

**Observations:**

**No. 1 - Scientists and American Naval Officers at Sea: The Gulf, Caribbean, and Canal Zone, 1930-1940**

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By 1930 the Navy had precisely defined the extent and style of its interwar commitment to oceanography. The Schofield Board ratified the practices developed independently by the Hydrographic Office after the ICO program failed to gain presidential and congressional approval. Secretary of the Navy Charles Francis Adams and the bureau chiefs found a personal approach to research familiar and agreeable because it seemed affordable and dovetailed well with the operational responsibilities of the fleet.

As a result, the Hydrographic Office did some of the most comprehensive surveys in its history and cooperated with universities and private research institutions as far as its budget and the political climate would permit. Work in the Pacific, Atlantic, and Caribbean on temperature, salinity, currents, gravity, water chemistry, and ocean

bottom topography, as well as basic mapmaking surveys were conducted alone or in cooperation with Scripps, the Woods Hole Oceanographic Institution (WHOI), Yale, the University of Washington, and other interested groups.

In the process the Navy formed close ties with scientists and the institutions that sponsored them. A network of personal relationships between officers and civilian scientists fostered cooperation and improved the scope and quality of the science they could do together in spite of financially hard times. In addition, the development of new research techniques and technologies enhanced their work and provided views of the ocean never before possible.

In a response to the International Hydrographic Bureau (IHB) in Monaco penned on 8 September 1931, Hydrographer of the Navy Rear Admiral Walter R. Gherardi provided some early insights into the Navy's ambitious plans and priorities for the decade. The IHB had asked for issues of importance to the United States that the Third International Hydrographic Conference might address when it met in

Monte Carlo in April 1932. The final conference program provided an indication of the interests expressed by all member nations and the subjects selected by Gherardi naturally displayed American interests. He urged the conference to call for both extensive coastal surveys in all parts of the world and a publication that would keep IHB members abreast of the progress of these surveys. He also advocated the completion of the International Bathymetric Chart of the World, and the multiplication and standardization of the type and quantity of data available on all hydrographic charts. Information on the latter should include the geographic limits of oceans and seas and echo-soundings for depth and bottom topography all expressed in the metric system.

Although Gherardi looked forward to the discussions in Monte Carlo, he did not intend to waste any time before initiating American naval surveys designed to pursue these goals and interests.

The civilian scientific community quickly and publicly supported the Navy's interest in performing more comprehensive and complete hydrographic surveys. In July 1930 the American Geophysical Union passed a series of resolutions supporting research programs designed

to provide a broader view and deeper knowledge of the ocean. NRC chairman George K. Burgess quickly brought these opinions to the attention of Secretary of the Navy Charles Francis Adams. Burgess and the AGU, among others, wanted the Navy to recognize the large number of potential allies it had in the civilian scientific community. The AGU felt that the Bureau of Navigation and the Hydrographer of the Navy simply needed to take advantage of the available professionals and scientific resources.<sup>i</sup>

Priorities at the Hydrographic Office remained consistent with the goals set by the ICO in 1924 and the suggestions made to the IHB by Gherardi in 1931. Although the Pacific increasingly drew the attention of American grand strategists during these years, the Navy applied the bulk of its limited oceanographic resources to the Caribbean and Gulf of Mexico region.

From the strategic point of view, the concentration on home waters was not entirely misplaced. A complete understanding of the sea passages into the Gulf of Mexico as well as an appreciation of the

oceanographic character of the approaches to the Panama Canal needed little justification. In a letter to Admiral Charles F. Hughes, Chief of Naval Operations, prepared in January of 1928, the Bureau of Navigation defended the need for new, more detailed surveys in the vicinity of the Canal Zone by citing the region's strategic importance in the event of war. By that time Hydro already had the results of a three-month reconnaissance of the Gulf of Panama and the Pearl Islands performed by USS Niagara, a steam yacht built in Wilmington, Delaware at the turn of the century and purchased by the Navy in 1917. The ship's crew erected a series of triangulation towers to determine better the accuracy of the available charts and found them significantly flawed.

Future plans outlined for the CNO projected a six-year program to fill out the picture and increase the Navy's knowledge of the region. The program included a complete schedule of triangulation measurements to improve the accuracy of charts. In addition, Hydro scheduled frequent off-shore soundings, in-shore soundings around the Pearl Islands and along the coast at the ten-fathom curve, and

surface and air observations to define the coastline more precisely. The Hydrographer used Niagara for most of the in-shore work with support from USS Hannibal, leaving USS Nokomis to execute the off-shore deep water research. In this effort the crews and scientific staff on board each ship gathered data on currents as well as temperature and salinity readings. Hydro's parent activity, the Bureau of Navigation, had difficulty all through these years finding adequate shallow draft auxiliaries to perform tasks close inshore. Nokomis was a yacht much like the Niagara, while Hannibal had greater displacement. Designed as the cargo steamer John Holland, Hannibal (AG-1) came down the ways at J. Blumer and Company of Sunderland in the United Kingdom in 1898. The Navy purchased the 4,000 ton vessel in April and commissioned her with the name of that extraordinary Carthaginian military leader on 7 June. Thus, while the American survey fleet had adequate medium and deep draft ships, vessels for shallow work remained scarce.

The process often took a great deal of time, but the results proved valuable and useful. By 1933 Hydro could offer for public

distribution detailed and large-scale charts covering the Pearl Islands and the eastern section of the Gulf of Panama from the Canal Zone to San Miguel Bay, an inlet on the Gulf. USS Fulton remained in the area to extend the survey both to the western portion of the Gulf and then southward to Cape Mala, at the western entrance to the Gulf of Panama. Hydro considered this work as part of its exploration of the Gulf-Caribbean area in spite of the fact that part of the Canal Zone geography, like Cape Mala and San Miguel Bay, actually lay on the Pacific side of the isthmus.<sup>ii</sup>

After Panama, USS Hannibal and Nokomis journeyed to Cuba to continue their survey work, only with a new twist. This time reconnaissance aircraft built by Loening Aeronautical Company supported their data collection effort. VJ Squadron Three-S began preparing for the survey at the Naval Aircraft Factory in Philadelphia in mid-February by testing their two, newly acquired OL-8-A amphibian aircraft. The officers and crew also collected spare parts and packed supplies, including two Fairchild K-3-A aerial cameras, for shipment to Key West on board a cargo vessel of the Mallory Steamship Company.

The survey began on 3 March 1929 after the USS Nokomis arrived to join her tender and houseboat USS Aramis at Nuevitas Bay on the northeast coast of Cuba. VJ-3S flew for the Nokomis until 10 March, shooting twenty rolls of mapping film and covering 1200 square miles. On board Nokomis, the technical staff developed the film each night to determine the necessity of repeating any flights. By 20 March the film was back in Key West and printed for use by the Hydrographic Office. With this effort the Nokomis concluded its portion of the mission and departed, leaving the VJ squadron to await the arrival of USS Hannibal to continue the research. After the ship made port at Mariel, the work resumed and the aircraft used eleven rolls of mapping film to cover another 730 square miles, completing their task on 6 April. From there the squadron moved their activities to the Texas coast to do some mapping photography along the Gulf coast without benefit of surface ship support. After the coastline work the squadron returned to Key West for decommissioning on 1 June 1929.

These aerial mapping techniques required great patience and care as well as considerable logistical support. The commander of the



squadron noted that the value of skilled and experienced aerial photographers increased after the hydrographic vessels departed. These ships carried the supplies and the developing facilities that permitted on-site evaluation of the day's work and repeat flights if necessary. Without this support the aircrews were on their own, and only skill and experience prevented the poor results that would require eventual repetition of the day's work.

The Fairchild K-3-A cameras performed to everyone's satisfaction, with one major exception. The photographers had a difficult time coordinating the shutter speed of the camera that captured the self-registering devices with that focused on the object of the survey. For the data to mean anything the self-registering devices had to provide time of day, altitude, date, and aircraft attitude on the same photograph as the primary image of the ocean, coastline, or landmass. To make things more difficult, the two negatives did not have the same density, making proper developing very difficult. This marred the performance of an otherwise excellent instrument. While successful, the Navy realized that it needed to continue working on

this technique and improving the training of the personnel involved.<sup>iii</sup>

During the 1930-1931 and 1931-1932 survey seasons Hydro kept Hannibal in the Gulf of Paria, a body of water between the mainland of Venezuela and the island of Trinidad, surveying one of the major routes linking the Atlantic Ocean and the Caribbean Sea. In each case the Navy worked through the Department of State to obtain the permission of the Venezuelan government. Hydro wanted to complete a detailed survey of the eastern portion of the Gulf, an area of 1100 square miles with 200 miles of coastline. Errors of anywhere from six to twelve miles rendered available charts covering critical portions of this region nearly useless.<sup>iv</sup>

During October 1931, Nokomis continued its Caribbean surveys.

Returning to Cuba, the hydrographic vessel worked along the northeastern coast from Nipe Bay eastward to Cape Maysi. Part of the ship's orders directed a resurvey of the Mucaras Reef and Diamond Point then under the jurisdiction of the British Bahamas.<sup>v</sup> In all of these cases and many others Hydro approached the local authorities

through the State Department to secure permission to continue the research. In return for their consent, the British and the participating Central and South American countries frequently asked for a copy of the data gathered and the charts drafted as a result of the research. A similar arrangement was made with Costa Rica in the spring and summer of 1932. Hydro received permission to do an extensive hydrographic, coastal, and aerial survey of the Costa Rican coast. Both countries benefitted, because the Costa Ricans wanted to improve the placement of lighthouses and buoys near coastal hazards and harbors. In this instance, the USS Fulton did much of the survey for the Hydrographic Office and the American officials and crews received exceptionally good treatment while on shore leave.<sup>vi</sup>

Not all of Hydro's efforts during these years consisted of surveys.

In the spring of 1932, George Littlehales of the Hydrographic Office reported on the Navy's exploration of the Bartlett Deep to the NRC's Committee on Submarine Configuration and Oceanic Circulation chaired by Thomas Wayland Vaughan. Gherardi's office took very seriously the recommendation of the Schofield Report that the greatest

depths of the ocean should take a primary place in naval research. Hydro planned to build upon the gravity investigations conducted in the Bartlett Deep by the Navy-Princeton Expedition of 1932. Both the submarine S-48 and the USS Chewink took deep echo-soundings of the area in support of the work done on board the former with the Vening-Meinesz gravity apparatus. This provided some of the earliest geophysical data ever obtained for the Caribbean region.<sup>vii</sup>

In the process of planning surveys and coordinating data collection, Gherardi cultivated relationships with the directors of the two premier oceanographic institutions to obtain assistance, instruments, and advice. Thomas Wayland Vaughan of Scripps and Henry Bryant Bigelow of Woods Hole recognized, along with Gherardi, that the scarcity of funds, ships, and personnel made them all mutually dependent. Only close cooperation would bring to fruition the goals pursued by all of them.<sup>viii</sup>

In August of 1932 Gherardi asked Bigelow for assistance in obtaining some instruments Hydro needed in its surveys. Bigelow

replied in early September that he had no spare instruments to loan, but perhaps he could help in another way. Recognizing that Hydro would have to spend about \$2000 to acquire the instruments it wanted, Bigelow offered WHOI's assistance in training naval officers to use the equipment. The director of the new institution reminded Gherardi that the "observations must be taken with great accuracy to meet modern standards." He wanted the admiral to assign one of his officers to WHOI's research vessel, Atlantis, scheduled to depart on 20 September for the Gulf of Maine. If someone from Hannibal went on the voyage, "he would see all the operations and have a chance to thoroughly familiarize himself with the whole procedure."

Admiral Gherardi wasted no time in accepting the offer. He wrote to Bigelow on 9 September that he found the suggestion very gracious and constructive and would certainly select a member of the Hannibal crew to accompany Atlantis to the Gulf of Maine. By 14 September Hydro ordered Commander Charles C. Slayton, commanding officer of Hannibal, to join the WHOI expedition. Slayton's experiences with data collection methods and his participation in the activities of the cruise

permitted Hydro to reap great benefit. As Gherardi commented to Bigelow in a letter penned on 30 September 1932, "There is nothing equal to the personal contact with those who have had continuing practical experience in the use of special apparatus and getting a first hand experience in its use."

The Woods Hole Oceanographic Institution also worked very closely with Hydro in its effort to study the waters of the Caribbean. Bigelow and his staff helped Gherardi in selecting the best and most scientifically significant temperature and salinity stations in the region. Columbus O'Donnell Iselin, Bigelow's assistant director and his successor in 1940, actually provided the information requested by the Navy. While Hydro naturally had its own idea about the schedule and route of its ships and the places where the Navy needed data collected, Gherardi still wisely solicited Bigelow's assistance. He never missed a chance to augment and perhaps improve Hydro's selection process while strengthening established ties with Woods Hole. The advice and training would help Commander Slayton and Hannibal when they returned to the Caribbean in November 1932. Friendship

and cooperation would also enable Hydro to benefit from the research Atlantis and her scientific team planned to do in the Caribbean during their general oceanographic survey of the region from the Windward Islands to the Yucatan Channel in February 1933.<sup>ix</sup> For Hydro, sowing the seeds of a long term relationship made operational, scientific, and fiscal sense.

Gherardi also cultivated a close professional connection with the Scripps Institution of Oceanography in LaJolla, California. He worked more closely with Thomas Wayland Vaughan than any other civilian scientific leader and both Hydro and Scripps profited immensely from the link. While all oceanographic institutions, universities, and seagoing businesses relied upon Hydro for essential navigational charts, only Scripps had the advantage of seeing the essential data for these charts before the information went to the publisher. By agreement with Gherardi, Scripps received the oceanographic survey data directly from ships like Hannibal and Nokomis. Vaughan convinced the Navy to permit Scripps scientists to perform the chemical and physical analyses necessary to render the information

useful for chart composition. This gave Scripps personnel the first opportunity to use the information to augment their vision of the ocean and it gave Hydro a way of "working up" the data at a minimal cost to the Navy.

Data analysis formed only a small part of the Scripps-Hydro interwar relationship. Vaughan also provided Gherardi's people with suggestions for stations to occupy at sea. At these particular locations both Hydro and the civilian scientists would find data on temperature, salinity, depth, bottom topography, and other types of knowledge that would provide information either indicative of a region or of particular interest for mapping or research purposes. Hydro did not always initiate the request for advice to plot station locations for a research voyage. Vaughan and his colleagues frequently offered their unsolicited advice, but the admiral repeatedly made it clear that he welcomed their requests and suggestions. He made it a practice to oblige Scripps and WHOI unless other commitments made it absolutely impossible.



The same policy applied to advice on scientific methodology and instrumentation. Often lacking sufficient funds to purchase adequate instrumentation for its research voyages, Hydro called upon private research institutions and other federal agencies for surplus or equipment on loan. Scripps or WHOI might make the loan, help find surplus, or, as in the case of Commander Slayton, offer to train personnel in lieu of actually furnishing hardware. Scripps offered all manner of instrumentation in response to Hydro requests during the interwar period including apparatus for collecting specimens from the ocean bottom and bottles for storing the valuable water samples that would return to La Jolla for analysis. These activities helped provide the Navy and commercial mariners with essential charts and critical information on the ocean environment. At the same time, civilian science found an invaluable ally who helped them sustain their scientific research. The Navy would discover soon enough that the alliance would prove as valuable in war as in peace.

Thomas Wayland Vaughan realized early the possibilities of the alliance with the Navy and took measures to strengthen and exploit it.

On 1 October 1932 he asked Admiral Gherardi if "it would be possible for one of our men to work on board one of your vessels while operating in the Gulf of Panama in order to carry out certain analyses." Along with the trip taken by Slayton on board R/V Atlantis at Bigelow's invitation, this request by Vaughan set a significant precedent for exchange of personnel for research and training purposes. Hydro immediately applied for permission to take a civilian scientist from Scripps on board Hannibal in the Gulf of Panama. By late November Gherardi received final approval from the Bureau of Navigation and informed Scripps on 9 December, writing to the institution's acting director, Eric G. Moberg, while Vaughan travelled in Europe on business. Five days later Moberg informed Hydro that he intended to send the Canadian Richard H. Fleming to Hannibal. Fleming worked as a research assistant at Scripps while pursuing his doctorate in chemical oceanography at the University of California. Moberg guaranteed Gherardi that Fleming's work would not interfere with shipboard routine. Indeed, much of the young chemist's work would derive from the vessel's regular water sampling efforts.

In spite of some technical difficulties, the voyage proved very productive. Fleming left San Diego on 27 April 1933 on board the USS Chaumont, a Navy transport of 8,300 tons displacement built in 1920 by American International Shipbuilding Corporation of Hog Island Pennsylvania. During the trip to Balboa in the Canal Zone, Fleming collected twenty samples of plankton and an equal number of ordinary seawater for salinity measurements. The crew also took water temperature readings at every "station," the common scientific term for planned interruptions in the vessel's progress to permit experimentation.

After his arrival on board Hannibal, Fleming took 423 oxygen determinations at eighty-five stations with samples obtained at a variety of depths from five to 1800 fathoms. The variation of oxygen saturation in Gulf water proved remarkable. From little or no oxygen in some samples, others displayed as much as 200 percent. The highest concentration Scripps had discovered at any of its Pacific ocean sites was 130 percent. In his report to Vaughan, Moberg quoted Fleming on his experience. Amazed by the oxygen content and the amount of

plankton, the Scripps student described the Gulf of Panama as "soup", comparable to the Gulf of Georgia.

"I have had a sample taken at practically all of the stations; there is a great variation in composition, some being practically all phytoplankton and others zooplankton. This certainly seems to be a most interesting region and I am sure an oceanographic boat could spend a year here quite profitably. [Moberg to Vaughan, 18 April 1933]"

The survey of the Gulf started on 9 March and ended fifteen days later. Although Fleming and the ship's company collected a substantial amount of data, the voyage did not pass without mishap. The expedition lost four days due to a collapsed winch and Fleming had to abandon any effort to evaluate the water for nitrates or phosphates because the Green-Bigelow sampling bottles did not hold enough to permit these tests as well as those for oxygen and salinity. High winds constantly challenged the crew's shiphandling skills and often blew Hannibal out of position, while Fleming and the ship's company experienced malfunctions by reversing thermometers of both the Fried and Lustig and the Richter and Wiese type.

Regardless of the difficulties, Gherardi found the voyage very fruitful and quickly thanked Scripps for providing the additional manpower and expertise. Fleming's work furthered his education, brought valuable data and knowledge to Scripps and Hydro, and did not interfere with the ship's survey mission for the Navy. Everyone derived benefit from the young scientist's "piggyback" ride on board Hannibal. To Moberg's satisfaction Gherardi wrote,

“Tentative arrangements are being made for a dynamic survey during the coming survey season of 1933-34, and I would like to be advised if the Scripps Institution of Oceanography would again assist us in titrating water samples and along other lines of endeavor germane to dynamic oceanography. [for context and citation see Moberg-Gerhardi correspondence, 1932-1933, endnote 11] “

Piggyback science on Navy ships, like that accomplished by Richard Fleming on Hannibal, continued, as would the services of Scripps for basic seawater and plankton analysis. With the Fleming voyage, Thomas Wayland Vaughan and Walter Gherardi fortified significantly the Bigelow-Atlantis precedent for civilian-naval cooperation in field

research.<sup>x</sup>

While tropical climates, like the Caribbean, Gulf of Mexico, and Canal Zone, seemed the perfect place for a rest, these seemingly idyllic settings did not offer hospitable conditions for hard, sustained, precision work. Rigorous schedules set by the Hydrographers during the interwar survey seasons and their instructions to naval survey ships certainly displayed the determination of Hydro to complete a precise and comprehensive survey of the Caribbean, Gulf, and Canal Zone. Hydro's intensive and prolonged deployments in the tropics lasted eight months or more without significant leave for the crews and officers. Orders specified exactly the extent of the coastline, deep sea, and shore surveys. To complement the aerial photographic sweeps of the shore, landing parties erected triangulation towers, scientific staff conducted hydrographic research out to the one hundred fathom curve, and sonic soundings provided data on the depth and bottom topography beyond that point. All of Hydro's survey ships periodically confirmed the sonic depth soundings with lead line measurements. To complement Hydro's survey research, all naval ships equipped with

the sonic depth finder (SDF) not only took frequent fathometer readings along their normal routes but also departed from these well travelled courses on diversions planned for them by Gherardi with the advice of Vaughan, Bigelow, or Iselin. At the end of each survey, the ships officers and scientific staff had to compose seven different reports covering, tides, currents, sailing directions, magnetic observations, results of the triangulation work, aids to navigation, and the dynamic oceanographic surveys completed on the voyage.

Hydro had to address the health, morale, and climate factor to insure the precision and desired accuracy of these surveys. On 11 July 1933, Admiral Gherardi endorsed to the chief of the Bureau of Navigation a request from the commanding officer of Hannibal for an alteration of Hydro's plans to include a period of thirty days leave in the course of a survey season. The officers and crew needed a significant time away from both their toil and the tropical climate to achieve the best results. After all, the basic instructions to the commander of a survey ship often included admonitions to impress upon an SDF operator the importance of his observations and that, although

soundings are recorded at regular intervals, any indication of shoaler water should be immediately followed by frequent determinations to ascertain the minimum depth. The navigator should be immediately notified by the recorder of any changes in depth.[Gherardi to CNO, 11 July 1933; see other sources from box 840A in endnote 12 for context on this issue]

This work required great care, constant attention, accuracy, repeated confirmation, and endurance. Only an alert crew could produce the desired results.

In the preface of his 1937 publication for the National Academy of Sciences entitled, International Aspects of Oceanography, Thomas Wayland Vaughan drew public attention to the increasingly significant role played by the Navy in data collection, dissemination, and oceanographic research. After applauding the recommendations prepared by the Schofield Board in 1929, he reminded his readers that the Navy's survey program already included "the most extensive systematic program of sounding for bottom configuration undertaken by any country." Vaughan concluded his prefatory remarks about the



Navy's role in interwar oceanography by emphasizing the scope of its oceanographic ambitions. After all, soundings formed only one component of Hydro surveys. According to Vaughan, "the Navy Department has endeavored to assist investigation in many other fields, so that it has now become one of the world's major agencies in oceanographic research."<sup>xi</sup>

Just as Vaughan's book appeared, the collaboration between the Navy and civilian science he described so well yielded a particularly valuable discovery in the Caribbean. Working with a submarine on underwater detection problems in the vicinity of Guantanamo Bay Naval Base in Cuba, the commanding officer of the destroyer USS Semmes (AG-24; ex-DD-189) Lieutenant David W. Hardin, and his executive and navigation officer, Lieutenant Charles F. Horne Jr., discovered that their sonar equipment worked very well early in the day but this level of performance declined significantly as morning passed into afternoon. Rear Admiral Harold G. Bowen, chief of the Bureau of Engineering, requested cooperation from WHOI and permission from the CNO to employ Semmes in conjunction with

Woods Hole's R/V Atlantis to discover if the problem lay in the Navy's imperfect understanding of the ocean environment. On 15 October 1936, Admiral Standley approved Bowen's plan to conduct joint research with WHOI in the Guantanamo area between 18 January and 14 February 1937.

On 13 November, Henry Bryant Bigelow met in his office at Harvard's Museum of Comparative Zoology with Hardin and Horne to plan the expedition. Since Bigelow spent most of the quiet winter months in Cambridge, away from the isolation of Woods Hole, the two officers did not have to travel all the way to Cape Cod. Motoring to Boston from the New London submarine base, home of their Experimental Division One, proved brief and much more agreeable.

There they met both Bigelow and the director of the Submarine Signal Company, Harold Fay. Bigelow planned to furnish Atlantis for the cooperative venture and Fay the sonar components.

Shortly thereafter, a team from Woods Hole led by WHOI assistant director Columbus Iselin returned to the Caribbean with the

USS Semmes and Lieutenant Hardin. At first, the oceanographers studied the water in and out of Guantanamo Bay for excessive oxygen bubbles produced by the resident marine life which might interfere with sonar sound transmission. In the course of their experiments, the WHOI-Navy team discovered something very different and significant. The horizontal echo-ranging transmissions from AG-24 were affected by the change in surface water temperature as the day became warmer. Iselin christened this process of diurnal heating the "afternoon affect." Specialists in acoustics already knew that temperature dramatically affected the behavior of sound underwater. But this phenomenon would vary according to season, time of day, depth, and location. Since a submarine did most of its work in the uppermost layers of the ocean, this knowledge had direct operational applications absolutely vital to the future success of American undersea warfare.

Admiral Bowen and his bureau engineers responded to the results of the Guantanamo effort with enthusiasm and excitement, immediately asking for WHOI's help with further underwater sound research in August and September of 1937. During these two months,

another party of naval officers, oceanographers, and sonar engineers journeyed to the Caribbean to gather more data on underwater sound propagation. This expedition uncovered the presence of thermal gradients, or layers of dramatic temperature decrease, and their effect on underwater sound transmission.<sup>xii</sup>

On this project, scientists used the bathythermograph, first developed in 1934 during a summer of research at Woods Hole by Carl-Gustav Rossby of MIT and refined over the next three years by his colleague, the South African, Athelstan Spilhaus.<sup>xiii</sup> This instrument provided scientists with data on temperature variation as the depth increased and allowed a better analysis of the all-important course of sonar signals through the water. While salinity played a minor role, in the end temperature determined the course taken by sound signals underwater. Knowing the temperature profile of a given region could prove a very potent weapon for offense or defense. As historian Susan Schlee observed,

“The [active sonar sound] beam was bent either upward or downward each time it passed from one layer into another (as light is bent

passing through a prism) and consequently it could fail to detect a submarine which lay directly in its path. The implications both for submarines and submarine hunters were not difficult to grasp.[Schlee, Unfamiliar World, 285-290]”

If he knew the temperature of the water as he descended from the surface, a submarine commander could hide just below the warmer upper layers and in close proximity to his hunters and completely escape detection. With discoveries like this, the work of Hydro and the civilian scientific community took on a different and, for the officer facing battle, critical aspect. A scientific appreciation of the ocean became more essential than ever before to strategic planning, tactical execution, and survival.

As the decade ended, the work done by the Hydrographic Office in the Caribbean, Gulf, and Canal Zone continued while conflict ravaged Asia and the possibility of war loomed in Europe. On its front, Hydro proceeded with coastal and deep ocean surveys off Costa Rica, Panama, Nicaragua, Columbia, and Venezuela using the USS Hannibal, Nokomis, Niagara, Leonidas, Bowditch, and Sumner. USS

Bowditch (AGS-4), built by Burmeister and Wain of Copenhagen in 1929 for the Grace Lines as the cargo-passenger ship M/V Santa Inez, displaced 5,405 tons and entered naval service in 1940. A conversion at the Norfolk Navy Yard later made her fit for survey service after Pearl Harbor. From a very different lineage, USS Sumner (AG-32; 1943: AGS-5) started its naval career as the submarine tender USS Bushnell (AS-20), beginning its work for Hydro in 1937 and receiving its new name and designation in 1940. Built in 1915 by Seattle Construction and Dry Dock Company, Sumner displaced 3,142 tons and participated in surveys in the Pacific as well as the Caribbean, Gulf, and Canal Zone.<sup>xiv</sup>

Although the interwar relationship and cooperative work between Hydro and the primary oceanographic centers in the United States obviously drew strength from the ease of communication between Vaughan, Bigelow, Iselin, Moburg, and Gherardi, the latter's departure from Hydro in 1935 did not cause great disruption. Both Scripps and Woods Hole quickly formed similar bonds with Captain Lamar R. Leahy, the admiral's successor. Indeed, Bigelow informed Leahy

during his tenure at Hydro that WHOI had made the Hydrographer of the Navy an ex officio member of the its board of trustees.

At Scripps, Thomas Wayland Vaughan retired as director in 1937 after a successful but debilitating bout with tuberculosis, making way for the Norwegian physical oceanographer Harald Ulrich Sverdrup. The new director continued the Vaughan relationship with the Navy but focused even more exclusively on the Pacific Ocean than did his predecessor. He suggested that Hydro shift the water sample analysis work from the Gulf and Caribbean to Yale's Bingham Laboratory. This would leave Scripps free to concentrate its limited resources exclusively on the Pacific and permit Professor A.E. Parr of Bingham to demonstrate his expertise in the oceanography of the Caribbean region to the Navy's benefit.

Little else changed in the Hydro-Scripps relationship created by Vaughan, Bigelow, and Gherardi. In 1937, Richard Fleming, assisted by Eric Moberg and fellow student and future Scripps director Roger Revelle, completed his comprehensive analysis of the data and

samples collected by Hannibal during six survey seasons, including the research done on his trip with the vessel to the Canal Zone. Most of this material found its way into Hydro publications and appeared on nautical charts published by the Navy. In addition, Sverdrup employed the precedent set by Vaughan and Gherardi in placing Fleming on board Hannibal by requesting a similar arrangement for Eugene C. LaFond, a Scripps technical assistant. LaFond joined USS Bushnell in Balboa in the early months of 1939 for a series of dynamic oceanographic stations off the American west coast. Unlike the Fleming experience, this time the naval vessel took its Scripps passenger from Balboa to San Diego, with an emphasis on the offshore Pacific rather than studying west coast waters in support of Canal Zone research.<sup>xv</sup>



## Endnotes:

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i..

National Archives, Washington D.C. Secnav

Gencorr 1926-1940, RG-80 box 828

Resolutions of the American Geophysical Union, 1929 and 1930 Burgess to  
SECNAV, 16 July 1930

ii..

National Archives, Washington D.C.

HO Gencorr 1924-1945, RG-37

box 145

BuNav to CNO, 23 January 1928

Secondary Sources

Stewart B. Nelson, Oceanographic Ships Fore and Aft (Washington D.C.: Office of the Oceanographer of the Navy, 1982) 90, 98.

iii..

National Archives, Washington D.C.

HO Gencorr 1924-1945, RG-37

box 146

Commanding Officer, VJ Squadron Three-S to Chief BuAer, 6 April 1929 Commanding

Officer, VJ Squadron Three-S to the Hydrographer, 30 April 1929

Photographic Mapping, Course P, Period P-3: The Compilation of Maps from Aerial Photographs, 23 October 1925

For Reference:

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USS Fulton (AS-1): Submarine tender built by the New London Ship and Engine Company, a subsidiary of Electric Boat Company, Groton CT. Displacement = 1,308, 226' 6" long, complement of 135, launched 6 June 1914, commissioned 7 December 1914.

iv..  
National Academy of Sciences Library

NRC Division of Geology and Geography: Report of the Committee on Submarine Configuration and Oceanic Circulation, 25 April 1931.

v..  
National Archives, Washington D.C.

HO Gencorr 1924-1945, RG-37

box 146

Assistant Secretary of State to SECNAV, 31 October 1931

Secnav Gencorr 1926-1940, RG-80 box 833

Gherardi: Memorandum to CNO, 14 September 1931

vi..  
National Archives, Washington D.C. Secnav

Gencorr 1926-1940, RG-80 box 834

Gherardi to Kriner, 27 May 1932

Secretary of state to SECNAV, 15 July 1930

Costa Rican Ministry of Foreign Relations to Eberhardt, 16 July 1930 White to

SECNAV, 27 October 1931

Gherardi to BuAer, 9 January 1932

Adams to Stimson, 19 November 1931

Gherardi to CNO, 2 November 1931

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Werlich to Pacheco, 4 January 1932

Evans to Commander, Fleet Air Base, Coco Solo, CZ, 14 March 1932

vii.  
National Academy of Sciences Archive

NAS Annual Meeting of the Division of Geology and Geography, 1932

Annual Report of the Committee on Submarine Configuration and Oceanic Circulation, 23 April 1932

The Navy-Princeton Expedition on board the S-48 in 1932 will be discussed in much greater detail in chapter six along with other unique joint ventures of this period.

viii.  
It should be recalled here that WHOI was created in 1930 and Bigelow assumed the directorship in that year.

ix.  
Data Library/Archives, Woods Hole Oceanographic Institution

Office of the Director, Administrative and Individuals 1930-1935

box 2

Bigelow to Gherardi, 8 September 1932

Gherardi to Bigelow, 9 September 1932

Gherardi to Bigelow, 30 September 1932

Bigelow to Jensen, 20 September 1932

Gherardi to Bigelow, 10 October 1932

Gherardi to Bigelow, 2 November 1932

Gherardi to Bigelow, 8 November 1932

Iselin to Gherardi, 20 October 1932

Gherardi to Bigelow, 21 October 1932

Bigelow to Gherardi, 24 October 1932  
[for a sense of the nature and extent of WHOI's working relationship with Hydro]

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Church to Hydro, 8 July 1931

Bigelow to Gherardi, 20 April 1932, 6 January 1933

7 February 1933, 1 February 1933, 19 January 1933

14 January 1933, 14 August 1933

Gherardi to Bigelow, 27 January 1933, 28 May 1935

Campbell to Secnav, 17 April 1935

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National Archives, Washington D.C.

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Gherardi to Vaughan, 16 August 1932

Gherardi to Vaughan, 3 August 1932

Vaughan to Gherardi, 17 May 1932

Gherardi to Vaughan, 28 July 1931

Moberg to Gherardi, 15 September 1932

Gherardi to Commissioner, Bureau of Fisheries, Department of Commerce, 20 September 1932 Moberg to Jensen,

1 October 1932

Gherardi to Moberg, 14 October 1932

Memorandum for the Hydrographer, 22 November 1932 Gherardi to

SECNAV, 16 November 1932

Hydro [Gherardi] to USS Hannibal, Telegram, 25 November 1932 Commanding Officer,

USS Hannibal to Hydrographer, 5 December 1932 Gherardi to Moberg, 9 December 1932

Moberg to Gherardi, 14 December 1932

Gherardi to Moberg, 12 January 1933

Watt to Hydrographer, 18 January 1933

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Moberg to Gherardi, 17 January 1933

Gherardi to Bigelow, 27 January 1933

Senn to Gherardi, 7 January 1933

COMELEVEN ACTION BUNAV INFO Hydro Office, telegram, 7 January 1933 Commander

USS Hannibal to Hydrographic Office, 31 March 1933

Moberg to Vaughan, 18 April 1933

Gherardi to Moberg, 3 October 1933

Moberg to Gherardi, 14 October 1933

Vaughan to Gherardi, 2 December 1933

Vaughan to Gherardi, 20 December 1933

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Data Library/Archives Woods Hole Oceanographic Institution

Office of the Director, Administrative and Individuals 1930-1935

box 1

Gardner to Bigelow, 20 October 1932

Bigelow to Gardner, 2 November 1932 [WHOI acquisition of an Atlas echo sounder -- a German type made in Boston and based upon Submarine Signal Company patents]

Office of the Director, Administrative, Institutions, Ships, Miscellaneous, and Individuals 1936-1941

box 4

Hydrographic Office File

Leahy to Bigelow, 29 May 1936

National Archives, Washington D.C. Secnav

Gencorr 1926-1940, RG-80 box 840A

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CNO to Commanding Officer, USS Hannibal, 28 October 1932 Gherardi to CNO,

11 July 1933

Commanding Officer, USS Hannibal to CNO, 30 June 1933

BuNav to CNO [movement orders for USS Hannibal], 13 December 1933

Inclosure [sic] "A," Specifications for the Survey of the West Coast of Central America from Morro Puercos to Burica Point, 11 December 1933

For the extent of the soundings taken by Navy ships along their regular routes or courses altered to accommodate the civilian scientific community see:

National Academy of Sciences Library

NRC Division of Geology and Geography

"Report of the Committee on Submarine Configuration and Oceanic Circulation," 35 April 1931 For offers of assistance from the Bureau of Engineering and Rear Admiral Harry Yarnell: National Archives, Washington D.C.

HO Gencorr 1924-1945, RG-37

box 144

Yarnell to Hydrographic Office, 9 June 1930 Gherardi to

BuEng, 19 July 1930

BuEng to Hydro, 4 September 1930 [vessels from other government departments equipped with various models of the SDF]

BuEng to Hydro, 19 August 1930 [various types of SDF models available -- Submarine Signal was the primary vendor at the time]

List of vessels equipped with echo sounding apparatus, BuEng, 13 August 1930 Publications Board to

Hydrographer, 23 March 1938 [insertion of SDF soundings on charts] Memorandum for Hydrographer,

4 March 1937

Secondary Sources [and others]:

Thomas Wayland Vaughan, International Aspects of Oceanography (Washington DC: National Academy of Sciences, 1937), vii-ix. Vaughan's volume took much longer to write than originally

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planned because he was diagnosed with Tuberculosis in 1934. At one point the National Academy of Sciences accepted an offer from H.A. Marmer of the U.S. Coast and Geodetic Survey to help Vaughan finish the work, but he too was distracted and not able to fulfill his promise. In the end, Vaughan once again took up the task, which was that of writer-editor-compiler, and completed the volume. [Vaughan to Brockett with enclosures, 13 May 1936, General 1936-1937, NAS: Committee on Oceanography, National Academy of Sciences Archive.]

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Data Library /Archives,Woods Hole Oceanographic Institution

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box 4

CNO to BUENG, 15 October 1936

Horne to Bigelow, 26 October 1936

Bigelow to Horne, 29 October 1936

Bowen to Bigelow, 2 November 1936

Horne to Bigelow, 3 November 1936

Horne to Bigelow, 5 March 1937

Bowen to Bigelow, 8 March 1937

Bigelow to Horne, 12 March 1937

Bigelow to Bowen 12 March 1937 Bowen to

Bigelow, n.d. March 1937 Bigelow to Bowen,

25 March 1937

Horne to Bigelow, 17 April 1937

For Reference:

Lieutenant Charles F. Horne Jr., Hardin's number two, also directed the Semmes's communications, radio, and underwater sound activities.

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Spilhaus was a student of Rossby at MIT in Meteorology and worked with the Army in the Far East in World War Two.

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National Archives, Washington D.C.

HO Gencorr 1924-1945, RG-37

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Leahy to CNO, 13 September 1935

Secondary Sources:

Stewart B. Nelson, Oceanographic Ships Fore and Aft (Washington D.C.: Office of the Oceanographer of the Navy, 1982), 110, 112

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Data Library/Archives, Woods Hole Oceanographic Institution

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box 4

Leahy to Bigelow, 29 January 1937

Leahy to Bigelow, 24 September 1937, File: Captain L.R. Leahy

National Archives, Washington D.C.

HO Gencorr 1924-1945, RG-37

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"Present Status of Work on the oceanographic observations made by the USS Hannibal in the Central American Region," by Richard H. Fleming, 29 April 1937

box 143

Sverdrup to Hydrographer, 21 May 1937

Leahy to Bureau of Supplies and Accounts, 4 June 1937 Leahy to Parr, 5

June 1937

Parr to Leahy, 7 June 1937

Leahy to Parr, 11 February 1938



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Parr to Leahy, 16 February 1938

Leahy to Parr, 21 February 1938

Bryan [Leahy's relief as Hydrographer of the Navy, 1938] to Sverdrup, 4 January 1939 Sverdrup to Bryan, 21 December 1938

Sverdrup to Bryan, 23 February 1939

Sverdrup to Bryan, 1 February 1939

Sverdrup to Bryan, 17 January 1939