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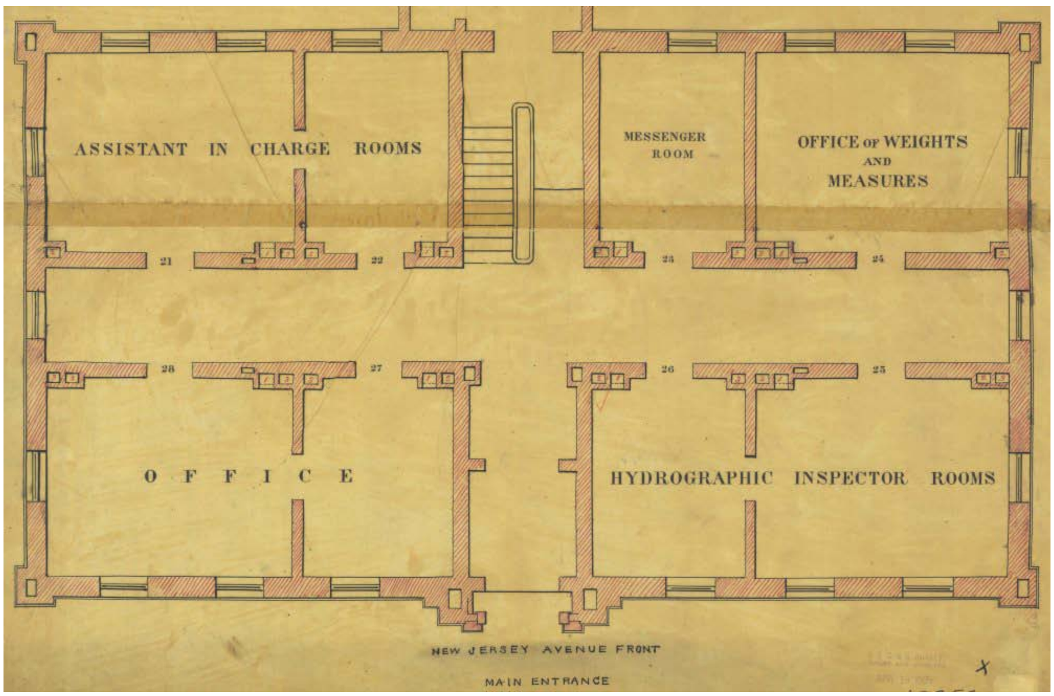
Carlile Patterson, the Great Captain of the Coast and Geodetic Survey (1874-1881)



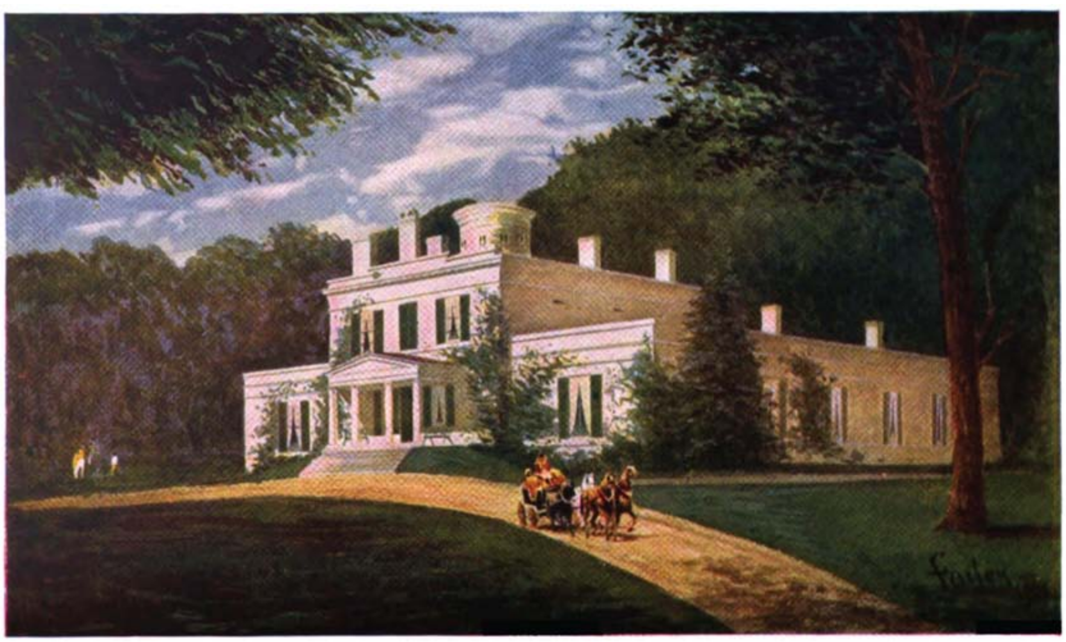
The Main Front Entrance to the Coast Survey Headquarters, circa 1872, with Captain Carlile Patterson's Office of the Hydrographic Inspector of the Survey

In 1874, an amicable transition in the leadership of the Coast Survey was made, as Benjamin Peirce returned to his primary role as an Endowed Professor of Mathematics and Natural Sciences and Philosophy at Harvard College, and Carlile Pollock Patterson ascended from his post as the Chief Hydrographic Inspector of the Survey to become Superintendent. Patterson led the Survey until the day he died suddenly in 1881. In many ways, his tenure was a golden age, if not the golden age, of the Survey. The fourth Superintendent, he was the first Survey leader chosen from the Survey's ranks, which reflected both his own abilities and the expanded capabilities of the Survey itself. Under

Patterson, every element of the Survey’s work flourished and new responsibilities in entirely new areas of the nation and its lands and waters came to the Survey. Fittingly, these expanded arenas of research and labor were reflected in a name change that would survive almost a century. Under Patterson, the US Coast Survey became the US Coast and Geodetic Survey. Geodesy had been there all along, as Ferdinand Hassler’s greatest gift to his adopted nation. But under Patterson, the science became literally visible in the agency.

Patterson Becomes a Captain

Carlile Patterson was born to captain ships and lead men. He was born in 1816 in Mississippi as the son of Commodore Daniel Todd Patterson of the Navy. Carlile Patterson’s brother Thomas Patterson became an admiral, and his sister George Ann married David Dixon Porter, who also became an admiral and was a major naval leader during the Civil War. On September 2, 1830, Carlile Patterson was appointed as midshipman in the US Navy. He served in the Atlantic Ocean and the Mediterranean Sea. He returned home and was educated at Georgetown College in Kentucky, where he graduated as a civil engineer in 1838. In the 1830s, he married Eliza Pearson who was the daughter of Joseph Pearson, a Congressman from North Carolina. His marriage gave him access to the Pearson estate called Brentwood where he and his wife Eliza eventually lived, and where Patterson himself died.



Brentwood, an estate in the County of Washington, in the District of Columbia
From a painting by Brig. General Joseph Pearson Farley.
The home of Carlile Patterson 1868-1881

Following his graduation as a civil engineer, Patterson returned to active naval service and was assigned to work with the US Coast Survey. It was there that he was introduced to the very beginnings of the realized fieldwork of the Survey under Ferdinand Hassler, on the seas and lands overlooking new York Bay and Harbor and the Environs, as Hassler's first great charts titled the area. In 1839, he was an officer aboard the Coast Survey brig *Washington* when that ship discovered the slave ship *Amistad* in Long Island Sound, the beginning of a remarkable story in American history. In 1845, he was assigned to lead hydrographic surveys in the Gulf of Mexico. In 1846, he prepared an analysis of the tidal patterns of Mobile Bay on the coast of Alabama[1]. Around 1848, around the time of the Mexican War, Patterson left active duty in the Navy and the Survey to work as a merchant marine steam ship captain. He resigned from the Navy on September 2, 1853, exactly 23 years after he began.[2]

Captain Patterson steamed into a part of the world that was transforming rapidly, and people like Patterson were major agents of the change. Gold was discovered in California, California itself was acquired by the United States through the Mexican War, and all at once a great many people wanted to travel to and from California. A major commerce sprang up, based on steamship travel from the Atlantic and Gulf coasts to Panama, overland travel to the Panamanian Pacific coast, and steamship travel from Panama to California. Captain Patterson specialized in the Panama to California journeys, which were quite lucrative, as the same steamships that carried miners to California also returned with gold bound for the coffers of Eastern banks. The steamship captains received a proportion of the wealth. Patterson worked for the Pacific Mail Steamship Company as Captain of such ships as the *Oregon* and the *Golden Gate*, between about 1849 and 1853.

Through this era, Patterson remained steadfast in his political beliefs as an abolitionist and supporter of the Union. His beliefs were displayed to dramatic effect in the matter of the admission of California as a free state in the Union. There was no legal slavery in California—slavery was abolished in California and throughout what had been the Spanish empire in the 1830s—nor was there much sentiment to establish slavery in the new American territory. However, there was strong sentiment in the southern states to resist the admission of any new free states into the Union because of the votes they would add to the abolitionist cause. But in 1850, California was admitted to the Union as a free state. There was no continental telegraph at the time, so the news had to travel by ship. As it happened, Captain Patterson in command of the *Oregon*, sailed through the Golden Gate on October 18, 1850 to deliver the news. His arrival was dramatic:

> "We were all excitement to hear the result of California's knock at the door of the Union; and as the day approached when the steamer would bring the decision, many eyes were strained toward Telegraph Hill. At length the signal went up – the *Oregon* was outside the heads and would soon be in the harbor. As she neared, another signal indicated that she carried flying colors, implying good news, and presently she appeared in sight of those, who like ourselves, overlooked North Beach, gay with streamers and flags of all nations, -- the Stars and Stripes most prominent,

[1] Patterson, Annual Report for 1846, App. 8, pp. 68-70.
[2] Callahan, 1901, p. 424.

> and above them, straightened out by the generous wind which seemed to blow a long breath on purpose, floated the longest streamer of all, displaying the words "California Admitted!" The roar of cannon rolled over the waters, and met answering roars from forts and ships."[3]

The subsequent celebrations in the city convey much about Patterson himself, considering that he was now a prominent member of the society of San Francisco as it had been so rapidly transformed in the new American era of California.

> "Such an occasion beyond all others demanded a proper celebration at San Francisco; and the citizens, accordingly, one and all, united to make the day memorable. A procession of the various public bodies and inhabitants of the city, with appropriate banners, devices, music and the like, marched through the principal streets to the plaza. The Chinese turned out in large numbers on this occasion, and formed a striking feature in the ceremonies of the day. The Honorable Nathaniel Bennett, of the Supreme Court, delivered a suitable oration to the people on the plaza, and an ode, composed for the occasion by Mrs. Wills, was sung by a full choir. During the day repeated discharges of fire-arms and a proper salute from great guns carried off some of the popular excitement, while the shipping displayed innumerable flags. In the evening, public bonfires and fireworks were exhibited from Telegraph Hill, Rincon Point, and the islands in the bay. The houses were likewise brilliantly illuminated, and the rejoicings were everywhere loudly continued during the night. Some five hundred gentlemen and three hundred ladies met at the grandest public ball that had yet been witnessed in the city, and danced and made merry, till daylight, in the pride and joy of their hearts that California was truly now the thirty-first State of the Union."[4]

Soon after this, Patterson brought his wife Eliza and their children out from Washington to Oakland, where Patterson was based for the next decade. He worked as a steamship captain, and also bought and sold real estate. It is likely that the Patterson home is included in the Coast Survey's first chart of Oakland.

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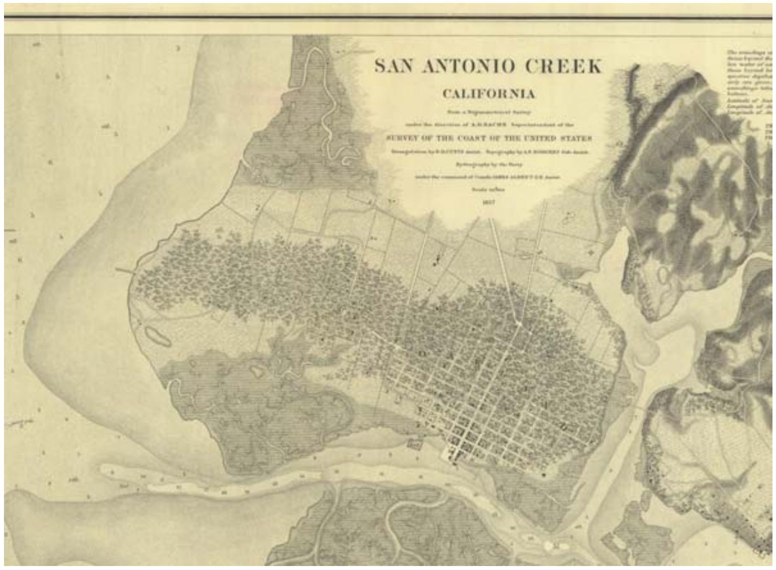
[3] Sarah Royce, *A Frontier Lady*.
[4] Alta California, October 20, 1850



Oakland, from Figure No. 62, the Annual Report of the Superintendent for 1857

But the nation was in turmoil, and war was looming. It was clear to all that the coming war would not be fought in California. Superintendent Bache had, by about 1858, started dismantling the Survey on the west coast, returning personnel to work in anticipation of the coming war. Bache also solicited his former officer to return to the Survey. It seems that the Survey's chief of the hydrographic division, Sidney Smith Lee, the older brother of Robert E. Lee, resigned to join the Confederacy. Patterson heeded the call, and returned to the agency he would be with until the day he died. As Bache's annual report for 1861 declared:

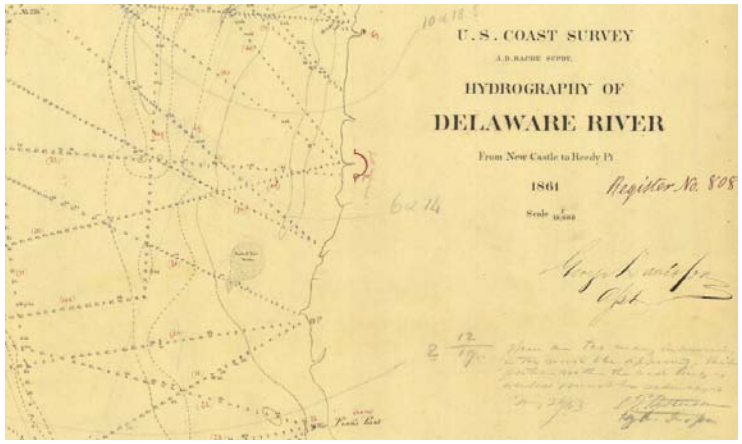
> "Captain C.P. Patterson, some years ago an officer of the United States Navy, and well known by his intelligence and sagacity as chief of one of the hydrographic parties of the Coast Survey, was assigned to duty as the head of the [hydrographic] division on the 6th of May. The principal occupation under the direction of its chief has been the examination and verification of original hydrographic work, including the charts resulting from it; furnishing sailing directions; compilation of hydrographic sketches, and making projections for hydrographic parties"[5].

Patterson became at once one of the most important officers of the Survey. Bache's initial plan for the coming war was to update, extend, and improve the many nautical charts and aids to navigation of the Survey covering the coastal waters and estuaries where the war would likely be fought. Patterson's division was at the heart of this enterprise. Patterson is listed as a co-compiler and author of the text for most of the volumes of Bache's "Notes on the Coast" the important series of lithographed memoirs

[5] Annual Report, 1861, p. 72.

that bundled coast pilot text, strategic sailing directions, and folded maps and wind and tidal diagrams in small discrete volumes for Union forces.[6]

Patterson was also critical to all “examination and verification of original hydrographic work”, which included major re-surveys of the Delaware River between the coast and Philadelphia, in anticipation of a possible Confederate invasion of the city.



A portion of H-808 (1861) a hydrographic re-survey of the Delaware River at Philadelphia with signatures of George Davidson and Carlile Patterson. Patterson’s note rejected the work as inadequate.

As a critical division chief, Patterson was in constant motion during the war, but always returning frequently to headquarters in Washington. But he was directly connected by family lineage or through their marriages with a major part of the leadership of the Union military, especially the Navy. His talents and also his connections must have become particularly critical around 1864, when the Survey’s great leader Alexander Dallas Bache was incapacitated outside Philadelphia while overseeing fortification work. Bache was both mentally and physically stricken, and, although he survived almost three years more, from that point on the entire leadership of the Survey was left in the hands of people like Patterson. Eventually Bache died in 1867. It was really only then that the post-war history of the Coast Survey began.

[6] Notes on the Coast of the United States. See :
http://www.nauticalcharts.noaa.gov/nsd/hcp_notesoncoast.html

Carlile Pollock Patterson (1816-1881)
(undated photograph)

As was examined in the chapter on Benjamin Peirce, the question of Bache's successor was both difficult and important, and Joseph Henry, first Secretary of the Smithsonian Institution and a major friend and ally of Bache, played the major role. Captain Patterson and Julius Hilgard were both potential candidates from within the Survey for Bache's post. However, Henry wanted a "scientist", and specifically Benjamin Peirce of Harvard. As noted, Peirce agreed to the post of Superintendent so long as he could maintain his professorship at Harvard and his primary residency in Cambridge, Massachusetts. There was a residential suite for Peirce built into the new Coast Survey headquarters for his use when occasionally in town. However, as the floor plan of the headquarters building makes clear (p.1) when one entered the Coast Survey's main building by the formal entrance from New Jersey Avenue, just a block from the Capitol, the very first office on the right was the suite of offices of Carlile Patterson. The very architecture says something about both his accessibility, and his ability to tolerate being accessible. Further, once Patterson and his family returned east from California, they never returned to the west. In 1868, Patterson's wife Eliza's mother died, and Eliza inherited Brentwood, the great estate in NE Washington just in time for the administration of President Grant (1869-1877). Patterson and Grant had known each other since 1852, when Captain Patterson had ferried Grant and his Army troops from Panama to assignments along the Pacific coast. With their experiences through the war on top of that, Patterson was as connected to the political life of the Capital as was possible. And Brentwood was a major center for socializing in the city, famous for its balls and relaxed parties on a beautiful hilltop site that was close to the city but also removed from and literally above the life of the crowded and pestilential city. It was in that world of the Capitol and the White House and Brentwood that the decision was made that Carlile Patterson would succeed Benjamin Peirce as Superintendent. Peirce was the first Superintendent whose tenure was not ended by death; Patterson was the first Superintendent chosen from within the Survey. It was as peaceful and cordial a transition as could be imagined. And thus began a short but golden age of the Coast Survey.

The Survey's Many Aids to Navigation

Maps and charts, tide tables, and other aids to mariners were fundamental to the mission of the Survey; but, since the beginning under Hassler, they came after the geodetic and astronomical foundations had been developed. Under the first three Superintendents there came a cascade of basic progress in the requisite sciences: vast and accurate data sets of such phenomena as tides registered at harbors, the complex hydrology of estuaries and rivers, etc. beginning under Hassler; novel uses of the telegraph as a scientific instrument as pioneered under Bache; and sophisticated tools for harmonic analysis under Peirce. These gave the Survey under Patterson the basis for a new generation of aids to mariners and navigation in general. In addition to new and updated versions of the harbor charts, sailing direction charts, and other charts that the Survey had published since Hassler, under Patterson the Survey created the "modern" series of Coast Pilots, which have remained continuously in print into the 21st century.

The Pacific and Atlantic models of the Coast Pilot were as distinctly different as the portions of both oceans that are American territorial waters. The Pacific Coast Pilot, under a variety of different names, was originated by George Davidson as essentially a side project for his voluminous energies. The original version was published as an annual report appendix in 1858.[7] These Pilots covered the coast of California, Oregon and Washington Territories, and the basic routes of the Inside Passages between the lower United States and Alaska. In 1867, after his initial voyage to Russian America (Alaska) he published a major report on the territory, its coasts, and many elements and resources of the land and sea.[8] Under Patterson, elements of both of Davidson's previous efforts were merged into the Pacific Coast Pilot (1880).[9]

Apart from San Francisco Bay and the interior seas of Washington Territory, the major part of the Pacific coast along the three western states is profoundly linear, with only a handful of offshore islands. The counterpart coast along the Atlantic is quite different, with rocky and indented harbors, many thousands of islands, profound bays and estuaries, vast barrier islands and seaside wetlands, etc. Under Patterson's predecessor

[7] Davidson, Directory for the Pacific Coast, 1858, pp. 297-458.
[8] Davidson, 1867, Alaska Territory; coast features and resources, pp. 187-329.
[9] Pacific Coast Pilot, Coasts and Islands of Alaska: Dixon Entrance to Cape Spenser with the Inland Passage, 1880

Benjamin Peirce, the Coast Survey had purchased the rights to the Atlantic Coast Pilot publications from the Blunt family in 1867. It took considerably longer, and considerably more personnel that George Davidson, to create the Survey's first version of its own Atlantic Coast Pilot. The first edition was published in the year of transition from Peirce to Patterson, in 1875.[10] In 1879, the Survey published a new, revised, and expanded version of the Coast Pilot.[11] The volume was massive (over 700 pages) and covered the coast only from Maine to Boston. So, the same year, the Survey began a series of Atlantic Local Coast Pilots, which were small folios covering sub-divisions of the coast. These started in Maine in 1879, and reached the southern coast of Florida by 1885 with Sub-Division 22.

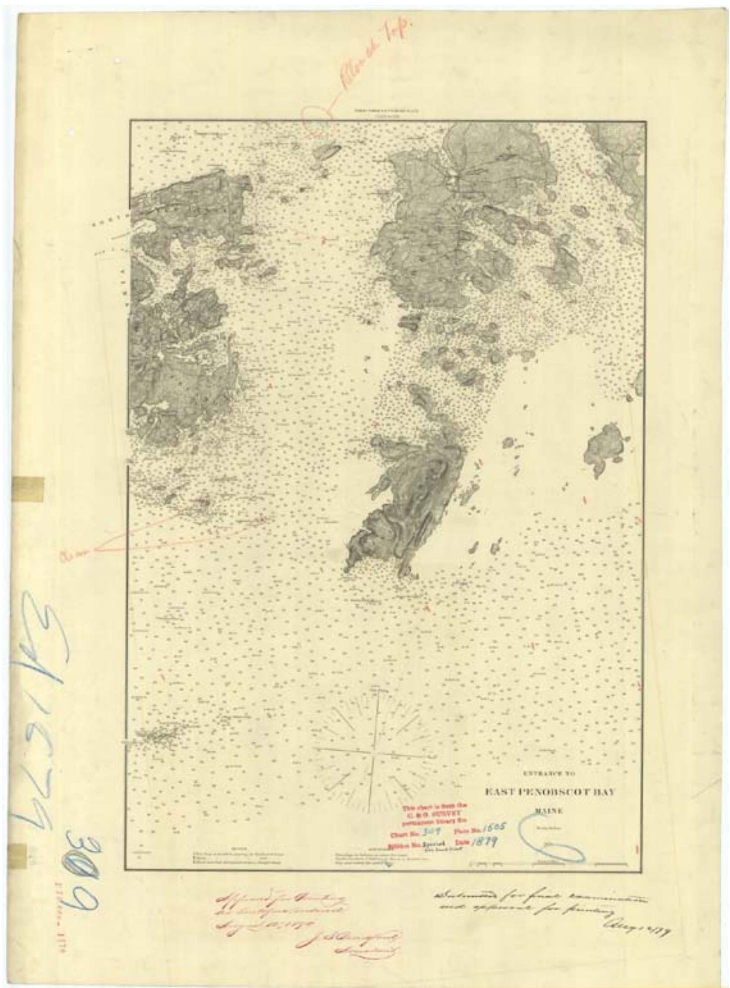
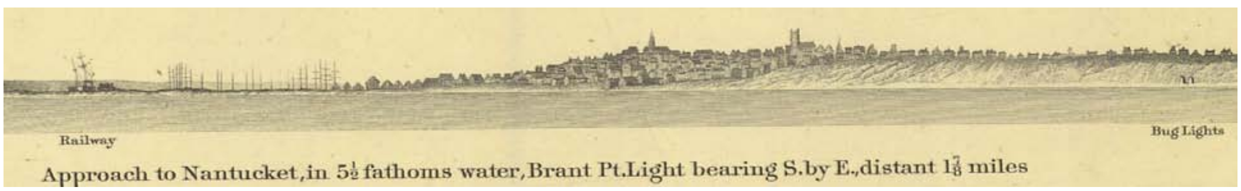


Chart 309 Entrance to East Penobscot Bay, Maine (1879)
Printers Proof for a chart published in the Atlantic Local Coast Pilot, Sub-Division 1 Passamaquoddy Bay to Schoodic. It bears corrections and the signature of Ass't. John Service Bradford, Coast Survey Assistant, who directed the Coast Pilots

[10] Coast Pilot for the Atlantic Sea-Board, Gulf of Maine and its coast from Eastport to Boston.
[11] Atlantic Coast Pilot, Eastport to Boston.

The new Atlantic Local Coast Pilots, like the large volume covering Maine to Boston, had a number of important cartographic innovations. In addition to harbor charts and smaller scaled sailing direction charts, these Coast Pilots featured a new map series of charts that "tiled" along the coast so that the entire coastline was covered at the same scale. The maps were printed on a fine semi-translucent vellum with engraved electrotype plates and folded into the volumes. The same plates were also used to make stand-alone separate copies of many of the charts printed on chart-quality paper.

The new Coast Pilots also featured a series of coastal views drawn by John Barker, who was hired around 1873 to create the views, starting in Maine and working steadily south. He was both a worthy successor to John Farley, the first major artist in the Coast Survey, and also a major innovator in his own right. As Barker progressed southward, his views became increasingly sociological or anthropological, as he rendered coastal American industry and society visible from the sea in extraordinary detail.



Approach to Nantucket, by John Barker. Published on the chart
Monmonoy Island to Block Island, 1874

Barker's primary task was to draw accurately key landmarks and profiles to aide mariners to determine their positions relative to harbor mouths, etc. But he rendered far more detail than that, leaving an amazing record of American culture and technology at a time of great transition in technologies and resources.

The Survey and American Industrial Rivers

The Coast Survey's principal objective in charting was always the American coasts, but from the beginning under Hassler the Survey had mapped the Hudson River up to the head of tides, which is 150 miles inland from Manhattan. During the Civil War, the Survey began mapping American freshwater rivers as they fought their way upstream with the Union forces. The Survey also accelerated hydrologic and current studies of rivers as a part of preparing for the defense of Philadelphia and other Union strongholds during the war. After the conflict, the Survey and its scientists continued research on freshwater rivers. This was clearly a major personal interest of Captain Patterson. In the relatively thin stock of Patterson's correspondence that survives in the Patterson-Winslow family papers, there is a letter to Patterson in Washington from George Davidson, written in 1866 from his home, then in Germantown, Pennsylvania. Davidson wrote several pages of detailed descriptions of proposed research, asking for Patterson's advice on how to proceed at certain points.

> "When we get above tidal waters, I shall try to get a line of soundings across the stream each day, and the width, so as to get a section of the

> stream. These with the velocity of the current will give us the amount of water then passing, and also the slope of the water surface. I have examined Hum[phrey's][12] physics formulae for that purpose and taken some of them for use. A full series of such observations at ordinary seasons, with a plan of the river to calculate the retarding force of the curves would give an approximate height above the tidal waters"[13].

These hydrological research questions were augmented by Patterson's cultivation of Congressional funding sources, and under Patterson the Survey began to map major American river systems, along the lower parts of the rivers and related bodies of water that were heavily used for navigation and trade. We may refer to these as 'industrial rivers": the Kennebec and Passamaquoddy in Maine, the Hudson River and Lake Champlain in New York and Vermont, the Passaic and Raritan Rivers in New Jersey, the Sacramento River and San Francisco Bay in California, and the Columbia River in Oregon and Washington Territory.

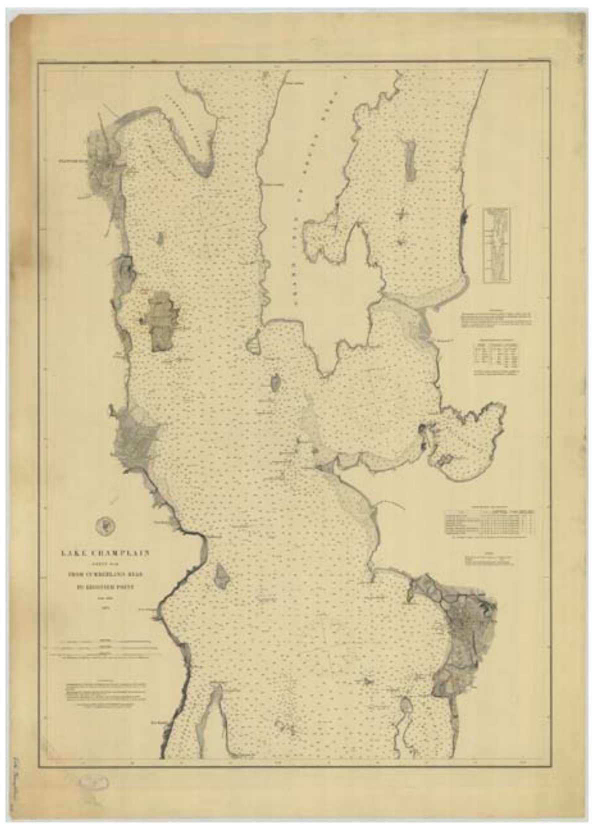


Chart 554, Lake Champlain, Sheet 2 (1879)
From Cumberland Head to Ligonier Point with the city and port of Burlington, Vermont

[12] The reference is to: Humphreys, Andrew and Henry Abbot, Report upon the Physics and Hydraulics of the Mississippi River, (Professional Papers of the Corps of Topographic Engineers, United States Army, no. 4 (1861).
[13] George Davidson to Carlile Patterson, July 1, 1866.

The Survey had performed detailed studies of harbors and their many changes since the beginning with Hassler's work in New York Bay and Harbor and the Environs. Under Patterson, these studies continued, and acquired much greater historic depth, as the Survey integrated historic charts and other data into their analysis, as in the case of the Survey's re-survey of Plymouth Harbor, Massachusetts.

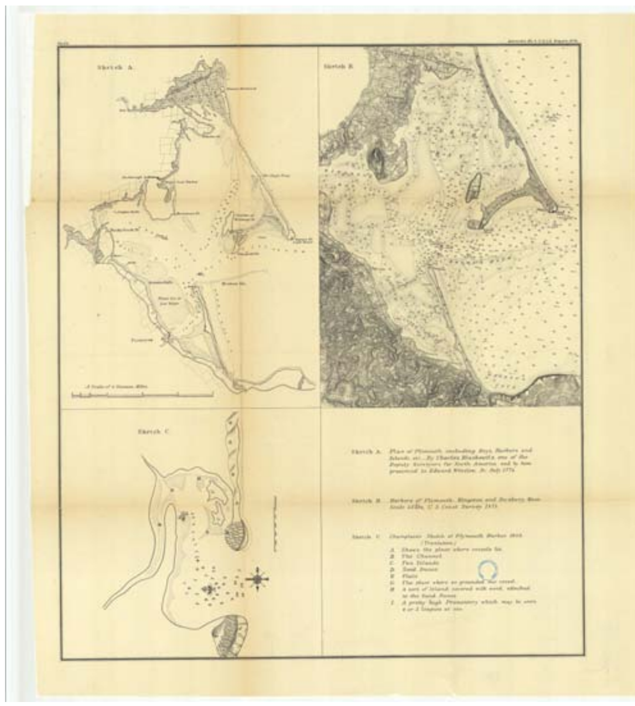


Figure No. 22 Studies of Plymouth Harbor in 1605, 1774, and 1875 (1876)

Charting the Routes between American Coasts

Captain Patterson had a celebrated career steaming between Panama and the American west coast during his years outside the Survey in the 1850s. Under Peirce, in 1873, Congress authorized hydrographic surveys for an anticipated set of sailing charts covering the major routes between Panama and San Diego, along with harbor chart scaled maps of various islands that could serve as harbors of refuge off the Mexican coast. Fittingly, under Patterson the first of the set was published, a chart of the northern part of the coastline of Baja California, including the first American published chart showing Scammon's Lagoon, the major grey whale breeding grounds first mapped in detail by Captain Scammon, an old friend of Pattterson. This was the first published Coast Survey chart to map outside American waters, apart from a chart of a harbor in Labrador, produced after a Survey ship went there for a solar eclipse.

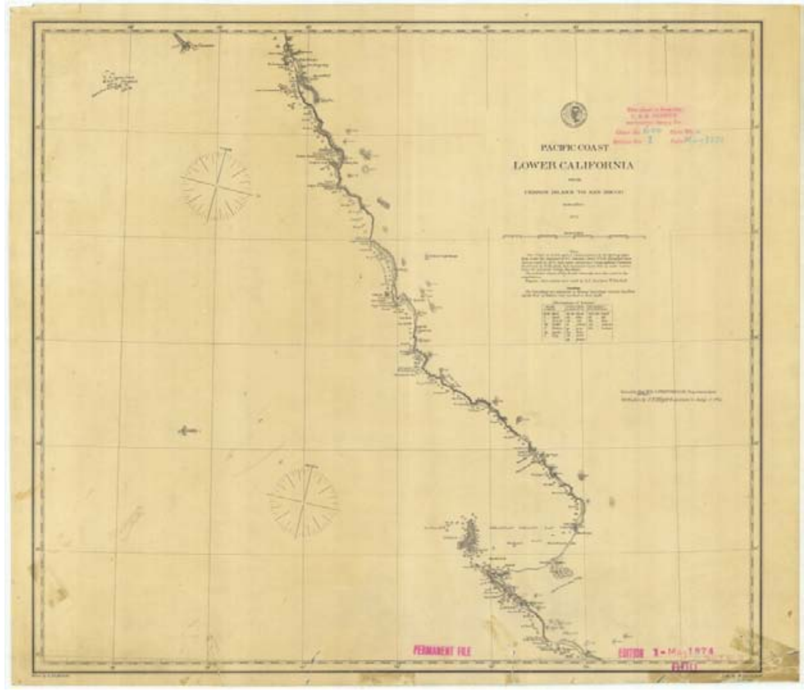
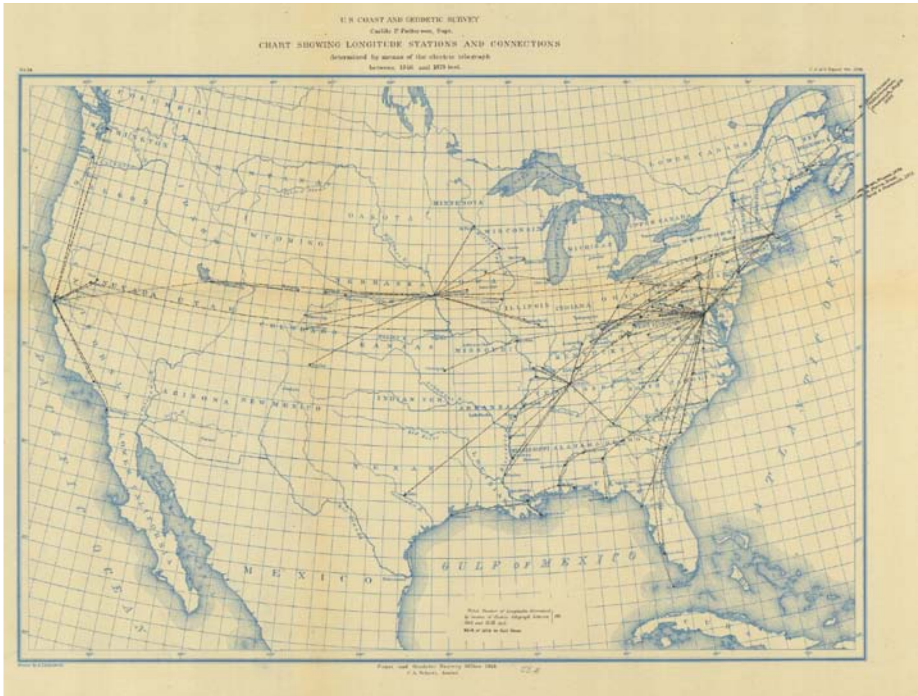


Chart 600 Lower California (1874)
From Cerros Island to San Diego

Scientific Research at Continental Scales, and larger still

Under Bache, the Survey acquired responsibilities on the coast of two oceans and the Gulf of Mexico. Under Peirce, the great project to stitch the Atlantic, Gulf, and Pacific coasts into one geodetic system began. Under Patterson, this project was much advanced. In addition, under Patterson the scope of Survey research and activities expanded substantially beyond continental scale to embrace truly global scientific research.

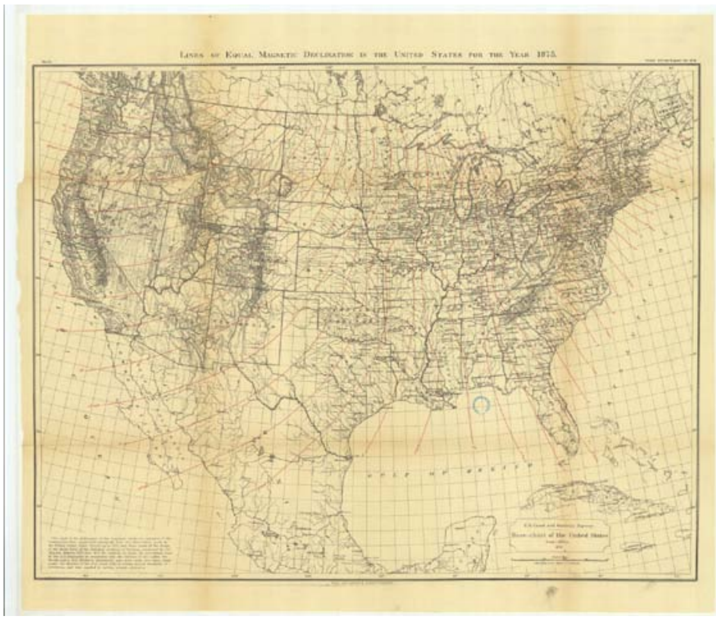
With the completion of the telegraph system that accompanied the Transcontinental Railroad, utilized by the Survey for telegraphic longitude (Bache's American Method), the Survey could provide precise positioning across the country for the burgeoning state and local mapping and surveying systems established in the great expansion of American settlements after the Civil War. Survey research and applications became increasingly continental.



Sketch No. 32 Longitude Stations and Connections determined by means of the electric telegraph, between 1849 and 1879from the annual report for 1879

Mariners at sea, and land surveyors on the prairie all required intensive use of the compass, and hence needed to know the local magnetic declination. As early as the immediate post-Civil War periods, the best minds of the Survey were envisioning a continental-scaled system of magnetic observatories to determine magnetic declination and its constant changes on a scale and with an accuracy consistent with extremely detailed applications. In 1870 and 1871, Charles A. Schott, the great computer of the Survey, was continuing work on the side for Joseph Henry of the Smithsonian Institution which he began during the war. In his workbook for 1870-71, he folded in a chart of anticipated magnetic declination for the year 1870, which the Survey had published in 1866. The chart featured fairly detailed isogonic lines in the Northeast, reflecting the number of terrestrial magnetic observatories and magnetic data that had been acquired there. There were much smoother (and hence more conjectural) isogonic lines on the Pacific coast, and no lines in the middle of the continent. Schott drew a hypothetical triangulated network of observatories that would provide the necessary data to fill in the declination system for the country. This triangulated network as such was never created, but magnetic observatories were set up temporarily at enough locations, that less than a decade after Schott's network was hypothesized, the Survey published a map of general magnetic declination that 'filled in" the United States.

Coast Survey 1866 Sketch of Magnetic Declination for the year 1870, overdrawn by Charles A. Schott with a hypothetical network of magnetic observatories (1870-71)[14]

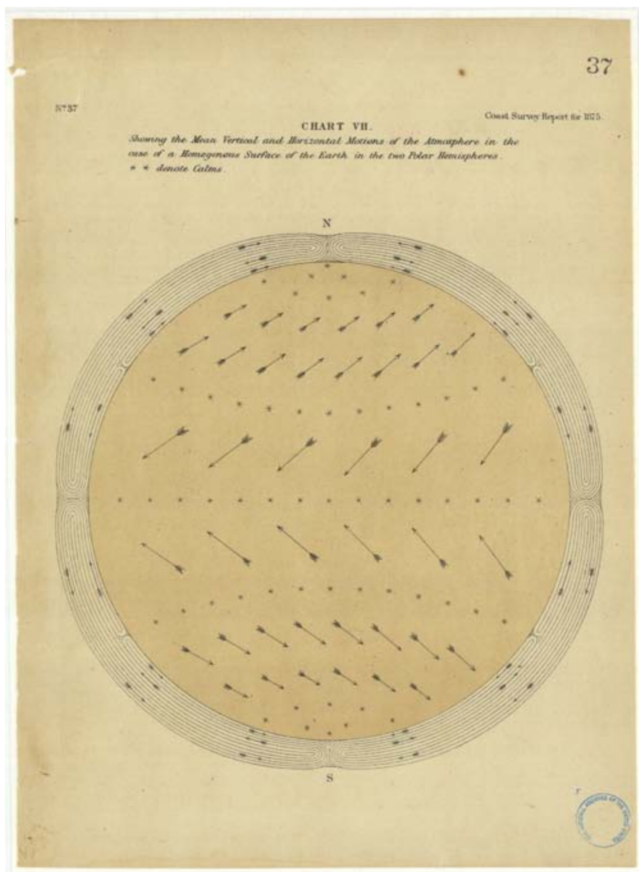


Sketch No. 24 Lines of Equal Magnetic Declination in the United States for the Year 1875 from the annual report for 1876

[14] Sketch folded into Schott's Memoranda Notebook 1870-71, work conducted for Joseph Henry and the Smithsonian Institution, now in the Library of Congress, Manuscripts Division, Schott Collection, Box 2.

The Survey and Ocean and Air Circulation

Under Peirce, a great new era of the applications of harmonic analysis to geophysical problems in many areas began. William Ferrel was a critical member of this core of Survey scientists. Under Patterson, he was working on his great analytical engine the Tide Prediction Machine, but it would take many years, until after Patterson's death, before it was completed. Ferrel made many studies of tides for specific harbors and coasts during this time. Ferrel also returned to the study of atmospheric circulation by tools of harmonic analysis which he had begun before working for the Survey. The project of the new Coast Pilots allowed him time and funding to revisit the subject in order to provide aids to mariners. Under Patterson, he published two major contributions to the subject. The first concentrated on general mechanics and motions of the global atmosphere, while the second was a pioneering analysis of cyclonic storm systems and tornados. The former treatise presented the first graphic rendering of the atmospheric circulation elements now known as Ferrel cells[15].



[15] Ferrel, 1875, Meteorological researches for the use of the Coast Pilot. Part I: On the mechanics and general motion of the atmosphere; Ferrel, 1878, Meteorological researches for the use of the Coast Pilot. Part II: On cyclones, waterspouts, and tornadoes.

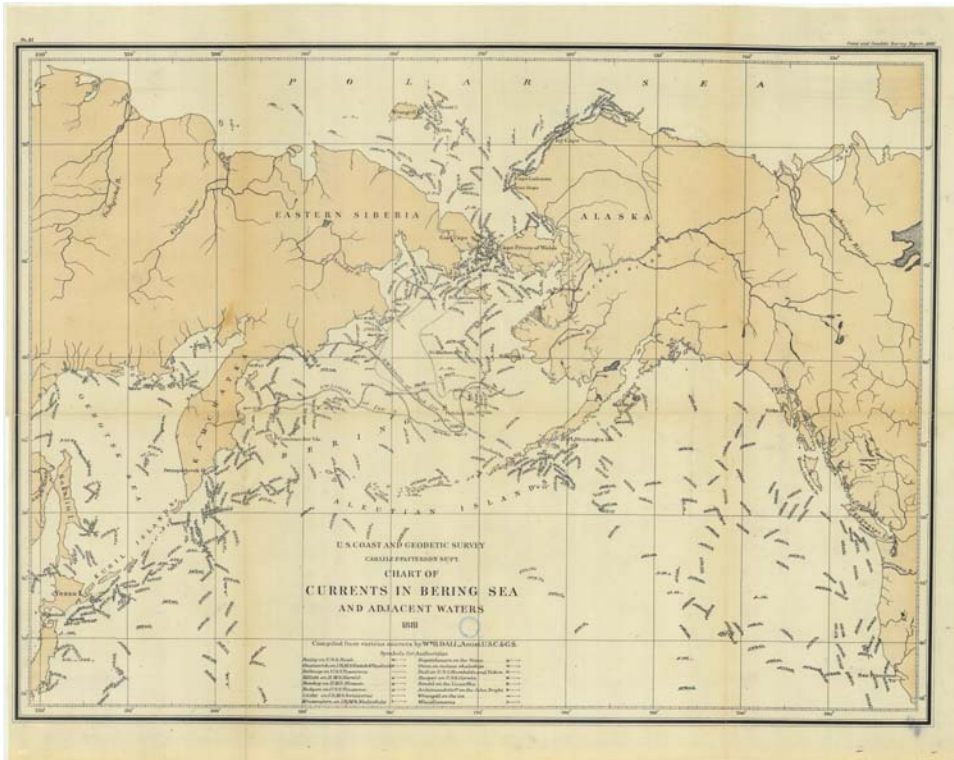
Chart No. VII Showing the Mean Vertical and Horizontal Motions of the Atmosphere, by William Ferrel, from Appendix 20, Annual Report for 1875

The atmosphere and weather were major concerns of almost all Survey personnel, in part because so much of the field work involved ships, most geodetic and hydrological and topographical work was dependent on clear visual observations over distances, and field work in general was so shaped by the local weather. Charles A. Schott, the Survey's greatest computer, also examined meteorological data analytically, performing much work on the side for Joseph Henry at the Smithsonian. Henry was, in part, struggling to design what could turn into a national weather observation and analysis system, and Schott was integral to the development of his data sets and even the design of the forms. He worked closely with the famed lithographer Julius Bien, who had worked in various ways with the Survey since the 1850s. At one point, Bien returned a corrected form for a template for a weather data chart to Schott. In the letter, Bien made a comment to his old friend that speaks volumes about the lives and values of the scientists and other workers of the Survey: "It gives me great pleasure to learn that you are satisfied with the work, after all appreciation from the right sources in the only true reward for conscientious labor".[16]

As the American coasts expanded, and with them the Survey's responsibilities, Survey scientists spent more time travelling farther and more frequently. In addition, the travel to far-flung destinations for observations of transient cosmic phenomena, such as solar eclipses and transits of planets, which began in earnest under Peirce, accelerated under Patterson. So it was that George Davidson and his small party went to Kyoto, Japan for the rare Transit of Venus in 1874, and returned with the rare map of Japan from the high Japanese official the Tykoon for Captain Patterson.

With the purchase of Alaska, the Survey acquired, as it were, the services of William H. Dall. Dall noted and mapped air and ocean currents between San Francisco and the Aleutians from his very first voyage for the Survey in 1871 and 1872. Under Patterson, Dall made many reconnaissance trips by sea and inland to Alaska and many adjoining regions. His decade of research on the system of the Bering Sea and its relation to the Pacific and Arctic Oceans was synthesized in his report published in Patterson's final year.[17]

[16] Bien to Schott, February 22, 1875.
[17] Dall, 1881, Bering Sea.



Sketch No. 81 Chart of Currents in the Bering Sea and Adjacent Waters by William Dall from Appendix No. 16, annual report for 1880

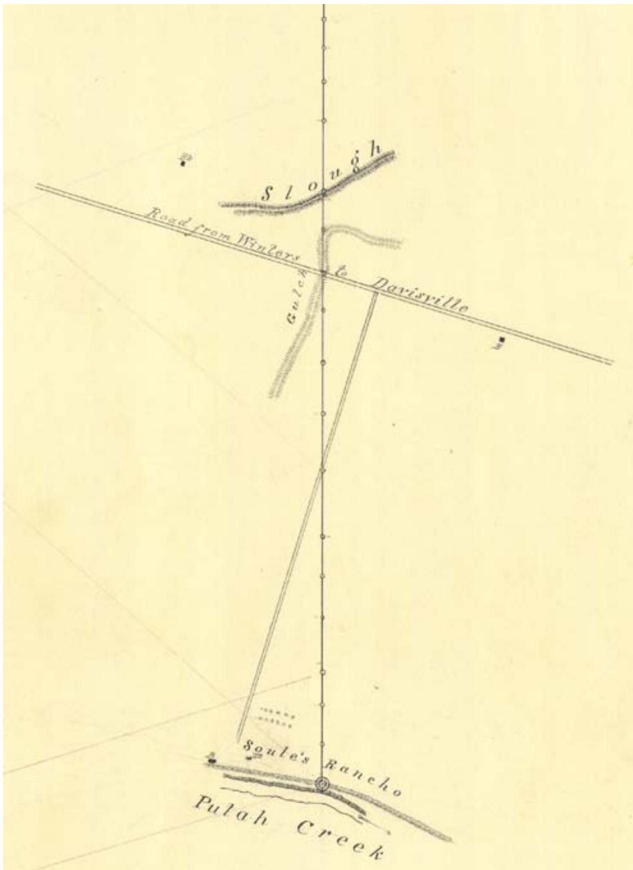
The Coast Survey becomes the Coast and Geodetic Survey

The Coast Survey had always been geodetic; that was Hassler's foundation. But as the foundational scientific agency in the US government, the Survey had always to be responsive to the needs and desires of Congress, or at least specific Congressmen, to obtain the funding required in order to function appropriately. In the post-war era, there were many "scientific" expeditions sent to the American west and southwest, led by present or former Army officers. US Navy officers still were assigned to the Survey, and filled many important roles, but US Army officers had been withdrawn from service with the Survey early in the Civil War, and the Army never returned. This soon led to a powerful tension between the Survey, and its many allies, and the myriad of potentially or actually competitor government science and mapping agencies then being formed, or at least promoted. The subject is a complex one, and will become far more complex after Patterson's death, as the Survey was plunged into its darkest era. But as a part of the process of solidifying its position and clarifying it primary responsibilities for American government science, in 1878 Patterson orchestrated the name change from Coast Survey to Coast and Geodetic Survey, to differentiate the Survey from the new geographical and geological surveys and agencies being formed or proposed.

And so, during an era popularly regarded as dominated by valiant expeditions led by Army veterans plunging farther and deeper and westerly, always westerly, into the great American west, at the very same time, the Coast and Geodetic Survey was busy occupying the very same country, or perhaps a little farther north than most of the other expeditions, but traveling in the opposite direction[18]. Instead of plunging into a savage wilderness, the Survey was leaving coastal California and the world city of San Francisco, enriched by the mines of the Comstock Lode and the cornucopia of agriculture in the Central Valley, and was headed easterly, ever easterly, at times guided by John Muir, into an eastern arid fastness inhabited by Mormons and Paiutes.

Peirce initiated the Triangulation Network of the Great Arc of the 39th Parallel in 1871; it would be decades before the arc was completed. Advancing the triangulation network westward from the Atlantic coast involved surveying approaches very similar to those Hassler had introduced when he began the Survey. Working eastward from the Pacific coast was different, for two reasons. First, there were great differences in mountainous terrain, and very different atmospheric conditions from those in the east. Second, out west there was George Davidson.

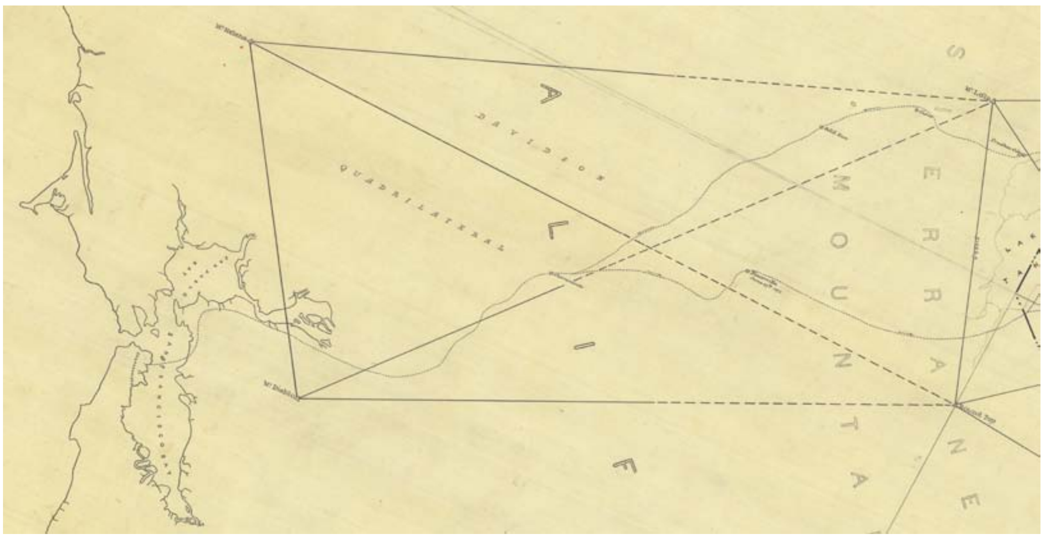
The western end of the great Arc was anchored by a particularly meticulously measured baseline, the Yolo Base Line, laid out on reasonably flat ground in the Central Valley of California, near the present city of Davis in 1876.



[18] For the westward-bound surveys, see Evans and Frye, 2009.

The southern end of the proposed base line, from T-1602 Preliminary Examination of the Yolo Base Line

George Davidson proposed to "ground" the western end of the triangulation arc by setting up a quadrilateral, a four-sided figure, composed of four very tall peaks, each visible from the others. From one of the peaks, Mount Diablo, the two ends of the Yolo Base Line were visible. Meticulous horizontal angles would be shot from each peak to all other peaks in the quadrilateral. Davidson immodestly proposed to name the quadrilateral after himself.

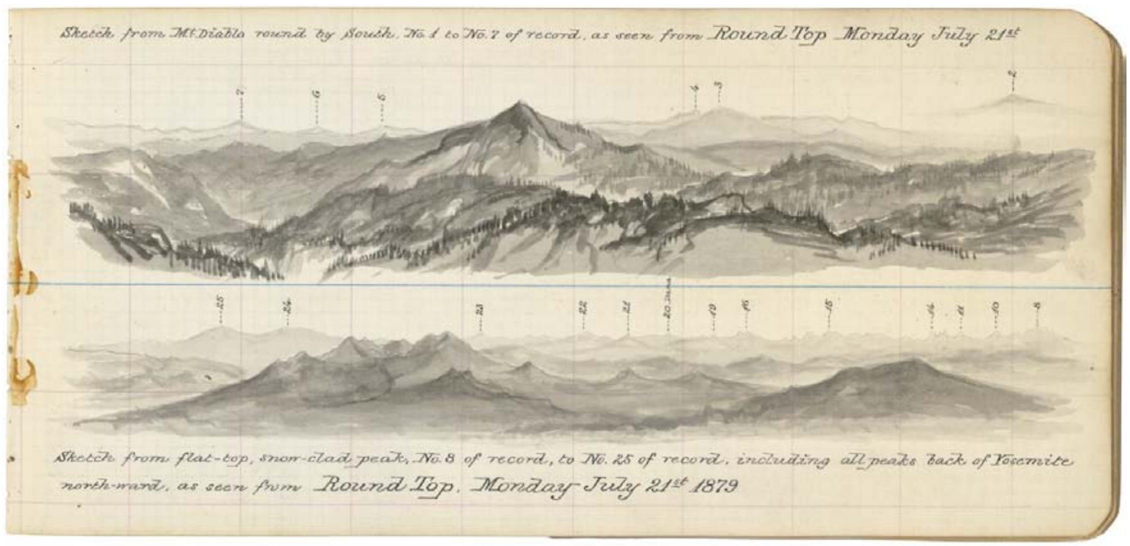


George Davidson's original 1878 schema for the Davidson Quadrilateral as projected and drawn by George Farquar, using angles computed by Davidson from preliminary reconnaissance from the peaks

As the project evolved, the plan grew larger and more complex. There would be two quadrilaterals, on either side east and west of the Yolo Base Line. Mount Diablo would be used to sight to the baseline ends, and also to serve as an observatory to shoot long time series of vertical angles to the seven tall peaks of the multiple Quadrilaterals, in order estimate their heights. The height estimates could then be used to check for possible atmospheric diffraction due to the great heights of the peaks. With the plan ready, the Survey set out for the Sierra Nevada in the long, fruitful field season of 1879.

The View from Round Top

A condensed example of the work along the entire network can be seen in the work accomplished in 1879 at the primary first-order triangulation station on the top of Round Top, a dramatically isolated tall peak, 10,381ft. or 3,164 meters tall in the Sierra Nevada range near Lake Tahoe in California. The triangulation between first order stations was the most exacting work of the Survey, and had been that way since Hassler. Using the latest model theodolites and heliotropes (pivoting mirrored reflectors which could flash tiny bright beams of light that could be seen as much as 100 miles or more away) Survey crews could extend the triangulation network rapidly and accurately over terrain entirely unlike that of the rounded and forested east coast. But the Quadrilateral mountains were necessarily the tallest ones available, and occupying the summits meant enduring intensely hostile conditions, waiting for appropriate weather for observations, and also waiting for other Survey crews to traverse the hundreds of miles necessary to get to the other stations within view. Under these conditions, Louis Sengteller, the head of the Drawing Division, camped on top of Round Top for nearly a month in the summer of 1879. His task was geodetic reconnaissance; he would find the farthest and highest mountains, which he and the rest of his Survey crew would then identify and evaluate as potential stations. After a terrible summer storm passed over Round Top with punishing fury and dangerous lightning, on July 21, 1879 Sengteller got the vista he had waited a month for.

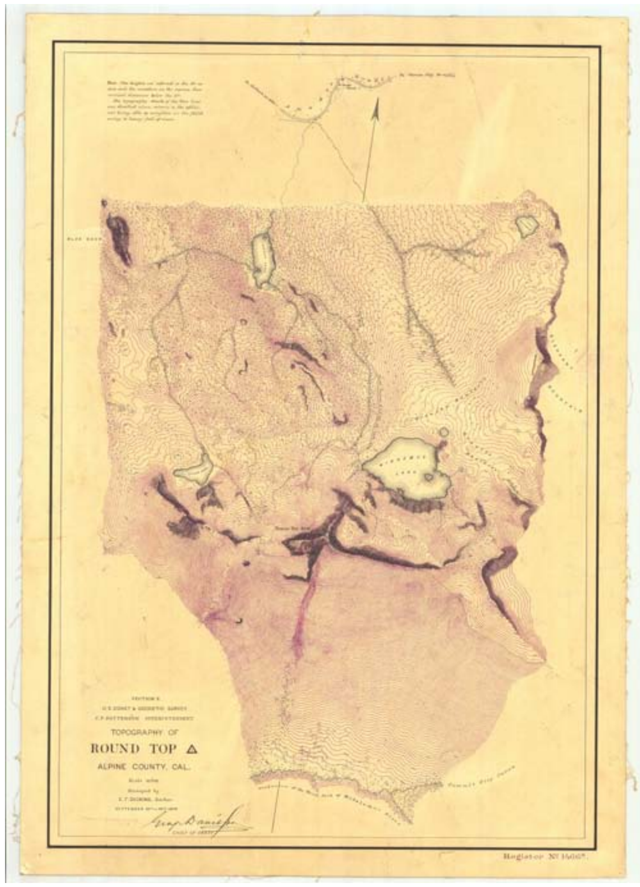


Sketch of Mountains as seen all around from Round Top, CA,
on Monday, July 21, 1879 by Louis A. Sengteller[19]

After geodetic reconnaissance came the triangulation work. It required an additional two months to have crews situated on the other stations at the right times with the right instructions and equipment. In September, a party under E.F. Dickens occupied Round Top for over two weeks. Heliotrope observations were best done near dawn and near dusk, and when atmospheric conditions allowed. This left the great majority of the time for other things. Several Survey crews that summer worked very hard on topographic surveying of their peaks, in collaboration with Edwin Hergesheimer, the great Survey draughtsman and topographer, who was preparing his manual of plane table surveying and possibly testing manual materials using the triangulation station crews. Dickson and his crew produced an extraordinarily detailed contoured map of the summit and its environs. It is part of a set of topographic maps of high country in the Sierra

[19] In Sengteller Reconnaissance Sketchbook No. 74, GAR series, Section X (California) 1879

Nevada, also including Mount Lola and the Moraines of Fallen Leaf Lake, by Hergesheimer himself, that were the cartographic fruits of the field season of 1879.

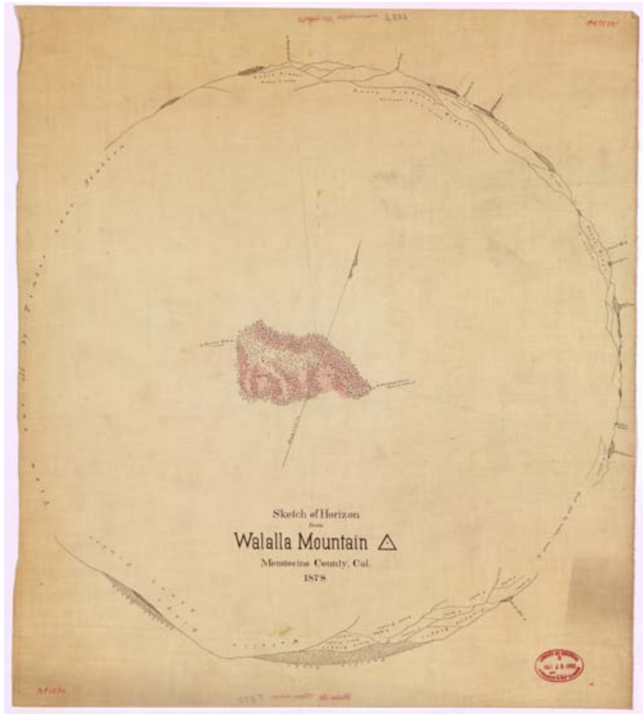


T-1466A Topography of Round Top, Alpine County, California
Surveyed by E.F. Dickens and party, September 13 to 30, 1879

The final objective of the many months of work getting to Round Top and back was the completion of the sightings of the horizontal angles between both sets of four peaks composing the Davidson Quadrilaterals. By calibrating the quadrilaterals to the precisely measured length of the Yolo Base Line, Davidson and his crews By integrating in the geometry of the baseline, as shot from Mount Diablo, and by resolving as many tiny errors due to atmospheric diffraction based on heights of the peaks, and other sources of error, the resultant geometric figure of the Davidson Quadrilaterals was the largest geodetic structure ever shot by observation to that time.

Davidson's original plan was to develop quadrilaterals in all directions radiating out from the original ones in central California, but the remarkably varied geography of California made this difficult, particularly to the north from central California. Assistant Cleveland Rockwell was dispatched into northern California beyond Point Arenas for reconnaissance. It was rugged and mountainous terrain, with many distinctive peaks.

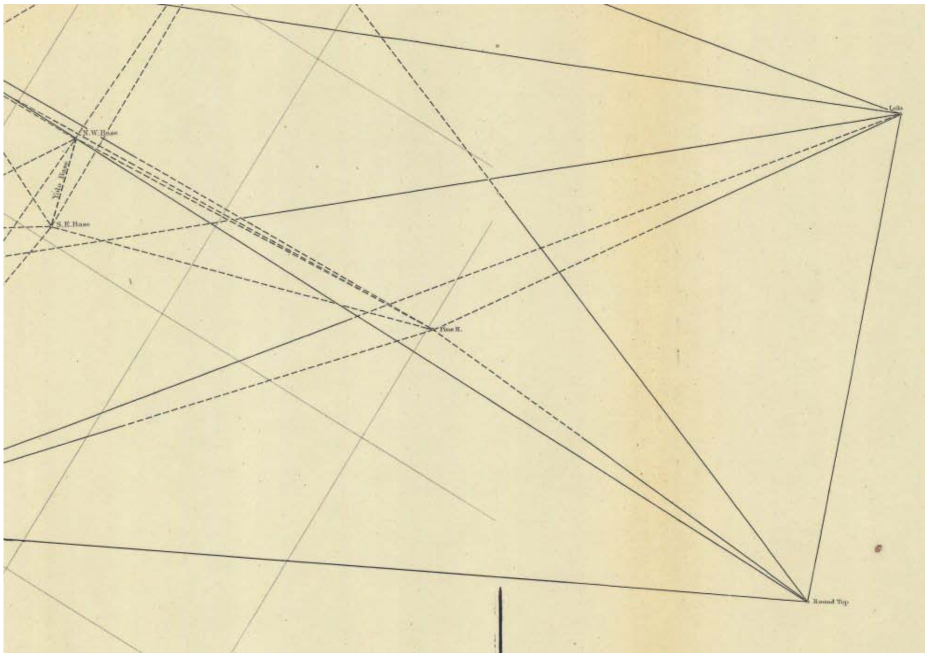
But, as Rockwell noted: “In this region it was found extremely difficult to observe on distant points because of the density of the redwood forest”.[20]



Sketch of Horizon from Walalla Mountain, Mendocino County 1878
By Cleveland Rockwell

As Rockwell and his party journeyed north into Humboldt County, the geography grew ever more problematic. They were able to find peaks and establish stations, “but with a disadvantage with respect of distance from the coast”. Finally they made it as far north as inland from Cape Blanco on the Oregon coast. “Some of the points from which observations were made are upwards of four thousand feet above the level of the sea. During the summer the heat of the rocks in the ascent was found very oppressive by the party. Much of the region traversed is extremely rough and destitute of trails”.[21] It is interesting that Rockwell, who was an accomplished artist, after retiring from the Survey, was a member of an exploring party that traversed the very same country, from the Oregon coast south and inland to Orleans, California on the Klamath River. This time, Rockwell and party made sure they traveled in spring, instead of summer. Rockwell filled sketch books with watercolors of beautiful native spring wildflowers in the mountains. These sketchbooks are now in the archives of the Oregon Historical Society.

[20] Rockwell, p. 48, Annual Report for 1878.
[21] Rockwell, ibid., p. 49.



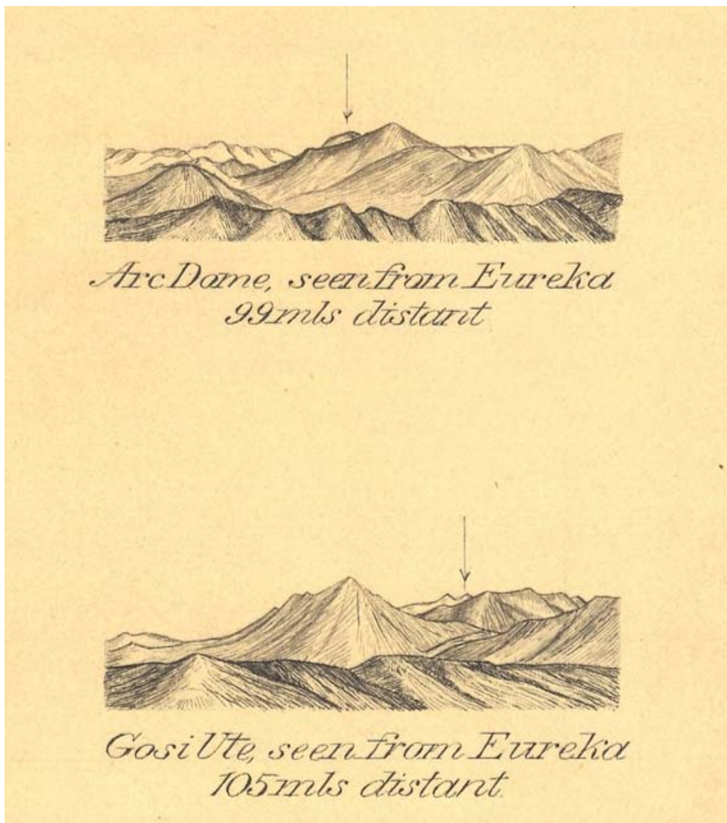
From Sketch No. 23, Progress of the Survey from Point Sal to Tomales Bay, CA Showing Round Top (lower right hand corner), Mount Lola (upper right), and the Yolo Base Line (upper left) (1879)

In other directions the convergence of terrain, vegetation, and atmosphere proved more favorable. With the geodetic foundation of the Quadrilaterals, horizontal angles could be shot eastward and northeastward to other tall peaks in the great Sierras. Benjamin Colonna, Davidson's chief assistant in the San Francisco office, was head of the party that climbed Mount Shasta, in far northern California for preliminary reconnaissance observations. His report of their observations gives a good sense of confidence and success of the Survey in extending the triangulation network, the very skeleton of the Survey since the first work of Hassler.

> "Friday, August 1, proved to be the day I had been waiting for. The wind had hauled to the northward during the night, and the smoke had vanished as if by magic. At sunrise, I turned my telescope in the direction of Mount Lola, and there was the heliotrope, 169 miles off, shining like a star of the first magnitude. I gave a few flashes from my own, and they were at once answered by flashes from Lola. Then turning my telescope in the direction of Mount Helena, there, too, was a heliotrope, shining as prettily as the one at Lola. My joy was very great; for the successful accomplishment of my mission was now assured. As soon as I had taken a few measures, I called Doctor McLean and Hubbard to let them see the heliotrope at Mount Helena, 192 miles off, and the longest line ever observed over in the world. In the afternoon the smoke had arisen, and Helena was shut out; but on the following morning I got it again, and my mission on Mount Shasta was finished. The French have been trying for some years to measure, trigonometrically, some lines from Spain across the

> Mediterranean to Algiers; they have only recently succeeded, and it has been a source of great satisfaction to French geodesists. Their longest line is 169 miles. The line from Mount Shasta to Mount Helena is 192 miles long, or 23 miles longer than their longest. And the glory is ours; for America, and not Europe, can boast of the largest trigonometrical figures that have ever been measured on the globe"[22].

Once past the redoubt of the Sierra Nevada in California and western Nevada, the Survey made rapid progress in the vast basin and range country of eastern Nevada and all of Utah. Under clear conditions in the arid expanse, observation lines of a hundred miles or more were easily performed.

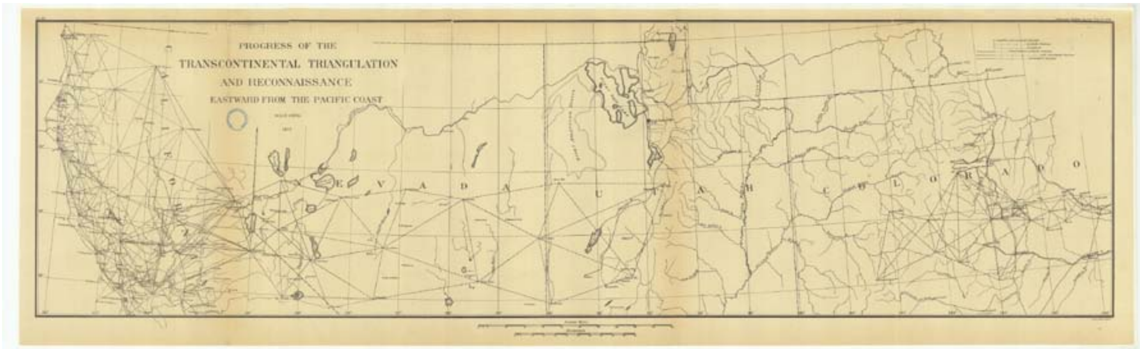


From T-2139 Transcontinental Triangulation and Reconnaissance
Showing Arc Dome and Gosi Ute (now Goshute) as seen from Eureka, Nevada (1879)

As a result, after a difficult but productive field season in 1879, the new Coast and Geodetic Survey had triangulated all the way from California to Utah. This work was a combination of reconnaissance surveying, and the more meticulous and corrected observations necessary for primary and secondary order geodetic stations. As Colonna

[22] B. Colonna "Nice Days on the Summit of Mt. Shasta" The Californian, March, 1880.

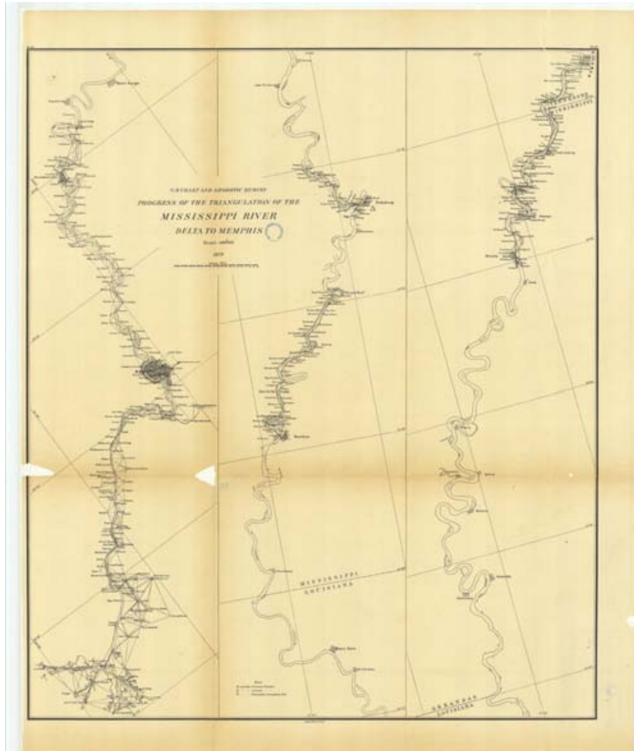
noted, at that time, there was nothing like this level of geodetic progress anywhere else on earth, not even Europe!



Sketch No. 30, Progress of the Transcontinental Triangulation and Reconnaissance Eastward from the Pacific Coast (1879)

The Survey and the Mississippi River Commission

The Mississippi River is another great American industrial river, but the work and research on the Mississippi performed by the Survey stands distinctly apart from the other major rivers of Patterson's era because of the political and hydrological context. Survey geodesists and cartographers had worked their way up the river during the Civil War as part of Admiral Porter's Mississippi Squadron. After the war, General Humphries (the man whose physics formulae George Davidson was adapting to his own hydrological studies, who had also been the assistant in charge of the Coast Survey office under Bache, 1847-1853) became the Chief of Engineers of the US Army. He and his allies were committed to major construction of levees as the way to control the river. There had been major floods in the Mississippi River Valley in 1862, 1865, 1869, and 1874. Even before the 1874 flood, the US Congress authorized the Coast Survey to conduct research and map the lower Mississippi River, in anticipation of major projects to come. The first stage of the Survey's work was a triangulation network, which was established from the Mississippi River delta upriver, and also established from St. Louis, Missouri going downriver. Eventually the entire river triangulation network was completed.



Sketch No. 19 Progress of the Triangulation of the Mississippi River
from the Delta to Memphis (1879)

The next stage in Survey work was to begin topographic and hydrographic surveying of the river to produce a map series, very similar to those produced for the other American industrial rivers. The surveys began in 1872 an 1873. By 1878, in Patterson's era, the Survey published a series of 13 charts, from Fort Jackson on the main channel of the river, and ending at Point Houmas, on a river bend between New Orleans and Baton Rouge. The series ended, because in 1879 the Mississippi River Commission was established,

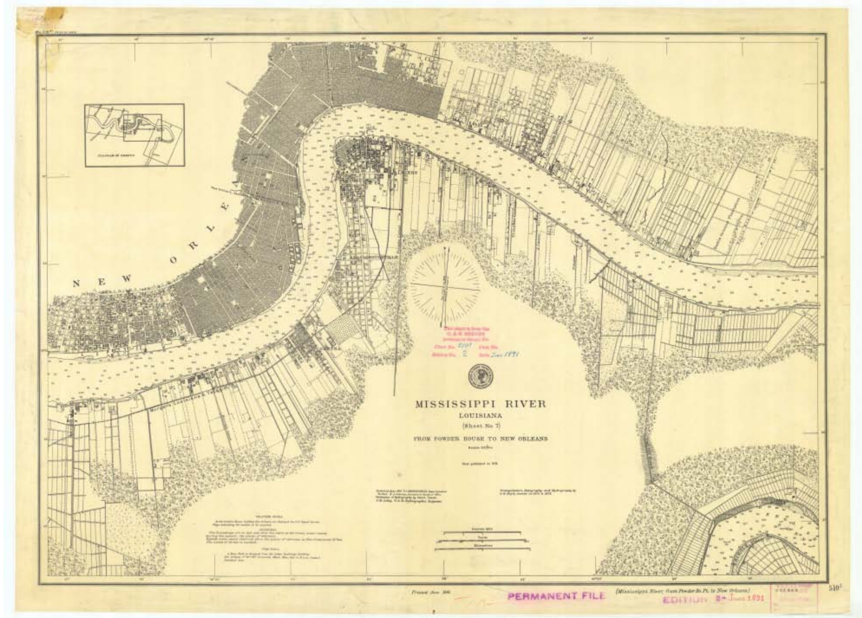


Chart 510, Sheet No. 7 Mississippi River from Powder House to New Orleans (1878)

The basic objective of the Mississippi River Commission was to create a body dedicated to a project for establishing control on the lower river for navigation and commerce. From the beginning, the membership of the commission was: three senior officers of the Corps of Engineers, one member from the Coast and Geodetic Survey, and three "gentlemen of quality" as they were originally specified, who would represent river landowners, shipping companies, boat builders, and the like[23]. The first Survey representative to the Commission was Henry Mitchell who was the Survey's best hydrologic scientist. However, the composition of the Commission dictated, from the beginning, that the Survey representative to the Commission would act primarily as a consultant or advisor to a decision-making process determined by the Army and the "gentlemen of quality". Thus, the Survey map series on the river was replaced by an entirely new set of charts developed by the Corps of Engineers, although they made use of the Survey's triangulation network. That would characterize the Survey's role on the Mississippi River Commission form then on, and essentially remains so today.

Charting Alaska and Native Peoples

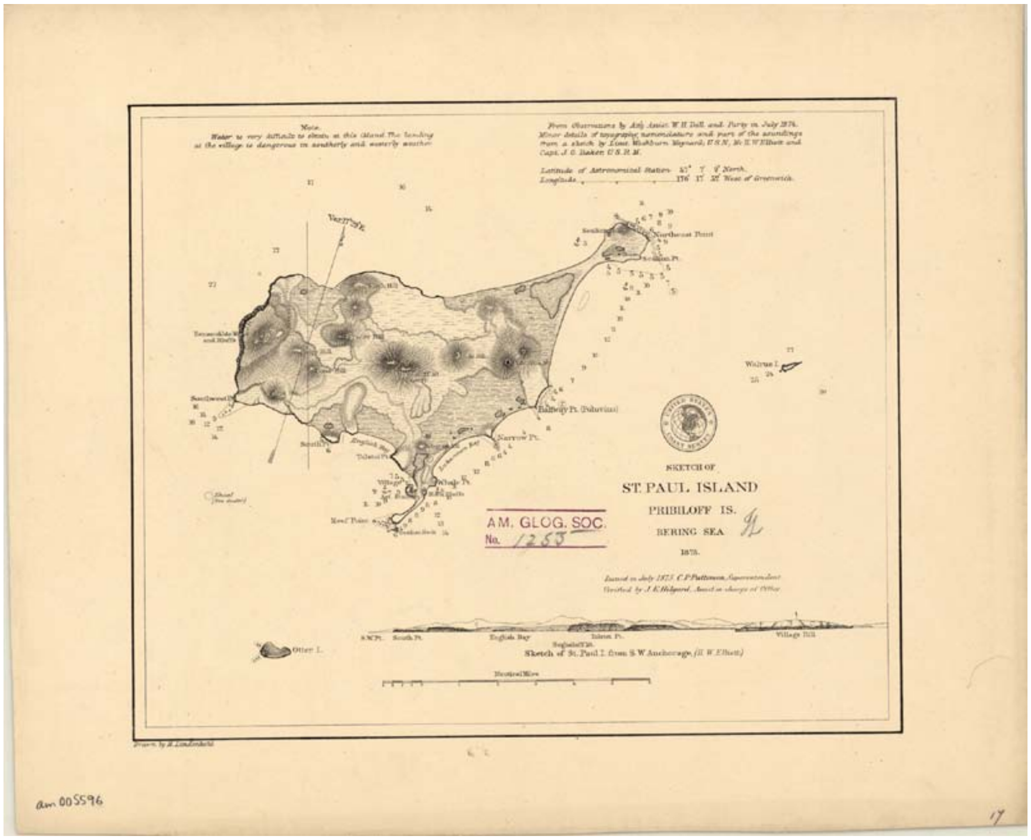
The two major chiefs of party from the Survey associated with work in Alaska in this era were George Davidson, who went north in 1867 and 1869, and William H. Dall, who had extensive reconnaissance experience in the region working for the Western Union Telegraph Company before working for the Survey. His first Survey voyage was 1871-72 to the Aleutians. He explored the coasts, the interior up the Yukon River, and throughout the Bering Sea and related places. He performed the first surveys of the major "Pribiloff" Islands, as he spelled them, in conjunction with (and apparently,

[23] Association of State Floodplain Managers, 2000.

sometimes friction with) Henry Elliott, the Special Agent of the Department of the Treasury. Elliott was a gifted artist, who became a major force in the preservation of the fur seal rookeries on the islands. In 1874, the Survey published a novel map of the land and sea areas in Alaska which Dall had explored.

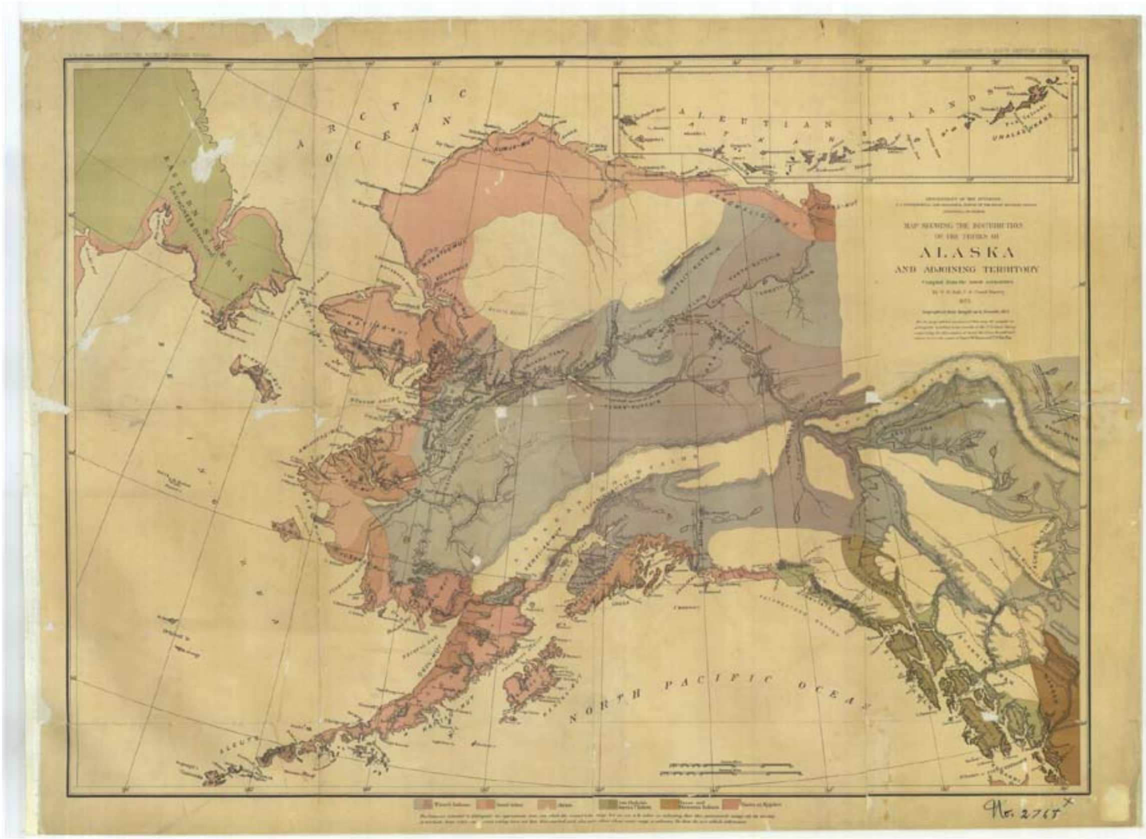
No. 22 Dall's Explorations in Alaska from the annual report for 1874

Under Patterson, the Survey published a series of charts of Alaskan ports, harbors, and islands, based on the Davidson and Dall explorations, and also on the historic charts of the same places made by Russian cartographers, which were transferred to the Coast Survey as a part of the purchase of Russian America. The Survey charts of St. George and St. Paul islands in the Pribilofs became the geodetic foundation for several series of critical fur seal rookery maps in later decades.



Sketch of St. Paul Island, Pribilof Islands, Bering Sea from observations
by William Dall and party, with view by Henry W. Elliott (1875)

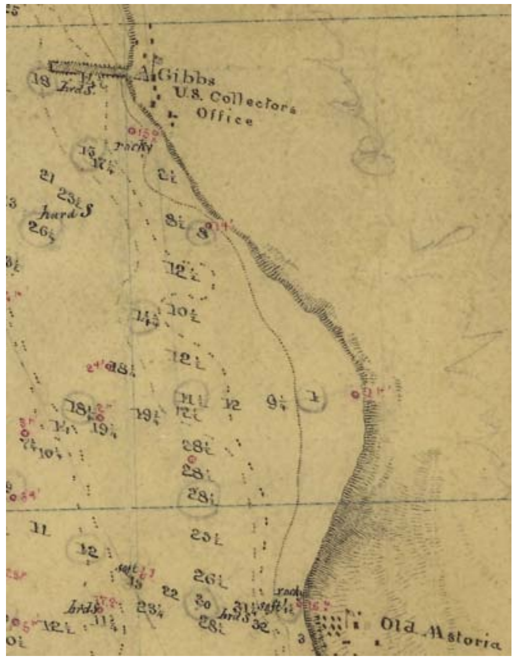
The west coast Survey under Davidson was particularly sensitive to and sympathetic about the native tribes and populations they encountered. Davidson since the 1850s had made a major point of acquiring native language vocabularies and information on native place names, most spectacularly in the case of the series of "Kohklux maps" created starting in 1869 with the Tlingit chief Kohklux and his two wives. William Dall continued and expanded this research during his many excursions on land and sea in Alaska and adjoining regions. All this research culminated in a set of reports, accompanied by two remarkable chromo-lithographed maps, which were published by John Wesley Powell as a part of the formation of what would eventually be Powell's Bureau of American Ethnology in the Smithsonian Institution. At the time though, Powell's enterprise was called the US Geographical and Geological Survey of the Rocky Mountain Region, which was one of the several enterprises of Army and ex-Army officers vying to develop what would eventually become the US Geological Survey. The first map and subsequent publication was the map by Dall with assistance from Davidson, of the native tribes of Alaska and adjoining territory. The base map is the Coast Survey's 1869 map of Alaska, with chromo-lithographed colors overprinted on the map coding for linguistic family. The section of the Chilkhat Pass between the Lynn canal and the Yukon is notable in that the basic linguistic information on the languages there came from Kohklux and his two wives.



Map showing the Distributions of the Tribes of Alaska and Adjoining Territory compiled from the latest sources by William H. Dall, with assistance from George Davidson (1875)[24]

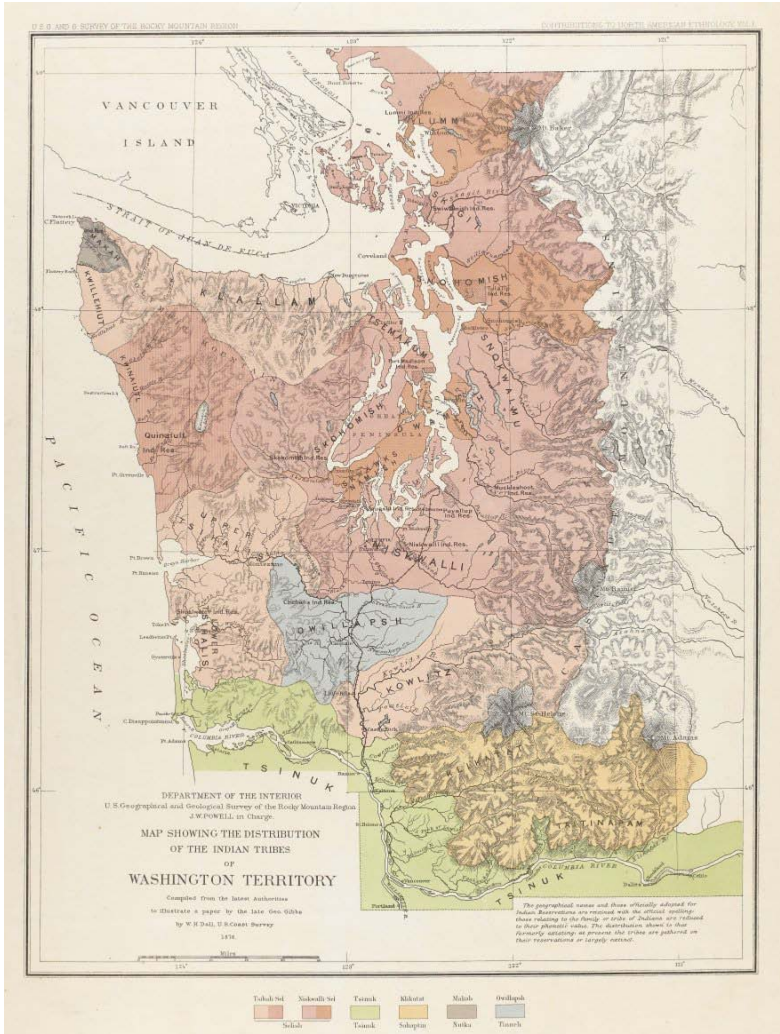
The following year, Powell published a long report written by the late George Gibbs on the Indian tribes and languages of Washington Territory and Northwest Oregon. Gibbs was a long time government agent who worked in various positions over decades, and who had become a major authority on the Indians of the region. George Davidson had known him since 1851, on his first reconnaissance up the Pacific coast. On that trip, the Survey had even mapped Gibbs' office at the government agency in Astoria on the Columbia River in Oregon Territory.

[24] See Dall, Tribes of the Extreme Northwest 91877).



From H-250 Part 2 Columbia River Entrance (1851)

To accompany the Gibbs' report, Powell commissioned William Dall to prepare another chromo-lithographed map of the linguistic distribution of Indian tribes in Washington Territory and Northwestern Oregon Territory. The map also functions as a map of the sum of territories that the Coast Survey had explored and mapped in its several decades of work on the west coast. And it maps as well the great sensitivities and sympathies of the personnel of the Survey to American Indians, then a rare phenomenon in the US government. The year the map was published, 1876, for example, was also the year of the Battle of the Little Bighorn.



Map showing the Distribution of the Indian Tribes of Washington Territory compiled from the latest authorities to illustrate a paper by George Gibbs by William H. Dall, published by J.W. Powell, US Geologic and Geographical Survey of the Rocky Mountain Region (1876)[25]

The Survey, the Blake and the Deep Ocean Basins

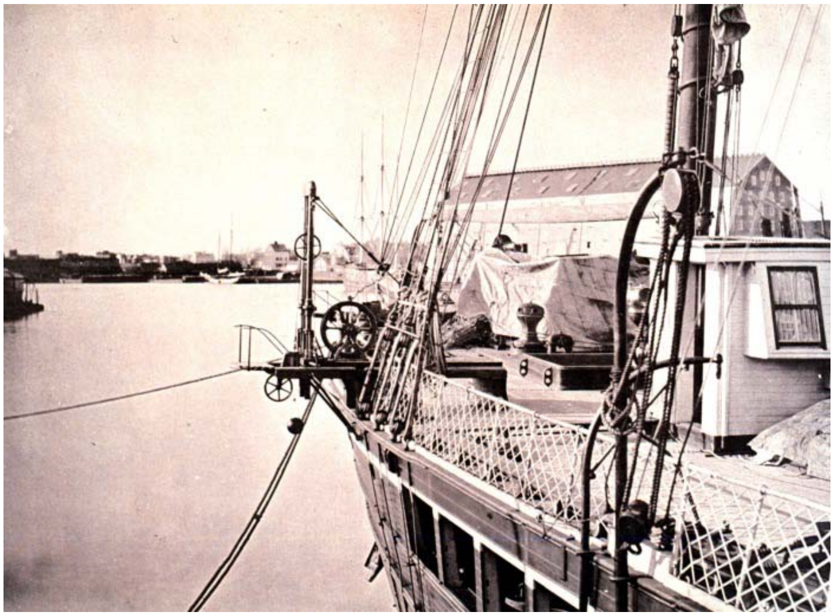
The Survey's mandate to pursue oceanographic research is as old as the idea of the Survey itself. As the initial bill passed by Congress in 1807 noted: "That it shall be lawful for the President of the United States to cause such examinations and observations to be made, with respect to St. George's bank, and any other bank or shoal and the soundings and currents beyond the distance aforesaid to the Gulf Stream".[26] Under Peirce, the Survey commissioned the *Blake*, the first modern American vessel specifically

[25] See Gibbs, Tribes of Western Washington and Northwest Oregon (1877).
[26] Section 2 of Act of Feb. 10, 1807, Sess. II, ch. 8, 2 Stat. 413-14 (1807).

designed for oceanographic research. As has been noted before, the work of the Blake was particularly paired to Alexander Agassiz, and the innovations he brought to oceanography from hard rock mining. Steel cable for sounding, and also dredging, became standard to all subsequent oceanographic research.

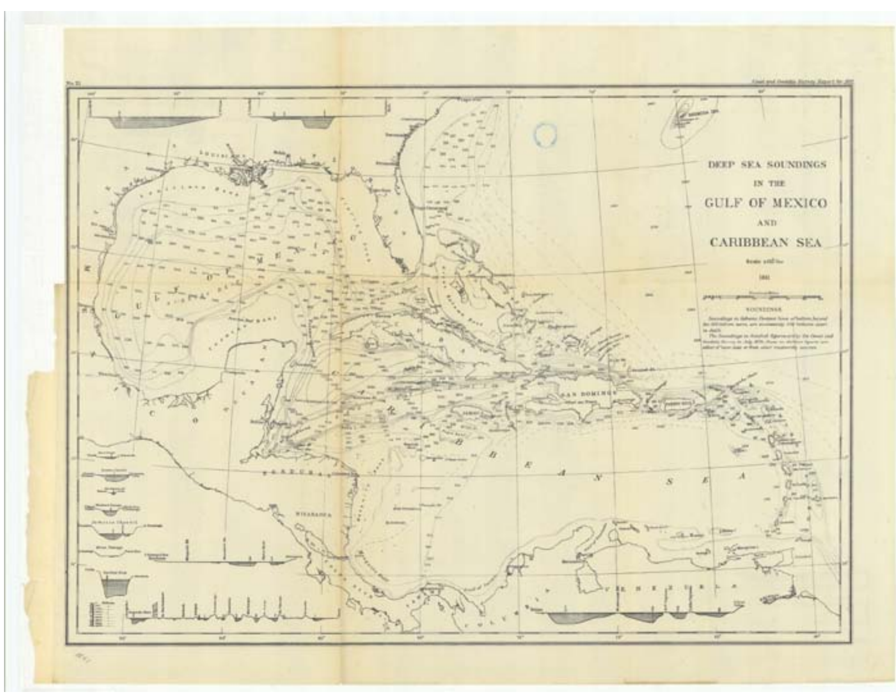
Plate 30: Steam Winch and Steel Wire on board the Survey ship "*Blake*" from "Deep Sea Sounding and Dredging" by Charles D. Sigsbee (1880).

Agassiz was joined in Survey oceanographic work by US Navy Captain Charles Sigsbee, who developed the Sigsbee Sounding Machine, which along with steel cable, became the great technologies that opened up deeper ocean basins and trenches and other deep features to the numbers and distributions of soundings necessary to characterize the features with relative confidence.



The Sigsbee Sounding Machine in position, run out for work on board the Coast and Geodetic Survey ship “Blake” (1880)

During Patterson’s era, the first publications bearing the results of the pioneering *Blake* surveys emerged. Soundings of the Gulf of Mexico, in particular, go back to the era of Bache in the late 1840s. But in the era of the *Blake*, the three-dimensional structure of the Gulf began to emerge.



Sketch No. 21 Deep Sea Soundings in the Gulf of Mexico and Caribbean Sea from the annual report for 1881

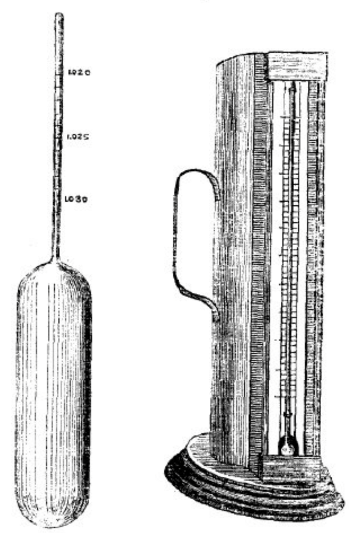
Many of the key instruments of oceanographic research were large and dramatic, but many others were small and intricate. A good number of the latter instruments developed and invented or improved in the Survey were associated with Julius Hilgard. By Patterson's era, Hilgard had been with the Survey for over two decades, having been hired by Bache in 1852. Almost two thirds of a century after Hilgard's arrival, Cleveland Abbe, long associated with the Weather Bureau but originally a scientist with the Survey, had noted that the Survey really coalesced around a primary triangle of A.D. Bache, Charles A. Schott the Survey's great computer, and Julius Hilgard.[27] Hilgard ran the headquarters, as the longtime Assistant in Charge of the Office. He also developed instruments for the research work of the Office of Weights and Measures, and also for many different arenas of scientific research the Survey engaged in.

APPENDIX No. 16.

DESCRIPTION OF AN OCEAN SALINOMETER, BY J. E. HILGARD, ASSISTANT UNITED STATES COAST SURVEY.

The density of sea-water in different latitudes and at different depths is an element of so great importance in the study of ocean physics as to have caused a great deal of attention to be paid lately to its determination. The instruments employed for the purpose have been, almost without exception, areometers of various forms. The differences of density as arising from saltiness are so small, that it is necessary to have a very sensitive instrument. As the density of ocean-water at the temperature of 60° Fahr. only varies between the limits of 1.024 and 1.029, it is necessary, in order to determine differences to the hundredth part, that we should be able to observe accurately the half of a unit in the fourth decimal place. This gives a great extension to the scale and involves the use of a series of floats if the scale starts from fresh water, or else the instrument assumes dimensions which make it unfit for use on board ship.

With a view to the convenient adaptation to practical use, the apparatus figured below has been devised for the Coast Survey by Assistant Hilgard.



The instrument consists of a single float about 9 inches in length. The scale extends from 1.020 to 1.031, in order to give sufficient range for the effect of temperature. Each unit in the third place, or thousandths of the density of fresh water, is represented by a length of 0.3 of an inch, which is subdivided into five parts, admitting of an accurate reading of a unit in the fourth place of decimals by estimation. The float is accompanied by a copper can, with a thermometer inserted within the cavity, which is glazed in front. In use, the can is nearly filled with water, so as to

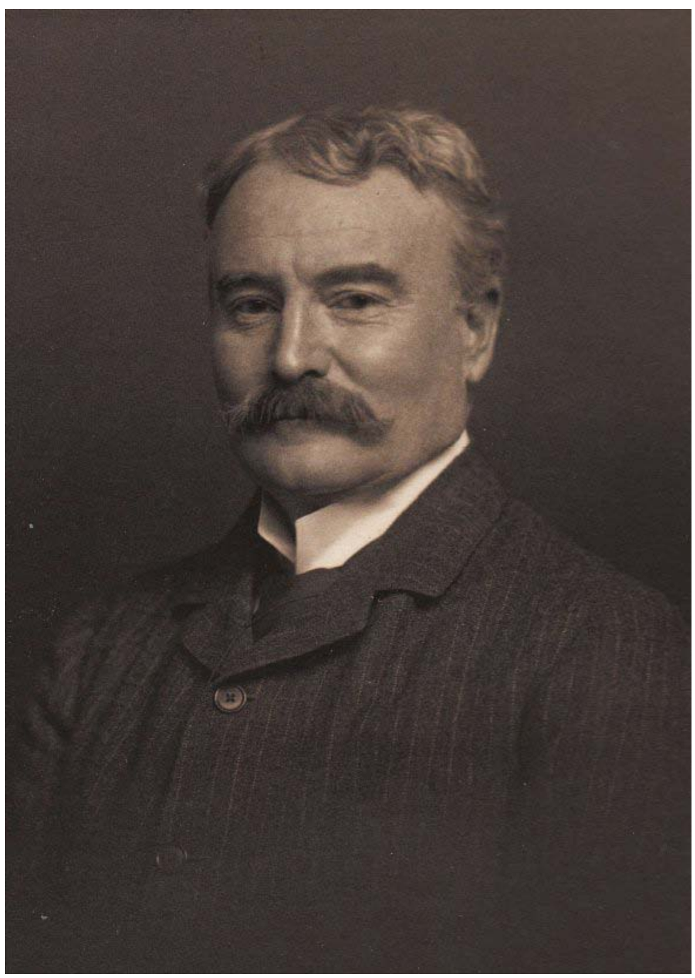
Description of an Ocean Salinometer by Julius Hilgard, Assistant in Charge of the Office Coast Survey Appendix No. 16, Annual Report (1874)

[27] Abbe, 1915.

In the difficult period following Bache's incapacity, Hilgard and Patterson were potential candidates to succeed Bache. As was discussed in the chapter on Peirce, Joseph Henry apparently actively discouraged Hilgard as a candidate for Superintendent, because he was a foreigner. Hilgard was passed over for Peirce, and Peirce was replaced by Patterson. It would soon be realized that, for Hilgard, his foreign birth was the least of his problems.

The Beginnings of the Special Oyster Work

Patterson came from a family of Navy officers, with many women relatives who married other Navy officers. Patterson's daughter Harriet would eventually be one such woman. The man she was to marry was Francis Winslow II, whom Patterson brought into the Survey to begin one of the most important research initiatives the Survey ever undertook in the 19th century, which in many respects was an early indication of what NOAA would become a century later.



Francis Winslow II
(undated photograph courtesy his descendant Edward Sisson)

Francis Winslow II was a son of Francis Winslow I, a Navy commander who died of yellow fever in the Union blocking squadron campaign in the South in 1862. Winslow II was sent to the Naval Academy to follow in his father's footsteps. Winslow apparently had some discipline problems. Perhaps because of this he was assigned to duty with the Coast Survey in 1876. Patterson welcomed Winslow to service beginning on a regular hydrographic party, but before doing so, Patterson requested Winslow report in person to the headquarters in Washington to talk to him[28]. It is fascinating to speculate about their conversation. Was Patterson cautioning Winslow about discipline? Or was Patterson evaluating Winslow as a candidate for a new type of marine research, one that Winslow eventually dedicated the rest of his life to?

The modern United States was founded in large part on maritime commerce and fisheries. Fisheries of many kinds were already in decline or exhausted by the middle 19th century. Over time, the federal government and the states turned their attention to research on fisheries and fish cultivation. Indeed, the 1807 law authorizing a Survey of the Coast mentioned studies of St. George's Bank specifically, the great fish nursery and site of rich fisheries offshore from New England. In 1871, Congress authorized the creation of the US Commission on Fish and Fisheries, originally under the Smithsonian Institution. The Commission (which originally was essentially one man, Spencer Baird) worked on fisheries research in New England. In 1873, Commission staff members used the Coast Survey steamer *Bache* for deep sea dredging, as they lacked their own equipment. Later that decade, when Winslow entered the Survey, research emphasis broadened and turned south to the Chesapeake Bay, and the rapid decline of the native Chesapeake oysters.

There were two great interrelated problems to the matter of the oyster fisheries of the Chesapeake Bay and elsewhere. The first was that no one really knew the mechanisms of oyster reproduction in the native American Atlantic coast oyster (then *Ostrea virginica*, now *Crassostrea virginica*). This ignorance limited artificial culturing of oysters, of course, but it also impacted management of the wild oyster stock as well. An interrelated question about the latter was the nature of the differences between the oyster populations on undisturbed beds (called natural beds) and those which were dredged or tonged or otherwise harvested (called managed beds). Winslow was assigned by Patterson to what was called "the special work" of oyster biology and management, an unprecedented new task for the scientists of the Survey. It turned out, Winslow had found his life's work. He essentially became the marine biologist he needed to be to learn how oysters reproduce and could be cultured. And, he applied the hydrographic surveying skills he learned in the Survey to oyster management by figuring out techniques to map and monitor oyster beds geodetically. The full fruits of his work would emerge over decades, but the first of these to emerge was his treatise on the oysters of the Chesapeake Bay and its estuaries.[29]

[28] Patterson to Winslow, Dec. 7th, 1876, In Patterson-Winslow Family papers, LOC Manuscripts Division.
[29] Winslow, Appendix No. 11, annual report for 1881. See also Keiner, 2009.

Winslow worked only two years' assignment under Patterson before the Navy called him to other duties. Winslow eventually left the Navy to pursue his oyster research. In 1880, Patterson wrote to Winslow upon his leaving the Survey:

> "I beg to express my regret that the terms of duty of Naval officers on this work do not permit your continuance in the service for a sufficient length of time to enable you to carry to completion the special work on which you have been engaged during the last two years… The admirable manner in which you have opened up this new branch of work of the Survey, with the energy, good judgment and intelligence you have shown in its initiation, with only the simplest instructions, deserve my warm acknowledgements. The methods suggested and the system adopted by you, and so successfully carried out with the limited means at your disposal will form the basis for all future work".[30]

And thus Patterson and Winslow parted officially in 1880. But Winslow was courting Patterson's daughter Harriet Livingston Patterson, so presumably they continued to meet under the great oak trees at Brentwood.

The Frontiers of Experimental and Scientific Cartography and Topography

Under Hassler, the geodetic network was absolutely foundational to the progress of the Survey. That remained the case for his successors. But, under Bache, it became critical to publish results promptly, and in particular to publish maps and charts of the most recent work. Under Pattterson, as we have seen, entire new series of maps and charts were developed. But there was also a profusion on novel maps and charts, many of them unique, several of them entirely original types of maps the likes of which had never before been seen or even imagined. The Survey even develop a numbered chart series, the "3000 charts", whose chart numbers began with "30xx" to accommodate the new charts.

One example was the chart of the topography of Mount Desert Island, off the coast of central Maine. The chart's engraver was John Enthoffer, the Chief Engraver of the Survey, after much service in Europe as institutes of military topography. In 1870 he had published a major treatise on topographical drawing, illustrated with topography taken from his work on specific Survey charts, such as the peninsula of Point Loma, at San Diego Harbor[31]. The Mt. Desert chart is distinctive, for a Coast Survey chart, in that, although it represents an island with a major port (Bar Harbor) offshore in the Atlantic Ocean, it has no hydrographic data of any kind.

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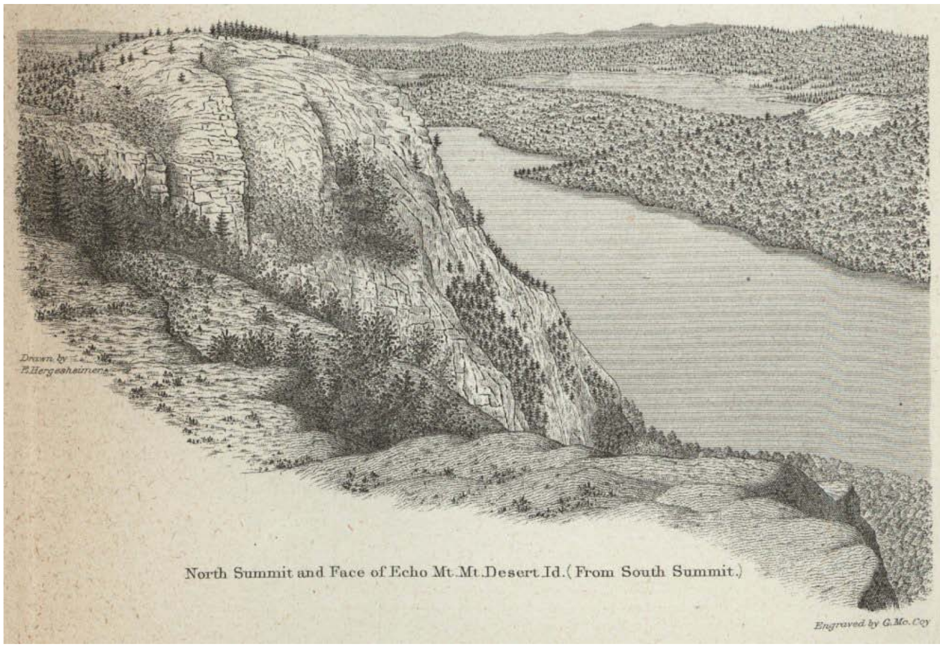
[30] Patterson to Winslow, January 6, 1880, in the Patterson-Winslow Family Papers
[31] See Enthoffer, Manual of Topography, 1870

Chart 3056 Mount Desert Island, Maine (1875)
Topography surveyed by J.W. Donn, engraved by J. Enthoffer

A natural complement to the chart is one of the many illustrations that Edwin Hergesheimer prepared for one of the many versions of his great treatise on the use of the plane table for topographical mapping, and the preparation of standardized types of topographical drawings[32].

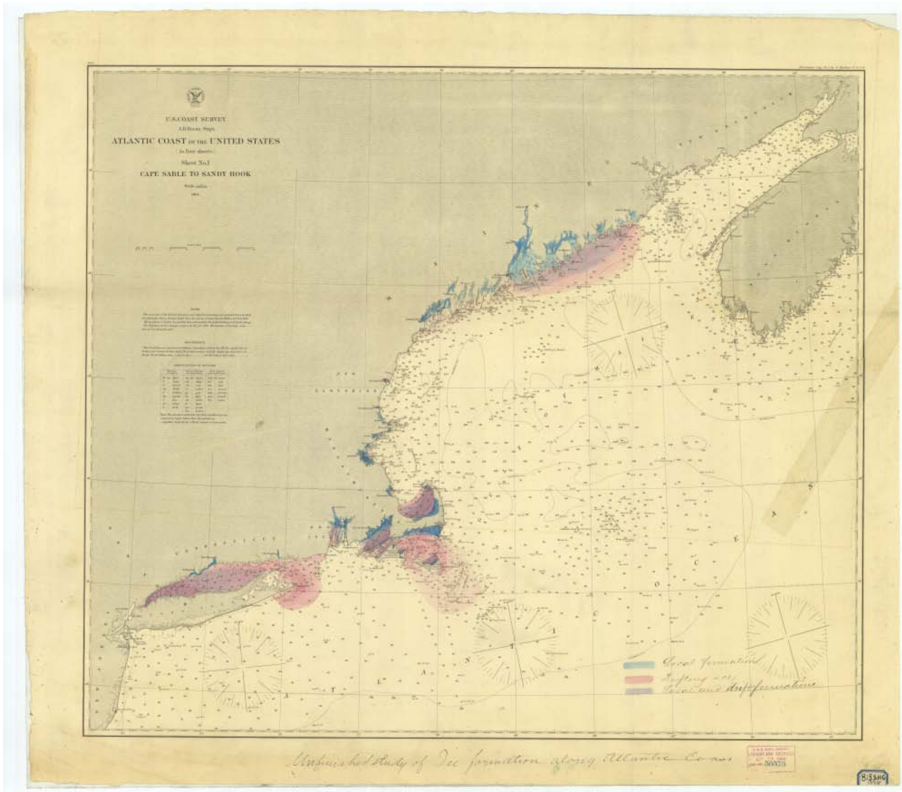
[32] E. Hergesheimer, Appendix No. 14, Annual Report for 1883.



North Summit and Face of Echo Mountain, Mount Desert Island, Maine
(from South Summit) Drawn by Edwin Hergesheimer From Appendix No. 14 Report on the preparation of standard topographical drawings. (1883)

The Cold Winter of 1874-75, Lt. Francis Bradbury, and the Ice Charts

The very active period in Survey work on the Atlantic coast that began with Patterson's tenure and the beginning of what would become the Atlantic Local Coast Pilots also happened to fall when an exceptionally cold winter settled on New England and the Atlantic Ocean offshore in 1874-75. US Navy Lt. Francis Bradbury was assigned to the Survey as a hydrographic surveyor, and also assistant in various aspects of the work of compilation of a myriad of data for the sailing directions and guides to hazards to navigation. Bradbury took a special interest in the extreme state of local and sea ice in the harbors and shipping lanes than winter. He began a study, ultimately left unfinished, by the end of his tour of duty with the Survey, to present and analyze the ice conditions, compared to normal winter conditions. He hand water colored 14 different Survey charts, at harbor chart and sailing direction chart scales, with the maximum extents of the ice that winter, along with the formation status of the ice.



The Atlantic Coast from Cape Sable to Sandy Hook over painted with winter ice at maximum extent, by Lt. Francis Bradbury. Ice of local formation is blue, drifting ice is pink, mixed formations are lavender (1875)

The Experimental Worlds of Charles S. Peirce

Charles Sanders Peirce came to the Survey courtesy of Bache, and then stayed with the Survey through his father Benjamin, when the elder Peirce was Superintendent. As was presented in the Peirce chapter, C.S. Peirce was the pioneer in Survey experimental work with many subjects, including gravitation. He established a pendulum station on the summit of Hoosac Mountain in western Massachusetts, which has a celebrated railroad tunnel and many access tunnels thorough it. The tunnels allowed the geological structure of the mountain to be known in great detail. Peirce used that structure and the local topography to create a model of local mass around the pendulum station, which allowed him to correct his gravitation measurements and also correct for the local contribution to astronomical deflection of the vertical. It also allowed him to create another chart in the Survey's 3000 series. It has got to be the most singular contoured topographic map ever published by the US government.

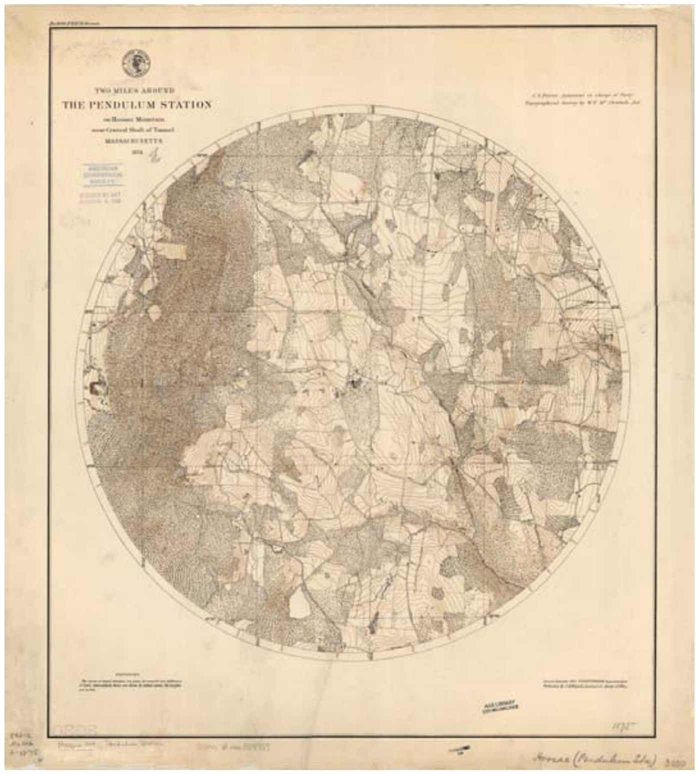
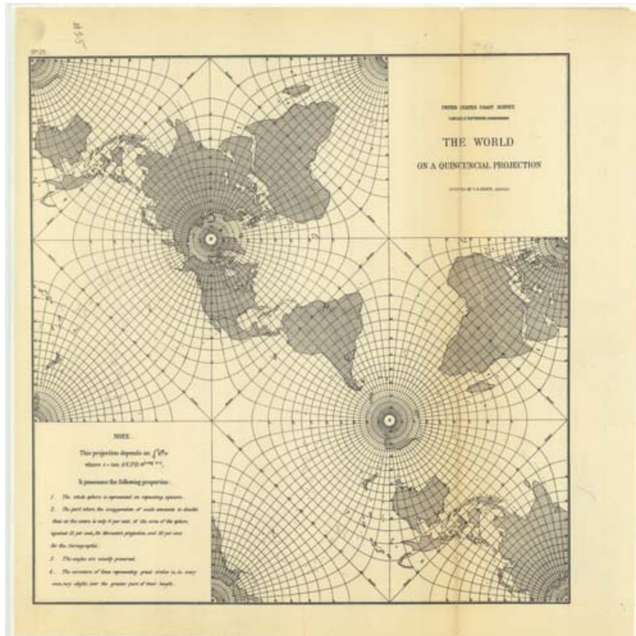


Chart 3030 Two Miles around the Pendulum Station on Hoosac Mountain, MA
near Central Shaft of the Tunnel by C.S. Peirce (1874)

During the Patterson era, Charles A. Schott and others published a series of appendices presenting and analyzing many disparate world map projections which could be used for various purposes. C.S. Peirce developed several new projections of his own especially his quincuncial projection. Peirce also was increasingly responsible for research on measurements and standards in the Office of Weights and Measures.



Sketch No. 25 The World on a Quincuncial Projection, by Charles S. Peirce (1877)

Patterson's Finale

Carlile Patterson was above all else the First Captain of the Survey, a master mariner, the chief hydrographic inspector for the nation. Under Patterson, the Survey did new and superb work in identifying and presenting hazards to navigation to keep mariners safe at sea. In 1878, Amherst College made Patterson an "honorary graduate" of the college, with the degree of Doctor of Letters (LL.D).

But under Patterson, for the first time, the Survey also produced charts like this final masterpiece: an aid to navigation to amusements, and to a class of mild hazards that were perhaps only self-inflicted: The US Coast and Geodetic Survey's chart of the excursion railroads, amusement parks, hotels, casinos, and bathing facilities of Coney Island.

Coney Island, New York as surveyed in 1878 and 1879 (1879) 25 cents.

On August 15, 1881, Carlile Patterson died suddenly at the family's great estate Brentwood, in the country outside Washington. Patterson began his tenure as Superintendent in the first smooth transition of leadership the Survey had ever seen; the sudden death of Hassler, and the prolonged incapacitation and decline of Bache had presented crises to the Survey and its allies. Patterson's sudden death plunged the Survey once again into crisis. Unfortunately, this crisis was not one to be resolved by an apt appointment of the correct successor. This reflects, in part, the choice of Patterson's successor and his fate, but it also reflects a larger and darker and more turmoiled context of the Survey and other enterprises in the federal government. As the first of many memorials and obituaries began to appear in the wake of Patterson's death, one noted presciently:

"When Patterson succeeded Benjamin Peirce It was a time of general commercial depression, when all appropriations were cut down close to, and often below, the point of efficiency. This was the case with appropriations for the Coast and Geodetic Survey, and the full powers of the Superintendent were put forth to keep unbroken the organization of the work, knowing well that once seriously impaired it could with difficulty be restored. This struggle the late Superintendent successfully maintained, despite every obstacle, to the close of his administration, and his death took place at a time when a bright prospect appeared in view".[33]

The Coast and Geodetic Survey and its people would spend at least the next two decades looking for another bright prospect to come in view.

[33] Carlile P. Patterson: Secretary Windom's Tribute to a Valuable Officer. The National Republican, Washington DC, Aug. 22, 1881.

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