John Cloud
NOAA Central Library
1315 East-West Highway
SSMC-3, 2nd Floor, E/OC4
Silver Spring, MD 20910
301-713-2607, ext. 126
301-713-4598 fax
John.Cloud@noaa.gov

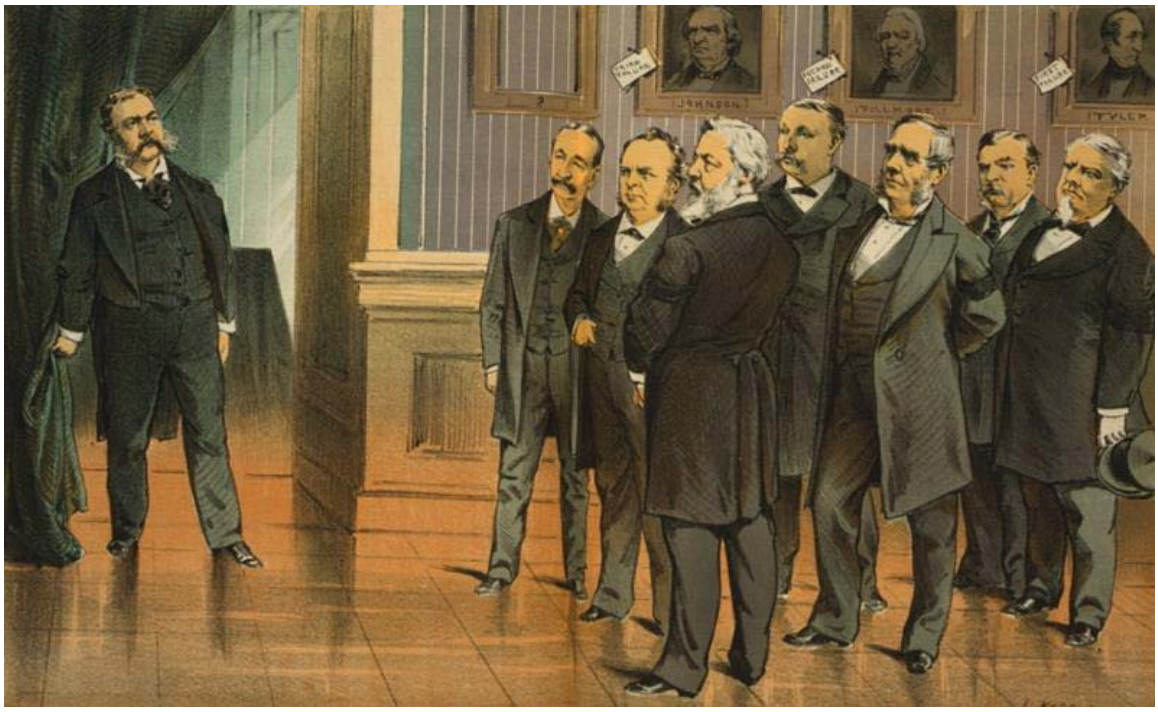
The Decline and Fall of Professor Hilgard (1881-1885)

Julius Eramus Hilgard in 1875 (left) and undated but later (right)

Two dramatic events in the city of Washington in the hot summer of 1881changed the history of the Coast and Geodetic Survey utterly. Both events were immediately experienced as separate tragedies; it would take some years for the full implications of their compounding to be realized. The first event was the assassination of President James A. Garfield on July 2, 1881 by a disgruntled office-seeker named Charles Guiteau in the main Washington train station. Although Garfield survived until September, he had been seriously wounded, and a series of medical errors compounded his injuries and eventually led to his death. During that time of crisis, Carlile Pollock Patterson, the 4th Superintendent of the Coast and Geodetic Survey died suddenly on August 15, 1881.

Patterson's death precipitated an immediate crisis for the Survey. Patterson had been an able leader, and was exceedingly well-connected to the leadership of American science and society. Continuity in the succession of the Survey's leaders had been aided for decades by the interventions of Joseph Henry, the Secretary of the Smithsonian Institution, but by 1881 he had been dead three years. For the first time since Ferdinand Hassler's death in 1843, there was no one great American champion of the Survey to pull the strings concerning the Survey's leader and its relation to Congress.

President Garfield's death led to far-reaching changes in the organization of the federal government, which took many years to take effect, by complex developments and processes. Garfield was succeeded the day after his death on September 18, 1881, by Chester A. Arthur (1829-1886), who served out the remainder of Garfield's single term. Garfield was a member of the Republican Party, and specifically the "Stalwart" faction, which was relatively opposed to reform of the civil service system and the abolition of political patronage in federal and state employment and appointments. Apparently to the surprise of many, Arthur's positions changed radically upon becoming President.



1881 cartoon from Puck showing President Arthur meeting his Cabinet. On the wall behind them are one empty frame and portraits of Andrew Johnson, Millard Fillmore, and John Tyler, the other three Vice-Presidents who succeeded Presidents who died in office.

President Arthur, once in office, became a champion of reform in the federal government, particularly known for his success persuading Congressional passage of the Pendleton Civil Service Reform Act of 1883. The law established the United States Civil Service Commission, which placed many and possibly most federal jobs under a merit system (the Coast and Geodetic Survey had promoted on merit since the time of Ferdinand Hassler) as opposed to previous methods of obtaining positions and maintaining them. These changes had varying effects on the many disparate federal agencies. And they invited a new era of vigorous scrutiny, by Congress and the press, of the functioning of federal agencies and their expenditures, in particular. Further, the US Geological Survey had been established in 1879, only two years before the deaths of Patterson and Garfield, and the considerable overlap between their work and that of the Survey created an inevitable jockeying for status and authority. And, on top of that, the Navy Hydrographic Office and its allies was preparing yet another campaign to take over the Coast and Geodetic Survey, as the Navy had periodically attempted for over half a century already. All these matters converged to influence the fate of Superintendent Patterson's successor.

An Introduction to Julius Erasmus Hilgard (1825-1891)

The Survey of the Coast began with a brilliant foreign immigrant, Ferdinand Hassler. After his untimely death his successor, the eminently connected American scholar and teacher A.D. Bache turned the Survey into the premier scientific agency in the federal government by a process that involved, in no small part, the ready inclusion of gifted foreign immigrants and their skills into the Survey. After Bache's decline and death, the eminent American mathematician Benjamin Peirce revived and extended the scientific research initiatives of the Survey in a very productive period, even though in many ways his was a caretaker administration, as he continued as an endowed professor at Harvard throughout his tenure. When Carlile Patterson became his successor in the only smooth transition in leaders the Survey had ever experienced, he became the first Superintendent of the Survey to have risen through the ranks of the Survey. All these disparate paths to leadership of the Survey then converged in the ascendancy of the 5th Superintendent, Julius Eramus Hilgard.

Hilgard was born in 1825 in the town of Zweibrücken in what was then the Palatinate, in what is now Pheinland-Pfalz, in western Germany. His father gave up a successful career in jurisprudence in Bavaria to immigrate to the United States "under the mistaken impression that ideal social and political conditions were to be found on a remote farm in Illinois, whither he accordingly transplanted his large family" when Julius was 10 years old. There the Hilgard family lived an agrarian existence, the Hilgard children largely home-schooled by their father in most subjects, except mathematics. From a very early age, Julius Hilgard's mathematical talents were recognized, and he instructed his father as well as his siblings in the subject. The Hilgard family's intellectual pursuits were largely isolated from their neighbors, and conducted primarily in German. Julius learned English primarily from books, and throughout his life he spoke the new tongue with a pronounced accent[1].

[1] Tittman, p. 462.

In 1843, Bache succeeded Hassler as Superintendent of the Survey, and its great transformation began. That same year, 18-year old Hilgard met Bache in Philadelphia, and in a subsequent letter to Bache Hilgard noted several errors in the formulas used to calculate geographic positions. Bache immediately offered him a job, but in a subordinate position, given his youth. Hilgard reputedly replied that he would rather do "high work at low pay than low work at high pay", and Bache hired him to the Coast Survey[2]. It was the only job he ever had for the rest of his life.

Sixty-eight years after that day in 1843 when Bache hired Hilgard, Cleveland Abbe published a memoir on the life of Charles Anthony Schott, the Survey's great computer. In that memoir, he stated that at the heart of Bache's transformed Survey was a primary triangle formed by Bache, Schott, and Julius Hilgard. Bache was the well connected American leader and the major ideas man; Schott was the great brain, although he also excelled at fieldwork and sought every opportunity "to breathe the pure air implied by geodesy and hydrography"[3]; Hilgard complemented them both by acquiring skills in every arena of the scientific activity of the Survey, but also functioning as a superb manager of the staff in the field and the office. "Hilgard's mind, in so far as his professional duties were concerned, was eminently practical. While directing large interests on the broadest plans, he grasped and gave attention to the minute and varied details of the work entrusted to him, introducing economies, by perfecting methods, in many ways, as, for instance, in substituting tapeline measurements along the sandy beaches for the slow and expensive methods of triangulation in vogue along the heavily timbered southern coasts".[4]

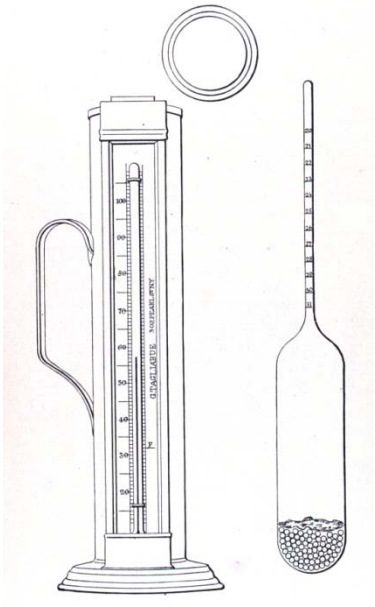
Hilgard was thoroughly versed in Survey field work, and headed a hydrographic field party at the age of 21, but his talents in administration and management of personnel were so critical that he soon became the Survey's first non-military Assistant in Charge of the Office. As such, he was at the center of the Survey's political, economic, and social life in Washington. For a short period of time shortly before the Civil War, he left the Survey, for reasons not presently known. However, in 1861, he resumed his old position, in large part to take charge of defending the Survey against another attempt by the Navy to absorb the Survey, this time under the excuse of the war. "[He] was recalled by Bache at the outbreak of the war, when the existence of the Survey was threatened by hostile legislation, to return to Washington and help save and maintain it"[5]. He successfully repelled the Navy's takeover bid, while at the same time the Survey and the Navy fought the war triumphantly and scientifically.

Hilgard was skilled at instrument use and instrument design, which led to increasing responsibilities in the Office of Weights and Measures. There, he helped shape the legislation introducing the metric system into the United States and he prepared

[2] Tittman, p. 463.
[3] Abbe, p. 89.
[4] Tittman, p. 464-465.
[5] Ibid, p. 463.

the standards of measurement that were distributed to the various states[6]. In 1872 he organized the Survey's initiative to determine telegraphic longitude between Europe and the United States using the trans-Atlantic cable, thereby integrating the great European observatories at Greenwich, Paris and Potsdam with their American counterparts, a feat which he afterwards described as a diplomatic triumph. He represented the United States at the convention in Paris to form the international bureau of weights and measures, and was later offered the directorship of the agency, but he declined it, and stayed with the Survey.

Hilgard had a great affinity for mechanical and scientific apparatus, and served as a judge of these at the Centennial Exposition in Philadelphia in 1876. He designed a number of important scientific instruments, including an ocean salinometer, which was used on voyages of the Survey ship *Blake* and the Fish Commission ship *Albatross* to measure the salinity of deep ocean water samples.



Hilgard's Ocean Salinometer, from Lt.-Commander Tanner's "Report on… the Albatross" in the Report of the Commissioner of Fish and Fisheries, 1883

Seawater salinity is closely correlated with seawater density. Hilgard was dissatisfied with the so-called "bobbing hydrometers" then used at sea to measure sea-water density. In 1877, he converted a hydrographic instrument to a hollow prism, minimum deviation refractometer to determine density optically. This was the beginnings of refractometry in physical oceanography[7]. Hilgard's technique of determining fluid density by refractometry was then developed by many other instrument makers, and instruments based on his idea became standards in oceanography.

[6] Tittmann, p. 464.
[7] Seaver, et al., p. 268

The Fery Refractometer, based on Hilgard's design

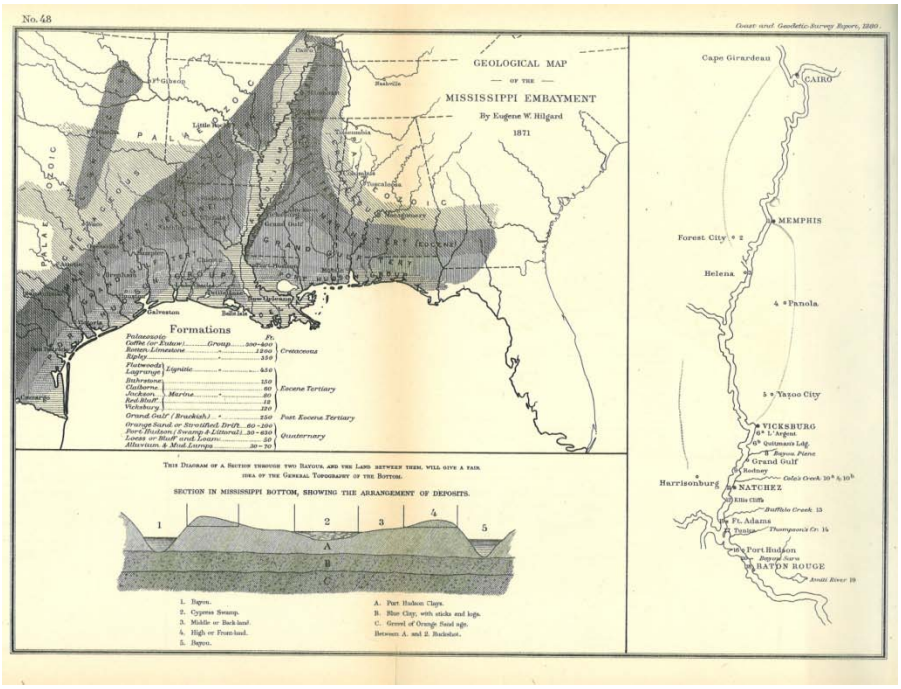
Hilgard, until the very end of his long career in the Survey, was universally admired and respected for his brilliance, initiative, and great generosity. He was a charter member of the National Academy of Sciences, a member of many American and international scientific societies, and served a term as President of the American Association for the Advancement of Science. While still a young man, he acquired the honorific of Professor Hilgard, and even while serving as Superintendent of the Coast and Geodetic Survey he was commonly referred to in the press as Professor Hilgard.

Professor Hilgard was a well-regarded public speaker, and his lectures were often published. As was noted in 1875, "[h]is essay on 'Tides and Tidal Action in Harbors' first published as a lecture before the American Institute, is remarkable for its lucid and terse exposition of principles without the aid of mathematical symbols. While possessing great facility in employing the aid of the higher mathematics, Mr. Hilgard systematically avoids, as far as practicable, their introduction in his writings, preferring to use logical statements of the processes of reasoning".[8]

In the late 1870s, while serving still as Assistant in Charge of the Office, he taught lecture courses on extended territorial surveying at Johns Hopkins University. It is ironic, then, that these lectures at the university in Baltimore were the only occasions in his life when Professor Hilgard ever attended a school. His career was hence contrastive to that of his younger brother, Eugene Woldemar Hilgard (1833-1916). Seven years younger than his older brother, as a very young ma he followed his brother to Philadelphia and then to Washington to meet Julius Hilgard's companions at the Coast

[8] Youmans, p. 618.

Survey, but when an opportunity arose to return to Germany to study chemistry, he took it. After a varied academic career, he received his PhD. under Professor Bunsen (as in the Bunsen burner) and returned to the United States, where his scientific career began in agriculture and geology in the state of Mississippi, on the eve of the Civil War. Despite chaotic times, Hilgard made pioneering discoveries about the geological history of the Mississippi River embayment (a term he coined) and the relations between geology and soil formation and agriculture. In 1880, as the Survey was very active in geodesic leveling of the Mississippi River system, along with Henry Mitchell's new role as the Survey representative to the Mississippi River Commission, the Survey published Eugene Hilgard's 1871 map of the Embayment in the annual report for that year.[9] Eventually Hilgard transferred to the Agricultural School at the University of California, Berkeley, where he spent the rest of his scholarly life. Hilgard Hall is named for him.



Geological Map of the Mississippi River Embayment, by Eugene Hilgard, 1871

The Coast and Geodetic Survey, Congress and the President, and Science in the Federal Government

The traditional approach to the history of the Coast Survey and other institutions of American science has been largely "from the top down", concentrating on the highest levels of leadership and policy and funding; this present enterprise is part of another approach entirely, an attempt to discern the history of the Survey "from the fieldwork up". Nevertheless, Hilgard's administration as Superintendent, and those of the next two successors, cannot be comprehended without reference to the standard histories of

[9] See E. Hilgard, 1871, and Little, Appendix No. 12, annual report for 1880

science in the 19th century, for never before this era nor since was the Survey buffeted and threatened by forces bent on great change in the agency, including its entire elimination. In the 1870s and 1880s there was a series of events, scandals, investigations and commissions, alliances and betrayals, which affected the Survey. In the middle of this period, in 1885, in about one month, Professor Julius Hilgard plummeted from his status as one of the most admired and productive scientists in the American government to that of a dishonest drunkard, the only leader of the Survey in its entire history who was forced to resign from office. But making sense of this dramatic fall requires attention to events both preceding and following his disgrace.

The 1870s and 1880s were a period of great contradiction in the sciences in the federal government. On the one hand, it was a tremendously productive period, characterized by major explorations of the deep ocean and elsewhere by the Survey, and a series of overland explorations of the inter-mountain west and its complex geology, and explorations and research in the Pacific from tropical islands in the south to the vast domain of Alaska and the Arctic in the north. New federal agencies were created and whole series of landmark publications were issued. On the other hand, the same time period was characterized by a profound shift in public and Congressional sympathies towards funding science by the government, such that for the remainder of the century "the Coast [and Geodetic] Survey and other scientific bureaus were continually harassed by the forces of economy".[10] Throughout its existence the Survey had fought off the U.S. Navy's attempts to take over the Survey; now it had to face similar overtures concerning newly created agencies, particularly the U.S. Geological Survey. Throughout this period, Democrats were steadily restoring their pre-war powers, so the Survey's relationships with Congress in general and specific Congressmen were changing rapidly. Finally in 1884 Grover Cleveland was elected the first Democratic President since before the Civil War. Within his first year in office, and his first set of political appointees, Professor Hilgard was dismissed and disgraced, but the Survey's travails would continue for over a decade more.

A short chronology of significant events that led to Hilgard's fall, and the aftermath, should begin with the Congressional request to the National Academy of Sciences to examine and make recommendations concerning the proposed new Geological Survey and its relationship to the Coast Survey. The NAS report, released in 1878, advocated the transformation of the Coast Survey into a Coast and Interior Survey in the Department of the Interior, with responsibilities for a national geodetic network and topographic mapping of the interior, in addition to nautical mapping and allied research along the coasts. This new survey would be complemented by a separate Geological Survey, with separate functions concentrating on mineral exploration and mapping and allied research. Instead, the Coast Survey became the Coast and Geodetic Survey, still under the Department of the Treasury, while in 1879 the Geological Survey was created in the Department of the Interior and given primary responsibilities for topographic mapping outside the coastal areas. In 1881, Hilgard succeeded Patterson as head of the Survey, while John Wesley Powell replaced Clarence King as head of the Geological Survey. Relations between these theoretical rivals were actually quite cordial,

[10] Manning, 1975, p. 188.

as Hilgard and Powell had become close friends during the years of negotiations and planning about the new survey. In 1882, Hilgard sponsored Powell's membership to the National Academy of Sciences, while at the same time beating back yet another attempt by the Naval Hydrographic Office to take over the Survey.[11] In 1884, Congress set up a joint committee to investigate the entire suite of scientific agencies in the federal government. The Commission worked for two years, and hence overlapped, and to some extent triggered, the fall of Professor Hilgard.

William B. Allison (1829-1908) Republican Senator
from Iowa and Chairman of the Allison Commission.

The Allison Commission was set up nominally to investigate all scientific agencies in the government. It's official title was "the Joint Commission to consider the present organizations of the Signal Service, Geological Survey, Coast and Geodetic Survey, and the Hydrographic Office of the Navy Department, with a view to secure greater efficiency and economy of administration of the public service in said bureaus.[12]

[11] Rabbitt, p. 9, 62.
[12] Allison, 1886.

In reality, there were two separate major investigations. The first was centered on the Coast and Geodetic Survey, and its relationship (or the lack thereof) with the Navy on the one hand, and with the new Geological Survey on the other. The second major investigation was concerned with the Signal Service of the U.S. Army, and particularly with its meteorological research and activities. Here the major question was whether a nascent national weather bureau should be a military or civilian institution[13]. A related matter, not directly addressed by the Allison Commission but closely related, was whether or not the Naval Observatory and its functions should also be turned over to civilian authority.[14]

The Allison Commission's deliberations were complicated by the fact that in 1884, Grover Cleveland was elected President. Thus in 1885 a Democratic administration entered Washington with political priorities that differed sharply from the successive Republican administrations that had occupied the White House for over a quarter century. The new Secretary of the Treasury appointed a brace of new auditors, including a former Confederate officer from Texas named James Q. Chenowith, who entered the Capital with an agenda. Within the year Professor Hilgard was to fall from grace.

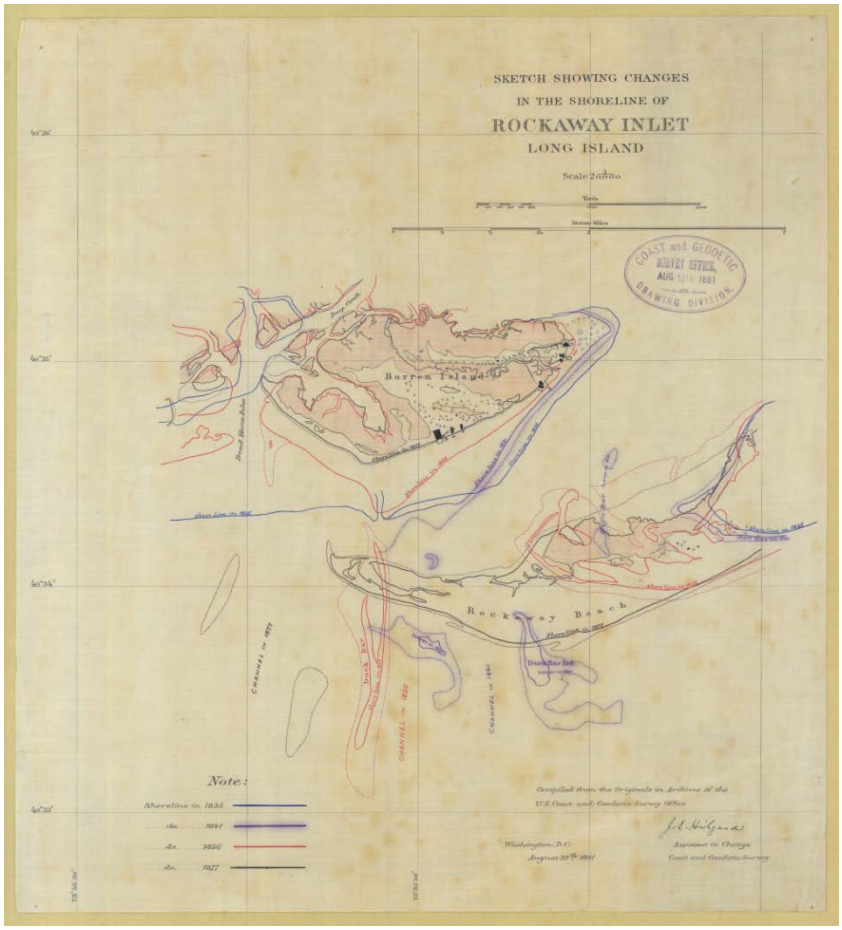
With this introduction to Julius Hilgard as a man and a scientist and a leader of the Survey, and the larger political context of the era, let us take a look at the realized work of the Survey during the short and abruptly truncated tenure of Professor Hilgard. Hovering in the background is the axe that is soon to fall, but then again, this is also just another episode in the very complex relationship of the Survey to the rest of the federal government and the thrust of science in American history[15].

Hilgard and the Survey at the transition in 1881

Julius Hilgard joined the Survey in 1843, when he was eighteen. Thirty-eight years later, Superintendent Carlile Patterson died, and Hilgard faced his third chance of becoming the head of the Survey. He had been considered, but rejected, by Joseph Henry as a successor to Bache in 1867, and he was evaluated again by Henry in 1874 when Benjamin Peirce decided to relinquish his absentee post and focus completely on his career at Harvard. With Patterson's sudden death, Hilgard had another chance at the position, at 56 years old. Apparently his chance came too late. By the time of his ascendancy, he had acquired some sort of physical and mental illness, which was either deeply mysterious or was of such a nature that it was never discussed. Hilgard's memorialist Otto Tittman, who had himself been Superintendent later on, described the sorrows of Hilgard's later life. He and his wife had 4 children, of whom 3 died young, and the last lived to be a young adult and then died, "leaving him childless and overwhelmed by grief at a time when a fatal illness had already begun its inroads on his mental and physical strength. This disease had seriously impaired his health when he

[13] Hawes, 1966.
[14] Rabbitt, pp. 9-10.
[15] The best overview to this remains Dupree, 1957, but much useful information may be found in Rabbitt, 1980, and Manning, 1975 and 1988.

was appointed to the superintendency, which, to use his own words, came 'too late'. He was conscious of his failing strength and ability while still occupying the position of superintendent, on more than one occasion he gave expression to the wish that the burden of his duties might be shifted to other shoulders".[16]



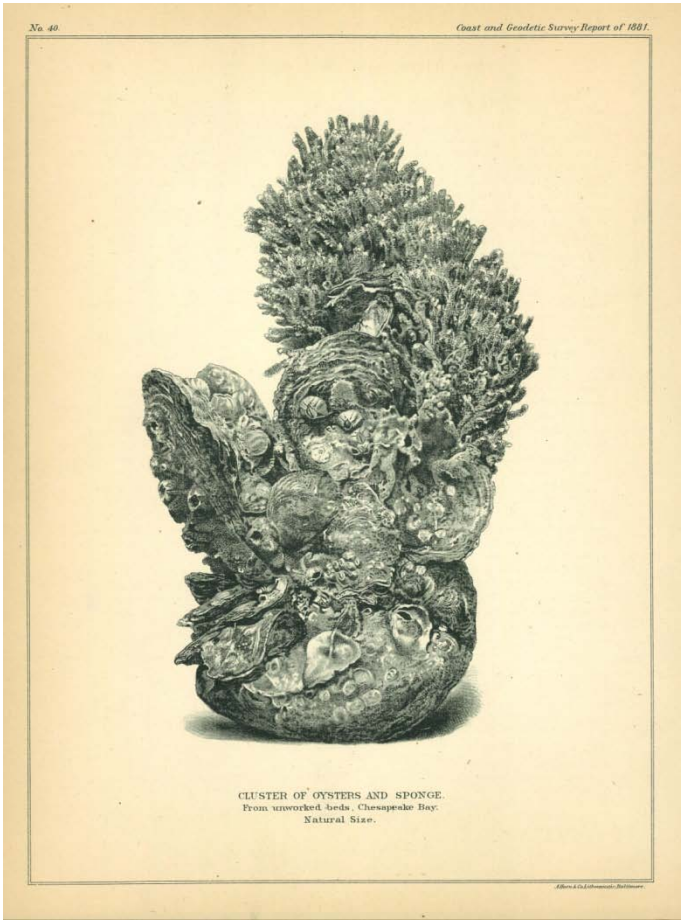
Changes in the Shorelines at Rockaway Inlet 1834 to 1881 approved by Julius Hilgard, "Assistant in Charge" August 21, 1881

When Carlile Patterson died suddenly , Julius Hilgard was immediately made the acting Superintendent in a role he had played during the Civil War when Bache was incapacitated, and which he also played for much of the Peirce superintendency, while Peirce remained in Cambridge, Massachusetts. But Hilgard, capable as he was, was still a foreign immigrant who spoke with a pronounced accent. It would be months before the U.S. Congress officially ratified him as Superintendent, leaving him in his perennial role in the Survey: "Assistant in Charge".

The range of projects completed or published in that fateful year of transition shows the Survey's remarkable productivity, despite the mounting pressures to economize and trim budgets. Superintendent Patterson had directed Lt. Francis Winslow

[16] Tittman, 1895, p. 465.

to begin the Survey's oyster work with biological research on oyster biology and reproduction, coupled to mapping oyster beds and reefs in Chesapeake Bay and Virginia rivers geodetically. Sadly, Patterson didn't live to see Winslow's great treatise.[17] Winslow's techniques for oyster research were the foundation for all subsequent American progress in the complex science of oysters.[18]



No 40, Appendix 11, Francis Winslow's first treatise on the status of natural oyster beds in Chesapeake Bay and tributary estuaries

1881 was the centennial of the end of the Revolutionary War signified by Cornwallis' surrender at Yorktown. The Survey created a specialized chart to commemorate the centennial. The chart featured contemporary topography and hydrography from recent surveys, with an inset map of the town of Yorktown as first surveyed in 1851, the 'oldest" version of the town the Survey had. The original copper plate was lavishly engraved, and then the plate image was transferred for lithographing and printed with a special dark "antique" ink. "The mapping merits the praise it has received from the topographical draughtsmen who have seen it"[19].

[17] Winslow, 1881.
[18] Keiner, pp.74-75.
[19] The Washington National Republican, October 3, 1881.

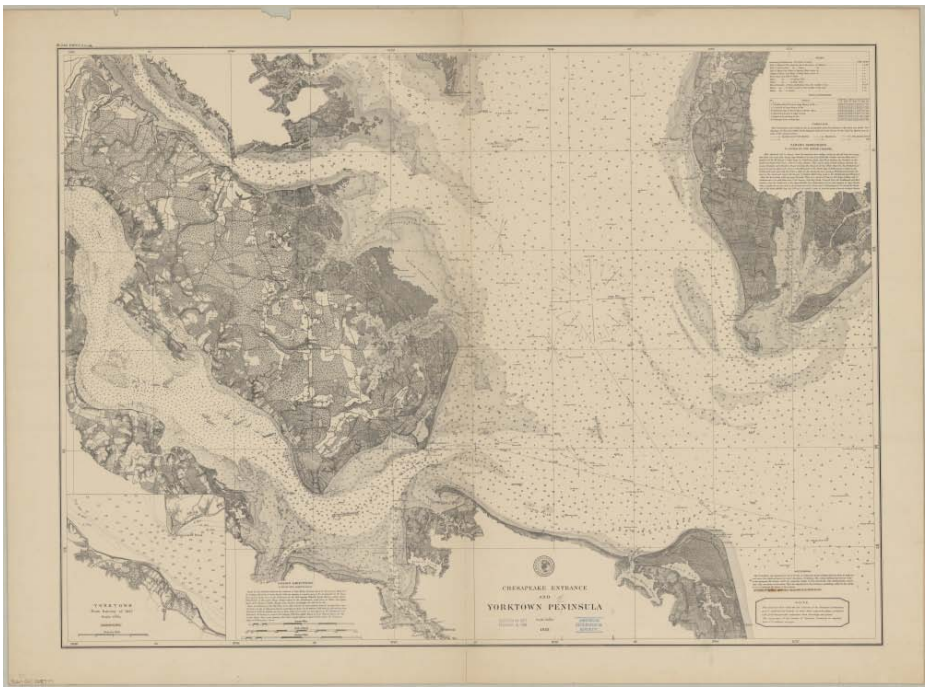
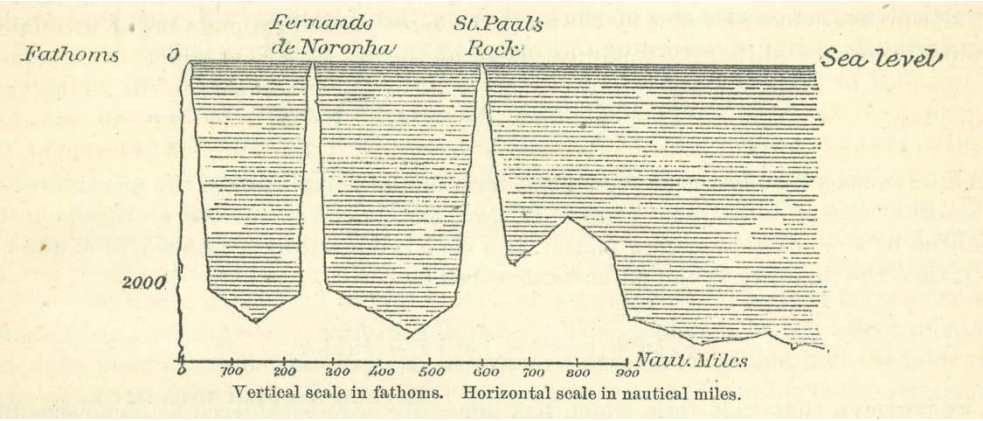


Chart 3007 Chesapeake Entrance and Yorktown Peninsula

The Survey's polymath Charles S. Peirce continued working on many research projects, including new map projections based on elliptical functions[20], work on fundamental standards of measurement as chief of research in the Office of Weights and Measures, and, finally, his pioneering research in the determination of the value of gravity as measured with systems of pendulums. Through his work, he deduced the ellipticity of the earth,[21] and he began to develop compensations for the gravity imbalances common to coastal observation sites, as they were located at the boundary between oceanic and continental masses and densities. As in many other matters, his research anticipated earth science methods and theories half a century or more ahead.



[20] See Craig, 1882.
[21] See Peirce, 1881.

Islands and oceanic crust. Form report on
Gravity corrections for coastal and island pendulum stations
From Peirce, Appendix No. 15, Annual Report for 1881.

Superintendent Peirce acquired the Survey ship *Blake*, and Superintendent Patterson had deployed it for pioneering deep-water soundings in the Atlantic and the Gulf of Mexico. Under Superintendent Hilgard, that work crystallized in ever more complex models of the deep sea terrain offshore.

Deep Sea Soundings in the Gulf of Mexico and the Caribbean,
with profiles and depiction of basins, Sketch No. 21, 1881

Essentially at the other end of the oceans that the Survey was responsible for mapping, William Dall, who was developing another entire research career as a mollusk specialist at the Smithsonian Institution, synthesized his own and other's data on sea currents and temperatures in the Bering Sea and adjoining waters, where he had been exploring since the 1860s.

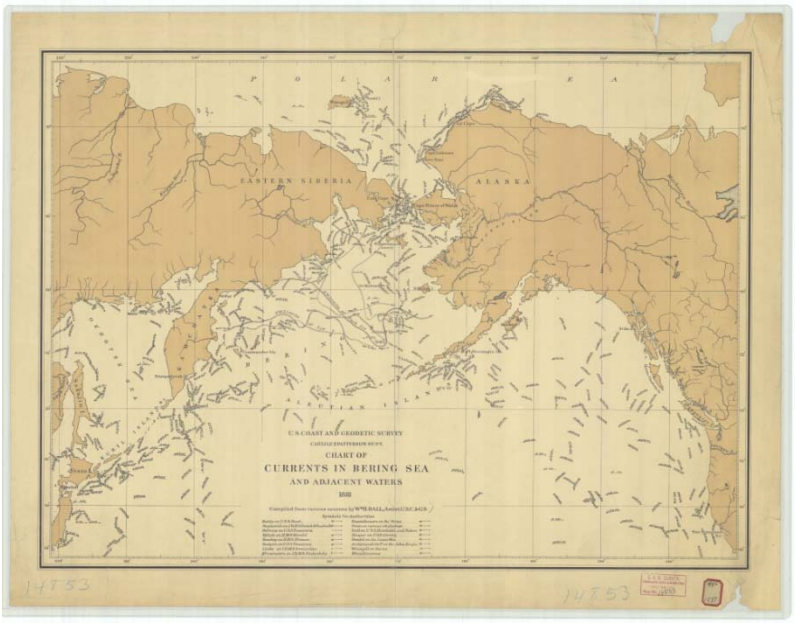


Chart of Currents in Bering Sea and Adjacent Waters, compiled from various sources by William H. Dall, 1881[22]

Edwin Hergesheimer, the master draughtsman of the Survey, continued his research in new and improved methods of topographic mapping and especially new standards of graphic conventions for specific landscape element classes, both botanical and geological.[23] He appears to have had a great affinity for volcanic landscapes and especially recent volcanism. His masterly studies of the landforms at The Dalles, on the Columbia River in Oregon and Washington, are extraordinarily detailed. He also developed novel graphic patterns to describe the eddy currents in the river.

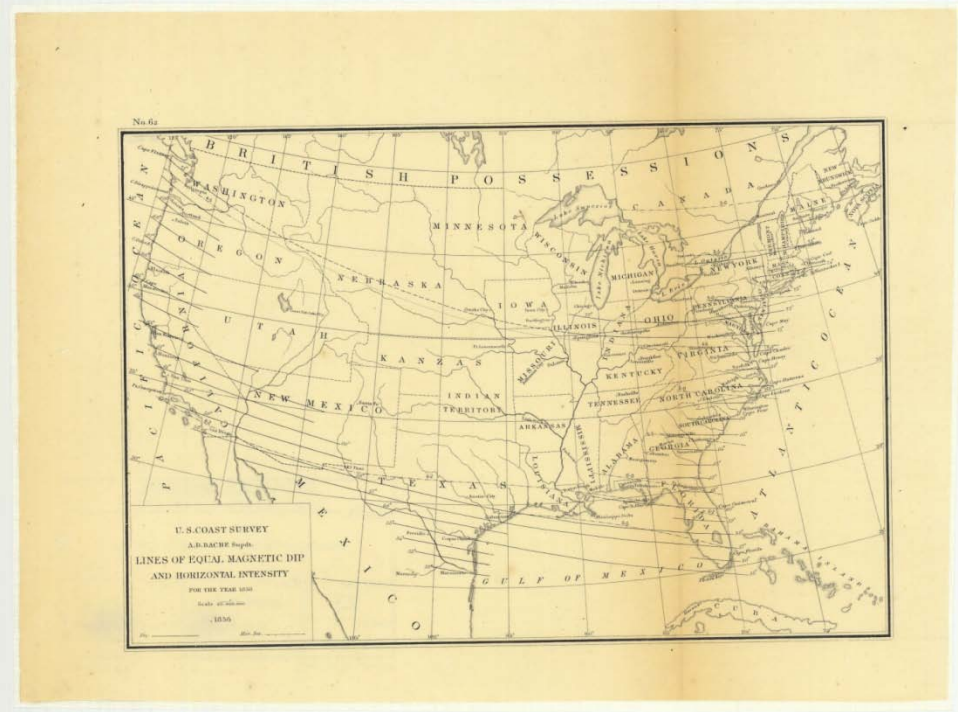
[22] See Dall, 1880.
[23] See Hergesheimer, 1881, 1883.

The Dalles on the Columbia River
Sketch No. 33, 1881

The Magnetic Year 1882 in the Survey

Research in terrestrial magnetism in the Survey really began under Superintendent Bache. As a young assistant, Julius Hilgard had collaborated with Bache to create and publish the Survey's first isogonic charts (charts of the lines of equal magnetic declination) in 1855 and 1856[24]. These were calculated for the continental United States back to the epoch of 1850, when the Survey began work on the Pacific coast.

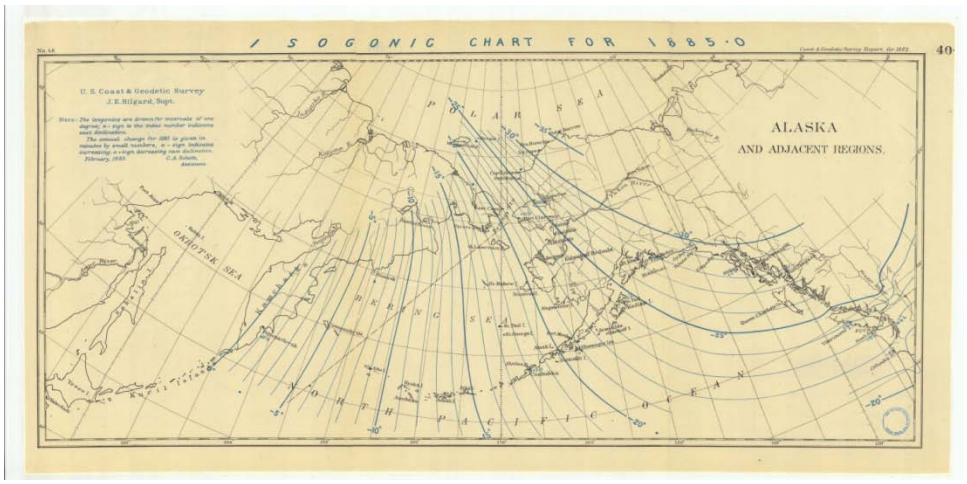
[24] See Bache and Hilgard, 1856. See Bauer, 1902, for the history of magnetic research in the Survey.



Lines of Equal Magnetic Dip and Horizontal Intensity
For the Year 1850, by A.D. Bache and J.E. Hilgard, 1856

In one of the few pleasing symmetries of Hilgard's short tenure, the Survey produced a new set of isogonic charts, projecting to the immediate future, to the epoch 1885.0 (January 1, 1885). As Charles Schott noted, "Of late years the magnetic work of the Survey, both in the field and in the office, having been pushed forward very actively, as may be seen in the recent publication of results, it appeared equally desirable to bring this new material into use at the earliest practicable moment".[25] Fittingly, one of the new isogonic charts was the first the Survey produced for Alaska and adjoining regions. George Davidson prepared a major work in astronomy, a field catalogue of 1278 stars with their mean places for the epoch year 1885.0.[26] This project was a very early instance of modeling and forecasting a geophysical parameter.

[25] Schott, 1856, p. 277.
[26] See Davidson, 1883.

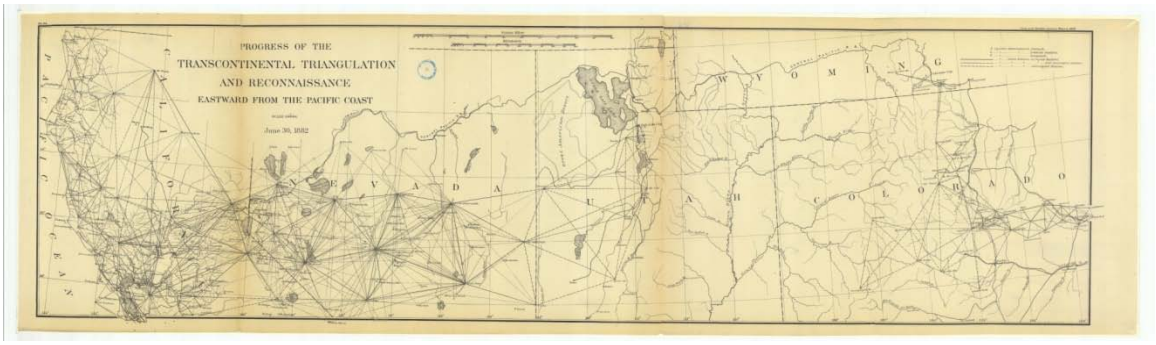


Isogonic Chart for 1885.0 for Alaska and
Adjoining Regions Sketch No. 40, 1882.

The ship *Blake* had over several years made sufficient soundings to reveal the basic structure of the Gulf of Mexico. Various Survey scientists, especially Adolf Lindenkohl, extended these investigations into pioneering research in what would now be called physical oceanography. Lindenkohl correlated the patterning of sea temperatures at the surface and at the bottom in a series of large hand-drawn and color washed original bathymetric maps, which would be foundational to subsequent publications in later years, presented in English in the Annual Report appendices, and in German in Petermann's Geographische Mitteilungen.

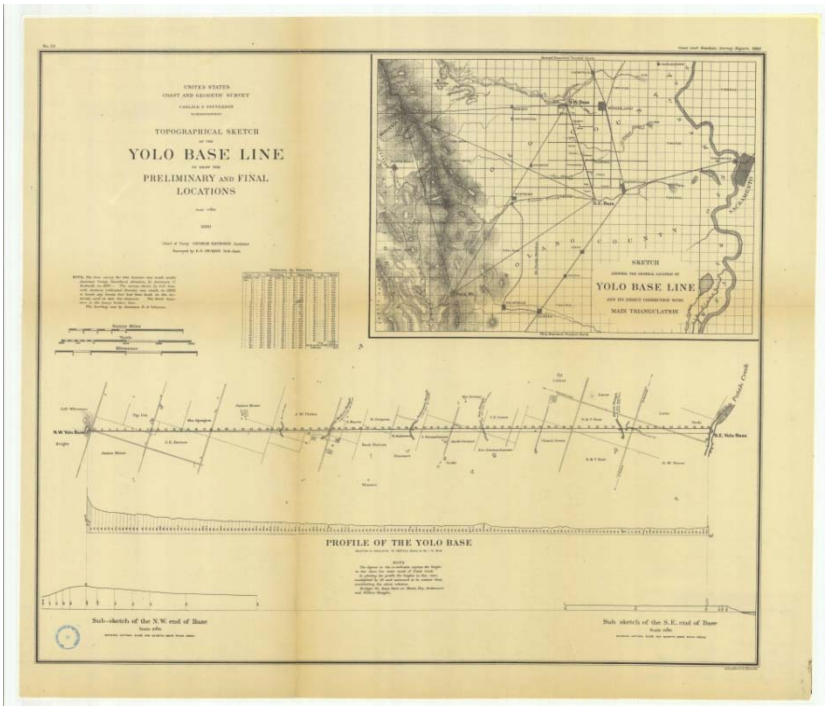
Waters of the Gulf of Mexico Showing Currents, Surface and Bottom Temperatures and Soundings
By Adolf Lindenkohl, 1882

The Great Arc of the 39th Parallel Survey had begun in 1871. 11 years later, in 1882, the network from the west had been completed only as far as central Nevada. From the east, reconnaissance had only been completed to Uncompaghre Peak with no observations having been completed from the Rocky Mountains to Salt Lake City. Although reconnaissance had been completed to Uncompaghre Peak from the east, large sections of the projected survey scheme remained to be done.



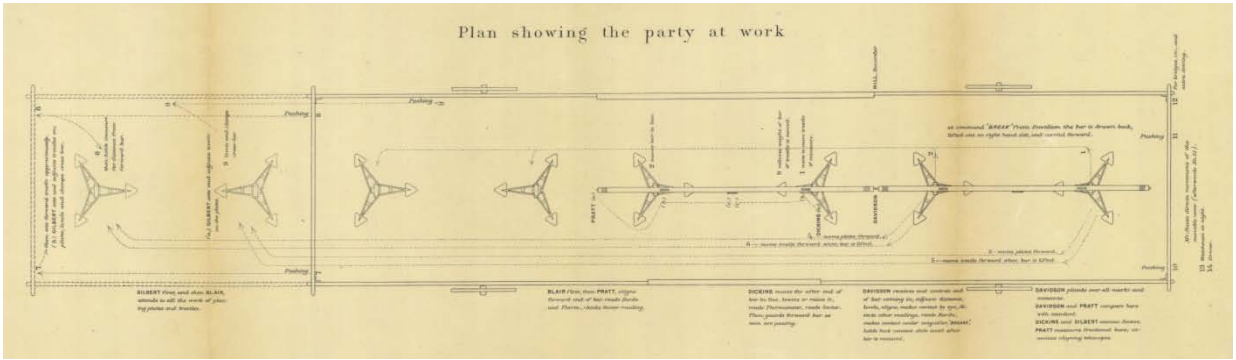
The Western Triangulation Network, No. 24, Annual Report for 1884

Many of the geodetic survey personnel returned to the western end of the network for continued work strengthening the Davidson Quadrilaterals. For various reasons, Davidson had revised his great western base line, the Yolo Base Line, located in as flat a terrain as could be found in the Sacramento River valley, with base line end monuments that could also be sighted clearly from the key sites of the original two quadrilaterals.



Topographical Sketch of the Yolo Base Line
To show the Preliminary and Final Locations, 1882

In 1882, the base line was re-monumented and measured, using the newest iteration of precise measurement, the Survey's 5-meter base apparatus. Davidson published 4 sketches in the annual report showing key hardware elements of the assembly, the construction plans for bridges to cross arroyos encountered on route, etc. The base line party in operation required a degree of coordination and precise, repeated operations by a team functioning almost like a living railroad train, slowly progressing along the track, and shielded from the intense California sun by a moving tent structure. Davidson showed the precise choreography of the team members as they made two sets of observations and moved one incremental step forward[27].



[27] See Davidson, 1882.

Use of the 5 meter Base Apparatus
Plan showing the party at work, 1882

Cartographic production work was not greatly diminished by the growing pressures to reduce budgets, and in fact, in lieu of expensive field operations it was often cheaper and easier to increase cartographic office work to deal with the inevitable backlog of work. Several aspects of the throughput of cartographic work and intellectual labor in chart making may be seen by examination of an interesting pair of map "originals" that the Survey found important enough to register into the Library and Archives Collection.

Unfinished Chart 672 Santa Monica to Point Conception (1881)

The unfinished manuscript chart shows how Survey hydrographers created grids of soundings in order to characterize the bottom as completely as possible. They then sketched shallow depth contours, and also determined which subset of soundings to keep on the chart, eliminating some because they cluttered the map.

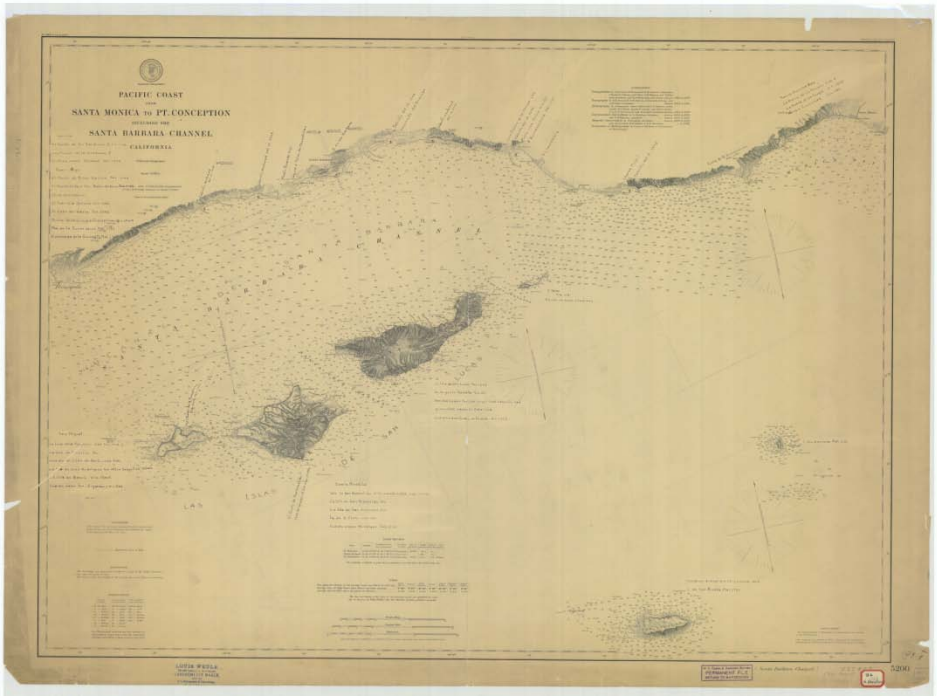


Chart 5200 Pacific Coast Santa Monica to Pt. Conception
With historic place names by George Davidson

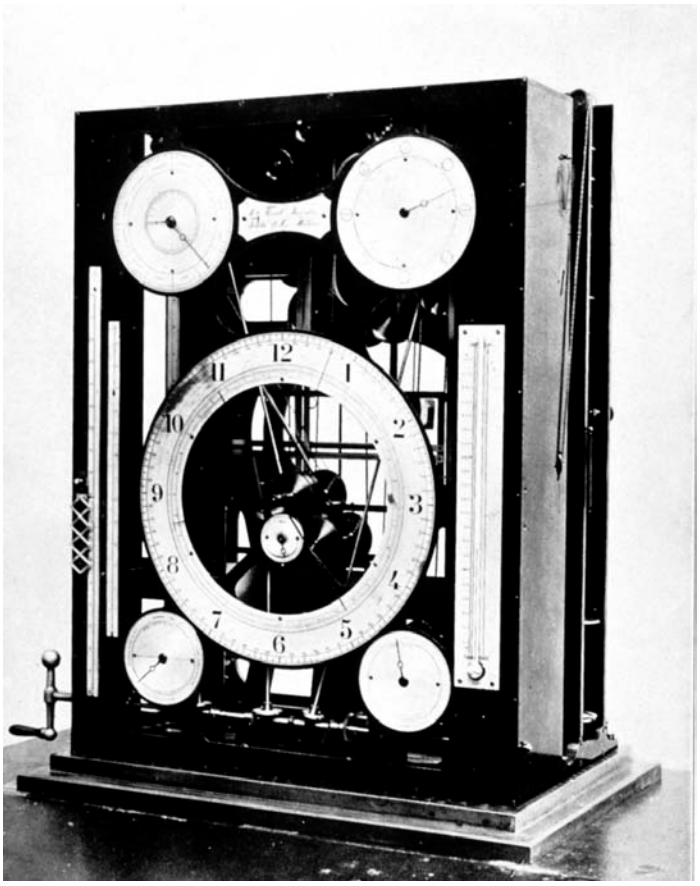
Geometry and the curvature of the earth limited the Survey's abilities to position soundings in the straits between the near and far Channel Islands—it would take the eventual development of Radio Acoustic Ranging in the 1930s, which was perfected using these very islands as an experimental laboratory, to "fill in" the chart.

The published version of the chart was a lithograph photographically transferred from a print from the original engraved plate. The much lighter print density of the coastal and island topography on the published chart, compared to the unfinished original, reveals the distinction between engraving and lithographing. This published chart is further interesting in that it was one of George Davidson's sets of sailing direction-scaled charts covering the entire Pacific coast that he hand-annotated with the many disparate place names for prominent places, mainly capes and points, as they were named by historic explorers and cartographers going back to Spanish, English, and Russian explorers back to the 1500s.

1883 and the Turning of the Tide

By Hilgard's tenure, William Ferrel had worked for the Survey for almost two decades. He did many kinds of investigations, but his major contributions were to develop methods of harmonic analysis applied to recurrent phenomena, and studies of weather and ocean phenomena, and global atmospheric and current circulations. Ferrel had been recruited to this work by Benjamin Peirce in 1867 when he became Superintendent. Much of this work culminated in 1883 with the completion of the

construction of his Tide Prediction Machine by the engineering firm Fauth and Co. in Washington, DC. William Thompson (Lord Kelvin) had completed the first mechanical Tide Predicting Machine in 1872-73, summing ten harmonic components. The Ferrel Tide Predicting Machine utilized 19 harmonic constituents, and was the first machine that could predict the derivative of the predicted tide, i.e., the time and amplitude of tidal maxima and minima.[28]



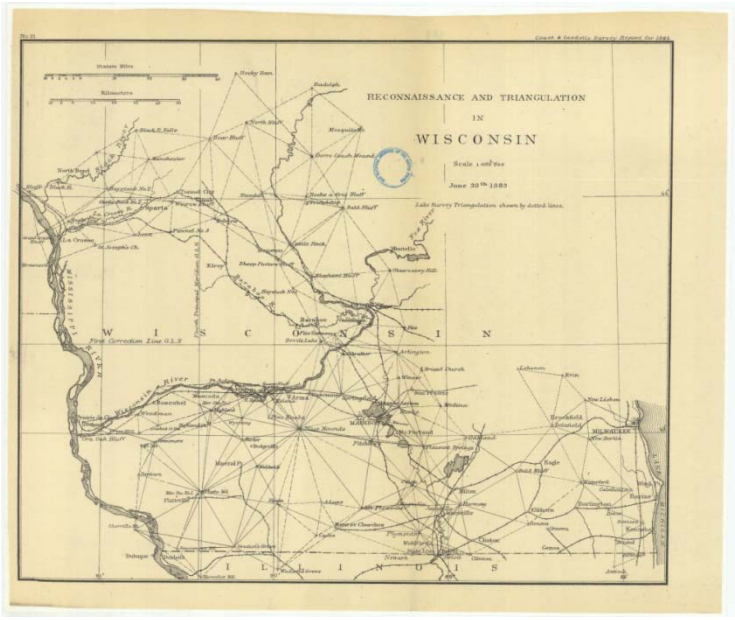
Ferrel Tide Predicting Machine

The Ferrel machine was used continually by the Survey until 1912, when it was displaced by Tide-Predicting Machine No. 2, one of the wonders in the history of analog computers. Eventually it was made obsolete by digital computers.[29] The Ferrel machine is now in storage in the Smithsonian National Museum of American History, and the No. 2 machine is in the NOAA Science Center attached to SSMC-4, Silver Spring, Maryland.

Geodetic survey crews continued the slow march across the continent from east and from west to continue work on the 39th Parallel Arc network. At the same time, the Survey continued working outward to the north and south extending first and second order geodetic control that could in turn be the basis for state and local positioning

[28] Cartwright, 1999, p. 106.
[29] See Hicks, 1967.

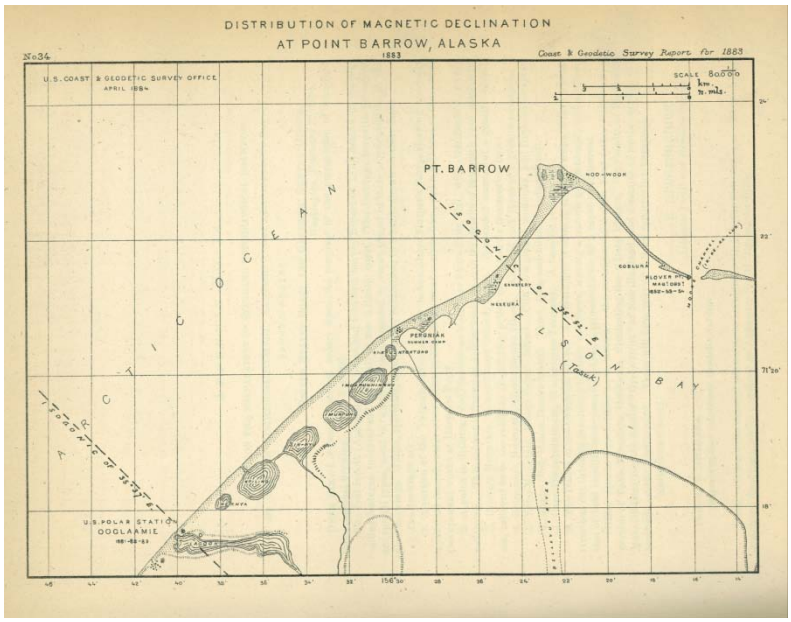
systems. One interesting element of this work completed in 1883 was the extension of Survey control into and across Wisconsin. In doing so, the Survey "tied in" to the Great Lakes geodetic network created by the Lake Survey of the Army Corps of Engineers. Less than a hundred years later, the Lake Survey would merge with the Survey in the National Ocean Survey.



Reconnaissance and Triangulation in Wisconsin
Including ties to the Lake Survey network, 1883

The Survey also participated in various ways with the American contributions to the first International Polar Year. The Survey contributed magnetic instruments and trained Army personnel who occupied a magnetic observatory at the U.S. Polar Station, at Point Barrow, Alaska from 1881 to 1883.[30]

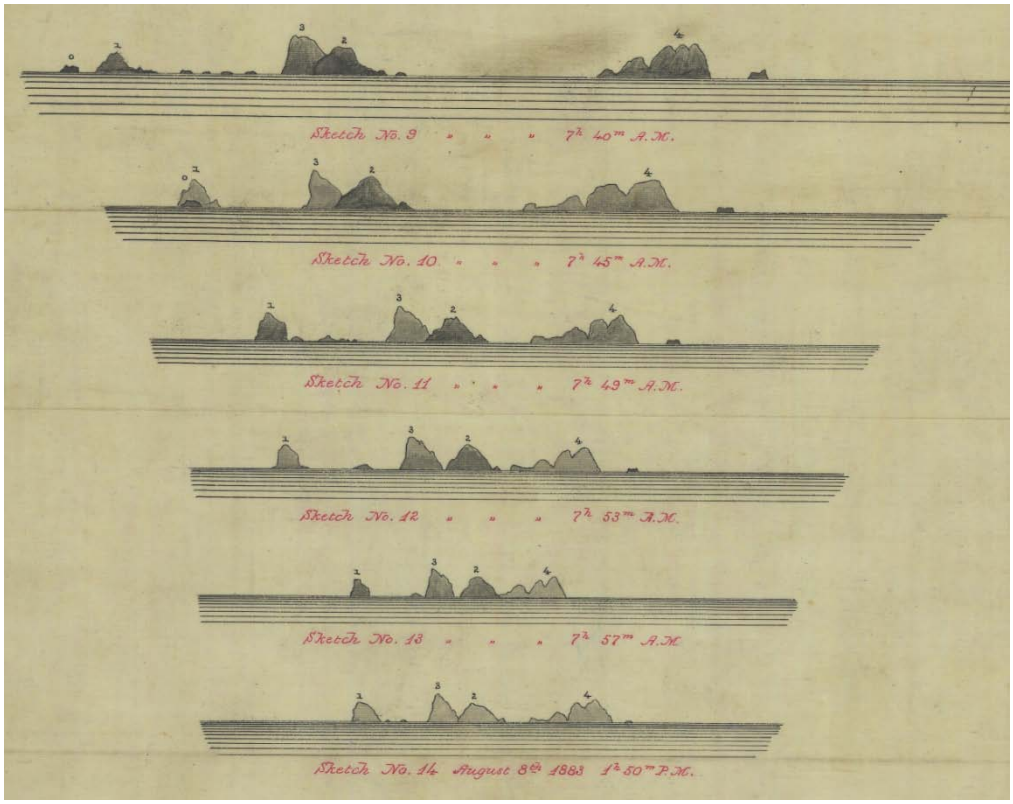
[30] See Schott, 1883.



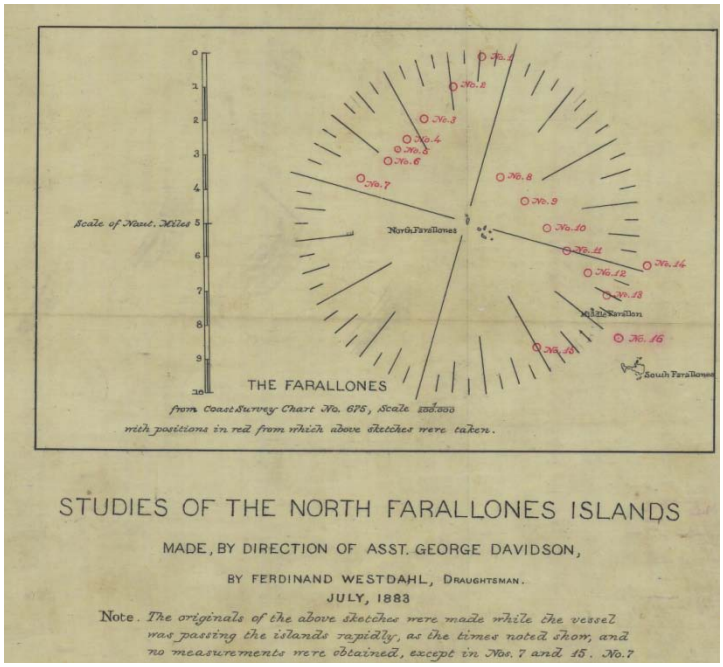
The Polar Year base and various Iñupiat compounds
At or near Point Barrow pm the Arctic Ocean

On the west coast, George Davidson was working on the plan for what would become his magnum opus, the 4th revised edition of the Pacific Coast Pilot, which would be published in 1889. In preparation for that volume, and in anticipation of a series of hundreds of new Pacific coastal views to replace the original views by William McMurtrie, dating back to the 1850s, George Davidson asked Ferdinand Westdahl to become an artist draughtsman of coastal views for the enterprise.

Ferdinand Westdahl (1843-1919) was a uniquely skilled hydrographer and geodesist who was also a draughtsman of unparalleled skill. He was born in Sweden and educated at the Swedish Navigation School. After immigrating to the United States, he worked for the Western Union Telegraph Company as part of its reconnaissance of telegraph cable routes between Alaska and Russia, which was also the gateway work to the Survey for William Dall. Westdahl joined the Survey in 1867. He was, until his death as the oldest living officer in the Survey, almost always at work on the Pacific Ocean, from California to Alaska to the Philippines. He and John Barker, who worked exclusively on the Atlantic coast, were the two greatest masters of coastal views in the Survey. Interestingly, the very foundational views of his career were carefully preserved. In 1883, George Davidson gave him a precise training exercise: sketching the cluster of small islets known as the North Farallones Islands, outside the Golden Gate in the Pacific. He had a bark at his disposal, and he sketched the islands at varying distances, from several locations and perspectives. It was Westdahl's version of "36 Views of Mt. Fuji".

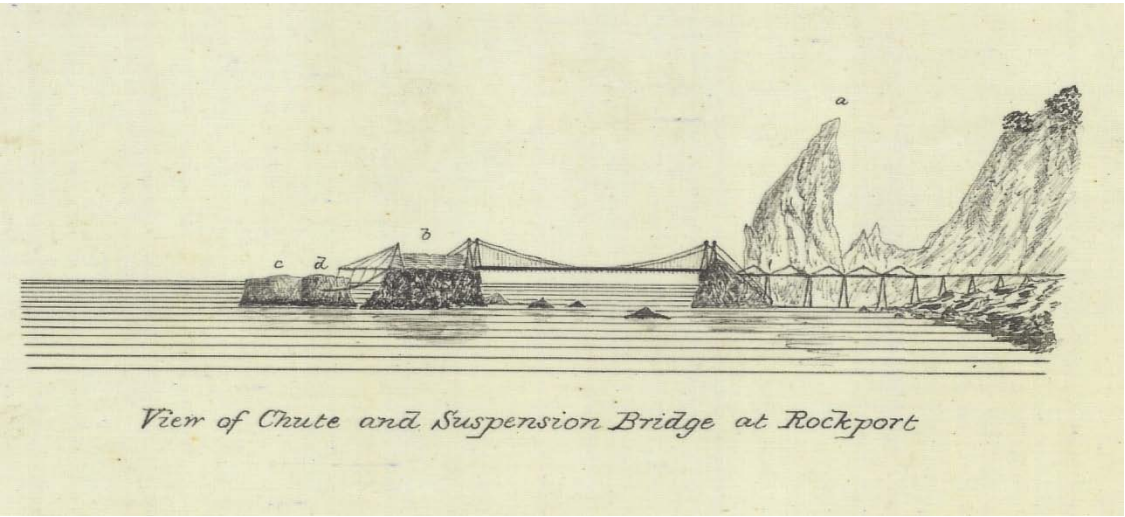


From Ferdinand Westdahl's Studies of the North Farallones Islands, 1883
Annotated tracing cloth version of the original views, now in the Library of Congress



Legend, Westdahl's Studies of the North Farallones Islands, 1883
A total of 17 views drawn in July, 1883

Between 1884 and 1886, Westdahl produced at least 400 views from the Mexican border at San Diego to Vancouver Island and the Georgia Strait. He also produced an unknown number of views as side drawings on topographic maps (t-sheets). These offer unparalleled sketches of the maritime technologies and transportation and commercial systems of the Pacific coast in an era before there were even rudimentary coast roads along most of the Pacific coast. Westdahl also utilized a convention of receding parallel lines to convey the waters of the ocean, imparting a calm zen-garden look to his drawings.



View of Chute and Suspension Bridge at Rockport, California
By Ferdinand Westdahl, from T-sheet 1322, 1883

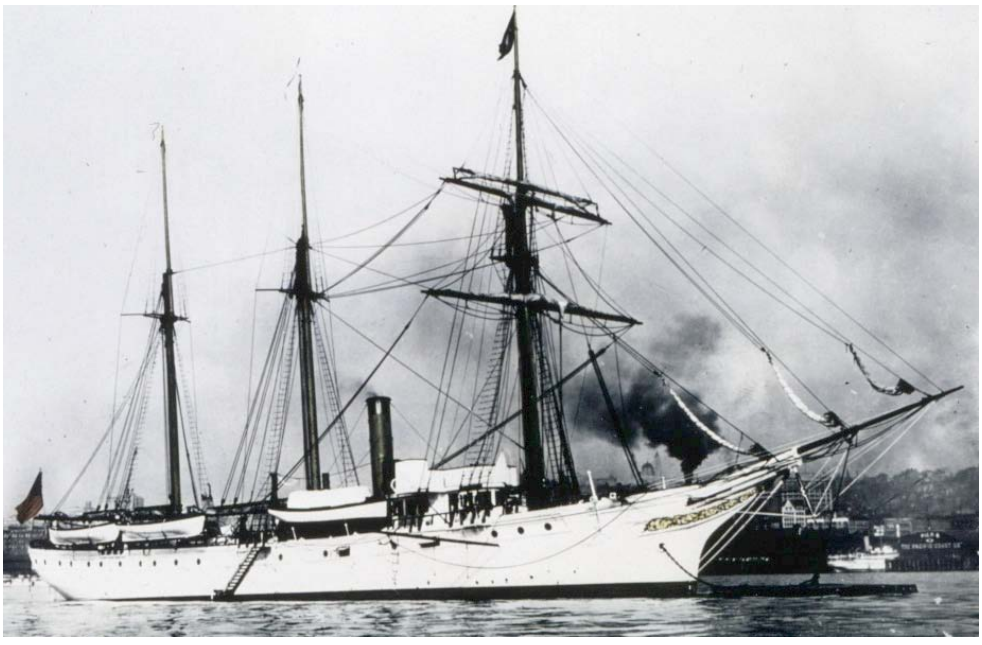
1884 The Last Good Year

President Arthur served out the term of the slain President Garfield and ended his career as President. In the election of 1884, Grover Cleveland was elected President, the first Democrat to occupy the position since before the Civil War. A difficult era of investigations and recriminations began in 1884 even before Cleveland's election, in a series of Congressional investigations. These, as they began, were not primarily concerned with the alleged improprieties and inefficiencies in federal agencies that would trigger Hilgard's downfall in 1885. As mentioned earlier, the Allison Commission hearings and investigations had two great objectives, one of which involved finding the right place and context for the Coast and Geodetic Survey, and its proper relationship to the work of the Naval Hydrographic Office on the one side, and the new US Geological Survey on the other. The testimony presented at the hearings, preserved and published in voluminous editions, offers extremely detailed data on the Survey and its functioning. In

1884 the reactions to the data were largely laudatory, but that would change radically the following year.

But 1884 began with as joyous a ceremony as can be imagined. Three years after Superintendent Patterson's sudden death in 1881, the Survey hydrographic survey vessel *Carlile P. Patterson* was christened in the cold January of 1884.

> "Miss Katie Patterson, the daughter of the late Superintendent, christened the vessel with a gaily decked bottle of champagne. At 11 o'clock the steamer glided gracefully into the water, her arch of Stars and Stripes floating in the breeze, while the surrounding tugs uttered their usual melancholy notes, indicative of welcome. Then everybody shook hands with everybody else and the ladies said the launch was 'just too beautiful for anything"…The *Carlile P. Patterson* is destined to survey the coast of Alaska, the scheme for the continuous survey of which was first planned by the later Superintendent… It was under the direction of the present Superintendent, Prof. J.E. Hilgard, that the special appropriation of $100,000 for the building of the vessel became available… The vessel will be manned by 13 officers and 40 men, who will be detailed from the Navy Department. Her first sail for Alaska will be in the Spring, and it is expected that she will be ready for active operations in the beginning of March, 1885".[31]



The Survey Ship *Carlile P. Patterson* (1883-1919)

[31] New York Times, January 16, 1884.

In 1884, the Survey published the first new chart series for the Potomac River since the charts created during the Civil War. These were unusual, particularly for the level of detail in the urban mapping of the City of Washington.

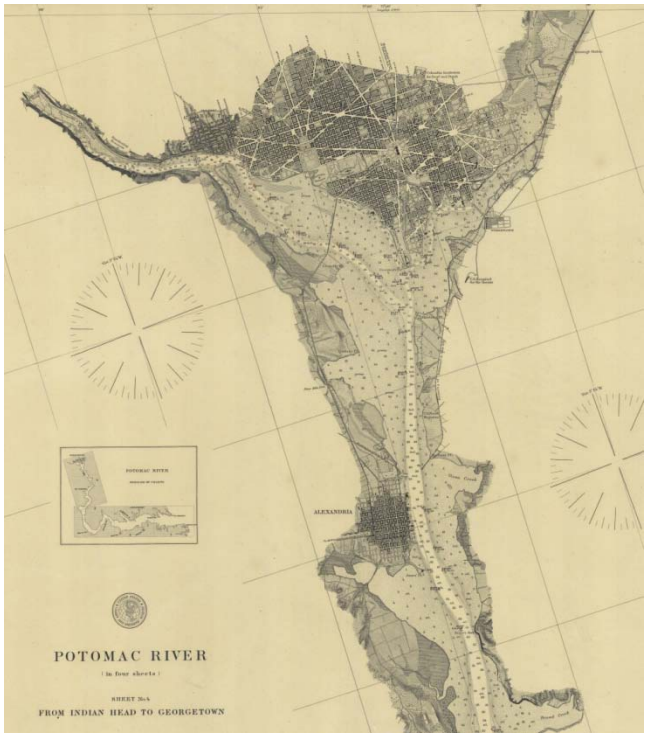
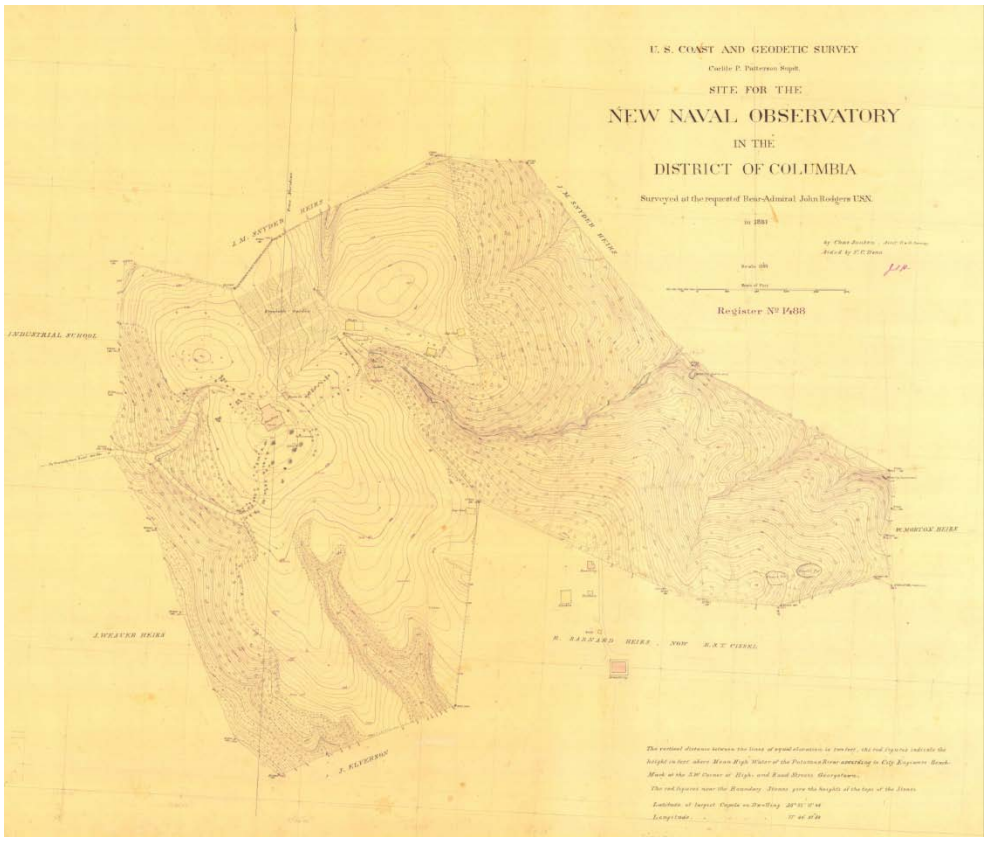


Chart 391 Potomac River, Sheet No. 4 1884
Cropped to show the City of Washington as distinct
from the County of Washington

Even though the Organic Act of 1871 had erased the distinction between the City of Washington, and the County of Washington, combining them along with the previously independent city of Georgetown in the unified District of Columbia, the Survey's map shows only the City and Georgetown. Later, Congress would authorize the Survey to map the areas of the previous county. During Hilgard's tenure, the Survey created a triangulation system and monuments designed to support a plane table survey of the entire District outside what had been the City of Washington.

The Survey did other surveys for specialized purposes outside of its usual mapping responsibilities. One such assignment under Hilgard's tenure was the task of preparing a detailed topographic map for the proposed site of the new Naval Observatory.



T-1488 Naval Observatory Site

Charles S. Peirce's invention and development of whole new classes of map projections based on systems of equations of elliptical functions led to a flowering of novel map projections for new applications (although many of Peirce's innovations, like the quinquncial projection were so advanced it would require half a century and the invention of aviation to make use of them). In 1884, the Survey released the North Atlantic Track Chart, the first long range route planning chart in its history, and the forerunner of many brilliant and cartographically superb aeronautical planning charts in the 20th century.

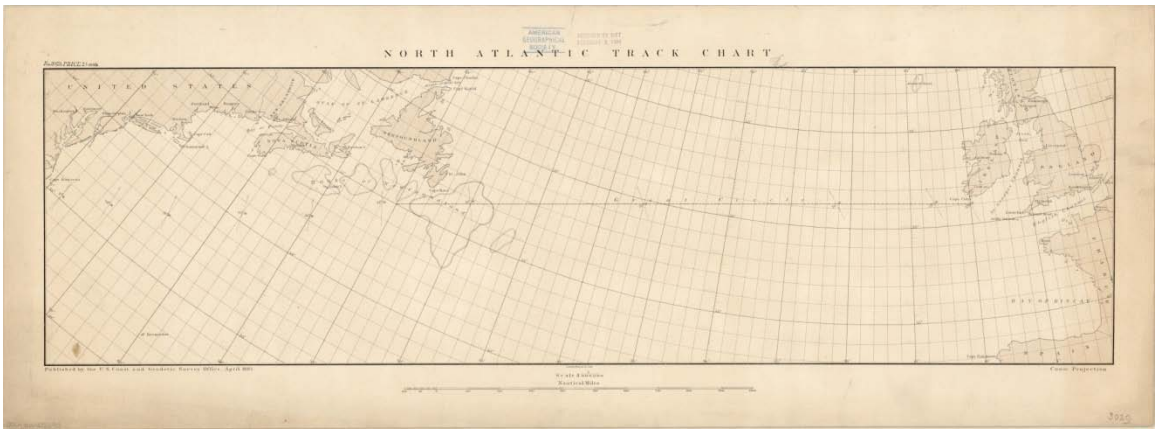
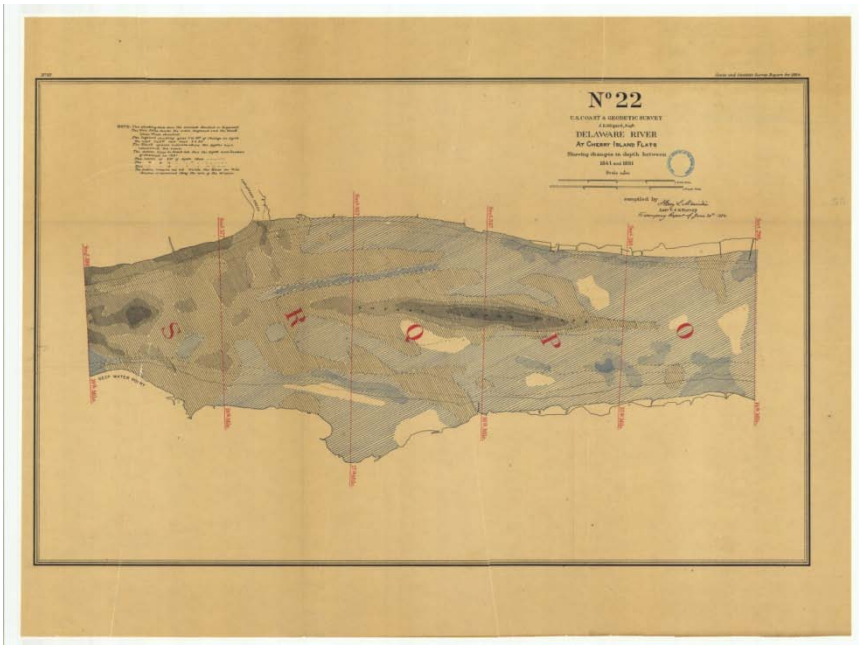
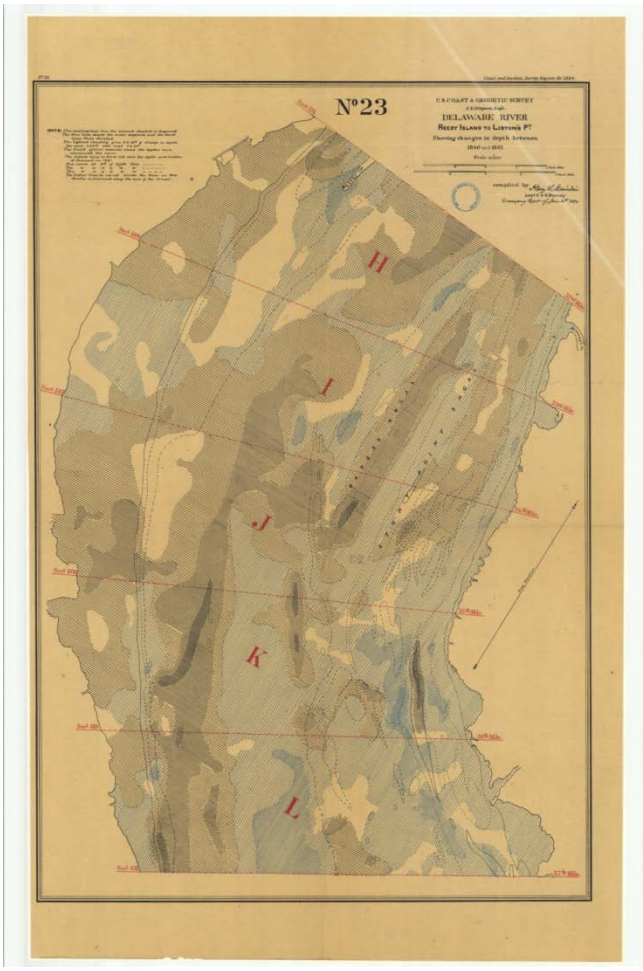


Chart 3029 North Atlantic Track Chart 1884
Developed on a Conic Projection

Cartographic sophistication was coupled with advanced hydrographic studies in Henry Marindin's study of hydrological and hydrographic changes in the Delaware River between the Survey's original studies in 1840-41, and Marindin's repeat studies in 1881.



Delaware River at Cherry Island Flats showing
Changes in depth between 1841 and 1881
by Henry Marindin, No 22, 1884

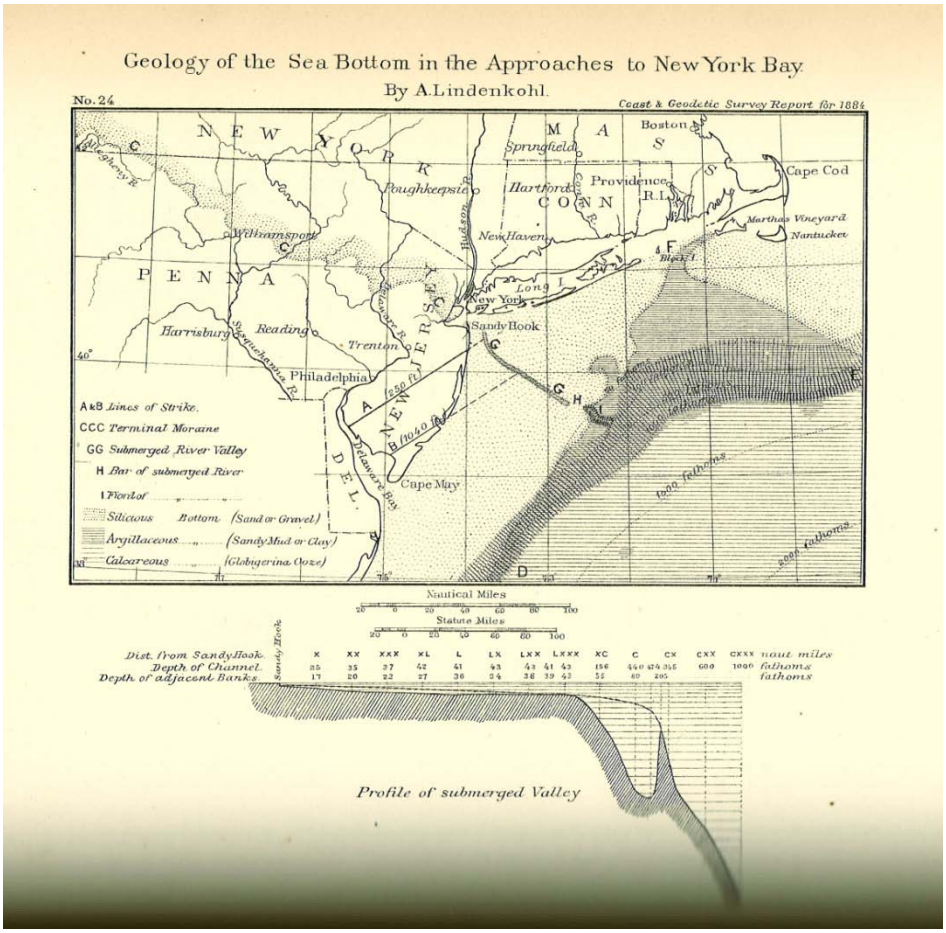


Delaware River from Reedy Island to Liston's Point
showing changes in depth between 1841 and 1881
by Henry Marindin, No 23, 1884

The red letters refer to river profile zones mapped as separate units. The colors of the river bottoms denote changes in the 4 decades between 1840 and 1881. Blue denotes deepening, black denotes shoaling, and the blank areas were substantially unchanged.[32]

Adolf Lindenkohl extended hydrographic and physiographic studies out to the edge of the continental shelf in his investigations of the submarine canyon of the Hudson River and the local geology of the area[33].

[32] See Marindin, 1884.
[33] See Lindenkohl, 1884.



Geology of the Sea Bottom on the Approaches to
New York Bay by Adolf Lindenkohl, 1884

This new sophistication of the Survey and its scientists in description and presentation of their research on deep ocean bathymetry and the functioning of ocean systems reached a certain melancholy finale, in retrospect, with the Survey's large 3-D models of the Gulf of Mexico and the Atlantic coast. The melancholy part is that the modeling of the Gulf of Mexico was particularly associated with Julius Hilgard[34], and the presentation and display of the various iterations of the models was considered to be a great triumph for him. Yet even at that moment dark forces were gathering against him.

But let us allow Hilgard a brief moment, once again, in the light shone by his achievements. Hilgard demonstrated the Gulf of Mexico model and lectured about it at meetings of the National Academy of Sciences and the American Association for the Advancement of Science. And the model was displayed at the Southern Exposition in Louisville, Kentucky in 1883. As reported later by Assistant Henry Blair of the Survey, the exhibits at the Exposition of a scientific nature were mainly by nine government agencies, including the Survey. "The object which attracted the most attention in the Coast and Geodetic Survey exhibit, Mr.Blair observes, was the model of the Gulf of

[34] See his Hilgard, 1880 in particular and also Hilgard, 1884

Mexico. Several applications for copies of it were received and many special visits were made to it by classes of advanced students, principals of schools, and other interested in geological and geographical studies"[35].

The Gulf of Mexico model, from Gulf Stream Explorations, No. 25, 1884

The model was Hilgard at his best: scientifically grounded on the best research, yet relatively accessible to all, the physical equivalent of Hilgard's preference, despite being a skilled mathematician, for lecturing and writing on mathematics without the use of mathematical symbols, "preferring to use logical statements of the processes of reasoning".

All that was about to end.

James Q. Chenowith, Slouching Towards Washington.

What eventually was known as the Allison Commission investigated federal scientific agencies from 1884 to 1886. Although there was some discomfort and some few serious issues raised, for the most part the Survey fared well before the Commission. The Commission was a joint panel of the Congress, so the budget cutting tendencies of the House were counter-balanced by the funds-restoring tendency of the Senate. And in any case, the full implications of the Commission really became realized after the Commission's work was done, in 1886.

[35] Blair, 1884, p. 489

In the middle of that process, though, Grover Cleveland, a Democrat, was elected President in November, 1884. Ho took office in March, 1885. The next month Cleveland appointed James Q. Chenowith to be the First Auditor of the Treasury Department. "He was an officer in the Confederate army and has served several terms in the State Legislature of Texas. He is a lawyer and a staunch Democrat".[36] Chenowith began his job on May 1, 1885. A month later, the Coast and Geodetic Survey was under his investigation. "The accounts of the Coast Survey for the portion of the last fiscal year which are now before First Auditor Chenowith have been suspended by that official, pending the completion of certain investigations which he has set on foot. The discoveries thus far are said to indicate that there have been many unnecessary expenditures and that in certain branches of the bureau great extravagance prevailed."[37]

The Survey was by no means Chenowith's only target. Scandal arose when Chenowith tried to fire a Civil Service top candidate named Kellar for a Treasury job because he was a Republican. This violation of the nascent Civil Service protocols now in place caused an uproar, known as the Kellar affair. Eventually Chenowith was forced to back down and apologize[38], although the scandal continued and Chenowith acquired a reputation for strong opinions quickly determined.

It is unclear what the next chain of events was, but within a month, headlines blared: "Coast Survey Surprise." "Acting on the recommendation of Judge Chenowith, First Auditor of the treasury, Secretary Manning [Sec. of the treasury] has suspended Prof. Hilgard, superintendent of the coast and geodetic survey; C.O. Boutelle, assistant superintendent; Mr. Morgan, disbursing agent; Mr. Saegmuller, chief mechanician; and Mr. Zumbrock, electrotypist of that bureau, pending an investigation into certain irregularities said to exist in the accounts of that branch of the service…. The Secretary has appointed… Mr. Thorne, chief clerk of the internal revenue bureau [and others] … to inquire into the alleged irregularities… Mr. Thorne… temporarily assumed charge of the office as acting superintendent."[39]

Hilgard protested the accusations, to no avail. "No instances of the alleged irregularities were cited, but Prof. Hilgard replied to the First Auditor indignantly denying the charges in toto, and asking of specific instances. He received no reply until he was informed of his suspension from office yesterday".[40] The news caused no little consternation in the capital. "The development of the case has caused a good deal of surprise, and a further report is awaited for with anxiety".[41] The New York Times published an editorial on the matter: "In the absence of proof the country will not readily believe that the officers of the Coast Survey have been unfaithful to their trust. Auditor Chenowith is not a conspicuous advocate of reform".[42]

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[36] New York Times, April 26, 1885.
[37] Ibid, July 2, 1885.
[38] Ibid., July 8, 1885.
[39] Ibid, July 25, 1885.
[40] Ibid, July 26, 1885
[41] Washington National Republican, July 27, 1885.
[42] New York Times, July 28, 1885.

Within the next week, the defenses of Hilgard and the rest of the Survey fell apart. Mr. Thorne was both acting superintendent and chief of the investigating committee examining the practices of the Survey. Whatever they found was determined to be damning. As Chenowith noted: "This branch of the service showed upon a first inspection irregularities which are glaring, and it was like unraveling a ball of twine—when it was started it kept coming out. Of course it is necessary to carry on this important branch of our government service, but one half of the money expended in this survey has been wasted. It may have been carried on according to scientific principles, but it surely was not managed on business principles". [43]

Matters got only worse. The New York Times published a long article only a week after its last reference to the scandal, with the headlines: "Drunk Most of the Time: Scandalous condition of the Coast Survey. Prof. Hilgard and some of his assistants continuously intoxicated—embezzlement, forgery, and frauds."[44] A few days later the committee's report was completed. "[It] reveals a sad state of things, much worse than anything intimated in the complaints of Auditor Chenowith"[45]. Essentially, what the committee discovered was a series of small improprieties and infractions that added up to a generalized disorderly bureau, compounded by a leadership vacuum at the top capable of noticing, let alone dealing with the embezzlement, pilferage and other problems that the committee found. In the end, much of all of it was blamed on Hilgard and his failures and intemperance; Hilgard had been suspended as superintendent, but now he resigned. "The present trouble in that branch of the public service is clearly traceable to an infirmity which has overtaken one man, whose long record of faithful and valuable service ought not to be lost sight of".[46] But whatever Hilgard's responsibilities and faults, as well as his virtues, it was over. He was gone from the Survey, and the Survey would now change. Although, for all that, of the others suspended in the initial scandal, Charles Boutelle was reinstated in the Survey, George Saegmuller insisted on a hearing, which absolved him of all charges against him, and Mr. Zumbrock returned to the Survey as a skilled electrotypist. Only Hilgard was utterly defeated and removed.

Chenowith had had a hot productive summer in the Capitol, and he saw clearly what worked. "When First Auditor Chenowith left for his vacation he gave directions for a thorough examination of the accounts and methods of the Geological Survey. This work was committed to gentlemen who have long been familiar with the subject. Upon his return he finds a full report ready for his inspection and action. It takes the ground that immense sums are wasted by this survey, and that a large proportion of its most costly work is being prosecuted without legal authority. It is likely that there will soon be a stoppage of accounts on an extended scale. There are grounds for the belief that the geodetic, topographic, and geological surveys now in progress in 17 of the older states will be declared wholly unauthorized. The contract with the state of Massachusetts to execute a topographical map of that State on a special scale is likely to be treated as

[43] Washington National Republican, August 4, 1885.
[44] New York Times, August 5, 1885.
[45] Ibid, August 7, 1885.
[46] Washington National Republican, August 11, 1885.

made without proper authority."[47] Of course, the US Geological Survey did not grind to a halt. Nor did Chenowith succeed so easily with his next target.

Chenowith next investigated the US Fish Commission, and specifically its director Spencer Baird, who was simultaneously the second Secretary of the Smithsonian Institution. Again, accusations were made of scandalous waste of funds and extravagances. These were easily rebuffed. Chenowith was summoned before his boss, Secretary of the Treasury Manning, who "scolded" him.[48] As the newspaper noted: "The Auditor means well, and would be a good officer if he had not allowed his head to be turned by his discovery of a bad state of affairs in the Coast Survey. His mistake was made in concluding that as there was one defective branch of the service the entire service must be rotten".[49]

Hilgard was dispatched in the hot summer of 1885. Chenowith's trajectory down was about as fast, ironically. By the winter months of 1886 he was being investigated for questionable expenditures of his own. His reign soon ended, and he returned to Texas.

But the Coast and Geodetic Survey had been disgraced, and Julius Hilgard, one of the ablest members it had ever produced, who had spent his life in the Survey, had resigned as a sick and broken man. As his memorialist Otto Tittman put it: "His retirement took place in 1885, and from that time on his lingering illness entailed great suffering, and several times brought him to the point of death. From each of these attacks he rallied back with less power of resistance until death relieved him of his sufferings, on May 8, 1891"[50].

Hilgard's era, which was the era of Coast Survey personnel who had worked with Bache, who invented the American Method, who fought and won the Civil War, was ending. For the first time in its history, the Survey would be led by a Superintendent who, at the outset, had no real idea what geodesy was about. Chenowith was gone, but the troubles he stirred up would continue for many years to come.

[47] New York Times, September 15, 1885.
[48] New York Times, November 23, 1885.
[49] Ibid.
[50] Tittman, 1895, p. 465.

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