansion in order to satisfy raw material requirements but also a global military watch." America emerged from the war as the world's leading military power, but ongoing security concerns and a "preparedness ideology" combined to promote an activist military policy, even in the midst of demobilization. Dominance of the Atlantic and Pacific oceans was considered "indispensable," and defense of the nation required creating military bases worldwide.[50]

Those commitments had important consequences for ocean science. "Considerable expansion of our knowledge of the oceans is necessary in order to aid in strategic and tactical planning," the first director of the Office of Naval Research stated. Scientific data gathering and the development of predictive models would enable the military to understand and control war fighting environments on the land, on the sea, and in the air. Revelle's comment that "the society which knows the most about its environment and how to turn it to account, is going to be the more likely to win the next war," highlighted the connection among geopolitical priorities, military objectives, and oceanographic research.[51] By the 1950s, fieldwork had become a hallmark of Scripps oceanography, and deep-sea expeditions a rite of passage for Scripps graduate students. But research at sea, the goal of previous generations of Scripps oceanographers, now served more than the purposes of science. It was also vital to America's global Cold War policy.

Conclusion

Research at sea underwent several changes in Scripps' first fifty years. Following an auspicious beginning, research cruises declined after World War I and throughout the 1920s. Sverdrup's emphasis on intensive area studies in the 1930s was followed by the commitment to worldwide expeditions after World War II. At various times marine biology, fisheries investigations, and dynamic physical oceanography dominated research at the institution. This paper claims that, in addition to the priorities of different laboratory directors, the changing political economy of science influenced the commitment to fieldwork at Scripps.

The importance of political economy, especially in the field sciences, is a subject that it often

overlooked in the study of natural history institutions. Oceanographic laboratories as well as natural history museums are dependent upon the opportunity to collect and examine specimens in their environmental context. Yet field studies, whether in the oceans or on land, require material and financial support. They also require access to locations where specimens can be found, studied, and collected. It is not only economic support but also political power relationships that make research in the field possible. The great natural history museums of the nineteenth and early twentieth centuries were the product of imperialism, and exhibits frequently embodied attitudes concerning the relationship between the colonizer and the colonized.[52] Imperialism did not play a role in Scripps oceanography in the early years, largely because research at sea rarely extended much beyond the coast of southern California. Yet World War I, World War II, and the advent of the Cold War profoundly changed that science and that institution. As this paper has indicated, the changed political economy of science, as evidenced by twentieth-century wars and America's global interests, played a crucial role in Scripps' development of a new and robust research program at sea. Historically economic support and political power relations have influenced work in the field sciences. It is worthwhile to consider the ways in which more recent developments, including the end of the Cold War, globalization, and bioprospecting are affecting today's institutions of natural history, oceanographic and otherwise.

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Notes

[1] For archival abbreviations see **Archives** (p. 201). Allen's article appeared in the *San Diego Evening Tribune*, UCPR, CU5, folder 1933: 804; W.E. Allen to Erik G. Moberg, 12 July 1933, ibid.

[2] On experimentalists and naturalists: Garland E. Allen, Naturalists and Experimentalists: The Genotype and the Phenotype, *Studies in History of Biology*, 1979, 3:179–209. Also: Keith R. Benson, Problems of Individual Development: Descriptive Embryological Morphology in America at the Turn of the Century, *Journal of the History of Biology*, 1981, 14:115–128; Jane Maienschein, Shifting Assumptions in American Biology: Embryology 1890–1910, *Journal of the History of Biology*, 1981, 14:89–113; Ronald Rainger, The Continuation of the Morphological Tradition: American Paleontology 1880–1910*, Journal of the History of Biology*, 1981: 14:129–158; Frederick B. Churchill, In Search of the New Biology: An Epilogue, *Journal of the History of Biology*, 1981, 14:177–191. On marginalizing museums: Steven Conn, *Museums and American Intellectural Life, 1876–1926* (Chicago: University of Chicago Press, 1998). For a discussion of one naturalist's reaction to the growing predominance of experimental biology see Ronald Rainger, *An Agenda for Antiquity: Henry Fairfield Osborn and Vertebrate Paleontology at the American Museum of Natural History, 1890–1935* (Tuscaloosa: University of Alabama Press, 1991), 105–122.

[3] Allen to Moberg, 12 July 1933; W.E. Allen to Scripps Staff, 15 July 1937, WEA, box 2, folder 37.

[4] Helen Raitt and Beatrice Moulton, *Scripps Institution of Oceanography: First Fifty Years* (San Diego: Ward Ritchie Press, 1967), 3–44.

[5] Raitt and Moulton, *Scripps Institution of Oceanography*, 31.

[6] The quotations are from Ellis LeRoy Michael, Dependence of Marine Biology Upon Hydrography and Necessity of Quantitative Biological Research, *University of California Publications in Zoology*, 1916, 15: i–xxiii, on iv, x. Also

William E. Ritter, The Marine Biological Station of San Diego: Its History, Present Conditions, Achievements, and Aims, *University of California Publications in Zoology*, 1912, 9:137–248, on 180–225.

[7] Ritter, The Marine Biological Station of San Diego. Ellis LeRoy Michael and George F. McEwen, Hydrographic, Plankton, and Dredging Records of the Scripps Institution for Biological Research of the University of California (1901–1912), *University of California Publications in Zoology*, 15, 1915: 1–206, on 3–48.

[8] William. E. Ritter, A General Statement of the Ideas and Present Aims and Status of the Marine Biological Association of San Diego, *University of California Publications in Zoology*, 1905, 2: i–xvii, on ii–ix. On quantitative methods: Michael, Dependence of Marine Biology Upon Hydrography, xix–xxi. Ellis LeRoy Michael, Classification and Vertical Distribution of the Chaetognatha of the San Diego Region, Including Redescriptions of some Doubtful Specimens of the Group, *University of California Publications in Zoology*, 1911, 8:1–170. Calvin O. Esterly, Limitations of Experimentation in Explaining Natural Habit as Illustrated by Diurnal Migration, *Science*, 1920, 52:307–310; Calvin O. Esterly, Possible Effect of Seasonal and Laboratory Conditions on the Behavior of the Copepod *Acartia tonsa*, and the Bearing of this on the Question of Diurnal Migration, *Ecology*, 1920, 1:33–40.

[9] George F. McEwen, The Distribution of Ocean Temperatures along the West Coast of North America deduced from Ekman's Theory of the Upwelling of Cold Water from the Adjacent Ocean Depths, *Internationale Revue der gesamten Hydrobiologie und Hydrographie*, 1912, 5:243–285. George F. McEwen, Summary and Interpretation of the Hydrographic Observations Made by the Scripps Institution for Biological Research of the University of California 1908–1915, *University of California Publications in Zoology*, 1916, 15: 255–356, on 255–279. On McEwen's work see: Eric L. Mills, Useful in Many Capacities: An Early Career in American Physical Oceanography, *Historical Studies in the Physical Sciences*, 1990, 20:265–311, on 270–280.

[10] Raitt and Moulton, *Scripps Institution of Oceanography*, 86–89; William B. Provine, Francis B. Sumner and the Evolutionary Synthesis, *Studies in History of Biology*, 1979, 3:211–240.

[11] Ellis LeRoy Michael and George F. McEwen, Continuation of Hydrographic, Plankton, and Dredging Records of the Scripps Institution for Biological Research of the University of California (1913–1915), *University of California Publications in Zoology*, 1916, 15:207–254, on 208. Mills, Useful in Many Capacities, 280–287.

[12] Deborah Day, Scripps Benefactions: The Role of the Scripps Family in the Founding of the Scripps Institution of Oceanography, in *Oceanographic History: The Pacific and Beyond*, eds. Keith R. Benson and Philip F. Rehbock (Seattle: University of Washington Press, 2002), 2–6, on 3.

[13] Philip J. Pauly, *Biologists and the Promise of American Life: From Meriwether Lewis to Alfred Kinsey* (Princeton: Princeton University Press, 2001), 208. The quotation is from William E. Ritter, The Relation of E.W. Scripps to Science, *Science*, 1927, 65:291–292, on 291. Also William E. Ritter, A Business Man's Appraisement of Biology, *Science*, 1916, 44: 819–822. William E. Ritter, *The Unity of the Organism or the Organismal Conception of Life*, 2 vols. (Boston: Richard G. Badger, 1919). On Ritter's biological philosophy: Eric L. Mills, *The Scripps Institution: Origin of a Habitat for Ocean Science* (La Jolla: Scripps Institution of Oceanography, 1993), 17–24.

[14] William E. Ritter, Scripps Institution for Biological Research (1917), in *Annual Report of the President of the University of California* (Berkeley: University of California Press, 1917–1918), 151–154, on 153; William E. Ritter, Scripps Institution for Biological Research (1918), in *Annual Report of the President of the University of California* (Berkeley: University of California Press, 1918–1919), 1–8, on 4.

[15] Ritter, The Marine Biological Station of San Diego, 225.

[16] One of Ritter's first attempts to come to grips with the relationship between pure and applied science is in: William E. Ritter, What the Scripps Institution is Trying To Do, *Bulletin of the Scripps Institution for Biological Research*, 1916, 1:19–24. William E. Ritter, The Problem of the Pacific, *Bulletin of the Scripps Institution for Biological Research*, 1919, 8: 1–8, on 8. Also William E. Ritter, Problems of Population of the North Pacific as Dependent upon the Biology, the Oceanography, and the Meteorology of the Area, *Science*, 1919, 50:119–125.

[17] William E. Ritter to Charles A. Kofoid, 18 October 1908, quoted in Keith R. Benson, Marine Biology or Oceanography: Early American Developments in Marine Science on the West Coast, in *Oceanographic History*, eds. Benson and Rehbock, 298–302, on 301.

[18] Ritter, Problems of Population of the North Pacific. In his annual report for 1919 Ritter included a document that outlined his changing views of the institution's objectives: "A Move in the Interest of the Future of the Institution." William E. Ritter, Scripps Institution for Biological Research (1919), in *Annual Report of the President of the University of California* (Berkeley: University of California Press, 1919–1920), 3–15, on 12–15.

[19] On the call for new ships and reliance on government agencies: Ritter, Scripps Institution for Biological Research (1919), 13–14; and Ritter, Scripps Institution for Biological Research (1920), in *Annual Report of the President of the University of California* (Berkeley: University of California Press, 1920–1921), 161–169, on 165. In 1920 Ritter, for the first time, began his annual report with a section entitled Oceanography and Hydrography. Boat work is noted in Ritter's 1920 report, 163, and Ritter, Scripps Institution for Biological Research (1921), in *Annual Report of the President of the*

University of California (Berkeley: University of California Press, 1921–1922), 183–188, on 184. On importance of the pier: W.E. Allen, Quantitative Studies on Inshore Marine Diatoms and Dinoflagellates of Southern California in 1921 and 1922, *Bulletin of the Scripps Institution of Oceanography*, 1927, 1:19–29; Calvin O. Esterly, The Periodic Occurrence of Copepoda in the Marine Plankton of two Successive Years at La Jolla, California, *Bulletin of the Scripps Institution of Oceanography*, 1928, 1:247–345; Wesley R. Coe, Season of Attachment and Rate of Growth of Sedentary Marine Organisms at the Pier of the Scripps Institution of Oceanography, La Jolla, California, *Bulletin of the Scripps Institution of Oceanography*, 1932, 3:37–86.

[20] Pauly, *Biologists and the Promise of American Life*, 206–215; Deborah Day, Bergen West: Or How Four Scandinavian Geophysicists Found a Home in the New World, *Historisch-Meereskundliches Jahrbuch*, 1999, 6:69–82, on 69–72.

[21] On Ritter and Merriam: Day, Bergen West, 71–72. On Merriam's role as chair of the NRC Pacific Exploration Committee: Ritter, Scripps Institution of Biological Research (1920), 165. On Ritter's participation on that committee and his comments on its objectives: Raitt and Moulton, *Scripps Institution of Oceanography*, 92–93. On postwar proposals for a government agency for oceanography: Gary E. Weir, *An Ocean in Common: American Naval Officers, Scientists, and the Ocean Environment* (College Station: Texas A&M University Press, 2001), 9–16.

[22] Weir, *An Ocean in Common*, 16–33. Thomas G. Thompson, Thomas Wayland Vaughan, *National Academy of Sciences Biographical Memoirs*, 1958, 32:399–437, discusses Vaughan's role on NRC committees on 403–405. E. Lester Jones to Thomas Wayland Vaughan, 14 November 1923, TWV, box 1, Correspondence February –December 1923; Thomas Wayland Vaughan to W.W. Campbell, 21 February 1924, and 11 March 1924, both in SDV, box 1, folder 1.

[23] Thomas Wayland Vaughan, Corals and the Formation of Coral Reefs, *Smithsonian Institution Annual Report for 1917*, 1919:189–276; Thomas Wayland Vaughan, Researches on Sedimentation, *Bulletin of the Geological Society of America*, 1920, 31: 401–410.

[24] Vaughan to Parker D. Trask, 2 February 1927, SDV, box 1, folder 28, and Vaughan to W.W. Campbell, 17 December 1928, SDV, box 2, folder 54. On Gee: Thomas Wayland Vaughan, Scripps Institution of Oceanography (1929), in *Annual Report of the President of the University of California* (Berkeley: University of California Press, 1929), 260–272, on 260, 264–265.

[25] The quote is from Thomas Wayland Vaughan to J.C. Harper, 28 October 1929, SDV, box 2, folder 52. Vaughan, Corals and the Formation of Coral Reefs, 200–206; Thomas Wayland Vaughan, The Madreporaria and Marine Bottom Sediments of Southern Florida, *Carnegie Institution of Washington Yearbook*, 1911, 10:147–155. By contrast see Michael, Dependence of Maine Biology on Hydrography, xi–xvi. Ritter's commitment to fieldwork is evident throughout *Unity of the Organism* and many other published papers. On Vaughan's students: Vaughan to Eldon Thorpe, 13 September 1929, SDV, box 2, folder 6. Roger Revelle, Report for Semester ending May 1933: Prospectus of Report on Carnegie Samples, SDR, box 6, folder Report for Semester Ending May 1933. Roger Revelle, *Marine Bottom Samples Collected in the Pacific Ocean by the Carnegie on its Seventh Cruise* (Washington, D.C.: Carnegie Institution of Washington, 1944), Publication 556, 72–80.

[26] Vaughan to W.W. Campbell, 22 Mar. 1930, SDV, box 2, folder 66. Also Raitt and Moulton, *Scripps Institution of Oceanography*, 108–111; and Harold L. Burstyn, Reviving American Oceanography: Frank Lillie, Wickliffe Rose, and the Founding of the Woods Hole Oceanographic Institution, in *Oceanography: The Past*, eds. Mary Sears and Daniel Merriman (New York: Springer-Verlag, 1980), 57–66. On Fox and Zobell: Vaughan to Monroe E. Deutsch, 14 Jan. 1932, SDV, box 3**,** folder 87.

[27] The quotations are from W.E. Allen, Memorandum Concerning the Staff Meeting of 29 April 1929, dated 1 May 1929, WEA, box 2, folder 37; and W.E. Allen to Scripps Staff, 15 July 1929. On using the ship: W.E. Allen, Catches of Marine Diatoms and Dinoflagellates taken by Boat in Southern California Waters in 1926, *Bulletin of the Scripps Institution of Oceanography*, 1928, 1: 201–246. On the decline: Allen to Moberg, 2 July 1933.

[28] Quotations are from: W.C. Crandall, Memo Concerning Boat at Scripps Institution, 13 November 1930, SFP, box 3, folder 43; W.C. Crandall, Memo Regarding Scripps Institution of Oceanography, 1 September 1931, SFP, box 3, folder 34. J.C. Harper to Robert P. Scripps, 22 September 1931, SFP, box 3, folder 43.

[29] On suggestions that there were problems with the family see Raitt and Moulton, *Scripps Institution of Oceanography*, 99–100, 112. Also Deborah Day to Ronald Rainger, 28 July 2003.

[30] Vaughan to W.W. Campbell, 11 May 1928, and 25 May, 1928, SDV, box 1, folder 47. Vaughan to Frank Lillie, 5 September 1929, SDV, box 2, folder 61.

[31] The controversy heated up again in 1933 when Allen published the "Caged Animal" article and criticized Vaughan at a meeting of the American Association for the Advancement of Science. Vaughan to Robert Gordon Sproul, 27 October 1933, UCPR, CU5, folder 1933:804. Vaughan's call for Allen's dismissal led Sproul to appoint a tenure committee to consider the matter. Eventually Allen agreed to cease making public remarks and was reappointed under conditions acceptable to Vaughan. Monroe E. Deutsch to Sproul, 13 October 1933, UCPR, CU5, folder 1933:804; Conference between Vaughan

and Moberg, 19–20 October, 1933, UCPR, CU5, folder 1933:20. On the tenure committee: C.G. Haines to Sproul, 10 April 1934, UCPR, CU5, folder 1934:37.

[32] Vaughan to Harper, 15 September 1931; Vaughan to Sproul, 10 May 1932 and 11 May 1932, SDV, box 2, folder 91; Vaughan to J. Stanley Gardiner, 13 May 1932, SFP, box 3, folder 35.

[33] Richard H. Fleming, Oceanographic Work of the U.S.S. *Hannibal* in the Central American Pacific*, Association internationale oceanographie physique, Proces verbeaux*, 1937, 2:104; Roger Revelle, Oceanographic Work of the U.S.S. *Bushnell* in the North Pacific*, Association internationale oceanographie physique, Proces verbeaux*, 1937, 2:105. On the *Pioneer*: Vaughan to C.B. Lipman, 18 July 1935, SDV, box 3, folder 110.

[34] Vaughan to Sproul, 6 February 1934, SDV, box 3, folder 98; Vaughan to G.D. Louderback, 4 April 1935, SDV, box 3, folder 107.

[35] Elizabeth N. Shor, The Role of T. Wayland Vaughan in American Oceanography, in *Oceanography: The Past*, eds, Sears and Merriman, 127–137, on 134–135.

[36] Vaughan to Henry Bryant Bigelow, 5 June 1935, SDV, box 3, folder 109; Vaughan to G.D. Louderback, 12 December 1935, SDV, box 3, folder 114. On Vaughan's role in selecting Sverdrup see Ronald Rainger, Adaptation and the Importance of Local Culture: Creating a Research School at the Scripps Institution of Oceanography, *Journal of the History of Biology*, 2003, 36:461–500.

[37] Robert Marc Friedman, Contexts for Constructing an Ocean Science: The Career of Harald Ulrik Sverdrup (1888–1957), in *Oceanographic History*, eds. Benson and Rehbock, 17–27. William A. Nierenberg, Harald Ulrik Sverdrup, *National Academy of Sciences Biographical Memoirs*, 1996, 69:339–374.

[38] On the curriculum: Sverdrup to Deutsch, 29 September 1936, UCPR, CU 5, folder 1936:20. Quotations are from Richard H. Fleming, "Fifty Years in Retrospect," 4 June 1980, RHF, box 3, folder Speeches and Lectures; and Friedman, *Contexts for an Ocean Science*, 22. See also Fleming to Roger Revelle, 31 July 1937, SBF, box 6, folder 194, Richard H. Fleming.

[39] Raitt and Moulton, *Scripps Institution of Oceanography*, 121–123.

[40] Sverdrup to Sproul, 11 January 1938, appendix 1, Plans for use by the Scripps Institution of Oceanography of the Research Vessel the *E.W. Scripps*, SDS, box 1, folder 11.

[41] H.U. Sverdrup and Richard H. Fleming, The Waters off the Coast of Southern California March to July 1937, *Bulletin of the Scripps Institution of Oceanography*, 1941, 4:261–378, on 317–336. H.U. Sverdrup and W.E. Allen, Distribution of Diatoms in Relation to the Character of the Water Masses and Currents off Southern California in 1938, *Journal of Marine Research*, 1939, 2:131–144. On fish: Sverdrup to O.E. Sette, 5 Jan. 1939, SDR, box 5, folder U.S. Fish and Wildlife Service, 1938–1940. The quotation is in Robert Marc Friedman, *The Expeditions of Harald Ulrik Sverdrup: Contexts for Shaping an Ocean Science* (La Jolla: Scripps Institution of Oceanography, 1994), 32.

[42] Memoranda of Cooperation between Scripps and the U.S. Fish and Wildlife Service, 19 April 1939, 22 October 1940, 28 April 1941, SDR, box 5, folder U.S. Fish and Wildlife Service, 1938–1940. Memorandum on Scripps Institution of Oceanography Project for Study of Recent Sediments in Relation to Problems of Petroleum Geology, September 1940, SDR, box 5. Roger Revelle to Thomas Wayland Vaughan, 16 April 1940, RR, MC6, box 1, folder 65. On Sverdrup's support: Revelle to Parker D. Trask, 12 May 1940, RR, MC6, box 1, folder 65. On the decline of the Scripps family's contributions: Minutes of the Special Meeting of the Board of Trustees of the Ellen Browning Scripps Foundation, 24 March 1938, UCPR, CU5 folder 1938:115. The last donation from the Ellen B. Scripps Estate or the E.B. Scripps Foundation was a pledge of $9,000 for 1941–42: O. Lundberg to James H. Corley, 4 September 1941, UCPR, CU5, folder 1941:414.

[43] Sverdrup to Sproul, 12 July 1938, SDS, box 1, folder 12. Although Sverdrup touted the importance of Revelle's research, he remained skeptical of Francis P. Shepard's work and continued to view Zobell as a laboratory scientist: Rainger, Adaptation and the Importance of Local Culture; Naomi Oreskes and Ronald Rainger, Science and Security Before the Atomic Bomb: The Loyalty Case of Harald U. Sverdrup, *Studies in History and Philosophy of Modern Physics*, 2000, 31:309–369, on 316–321. H.U. Sverdrup, Martin W. Johnson, and Richard H. Fleming, *The Oceans: Their Physics, Chemistry, and General Biology* (New York: Prentice Hall, 1942).

[44] Oreskes and Rainger, Science and Security Before the Atomic Bomb, 309–369; Ronald Rainger, Science at the Crossroads: The Navy, Bikini Atoll, and American Oceanography in the 1940s, *Historical Studies in the Physical and Biological Sciences*, 2000, 30:349–371.

[45] Rainger, Science at the Crossroads, on 360–364.

[46] Raitt and Moulton, *Scripps Institution of Oceanography*, 137–151; Ronald Rainger, Patronage and Science: Roger Revelle, the U.S. Navy and Oceanography at the Scripps Institution, *Earth Sciences History*, 2000, 19:58–89, on 74–79. On classes: Butler King Couper to Columbus O'Donnell Iselin, 29 September 1946, WDI, box 11, folder 6. Ronald Rainger, Interview with Warren Wooster, 21 July 1997, Seattle, Washington, in the author's possession. Also see Elizabeth Noble Shor, *Scripps Institution of Oceanography: Probing the Oceans 1936–1976* (San Diego: Tofua Press, 1978), 482.

[47] Quote is from [Roger Revelle], The Military Aspects of the Geophysics Branch Program, SSF, box 26, folder 36,

U.S. Navy Office of Naval Research, February 1947–1948. Rainger, Patronage and Science.

[48] H.E. Le Grand, *Dritfing Continents and Shifting Theories: The Modern Revolution in Geology and Scientific Change* (Cambridge: Cambridge University Press, 1988), 170–187. Naomi Oreskes, *The Rejection of Continental Drift: Theory and Method in American Earth Science* (New York: Oxford University Press, 1999), 267–276.

[49] [Revelle], The Military Aspects of the Geophysics Branch Program.

[50] Thomas G. Paterson, *On Every Front: The Making and Unmaking of the Cold War*, revised ed. (New York: W.W. Norton and Company, 1992), 41–82, 96–118, quote on 107. Melvyn P. Leffler, The American Conception of National Security and the Beginnings of the Cold War, 1945–1948, *American Historical Review*, 1984, 89: 346–381, on 349–356; Michael S. Sherry, *In the Shadow of War: The United States Since the 1930s* (New Haven: Yale University Press, 1995), 123–144.

[51] Chief Office of Research and Inventions to Hydrographer, 31 January 1946, NARACP, Record Group 298, accession 5332, box 22, folder Oceanography. [Revelle], The Military Aspects of the Geophysics Branch Program.

[52] Rainger, *An Agenda for Antiquity*. Susan Sheets-Pyenson, *Cathedrals of Science: The Development of Colonial Natural History Museums during the late Nineteenth Century* (Kingston, Ont: McGill-Queens University Press, 1988). Also Ivan Karp and Steven D. Lavine, eds. *Exhibiting Cultures: The Poetics and Politics of Museum Display* (Washington, D.C. Smithsonian Institution Press, 1991); and Sharon MacDonald, ed. *The Politics of Display: Museums, Science, and Culture* (London: Routledge, 1998).

Archives

W. E. Allen Papers, Scripps Institution of Oceanography, La Jolla, California . . . . . WEA
Richard H. Fleming Papers, University of Washington, Seattle, Washington . . . . . RHF
Carl Leavitt Hubbs Papers, Scripps Institution of Oceanography, La Jolla, California . . . . . CLH
John Issacs Papers, Scripps Institution of Oceanography, La Jolla, California . . . . . JI
National Archives and Records Administration, College Park, Maryland . . . . . NARACP
National Archives and Records Administration, Washington, D.C. . . . . NARADC
Roger Revelle Papers, Scripps Institution of Oceanography, La Jolla, California. . . . . RR
Scripps Biographical Files, Scripps Institution of Oceanography, La Jolla, California . . . . . SBF
Scripps Family Papers, Scripps Institution of Oceanography, La Jolla, California . . . . . SFP
Scripps Institution of Oceanography, Subject Files . . . . . SSF
Scripps Office of the Director Records, Revelle, La Jolla, California . . . . . SDR
Scripps Office of the Director Records, Sverdrup, La Jolla, California . . . . . SDS
Scripps Office of the Director Records, Vaughan, La Jolla, California . . . . . SDV
Thomas Wayland Vaughan Papers, Scripps Institution of Oceanography, La Jolla, California. . . . . TWV
University of California, Institute of Marine Resources, Scripps Institution of Oceanography, La Jolla, California . . . . . UCIMR
University of California, Office of the Presidents' Records, Bancroft Library, University of California, Berkeley . . . . . UCPR
Woods Hole Office of the Director Records, Iselin, Woods Hole Oceanographic Institution, Woods Hole Massachusetts . . . . . WDI

References

Allen, Garland E., Naturalists and Experimentalists: The Genotype and the Phenotype, *Studies in History of Biology,* 1979, 3:179–209.

Allen, W.E., Quantitative Studies on Inshore Marine Diatoms and Dinoflagellates of Southern California in 1921 and 1922, *Bulletin of the Scripps Institution of Oceanography,* 1927, 1:19–29.

Allen, W.E., Catches of Marine Diatoms and Dinoflagellates taken by Boat in Southern California Waters in 1926, *Bulletin of the Scripps Institution of Oceanography,* 1928, 1:201–246.

Benson, Keith R., Problems of Individual Development: Descriptive Embryological Morphology in America at the Turn of the Century, *Journal of the History of Biology,* 1981, 14:115–128.

Benson, Keith R., Marine Biology or Oceanography: Early American Developments in Marine Science on

the West Coast, in *Oceanographic History: The Pacific and Beyond*, eds. Keith R. Benson and Philip F. Rehbock (Seattle: University of Washington Press, 2002), 298–302.

Burstyn, Harold L., Reviving American Oceanography: Frank Lillie, Wickliffe Rose, and the Founding of the Woods Hole Oceanographic Institution, in *Oceanography: The Past*, eds. Mary Sears and Daniel Merriman (New York: Springer-Verlag, 1980), 57–66.

Churchill, Frederick B., In Search of the New Biology: An Epilogue, *Journal of the History of Biology*, 1981, 14: 177–191.

Coe, Wesley R., Season of Attachment and Rate of Growth of Sedentary Marine Organisms at the Pier of the Scripps Institution of Oceanography, La Jolla, California, *Bulletin of the Scripps Institution of Oceanography,* 1932, 3: 37–86.

Conn, Steven, *Museums and American Intellectual Life*, 1876–1926 (Chicago: University of Chicago Press, 1998).

Day, Deborah, Bergen West: Or How Four Scandinavian Geophysicists Found a Home in the New World, *Historisch-Meereskundliches Jahrbuch*, 1999, 6:69–82.

Day, Deborah, Navy Support for Oceanography at SIO, Scripps Archives Website *http://sclib.ucsd.edu/sio/archives/siohstry/histories/onr.html*

Day, Deborah, Scripps Benefactions: The Role of the Scripps Family in the Founding of the Scripps Institution of Oceanography, in *Oceanographic History: The Pacific and Beyond*, eds. Keith R. Benson and Philip F. Rehbock (Seattle: University of Washington Press, 2002), 2–6.

Day, Deborah, Significant NSF-Sponsored Research at SIO 1950–2000, Scripps Archives Website *http://sclib.ucsd.edu/sio/archives/siohstry/histories/nsf.html*

Esterly, Calvin O., Limitations of Experimentation in Explaining Natural Habit as Illustrated by Diurnal Migration, *Science*, 1920, 52:307–310.

Esterly, Calvin O., Possible Effect of Seasonal and Laboratory Conditions on the Behavior of the Copepod *Acartia tonsa*, and the Bearing of this on the Question of Diurnal Migration, *Ecology*, 1920, 1:33–40.

Esterly, Calvin O., The Periodic Occurrence of Copepoda in the Marine Plankton of two Successive Years at La Jolla, California, *Bulletin of the Scripps Institution of Oceanography*, 1928, 1:247–345.

Fleming, Richard H., Oceanographic Work of the U.S.S. *Hannibal* in the Central American Pacific, *Association internationale oceanographie physique*, *Proces-verbeaux*, 1937, 2:104.

Friedman, Robert Marc, *The Expeditions of Harald Ulrik Sverdrup: Contexts for Shaping an Ocean Science* (La Jolla: Scripps Institution of Oceanography, 1994).

Friedman, Robert Marc, Contexts for Constructing an Ocean Science: The Career of Harald Ulrik Sverdrup (1888–1957), in *Oceanographic History: The Pacific and Beyond*, eds. Keith R. Benson and Philip F. Rehbock (Seattle: University of Washington Press, 2002), 17–27.

Karp, Ivan, and Steven D. Lavine, eds. *Exhibiting Cultures: The Poetics and Politics of Museum Display* (Washington, D.C. Smithsonian Institution Press, 1991).

Leffler, Melvyn P., The American Conception of National Security and the Beginnings of the Cold War, 1945–1948, *American Historical Review*, 1984, 89:346–381.

Le Grand, H.E., *Drifting Continents and Shifting Theories: The Modern Revolution in Geology and Scientific Change* (Cambridge: Cambridge University Press, 1988).

MacDonald, Sharon, ed. *The Politics of Display: Museums, Science, and Culture* (London: Routledge, 1998).

McEwen, George F., The Distribution of Ocean Temperatures along the West Coast of North America deduced from Ekman's Theory of the Upwelling of Cold Water from the Adjacent Ocean Depths, *Internationale Revue der gesamten Hydrobiologie und Hydrographie*, 1912, 5:243–285.

McEwen, George F., Summary and Interpretation of the Hydrographic Observations made by the Scripps Institution for Biological Research of the University of California 1908 to 1915, *University of California Publications in Zoology*, 1916, 15: 255–356.

Maienschein, Jane, Shifting Assumptions in American Biology: Embryology, 1890–1910, *Journal of the History of Biology*, 1981, 14:89–113.

Michael, Ellis LeRoy, Classification and Vertical Distribution of the Chaetognatha of the San Diego Region, Including Redescriptions of some Doubtful Specimens of the Group, *University of California Publications*

in Zoology, 1911, 8:1–170.

MICHAEL, ELLIS LEROY, Dependence of Marine Biology upon Hydrography and Necessity of Quantitative Biological Research, *University of California Publications in Zoology*, 1916, 15:i–xxiii.

MICHAEL, ELLIS LEROY, AND GEORGE F. MCEWEN, Hydrographic, Plankton, and Dredging Records of the Scripps Institution for Biological Research of the University of California (1901–1912), *University of California Publications in Zoology*, 1915, 15:1–206.

MICHAEL, ELLIS LEROY, AND GEORGE F. MCEWEN, Continuation of Hydrographic, Plankton, and Dredging Records of the Scripps Institution for Biological Research of the University of California (1913–1915), *University of California Publications in Zoology*, 1916, 15: 207–254.

MILLS, ERIC L., Useful in Many Capacities: An Early Career in American Physical Oceanography, *Historical Studies in the Physical Sciences*, 1990, 20:265–311.

MILLS, ERIC L., *The Scripps Institution: Origin of a Habitat for Ocean Science* (La Jolla: Scripps Institution of Oceanography, 1993).

NIERENBERG, WILLIAM A., Harald Ulrik Sverdrup, *National Academy of Sciences Biographical Memoirs*, 1996, 69: 339–374.

ORESKES, NAOMI, *The Rejection of Continental Drift: Theory and Method in American Earth Science* (New York: Oxford University Press, 1999).

ORESKES, NAOMI, AND RONALD RAINGER, Science and Security before the Atomic Bomb: The Loyalty Case of Harald U. Sverdrup, *Studies in History and Philosophy of Modern Physics*, 2000, 31: 309–369.

PATERSON, THOMAS G., *On Every Front: The Making and Unmaking of the Cold War*, revised ed. (New York: W.W. Norton and Company, 1992).

PAULY, PHILIP J., *Biologists and the Promise of American Life: From Meriwether Lewis to Alfred Kinsey* (Princeton: Princeton University Press, 2001).

PROVINE, WILLIAM B., Francis B. Sumner and the Evolutionary Synthesis, *Studies in History of Biology*, 1979, 3:211–240.

RAINGER, RONALD, The Continuation of the Morphological Tradition: American Paleontology 1880–1910, *Journal of the History of Biology*, 1981, 14:129–158.

RAINGER, RONALD, A*n Agenda for Antiquity: Henry Fairfield Osborn and Vertebrate Paleontology at the American Museum of Natural History, 1890–1935* (Tuscaloosa: University of Alabama Press, 1991).

RAINGER, RONALD, Patronage and Science: Roger Revelle, the U.S. Navy, and Oceanography at the Scripps Institution, *Earth Sciences History*, 2000, 19:58–89.

RAINGER, RONALD, Science at the Crossroads: The Navy, Bikini Atoll and American Oceanography in the 1940s, *Historical Studies in the Physical and Biological Sciences*, 2000, 30:349–371.

RAINGER, RONALD, Adaptation and the Importance of Local Culture: Creating a Research School at the Scripps Institution of Oceanography, *Journal of the History of Biology*, 2003, 36:461–500.

RAITT, HELEN, AND BEATRICE MOULTON, *Scripps Institution of Oceanography: First Fifty Years. San Diego* (Ward Ritchie Press, 1967).

REVELLE, ROGER, Oceanographic Work of the U.S.S. *Bushnell* in the North Pacific, *Association internationale oceanographie physique, Proces-verbeaux*, 1937, 2:105.

REVELLE, ROGER, *Marine Bottom Samples Collected in the Pacific Ocean by the Carnegie on Its Seventh Cruise* (Washington, D.C.: Carnegie Institution of Washington, 1944), publication 556.

RITTER, WILLIAM E., A General Statement of the Ideas and Present Aims and Status of the Marine Biological Association of San Diego, *University of California Publications in Zoology*, 1905, 2:i–xvii.

RITTER, WILLIAM E., The Marine Biological Station of San Diego: Its History, Present Conditions, Achievements, and Aims, *University of California Publications in Zoology*, 1912, 9: 137–248.

RITTER, WILLIAM E., A Business Man's Appraisement of Biology, *Science*, 1916, 44: 819–822.

RITTER, WILLIAM E., What the Scripps Institution is Trying To Do, *Bulletin of the Scripps Institution for Biological Research*, 1916, 1:19–24.

RITTER, WILLIAM E., Scripps Institution for Biological Research (1917), in *Annual Report of the President of the University of California* (Berkeley: University of California Press, 1917–1918), 151–154.

RITTER, WILLIAM E., Scripps Institution for Biological Research (1918), in *Annual Report of the President of the University of California* (Berkeley: University of California Press, 1918–1919), 1–8.

RITTER, WILLIAM E., The Problem of the Pacific, *Bulletin of the Scripps Institution for Biological Research*, 1919, 8:1–8.

RITTER, WILLIAM E., Problems of Population of the North Pacific as Dependent upon the Biology, the Oceanography, and the Meteorology of the Area, *Science*, 1919, 50:119–125.

RITTER, WILLIAM E., *The Unity of the Organism or the Organismal Conception of Life*, 2 vols. (Boston: Richard G. Badger, 1919.)

RITTER, WILLIAM E., Scripps Institution for Biological Research (1919), in *Annual Report of the President of the University of California* (Berkeley: University of California Press, 1919–1920), 3–15.

RITTER, WILLIAM E., Scripps Institution for Biological Research (1920), in *Annual Report of the President of the University of California* (Berkeley: University of California Press, 1920–1921), 161–169.

RITTER, WILLIAM E., Scripps Institution for Biological Research (1921), in *Annual Report of the President of the University of California* (Berkeley: University of California Press, 1921–1922), 183–188.

RITTER, WILLIAM E., The Relation of E.W. Scripps to Science, *Science*, 1927, 65:291–292.

SHEETS-PYENSON, SUSAN, *Cathedrals of Science: The Development of Colonial Natural History Museums during the late Nineteenth Century* (Kingston, Ont: McGill-Queens University Press, 1988).

SHERRY, MICHAEL S., *In the Shadow of War: The United States Since the 1930s* (New Haven: Yale University Press, 1995).

SHOR, ELIZABETH NOBLE, *Scripps Institution of Oceanography: Probing the Oceans 1936 to 1976* (San Diego: Tofua Press, 1978).

SHOR, ELIZABETH NOBLE, The Role of T. Wayland Vaughan in American Oceanography, in *Oceanography: The Past*, eds. Mary Sears and Daniel Merriman (New York: Springer-Verlag, 1980), 127–137.

SVERDRUP, H.U., AND W. E. ALLEN, Distribution of Diatoms in Relation to the Character of the Water Masses and Currents off Southern California in 1938, *Journal of Marine Research*, 1939, 2:131–144.

SVERDRUP, H.U., AND RICHARD H. FLEMING, The Waters off the Coast of Southern California March to July 1937, *Bulletin of the Scripps Institution of Oceanography*, 1941, 4:261–378.

SVERDRUP, H.U., MARTIN W. JOHNSON, AND RICHARD H. FLEMING, *The Oceans: Their Physics, Chemistry and General Biology* (New York: Prentice Hall, 1942).

THOMPSON, THOMAS G., THOMAS WAYLAND VAUGHAN, *National Academy of Sciences Biographical Memoirs*, 1958, 32:399–437.

VAUGHAN, THOMAS WAYLAND, The Madreporaria and Marine Bottom Sediments of Southern Florida, *Carnegie Institution of Washington Yearbook*, 1911, 10:147–155.

VAUGHAN, THOMAS WAYLAND, Corals and the Formation of Coral Reefs, *Smithsonian Institution Annual Report for 1917*, 1919:189–276.

VAUGHAN, THOMAS WAYLAND, Researches on Sedimentation, *Bulletin of the Geological Society of America* 1920, 31: 401–410.

VAUGHAN, THOMAS WAYLAND, Scripps Institution of Oceanography (1929), in *Annual Report of the President of the University of California* (Berkeley: University of California Press, 1929), 260–272.

WEIR, GARY E., *An Ocean in Common: American Naval Officers, Scientists, and the Ocean Environment*. (College Station: Texas A&M University Press, 2001).

Appendix

Financial Support for the Scripps Institution of Oceanography 1903-1955

Financial support for the Scripps Institution changed considerably in the 1940s and 1950s. Prior to those decades the institution relied primarily on funding from private sources. By far the most significant contributors were the members of the Scripps family. From 1903 to 1912 E.W. Scripps and Ellen Browning Scripps provided "almost all the operating funds for the station . . . ." [Day, Scripps Benefactions, 2.] E.W. Scripps donated his yacht, the *Loma*, and during his lifetime contributed over $50,000 to the institution. His sister's contributions were even larger. In 1906 she gave $50,000 to the fledgling biological station and the following year donated $1,000 to purchase the site for the biological laboratory. In 1909 she established a $150,000 endowment for the institution and by 1914 had given an additional $160,000 in donations. During the 1920s and 1930s she annually donated at least $9,000 per year to the institution, and made arrangements for her estate to continue those contributions after her death. Ultimately Ellen Browning Scripps gave over $400,000 to the institution. She likewise provided funding for the construction of the George H. Scripps Laboratory, the roads, and the pier. She also gave the money to construct the laboratory's ship, the *Alexander Agassiz*. In the years 1912 to 1946, the institution's overall expenses totaled $2,683,523, of which the Scripps family provided more than $1,300,000 or 53%. (Day, Scripps Benefactions, 2; Raitt and Moulton, *Scripps Institution*, 37, 40, 48, 53, 67-68; Regents of the University of California, Finance Committee Report, 18 September 1946, UCPR, CU5 folder 1946:414).

Other agencies also assisted the institution. Beginning in 1912, when the biological laboratory became part of the University of California, the State Legislature and the Regents made annual appropriations to the institution. Originally that contribution was $7,500 per year (Raitt and Moulton, *Scripps Institution*, 68), but by the 1920s and 1930s the appropriation averaged around $22,000 per year. During the 1930s Vaughan suggested an annual increase from the University and the Scripps family, and by the early 1940s the State of California's annual contribution had increased to approximately $45,000 per year (Sverdrup to Sproul, 18 December 1939, SDS, box 1, folder 15). In addition the State of California and the Rockefeller Foundation each donated $40,000 for the construction of Ritter Hall. During World War I federal agencies sponsored research on kelp and fish. W.C. Crandall, the institution's first business manager who also had an interest in marine biology, received support from the Department of Agriculture's Bureau of Soils for studying the potential uses of kelp as a fertilizer. The U.S. Bureau of Fisheries called on Scripps to study the distribution of tuna, while the Federal Food Administration sponsored research on plankton as a food supply for commercial fish. George F. McEwen's work on weather forecasting brought in additional funds. By the late 1920s and early 1930s several public utility companies and various agricultural interests were contributing about $6,000 per year to that project, although Sverdrup ended it when he became director (Raitt and Moulton, *Scripps Institution*, 90–91, 106–107).

Although support from the Scripps family continued throughout the 1930s, by 1938 those contributions had begun to decline and increasingly the institution relied on other patrons. In 1937 the institution assumed administrative responsibility for Francis P. Shepard 's $9,000 grant from the Geological Society of America. Revelle and Shepard also received several additional grants from geological organizations and oil companies in support of their investigations on the source of oil. The largest of those was a $2,500 grant from the GSA that supported the 1940 Scripps Expedition to the Gulf of California (W.S.W. Kew, Roger Revelle, and Francis P. Shepard, 12 March 1940,

SDR, box 4, folder Grant Applications 1933-41). In addition that research resulted in a long-term grant from the American Petroleum Institute. In 1942 the API awarded Scripps a $6,500 grant; by 1950 it had given the institution over $80,000. (API Research Project 45A, 1942-1945, SSF, box 16, folder 26; Roger Revelle to Chief of Naval Research, 28 December 1950, SDR, box 1). From 1939 to 1941 Sverdrup successfully negotiated contracts with the U.S. Fish and Wildlife Service for studies of the California sardine. In 1939 and again in 1940 Scripps received $2,000 for that work, and during the fiscal year 1941 approximately $2,800. (Memorandum of Cooperation between the U.S. Fish and Wildlife Service and the Scripps Institution of Oceanography, 19 April 1939, SDR, box 5; Sverdrup to O.E. Sette, 16 October 1939, SSF, box 16, folder 21; Memorandum of Cooperation between the U.S. Fish and Wildlife Service and the Scripps Institution of Oceanography, 5 November 1940, SDR, box 5; Report on the Investigations during the Fiscal Year 1941 between the Scripps Institution of Oceanography and the Fish and Wildlife Service, U.S. Department of the Interior, Concerning Cooperation in Investigations of the Marine Fisheries of the Pacific Coast, SSF, box 15, folder 24).

During WWII the Scripps Institution, while still drawing on Ellen Browning Scripps' endowment and the regular appropriation from the State of California, began receiving greater support from federal agencies. From the mid 1930s to 1941 Scripps was able to hire numerous workers with money from the Works Project Administration. When the National Defense Research Committee established the University of California Division of War Research in July 1941, the University turned over the *E.W. Scripps* to the government. The government paid the university $70 per day for the ship, resulting in $127,750 in income over five years. From 1941 to 1943 the Kelco Company paid Scripps $3,400 for research on kelp, and the Fish and Wildlife Service supported C.K. Tseng's agar research (Scripps Research, 1932-1949, SSF, box 16, folder 15; SSF, box 16, folder 32).. In 1937 Sverdrup signed a contract with the Navy Bureau of Construction and Repair for work on anti-fouling agents to protect ship hulls. The original contract was small, only $480 in expenses and salary for one Navy officer, but by 1940 the project included several workers and amounted to $12,000 (Sverdrup to Sproul, 24 October 1940, UCPR CU5 folder 1940: 414A). In 1942 the Army Air Force agreed to pay Scripps $34,000 for work on isothermal charts, meteorology, and oceanography. Sverdrup's security clearance problems prevented him from participating, but several other members of the Scripps staff worked on the project (Don Z. Zimmerman and John B. Ackerman to Regents of the University of California, 4 June 1942; Sverdrup to Sproul, 15 June 1942, both in SSF, box 16, folder 37). By 1943 the contract had increased to $46,700 (SSF box 16, folder 38). A year later when Sverdrup received clearance, the Navy Hydrographic Office negotiated a contract for $39,000 for research on several topics including sea and swell forecasting. (Navy Hydrographic Office to Regents of the University of California, 14 August 1943, Record Group 37, entry 48, box 124, folder HI, NARADC). By 1945 that contract had increased to $100,000 (Sverdrup, Plan for Oceanographic Work at the Scripps Institution of Oceanography under the Hydrographic Office Contract, 1 March 1945 to 30 June 1946, SSF, box 5, folder 55). The Hydrographic Office also sponsored Scripps' work on the bathythermograph, an instrument that measured seawater temperature at depth. Other military agencies that were supporting Scripps in 1944-45 included the Navy Bureau of Ships ($6,000 for research on breakers and surf, and $18,000 for study of the oceanography of the surface layers), and the Amphibious Training Command for teaching courses on sea, swell and surf forecasting ($4,700). (Sverdrup to Robert M. Underbill, 15 February 1945, SDS, box 1, folder 26; Sverdrup to Sproul, 1 July 1946, UCPR CU5 folder 1946:414; Sverdrup to B.E. Dodson, 6 June 1944, SSF, box 16, folder 40).

Following WWII, scientific, educational, and military needs resulted in a tremendous increase in Scripps' financial resources. In 1947 the State of California, concerned about the continuing

decline in the annual catch of the California sardine, sponsored a massive research effort that relied on several agencies, including Scripps. In that first year the state provided Scripps with $300,000 for its work on the project. For the fiscal year 1948 that contract was increased to $400,000, and by the mid 1950s the Scripps Marine Life Research Program was receiving over $500,000 annually (Minutes of the Meeting of the Sardine Research Committee, 13 March 1947, SSF, box 13, folder 11; Russell Barthell to Sproul, 14 October 1947, SSF, box 13, folder 15; Report of the Marine Life Research Budget, 1956, CLH, box 24, folder 9).

In addition, considerable research on fish took place through the Institute of Marine Resources, a new organization established by Revelle in 1953. As a university-wide center IMR was separate from Scripps, but it contributed significantly to research and resources in La Jolla. Beginning with the university's appropriation of $22,000 in 1953, the state's contribution reached $175,000 by 1960 (UCIMR, Meeting of 29 March 1961, Office of the Director Records, box 7, folder 393). Projects included studies of fish distribution and fluctuation, development of artificial bait, and synthesis of new food products from fish fat and protein. But Revelle was eager to expand the institute's mission and by the mid 1950s IMR had become a center for ocean engineering. As such it attracted the interest of numerous federal agencies and private organizations. One notable contributor was the American Petroleum Institute, which had previously sponsored Scripps research on sources for oil. That organization continued its support of Scripps by helping to fund a new foraminifera laboratory, but in addition the API launched a new project on recent sedimentary processes that was based in IMR. By 1955 the API contribution totaled $125,000 per year. Other IMR projects included research on marine minerals, notably manganese deposits, water pollution, marine corrosion, and food technology. Atomic Energy Commission support for studies of nuclear waste disposal quickly became a major source of income (A Partial List of Research Projects, January -September 1953, UCIMR, box 6, folder 76; Annual Report, 23 April 1956, UCIMR, box 7, folder 392).

The biological sciences attracted far less funding than the work in fisheries biology, ocean engineering, or geophysics. Most of the support came from foundations and individual contributors. While it is difficult to track funding for individual researchers and graduate students, one of the most important patrons was the Rockefeller Foundation. From 1947 to 1950 it contributed $19,000 for studies in marine biology. In the mid 1950s, when Revelle sought to replace traditional marine biology with research in genetics, physiology, and experimental biology, the Rockefeller Foundation launched that initiative with a $1,000,000 grant to Scripps. (Shor, *Scripps Institution of Oceanography,* 202).

By far the greatest financial support came from the military, especially the Navy. Deborah Day, the Scripps Archivist, has estimated that from 1945 to the mid 1960s Navy sponsorship accounted for 80 to 90% of the Scripps budget (Day, Navy Support for Oceanography at SIO). Most of that money came from the Hydrographic Office, the Bureau of Ships, and the new Office of Naval Research. In 1946–47, in addition to the $100,000 from the Hydrographic Office, Scripps received $132,000 from ONR for general work in oceanography and a project on fog forecasting, and $105,000 for various projects from the Bureau of Ships. By 1948 support from ONR and the Bureau of Ships alone totaled $963,475 (Scripps Contracts, 5 May 1948, UCPR CU5, folder 1948:414). With the onset of the Korean War those amounts increased dramatically. Between 1949 and 1955 Scripps had 13 separate, multi-year contracts with ONR totaling $7,840,164, while Bureau of Ships funding rose to almost $500,000 per year (Scripps Federal Contracts, 8 September 1955, SSF, box 5). Other military agencies also sponsored Scripps' research. The Air Force was responsible for almost all funding of the Visibility Laboratory; in addition Scripps was under contract with the Air Force Cambridge Research Laboratory for $50,000 per year. In 1954 the Air

Force negotiated two additional contracts with Scripps, one for work on air/sea boundary problems, the other on storm surges at sea, for a total of $64,000 (Proposed Budget Expansion for National Defense, 13 December 1950, UCPR CU5 Series 4, box 32:29; Scripps Federal Contracts, 8 September 1955, SSF, box 5). In 1949 Scripps and the Army Corps of Engineers Beach Erosion Board entered into a contract for $45,000; by 1953 it was $120,000 (Scripps Contracts, 12 March 1953, SSF, box 5). During those years Scripps scientists participated in several major expeditions to the Pacific. Those voyages produced important scientific contributions, but in addition they included analyses of the effects of nuclear bomb testing. Beginning in 1952 and continuing into the late 1950s, the Armed Forces Special Weapons Project paid Scripps $500,000 per year for assistance on atomic bomb tests in the Pacific (University of California, Scripps Institution of Oceanography, "Proposal to the Atomic Energy Commission for a Study of Oceanic Disposal of Nuclear Wastes in the Offshore Waters of California," [1955], JI, box 38, folder Proposals Atomic Energy, 1955).

In addition to contracts, the military provided considerable material support to Scripps. Navy ships worked side by side with Scripps vessels in the Pacific, and that agency provided logistical support as well as funding for equipment, scientific instruments, new buildings, and various other items. Complete data on military support are not available since many records remain classified. Although the National Science Foundation became an important patron of Scripps oceanography in the 1950s, military sponsorship far surpassed any other source of support for the institution (Day, Significant NSF-Sponsored Ocean Research at SIO, 1950-2000).