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THE COAST SURVEY 1807-1867
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Ferdinand Hassler was born on the eve of the American Revolution on October 7, 1770, in the town of Aarau, Switzerland. Aarau is in the northern German-speaking region of Switzerland and Hassler grew up speaking German as his native tongue. His father was a wealthy manufacturer of watches and quite active in civic affairs. At varying times he was a member of the town council, head of the Board of Taxes, Superintendent of Public Works, and Superintendent of the Cathedral.

Echoes of this obscure report reverberated years later in the founding of the United States Survey of the Coast.

Over the next five years, Hassler worked with Tralles in the survey of Bern, executed a separate survey of the boundary between the Cantons of Bern and Solothurn, and took many independent excursions for further education and personal collecting of scientific instruments and books. This work introduced him to most of the eminent scientists of Europe and he became quite proficient in the mathematics, geodesy, astronomy, metrology, chemistry, physics, and mechanical engineering of the day. His personal work in metrology included collecting copies of many of the European standards of weights and lengths.

In 1803, it became apparent that the French intended to take over the survey of Switzerland. This caused Tralles, Hassler's friend and mentor, to leave Switzerland for the Royal Academy at Berlin. If Tralles had stayed on in Switzerland, Hassler probably would have stayed. Instead, in 1804, Hassler made up his mind to seek a new life in America and engaged in an enterprise to form a company to purchase a large tract of land in the southeast part of the United States.

The LIBERTY sailed for Philadelphia and arrived in October 1805. By some accounts [(5)](6), Hassler had reason to learn on this trip of the necessity for good charts of the coast of the United States as the captain of the LIBERTY had a stroke following a terrific storm. Hassler chose to navigate the vessel to the New World instead of turning back for Europe. After a passage of two and a half months, he piloted the ship up Delaware Bay to Philadelphia. If a true story, this was an auspicious beginning to Hassler's association with the seacoast of the United States.

He acquired American citizenship as rapidly as possible and began making contacts in the scientific community. Perhaps it was fate, but Philadelphia was then the center of American science. On December 6, 1805, Hassler attended a meeting of the American Philosophical Society and by spring of 1807 was elected a full-fledged member. Thomas Jefferson, then serving his second term as President of the United States, was also President of the Philosophical Society; this connection provided Hassler with access to high political office which he would use to good advantage throughout his career. Through his association with the Philosophical Society, he formed a life-long friendship with John Vaughn, a scientifically-minded philanthropist who aided Hassler both financially and politically throughout much of the remainder of his life.

During 1806, letters were written by Dr. Robert Patterson, Director of the Philadelphia Mint, and John Vaughan to President Jefferson concerning Ferdinand Hassler and the impression that he had made upon them and the members of the American Philosophical Society. In Patterson's letter of March 3, 1806,[8] he included a short autobiographical sketch prepared by Hassler stating his experience and qualifications. In Vaughan's letter of December 20, 1806,[9] he mentioned that he had purchased Hassler's standards of length and weight and described as well an attempt to engage him for surveying "York Island, for the Corporation of New York" and continuing that survey up the Hudson River Valley to Albany. The goal of continuing the survey to Albany was to measure a degree of latitude and give the United States the opportunity to help in establishing the meter as a universal standard of lineal measurement defined as one-ten-millionth of the distance from the North Pole to the Equator. Thus, the first suggestion of a geodetic survey within the United States had its roots in national pride and the desire to assist in establishing an international standard of length. Because Hassler fell ill and the government of the "Corporation of New York" changed in the meantime, this survey was never conducted.

Given the nature of the above correspondence and plans, it seems probable that the honor of first suggesting a Survey of the Coast based on scientific principles should reside with Robert Patterson and John Vaughan. It would also seem that, if Ferdinand Rudolph Hassler had not come to the United States, the beginnings of such an endeavor would not have been considered for many years in the future. Within sixteen months of Hassler's arrival in America, the following act [10] was passed by Congress on February 10, 1807:

"Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the President of the United States shall be, and he is hereby authorized and requested, to cause a survey to be taken of the coasts of the United States, in which shall be designated the islands and shoals, with the roads or places of anchorage, within twenty leagues of any part of the shores of the United States; and also the respective courses and distances between the principal capes, or head lands, together with such other matters as he may deem proper for completing an accurate chart of every part of the coasts within the extent aforesaid."

President Jefferson directing the Swiss-born Albert Gallatin, the Secretary of the Treasury, to issue a notice to all interested scientific men in the United States asking for plans for bringing a survey of the coast into effect. Gallatin's letter, dated March 25, 1807,[12] specifically requests to know how a surveyor would: 1) ascertain by astronomic position the true position of "a few remarkable points on the Coast; 2) conduct a trigonometrical survey of the Coast between the points which have been determined astronomically; and, 3) conduct "A Nautical Survey of the Shoals and Soundings off the Coast" of which the trigonometrical survey would be the basis for determining the position of soundings and hazards to navigation. Gallatin also inquires whether it is possible to make a correct survey with one vessel alone and whether it is possible to determine one's location relative to three visible objects on shore.[13]

Hassler responded to Gallatin's letter on April 2, 1807.[14] The quick response would indicate that he was aware such a notice might be forthcoming and that he had been considering the problem of conducting a survey of the coast for some time. Hassler's letter was written in French, as he trusted his ability to communicate complicated ideas in that language much more than he trusted his English at that time. The twelve responses to Gallatin's notice were evaluated by a committee of the American Philosophical Society headed by Robert Patterson. Patterson had submitted a plan himself for a survey of the coast. On July 23, 1807, Hassler was notified that his plan was selected as the best of those submitted. He and Isaac Briggs, who later became a famous engineer associated with the building of the Erie Canal, were selected for the execution of the survey.

However, no action was taken to begin the survey until 1811 because of the unsettled international political climate.

Jefferson's successor, James Madison, reinstituted the Survey and sent Hassler to Great Britain in late 1811 to procure survey instruments. Because of continuing difficulties between the two nations, Madison declared war on Great Britain eight months after Hassler's arrival in London.

Perhaps the letter that so enthralled Hassler was the one from Albert Gallatin inquiring whether he would be willing to proceed to London to procure and supervise the construction of instruments for the Survey of the Coast. Although it appears that negotiations for such an endeavor were going on in late 1810, Gallatin formalized his offer to Hassler on April 16, 1811.

He arrived in London October 10 and commenced visiting instrument makers. He allocated the work of producing clocks, chronometers, and the main surveying instruments between various "artists" by early November. The first cloud of this stay in Europe appeared with the awareness that Edward Troughton, who was selected to produce the main instruments, was "yet occupied with the mural circle of Greenwich" and that this could cause a longer stay than had been planned. Four long years later, Hassler returned to the United States.

On January 5, 1816, Hassler presented a plan to A. J. Dallas, the Secretary of the Treasury, for putting the Survey of the Coast into operation.
Another problem was the divergent motivations of Congress and Hassler regarding the end products of the Survey of the Coast. Hassler saw an opportunity to accomplish a lasting work of value to humankind and reflect scientific glory upon his adopted land. Congress, on the other hand, wanted immediate results in the form of charts guiding mariners in and out of American ports. Nothing more -- nothing less. Congress had no interest in funding a scientific work, even if that science was the basis for accurate charts of our Nation's waters.

This second problem was exacerbated by Hassler's lack of understanding of the reality of American politics.

The fourth great endeavor that Hassler envisioned was the establishment of a national mapping organization. It was Hassler who introduced plane table mapping for topography to the United States; a description of the plane table and alidade and their use is included in the "Papers." Hassler's belief concerning topographic mapping was that: "... all the data should be collected, to enable the government to judge with propriety of the plan of any public undertaking or service, such as roads, canals, means of defence of the country, &c. That the survey of the coast was to contain all these data, besides the mere outlines of the coast, and that they were as necessary as the soundings outside of the line of the coast, appeared to me too evident to admit of any doubt, and I would have considered the full aim of the work missed without them."(12)
Among the cookbook-style listings of the "Papers," Hassler details 13 steps in measuring a baseline (24), 6 steps in observing horizontal angles to systematically remove error (25), 7 steps for reading vertical angles (26), and 13 steps for the proper use of a hand-held reflecting circle (27).
Within his response, he duplicated a personal letter dated December 3, 1825, from the recently deceased Thomas Jefferson to add to his counterattack. In this letter Jefferson writes Hassler, "I regret much that it [the Survey of the Coast] was not carried into execution, as, independently of the permanent security it would have procured for the navigation of our coast, it would have been an honorable monument of the state of science at this early period of our history."
Hassler was in his element while engaged in field operations. He loved the work and was surrounded by men who had deep respect for his knowledge and also had gratitude for his caring for their welfare as he had secured them decent wages and per diem. Sands described him as

"quaint in his manner, but greatly admired and respected by his assistants, being always genial and very accessible, except to those whom he suspected of being unfriendly to him; with such he would give way to displays of temper that would simply astound us."[(31)]

He would travel about the country in his "curious old carriage" traveling from survey crew to survey crew inspecting their work. As mentioned earlier, the carriage was designed primarily for the safe transportation of his instruments; "... but the additional provisions for his individual comfort were ingenious.... A little spirit-room, as it were, was underfoot for his Swiss wines, the seats providing lockers for the little baggage he carried and the stationery and books that always accompanied him."

FIELD WORK

The order of the field work under Hassler was generally: 1) reconnaissance for primary triangulation; 2) base line measurement; 3) primary triangulation including astronomic observations for latitude, longitude, and azimuth when possible; 4) secondary triangulation; 5) plane table mapping; 6) sounding operations; and 7) measurement of a new baseline at the termination of a section of primary triangulation allowing the verification and closing out of all previous work in the section between baselines.

The reconnaissance for, and conducting of, primary triangulation was done by Hassler himself, as he trusted no one else to conduct this critical work on which all else depended. The reconnaissance was done in late fall or early spring "for the naked woods will admit many views hidden in the summer by the branches and leaves, which may be afterwards cleared away for the work of actual triangulation...." There were no topographic maps or helicopters to help determine appropriate locations for these signals. Obtaining "this geometrical view of a country" was done with great difficulty and required "great attention and a kind of geometric eye,"[(1)] or, as would be said today, "a feel for the work." These stations were generally placed well inland and followed high ridges to assure developing lines of sight of twenty to forty miles between primary stations. The secondary triangulation crews were headed by James Ferguson and Edmund Blunt, who had been hired in early 1833. (Lieutenant John Dahlgren headed a secondary triangulation party for a short time in 1837.) Their job was to tie into the primary stations and establish a series of stations at ten-mile and lesser intervals for use by the plane table mapping parties, tertiary triangulation parties, and sounding crews. The secondary triangulation operations were not significantly different from the primary work. The basic difference was that there were shorter lines, more set-ups, and less accurate instruments being used in the secondary work; all leading to slightly less accurate results. The lesser accuracy was offset by having the work bracketed by higher accuracy primary work. Procedures and computations were similar.

Working right behind the secondary triangulation crews were the plane table crews. The plane table had been introduced to the United States by Hassler, and his first plane table crew was headed by a Swiss emigrant, Charles Renard. Renard began work along the shores of Great South Bay in the fall of 1834, surveying in signals, and developing shoreline for Lt. Thomas Gedney on the JERSEY. The following year, C. M. Eakin, a former Army Topographic Engineer, was made head of a second party supporting the work of Lieutenant George S. Blake on the EXPERIMENT. These men in turn trained others, including many naval officers, to take over as heads of parties in their turn. By the end of 1838, there were 10 plane table parties operating in the field.

Life on the field parties of the early Survey involved "roughing it"; living in tent camps or staying at the occasional inn or hotel when engaged in triangulation or plane table work and living on the small ships when engaged in hydrographic work. RADM Benjamin F. Sands, who spent fifteen

years on the Survey, was assigned to various hydrographic, plane table, and triangulation parties from 1835 to 1842 and left an account of his life in the field.[3] [4]
LIBRARY OF THE UNIVERSITY OF CALIFORNIA. Class University of California Berkeley FROM REEFER TO REAR-ADMIRAL Reminiscences and Journal Jottings OF NEARLY HALF A CENTURY OF NAVAL LIFE BY BENJAMIN F. SANDS Rear- A dmiral U. S. Navy. 1827 to 1874 NEW YORK FREDERICK A. STOKES COMPANY PUBLISHERS Copyright, 1899, by Frederick A. Stokes Company

I was directed to stow next to him, and as it was impossible, without great discomfort, for a single individual to reverse his position, a spirit of fairness led us to adopt a rule that all should turn over at the same time, and my duty, as the youngest of the party and the readiest for fun, was to give the word " spoon," when any got tired of their position, and then we could all turn promptly and together.

Although I was not much of a draughtsman (we were all new to the work, as the whole manner of it was new to this country), still being quite handy with the pen, I was directed to take the work of putting our work in ink and I improved considerably as the labor progressed. There was work enough putting the field work on the fair copy, and in the reduction of soundings and plotting the angles, and in preparing the charts for the next summer's work which we would enter upon with greater experience.

The plane-table was a new instrument then to this country for practical topography, and even West Point officers preferred the chain and com- pass for details of the coast. But it was used for topography in Switzerland and in the ordnance survey of England, and having been adopted by Mr. Hassler, nothing remained for us but to be taught its use. Fortunately a young Swiss emigrant was found who had recently landed and was familiar with this work in his native land, and who had been employed at it in the topographical survey of France. He was at once placed in charge of the first plane-table party, and we were glad to serve with him for the sake of the instruction he could give us. When I joined the party we entered upon the survey of New York Bay and its environments. We camped with our party, consisting of the ob- server's instrument-bearer, chainmen and flagmen, at a number of different places, including Governor's. Island, Berriman's Island, near Flushing Bay, Elysian Fields, Hoboken, Fort Lee on the Hudson and West Chester on the Harlem.

The plane-table had become very popular with us all, being a most handy instrument for topographical work, and a great economy in time, since we could, upon the prepared sheets, place down all the features of the country and the details of its topography in pencil as we progressed, ready for inking in office-work, without the necessity of notes to be summarized at night and blotted with errors to be corrected on the succeeding day in the field as was usually the case when working with the surveyor's compass and chain. Upon the plane-table the work was done upon the spot, and proved itself as we went on, errors, if any, being promptly and easily detected and corrected before moving the instrument from the spot, thus making the sheet ready for the ink when removed, to be replaced by others in succession during the season as we progressed. Moreover we felt the great relief this instrument gave us when we returned to the camp at the end of each day's work ; there was a certainty that the work was correct, and as it did not require revision we could always enjoy the rest and relaxation that followed upon a good day's work in the field.

Long Island - We shifted camp every ten or twelve miles, finishing up the work as we went, and pitched our tents at the most convenient locations convenient to sup- plies and post-offices,

Babylon, Amagansett, East and West Hempstead, and Montauk Point being each occupied during the summer by our party.

NJ Coast - As we proceeded on our work down the coast road we found more villages, and the farms were closer together, which gave us increased facilities in selecting our camping ground as we changed from place to place. We usually selected some orchard near a well or spring, and we procured plentiful supplies of butter and milk and eggs from the farm-

Our encampments were some ten or twelve miles apart, our surveying taking up the land by the coast and road, five miles north from the camp and five miles south, and when that was worked in we would fix upon another camp, ten miles or so further south, and thus through the season proceed with our surveying, creating, as we moved, quite a sensation amongst the natives by reason of our caravan, which was necessarily quite extensive.

The details of the survey were becoming intricate and required more time in completing them. Our instructions were to take the first post-road from the shore line and to parallel with it for interior boundary, putting in all the details upon and between it and the shore line. The latter was a barren beach of sand hills, mostly narrow and cut up by inlets, with a wide salt marsh between it and the fast land, upon which ran the post-road where we encamped among the arable fields near the farm-houses. This salt marsh was cut up by innumerable thoroughfares or tidal creeks, making it tedious work surveying, as the chain could seldom be used, and a boat was necessary to carry the party with our instruments from point to point in the work, using the " three point problem " in accomplishing it. By employing men from the vicinity, I was able to get the names of localities with accuracy, in the familiar nomenclature of the neighborhoods, and it made their remarks quite amusing as we developed the windings of these creeks in the progress of the day's work. "That's Bill's Duck-blinds," said one. "There's Sal's Cut," said another. "This is Tom's Creek, Nan's Thoroughfare," etc., etc., and I jotted down all the familiar names of the place, to be faithfully recorded on the map as we went along. By October we had finished our work at Tuckertown, and had run the shore line of that side of Little Egg Harbor, when we had to cross that Bay in sloops to transport our equipage to the other side, that we might finish the season with the completion of the Bay shore line.

UNDER the energetic and intelligent superintendence of Mr. Hassler, the coast survey grew very popular, and as the knowledge of its workings extended, it became firmly established in public favor as a work of great importance and usefulness to the young Republic. Service upon it was sought as a most honorable employment for naval officers when not on duty in their service at sea. The brightest of the young officers applied for this duty as an instructive school in a branch of their profession useful in peace or war, its objects being such as are as beneficial to our navy as to the commercial marine, and it being fitting and most proper that the naval officer should, as a part of his professional training, be well instructed in the methods and purposes of the coast survey, not only for the profit immediately to be derived from a thorough familiarity with our own coasts and harbors, but for future application of the knowledge thus attained, in the survey of foreign coasts and harbors and in the discovery of dangers to sea-going vessels such as were hitherto unknown and not suspected.

Excerpts from Sands

Our life on this duty had in it a good deal of what is called " roughing it." Six of us were assigned to the triangulation points along the shore, and we were obliged to camp out, and for our accommodation one tent was provided, and a smaller one for our steward and the cooking-stove. Our beds, or rather I should say our bed, was made of straw, spread from one side of the tent to the other and covered over with a tarpaulin to pro- tect us from the dampness of the sand

beneath, and thereon we, all six of us, had to turn in "all stand- ing," i. e., with our clothes on, " spoon fashion," with overcoats doing duty as extra blankets whenever the weather became cool enough to require us to put them on.

In 1842, two major items of capital equipment were delivered to the Coast Survey: the long-awaited dividing engine and a copper-plate printing press. The dividing engine had been ordered in 1832 from the shop of Edward Troughton, the master instrument maker who had produced many of the early Coast Survey instruments at Hassler's direction. Troughton died during the production of this instrument and the work passed to his partner, Mr. Simms. The engine was used in dividing circular instruments into ever finer angular divisions and was particularly valuable in the production of theodolites. When it arrived in the United States, it was the finest machine tool in the western hemisphere. To give an idea of the accuracy of this instrument, it was at least capable of discerning one second of arc, better than the one millionth part of a circle. Hassler pointed out: "The engine is unique in its kind in this country, and of great value even for the general progress of the art of the mechanicians in this country, besides the services the coast survey will derive from it." [(7)]

In 1841, the political situation had changed as Van Buren had been defeated and Levi Woodbury was no longer Secretary of the Treasury. President William Henry Harrison died within one month of taking office and Ewing didn't last through the year. John Tyler became President and by the end of 1841, Walter Forward was Secretary of the Treasury.

Lieutenant Glynn influenced Representative Caleb Cushing of Massachusetts to engage the House of Representatives in debate on the Coast Survey as an adjunct to a request for funds to print charts of the areas that he had surveyed. Cushing, during two separate days of Congressional debate called for a resolution to investigate the Coast Survey.[(4)] He contended that the Coast Survey "was under the charge of an officer, who was almost independent of the Government, almost independent of Congress, who received the salary of six thousand dollars a year for superintending it at the expense of one million" and asked, "...what were the fruits of that expenditure?" Cushing then espoused the belief that a triangulation survey is inapplicable to the low-lying coastal regions of the southern states betraying Navy agitation for the "chronometric surveys." [This, in effect, was a direct challenge to the scientific methods advocated by Hassler.] He accused Hassler and his assistants of delaying the completion of the work because of the "high compensation paid, and especially the allowance of an extra per diem to some of the persons employed which tended to operate as a sort of premium upon procrastination...." Cushing related that, "It had been confidently asserted that Mr. Hassler kept to himself important facts ascertained in the survey.

Hassler also was sensitive to not having printed any charts up to the time of the inquiry with the exception of a few small charts produced at the request of Congress and not for general distribution. His goal in chart engraving and publication was to produce charts that were second to none in the world in accuracy of content and beauty of presentation. To achieve accuracy of content, at least in Hassler's mind, required that the primary triangulation for a given section be verified by tieing into a measured baseline prior to the publication of any information from that section. As a consequence, it was his intention to delay publication of all charts and other information from Point Judith, Rhode Island, to the unspecified location of his second base line somewhere to the south.[(11)] But more importantly, there were no skilled copperplate engravers in the United States who were capable of producing work to Hassler's standards. It was not until late 1841 that he was able to acquire two engravers from Hamburg, Selmar Siebert and T. A. Rolle, to serve as the seeds for his engraving group.

Concerning the employment of naval officers on the Survey, he stated emphatically: "....whether they do not find, from their experience, that the navy is indebted to the coast survey, and not the coast survey to the navy."[(14)]

This may sound like arrogance of the highest degree, but the Coast Survey did serve as a school for naval officers and gave many promising officers command at a much earlier stage of their careers than was possible with most naval duty of the time. Benjamin Sands seconded this view as did many other naval officers of the Nineteenth Century.

BACHE

Who was Alexander Dallas Bache? Why did the American scientific community throw its prestige behind him for appointment to the office of Superintendent of the Coast Survey? Bache was born on July 19, 1806, into a family for which public service came naturally. He was a great-grandson of Benjamin Franklin and the grandson of Alexander James Dallas, Secretary of the Treasury at the time Ferdinand Hassler was appointed to head the Survey of the Coast. When 15 years old, Bache entered West Point as the youngest cadet in his class and graduated in 1825 at the head of his class. During his time as a cadet, he did not receive a single demerit. Upon graduation, he was assigned to continue on at West Point and teach Mechanical Engineering, although most of the cadets were older than he. After two years at Fort Adams, Bache resigned his commission after being appointed Professor of Natural Philosophy and Chemistry at the University of Pennsylvania in Philadelphia.

Bache's career as an educator and scientist began at this time. He spent the next seven years at the University of Pennsylvania, during which time his reputation as one of the foremost American men of science was established. He had a broad range of interests and wrote papers on chemistry and physics, established the first permanent magnetic observatory in the United States in the garden next to his house, studied the motion of winds in tornadoes, investigated the measurement of rainfall as related to wind direction and height of measuring instrument above the ground, and a plethora of other subjects. Besides writing papers for publication, he was also the influential editor of the Journal of the Franklin Institute, a position which gave him access to all of the leading American scientists of his day.

Several prominent scientists were either hired as Assistants in the Survey or worked under contract to the Survey on specific tasks requiring their expertise while retaining their positions at their respective organizations. Among this group were Benjamin Peirce of Harvard, the foremost American mathematician of the mid-Nineteenth Century; the great naturalist and paleontologist, Louis Agassiz of Harvard; Elias Loomis of the forerunner to New York University with whom Bache had studied the effects of a tornado in the 1830's; the microscopist Jacob Bailey of West Point, who was the first to examine the bottom specimens acquired by the Coast Survey; the astronomers Maria Mitchell of Nantucket (possibly the first professional woman ever hired by the Federal government), Ormsby M. Mitchel of the Cincinatti Observatory, William Cranch Bond of the Cambridge Observatory, and E. Otis Kendall of the Central High School of Philadelphia; and the mathematician and astronomer Stephen Alexander of Princeton.

The major hydrographic accomplishment of this half decade was the survey of Nantucket Shoals.

The most important and long-lasting geodetic innovation of this period was the development of a method to determine differences of longitude by the telegraph. This technique came to be known as the "American Method" and was emulated world-wide.

Perhaps Bache's greatest strength as a leader was his ability to attract men having great potential to the Coast Survey. A prime example of this was the caliber of Army officer who volunteered to serve on the Survey. Although there were less than 50 Army officers (an average of 12 were on duty at any given time between 1850 and the beginning of the Civil War) who served on the Survey from the death of Hassler to the Civil War, twenty-five of these men rose to the rank of Brigadier General or higher during or immediately after the Civil War. Among these men were Major Generals Andrew Atkins Humphreys, Edward O.C. Ord, Isaac Ingalls Stevens, John G. Foster, John C. Tidball, Rufus Saxton, T. J. Cram, and Henry W. Benham, all of whom served for the Union. General Joseph Johnston, Lieutenant General Ambrose P. Hill, and Major Generals Martin Luther Smith and Roswell Ripley served with the Confederacy. Three graduates of West Point who stood at the head of their class and served with the Coast Survey were Isaac Ingalls Stevens, Henry W. Benham, and W.P. Trowbridge. (Bache also stood at the head of his West Point Class when he graduated in 1825.) Edward B. Hunt, who was perhaps the most scientifically inclined of all ante-bellum West Point Army officers, graduated second in the class of 1845 and served with the Coast Survey through most of the 1850's. He conducted many special studies for Bache and published a number of articles in the Proceedings of the American Association for the Advancement of Science and the annual reports of the Coast Survey. He strongly allied himself with Bache on most issues and served as a spokesman for the Survey on many occasions.

The years 1850 through 1860 were the highwater mark of the Coast Survey. Never again would its budget approach 1/2% to 1% of the total Federal budget. Never again would the head of the Survey exert such an influence on American science as did Alexander Dallas Bache during those years. With the coming of the Civil War, the Coast Survey was relegated to a minor position in national affairs and never returned to its pre-war prominence

In the years 1844 to 1890, the Coast Survey reports reflect the growth of Nineteenth Century American physical science. In particular, the evolution of many facets of the disciplines of Geodesy, Geophysics, Hydrography (in the sense of measuring depths for nautical charting), Topography, and Oceanography are traced in the reports of the Coast Survey. Not surprisingly, as related to the work of the Survey, there are also major papers on astronomy, geology, meteorology, metrology (the Office of Weights and Measures, forerunner of today's National Institute of Standards and Technology, resided within the Coast Survey and Coast and Geodetic Survey), geographic exploration, harbor improvements, printing technology, engraving, photography, science policy and politics, philosophy, mathematics, error analysis, and national defense.

The single-minded purpose of Ferdinand Hassler, a Swiss immigrant, is what first brought the Coast Survey into existence. As the first Superintendent of the Coast Survey, 1816-1818 and 1832-1843, he imbued the organization with love of "truth" and unswerving compromise with the twin principles of accuracy and precision. His motto was: "It is the duty of every man to be honest and to do good." Hassler ***was*** the Coast Survey. Following his death in 1843, Alexander Dallas Bache, a great-grandson of Benjamin Franklin, took over the helm of the Coast Survey. Bache, with his friend Joseph Henry, was dedicated to elevating American science to the front ranks of the world community. As opposed to Hassler who was politically naive, Bache moved smoothly through the American political scene for the benefit of the Coast Survey and American science. The Coast Survey prospered during his tenure as Superintendent and became the first great science organization of the United States Federal Government. Professionally, he became a guiding light of the American Association for the Advancement of Science [presided over three of the first six meetings of the AAAS] and was a founder of the National Academy of Sciences.

AN INVENTORY OF THE COAST - A FIRST CRITICAL LOOK

In retrospect, the most valuable aspect of early Coast Survey topographical mapping was that it afforded a first look, or snapshot, of the state of the United States coastal environment in an early stage of development. Much of the coast was still in a pristine condition. Coast Surveyors worked from the rock-bound coasts of New England to the sand beaches, swamps, and marshes of the Southeast and Gulf Coasts. Their job was to observe and record the land in minute detail. They left many first-hand descriptions of their observations as well as hundreds of survey sheets. The topographic sheets included natural and cultural features such as: rock outcrops, cliffs, hills, and mountains; sand beaches and dune fields; coastal islands; marsh land; mangrove swamp; prairie lands; inlets; streams and rivers; the limits of pine and deciduous forests; cultivated fields; fence lines; roads, paths, and city streets; and piers, residences, commercial establishments, and public buildings.

Coast Survey topographers reported upon their progress, methods used in conducting a survey, and the nature of the area covered. In many instances, the topographer's map and report were the first detailed description of the area surveyed by a professional surveyor and engineer. In the aggregate, these surveys and reports were the first critical look at the total United States coastline. A few selected descriptions of areas, beginning in New England and working to the Rio Grande, are included to give an idea of the state of the United States coastline in the 1850's.

Henry Laurens Whiting, the dean of Coast Survey topographers, wrote: "The limit of land and water is the most striking and important outline which exists in nature...." To define this boundary between land and water, the Coast Survey sent topographic mapping crews to every part of the far-flung coast of the United States. In the period 1850 through 1860, 7,295 square miles were surveyed which encompassed more than 25,000 lineal miles of shoreline including tidal rivers and creeks. Superintendent Bache sent out an average of 17 topographic parties per year, each of which surveyed nearly 40 square miles.

There were three major facets to the topographic mapping conducted by the Coast Survey during the 1850's. The most significant result of Coast Survey topographic work was that for many areas it was the first systematic scientific inventory of the United States coastline's nature and characteristics. Often coupled with this first mapping was the tacit encouragement of settlement and the development of commerce. The second major result of this early mapping was to determine the extent of man-made and natural changes occurring since previous mappings of a given area. Resurveys became increasingly common towards the end of the decade. The third result from this mapping was the determination of the topography and characteristics of given areas for planning the construction of defense and public works installations. Surveys for forts, port facilities, lighthouses, and even aqueduct routes for the Washington, D. C., water supply were included among this genre of survey.

The principal tool used by the topographers was the planetable, a flat drawing board which could be attached to a tripod with an adjustable head which allowed leveling the board and orienting it with respect to direction. The topographer fastened a base projection with precisely plotted signals at a scale of 1:10,000 or 1:20,000 on the board and oriented it with respect to north. The topographer then occupied a series of known sites and observed selected cultural and natural features. The observing instrument was an alidade which was placed on the planetable and centered over the geographic location of the topographer's station on the projection sheet. The alidade was equipped with a straight-edge which lay in the same vertical plane as the alidade's line-of-sight. The topographer mapped features of interest by drawing rays along the straight edge emanating from the plotted geographic position of the topographer towards the observed feature.

The intersection of rays drawn from various stations located the feature. Elevations were derived from vertical angle observations to the features. Of course, not every point along linear features such as cliffs or dune lines would be observed upon, so the topographer used his engineering and artistic abilities to fill in the gaps. Depending upon the nature of the terrain, culture, weather, and other factors, the topographer might have used supplementary methods such as chain and compass traverses, horizontal sextant angles, theodolite intersections, and, as a last resort, estimation and sketching.

Henry Laurens Whiting was the recognized leader of many talented topographers associated with the Coast Survey in the Nineteenth Century. It was said of Whiting that he could make a better map of the far side of a hill without seeing it than others could while standing before it. Whiting began work with the Coast Survey in 1838 and served continuously until his death in 1897. During the 1850's he worked at various times in most coastal states between New Hampshire and Georgia. Other notable Coast Survey topographers from this period included Alexander Wadsworth Longfellow, the brother of the poet Henry Wadsworth Longfellow; Ferdinand Gerdes, the principal assistant on the Gulf Coast for much of his career; Charles M. Bache and Richard M. Bache; Isaac Hull Adams, John Seib, and J. B. Gluck; Augustus F. Rodgers, a brother of Rear Admiral John Rodgers, who conducted much of his work on the West Coast; and a number of younger assistants such as Cleveland Rockwell, James Lawson, Clarence Fendall, J. G. Oltmanns, J. W. Donn, F. W. Dorr, and Samuel A. Wainwright.

RESURVEYS - LOOKING AGAIN

As the surveys progressed, occasionally shoreline changes occurred between the work of the reconnaissance and triangulation parties and that of the topographic parties. Sometimes signals established by the triangulation parties would be awash or completely eroded away by the time a topographic party commenced its work. Dramatic changes were usually the result of great storms that swept over barrier islands or pounded the mainland; but relentless tides and currents, although effecting changes not apparent to casual observers, continually sculpted the evolving shoreline. It became increasingly apparent that change was the one constant along much of the East Coast and Gulf Coast as the result of the unremitting action of wind, wave, tides, currents, and, in many instances, human activity.

HYDROGRAPHY

The hydrography, like the topography, consisted of original surveys, resurveys of areas suspected to have changed, and surveys for special purposes. Techniques used in the 1850's differed little from those used in the early surveys by Lieutenants Commanding Thomas Gedney and George Blake. Inshore surveys were done by sounding boats or small shallow-draft schooners. The survey boats were usually whale boats which could have up to six oarsmen, a coxswain, a leadsman, one or more anglemen taking horizontal sextant angles, a recorder, and a boat officer. The survey boats operated either independently or deployed from a mother ship that anchored in the working area. Offshore surveys were generally conducted by a ship although occasionally boats would be launched from mother vessels far offshore to conduct surveys of shoals. Precise positioning was accomplished by azimuth intersections from shore observers co-ordinated by signaling from the sounding vessel or by horizontal sextant angles observed on the survey vessel.

The goals of Coast Survey hydrography were: 1) to discover and make known the nature and location of hazards to navigation; 2) to assist navigators by defining and describing the nature and configuration of the sea-bottom; 3) to ascertain whether the winds, tides, currents, and sediments of an area would cause the sea-bottom configuration to change; 4) to predict the rate and direction of changes in sea-bottom configuration; and 5) to observe and predict changes that would result from human activity. Although not strictly a hydrographic function, the determination and survey

of sites for lighthouses, buoys, and other aids to navigation were also a major function of Coast Survey field parties in the 1850's.

THE SURVEYS

Most hydrographic surveys resulted in few, if any, discoveries of note. They provided snapshots of the bottom configuration of an area at the time surveyed, and, in general, were a form of insurance for mariners that increased the probability that an area could be safely transited. During the period from 1850 to 1861, the Coast Survey maintained an average of 10 hydrographic survey parties in the field and finished 520 hydrographic surveys. The average survey during those years encompassed 56 square nautical miles and had over 8,000 soundings obtained primarily by a leadsman swinging the lead and calling out the depth. To obtain those 8,000 soundings, vessels were sailed, steamed, or rowed an average of 217 miles per survey.

Buried within the statistics was the fact that there were basically two different kinds of surveys. Harbor and harbor approach surveys differed significantly in the density of soundings and intensity of work required as opposed to offshore surveys. The harbor surveys were done at a larger scale than the offshore surveys with correspondingly greater detail. Two large surveys (as compared to the "average" survey for number of soundings and miles of sounding line) accomplished in 1853 illustrate the difference between the two basic types of surveys. Lieutenant Commanding John Maffitt on the Coast Survey Schooner CRAWFORD conducted a survey of the Georgetown, South Carolina, harbor and its approaches. In the course of this survey of a relatively small area his boats ran 598 miles of sounding line in approximately 100 square nautical miles, obtained 68,520 soundings, took 90 bottom samples, and observed 9,850 angles to position the sounding vessels.[(98)] During the same year, Lieutenant Commanding J. J. Almy with the steamer HETZEL and the Coast Survey Schooner GRAHAM conducted a survey of the outer coast from Prout's Island, Virginia, to Cape Henry Light, a distance of thirty-three miles. On this survey, Almy ran 1,176 nautical miles of sounding line in an area of approximately 500 square nautical miles, obtained 18,106 soundings, took 37 bottom samples, and measured 5,778 angles for determining position of the sounding vessels.[(99)] The inshore survey required 115 soundings per mile of sounding line while the offshore survey required only 16 soundings per mile of sounding line, a ratio of 7:1. Sounding density was approximately 680 soundings per square mile for the Georgetown survey and 36 soundings per square mile for the Virginia survey. For vessel positioning, a fix was obtained approximately every 0.20 mile for the offshore survey while the corresponding value was 0.06 mile for the inshore survey. As in either case the survey vessel was advancing at approximately the same velocity through the water, it becomes apparent that the rate of data collection was much higher on the inshore work than on the offshore work. The record-keeping and plotting of survey observations were also correspondingly greater for the inshore work.

With both types of surveys, crews built signals and established shore camps for theodolite observers (observing time-coordinated azimuths to the survey vessel upon signal from the vessel,) installed tide staffs that required constant observation during the times of hydrography, and observed currents at critical locations. In the offshore Virginia survey, Lieutenant Commanding Almy observed 5 current stations; at Georgetown, Maffitt observed 16. Almy observed seventy-eight high tides and seventy-seven low tides during the course of his survey by means of 3,546 observations by observers reading the tide staff every 15 minutes. These readings were meant to correct the depths measured by the leadsman to mean low water. Maffitt's tidal effort was comparable as "observations were made by reliable and careful men, day and night." Although self-registering tide gauges had been introduced a few years earlier, their use was not wide-spread and many tide observations were made by visual observation of tide staffs well into the late

Nineteenth Century.

THE DISCOVERIES

Prior to 1850, the Coast Survey had made about 20 discoveries of hazards to navigation, hydrographic features that would help the mariner position his vessel, or new routes and channels that would shorten the sailing time of a mariner approaching or leaving port. By the end of 1860, that number had swollen to well over 150. Surprisingly, many of these discoveries were made in well-traveled waters including approaches to harbors and within marked channels.

Perhaps the most surprising discovery of this era was Stellwagen Bank, on the main route into Boston harbor. This bank is just a few miles to the north of Cape Cod and stretches toward Cape Ann. It is over twenty miles in length and five miles across and lies in the path of major routes from Boston to Europe and points south. In 1854, Lieutenant Commanding Henry Stellwagen, U. S. N., Assistant in the Coast Survey, discovered this bank in the course of regular hydrographic surveys. He underscored the importance of this discovery in his report: "I consider promulgation of this discovery as very essential to navigators, and that the knowledge of it will highly benefit commanders of vessels bound in during thick weather, by day or night. By it they can not only ascertain their distance to the *eastward* of the coast, but, by attention to the lead after passing inside, a good idea of latitude may also be obtained...."[(110)] Attention to the lead included both depth and bottom characteristics. In Stellwagen's initial survey of the bank, he ran six lines crosswise and two lengthwise. Besides general depths of 10 to 15 fathoms, he determined, "The northern end of the bank has rocky bottom, with, however, a slight covering of fine black sand. The middle and southern parts are coarse white and yellow sand. The bottom inside of the bank, in deep water -- and this is quite an important observation -- is generally a green unctuous mud, or ooze."[(111)]

In 1856 the Coast Survey Schooner GALLATIN, under Lieutenant Commanding C. R. P. Rodgers, U. S. N., Assistant in the Coast Survey, and cousin of John Rodgers, was working in the well-frequented waters of Nantucket Sound. Rodgers reported on the frustrations of attempting to conduct hydrographic surveys in an area subject to haze and fog. The positioning method adopted was that of intersecting azimuths observed by shore parties. However, "Many miles of soundings were run, but day after day, upon communicating with the theodolite observers on shore, it was found that they had not been able to follow us with their telescopes, and that part of our labor had been fruitless.... The task was peculiarly difficult; the haze which prevails in that vicinity, the rapid tides, the rough sea, and the broken character of the bottom, presented obstacles to be surmounted only by the most patient perseverance."[(113)] Rodgers worked in the area the year before and had not altered his opinion of the weather conditions as he reported, "The wind in this locality is rarely moderate; when there is not a flat calm, the breeze is usually fresh enough to baffle or impede the hydrographer, while in the frequent fogs he also finds a formidable enemy."[(114)]

Rodgers hired a small steam vessel, the FIRE FLY, which made it possible to work in the adverse wind, current, and sea conditions. His "patient perseverance" was rewarded by the discovery of a shoal northwest of Nantucket Island. This shoal, which Rodgers designated Edwards Shoal, lay "in the channel-way south of the Cross Rips, surrounded by deep water, and its crest is a narrow ridge, more than half a mile in length, with only ten and twelve feet water upon it...."

Lieutenant Commanding C. R. P. Rodgers[(115)], who spent over six years on the Coast Survey, was amazed that this shoal had not been previously discovered. He commented: "It is remarkable that a shoal like this, so constantly passed by vessels beating through the southern channel of

Nantucket sound, should have been so long unknown, and particularly that it should have escaped the notice of pilots.

1836

Sixth report of F. R. Hassler, as superintendent of the survey of the coast of the United States, and the construction of standards of weights and measures, rendering account of the works of 1837.

1. As soon as the arrangements made last spring for the compensation of all the persons employed in the two works under my charge were completed, I immediately made the organizations of the works for the summer, and proposed such additional appointments as the state of the works required. A number of plane-table parties were organized, and sent out, sufficient to fill up the intermediate parts stated in my last report as necessary to be completed, and to extend them farther easterly and southerly, as much as the time and weather would allow. Thus, nine parties were

2. The two parties for secondary triangulations were occupied like last year: the one in New Jersey, towards the Delaware; the other over Long Island sound; in continuation of the plan which I had originally formed to accelerate the work by this distribution of the parties to both sides; both in extension of their preceding work.

3. The two sounding parties were equally continued, upon the plan stated in my last report: the one in the neighborhood of New York, the other in Long Island sound.

4. For a long time, the season was so eminently contrary to the field operations, that the exertions of all these parties were not rewarded with the deserved success; and they uniformly stated that it would be entirely impossible to attempt any thing for the primary triangulation.

gradually put in activity, from the latter part of April onwards, some of which acted at first jointly, until they were all equally provided with instruments; at the completion of which the mechanicians were engaged in the workshop established for that purpose in the office at Washington.

8. For the main triangulation those stations have been occupied by me, which bind up the station points of the works of 1833, and 1834, and unite the secondary triangulation of the eastern side of Long Island and Rhode Island on the east, and of the Jerseys, below the bay of New York, on the southwest, with proper extensions.

The new theodolite of thirty inches diameter, which was used for the measurement of these angles, has proved of great advantage for the accuracy, by its stability; in which, I presume, it exceeds any instrument ever constructed for field-work, and its great optical power of telescope and microscopes.

9. Heliotropes, of which I had begun the use last fall, have this year been used for most of the station-points, and for the base-points exclusively. I caused one to be constructed in our shop last winter, after the two received the previous summer from Gottingen, by the kind assistance of Professor Gauss, the inventor of this instrument; and during my work this summer I received four more: all (seven) are now in activity. The aim of the instrument is to reflect the sun's image from the station-point, at which they are placed, to the observer on his station, thereby perpetuating, for any time required, or allowed by the sunshine, the reflection of the sun's rays, which is otherwise given by my tin signals, at that certain time, for which the angle of the cone is constructed, as I have heretofore explained.

10. These new instruments require a man of some intelligence to attend to them, and to replace them about every four minutes, according to the

12. By the plane table works, all the topography which remained to be filled up between the parts of Jersey, on Navesink, Staten island, &c., and the shore of the sound, on the main land of New York, Long island, and Connecticut, upon which I reported last year, has been entirely filled up. The proper points were furnished all along to guide the operations of the sounding parties. The part about New York has been extended up the North river, to about three miles above King's Bridge. Whether it will be proper to extend it up, till it includes Tappan bay, as I thought at first, I shall nearer investigate this winter. Likewise, the interior of Long island, between the two shore parts, has been filled up. Both parts of the shore of Long Island sound have been further surveyed, as far as Milford, in Connecticut, and to Drowned Meadows, on Long island; the topographical parties furnishing the data to ground the sounding operation upon, as they went along, in the same manner as they had received their guide from the primary and secondary triangulations. They extended more or less in the interior of Connecticut, towards the points of the main triangulation, lying in the rear, as circumstances admitted.

13. In the course of the coming winter, I shall cause all these works, with some of the principal soundings, to be brought together, on a reduced scale, to a sketch map; like I have done in former years, which will show

again the state of the whole work, at this time; and, by its comparison with the similar sketches of the former years, the progress which the work has made in each year. As this can never be done until all the works have been collected in Washington, and reduced for that purpose, these sketches can never be presented with the yearly reports, similar to the present, as they fall in a time when all is yet in full activity otherwise. They can, besides that, in any case, be no more than a register of the work, as it progresses.

14. Already the above shows: that the naval part has kept pace with the topographical parts, as they always work together, in assorted parties. The two hydrographic parties have worked up all the soundings between the shores quoted above, as surveyed by the topographical parties, from which they receive always the points, upon which their determinations must be grounded, in proportion as they progress; for the water itself admits no fixed points, affording any security for the hydrographic works.

Then weights and measures.

F. R. HASSLER.

HARROW HILL, NEAR HEMPSTEAD HARBOR, L. I.
November 18, 1837.

25th CONGRESS,
3d *Session.*

[SENATE.]

[4]

REPORT

FROM

THE SECRETARY OF THE TREASURY,

TRANSMITTING

A report from the superintendent of the coast survey, and of the fabrication of standard weights and measures, showing the progress in those works during the present year.

DECEMBER 6, 1838.
Read, and ordered to be printed.

TREASURY DEPARTMENT,
December 5, 1838.

SIR: I have the honor, herewith, respectfully to transmit to the Senate a report made to me by Mr. F. R. Hassler, superintendent of the coast survey and of the work for the fabrication of standard weights and measures, exhibiting the progress made in said works during the present year.

I have the honor to be, very respectfully, your obedient servant,

LEVI WOODBURY,
Secretary of the Treasury.

To the Hon. WM. R. KING,
President of the United States Senate.

sidered as of influence in any practical use of these standards.

F. R. HASSLER.

WASHINGTON CITY, *June* 26, 1838.

Instructions relating to the use of the standard weights.

1. Never touch the weights with the hand, in any case whatsoever.

2. The weights are to be lifted out and in their places, and in any case of their being moved, by means of the fork, or hook, covered with leather, which are added to the boxes for that purpose, and fitting the different weights.

3. When the weights are taken out of the box, they must always be placed upon clean white paper, that they may not become scratched or soiled; as well when placed on a balance as otherwise.

4. The whole collection must be kept in a safe and dry place, free from all disturbances or danger of damage.

5. They must never be moved away from under the care of the officer

More on weights

6. These assistants have returned to their work at the secondary triangulation, and I continue my own works on stations of the main triangulation, as long as the season may allow me any favorable chance.

8. Thus the secondary triangulation has been continued this year, southerly in New Jersey and Pennsylvania, for the elements of the detail surveys of the Delaware, the outer sea shore, and Barnegat bay, towards Cape May, and those neighborhoods.

9. In like manner the secondary triangulation to the east of the main lines, between Tashua, Friarshead, and Mount Carmel, east of New Haven, and New London, has been completed, and extended until over the Rhode Island shore, &c., on the main, and over all the islands, between the east of Long island and the main shore.

10. The task of the topographical parties for this year was, as alluded to in my last report, the continuation of the detail surveys, easterly from where they left off the year before, which was stated in the last report.

A. To the end of Long island, as well on the sea shore, as on the shore of Long Island sound, with all the interior, to Montauk point, the eastermost extremity of Long island, and over all the numerous islands and bays within and near north of it, till Fisher's island, inclusive. This has been fully and properly executed by the five topographical parties that were engaged in it.

B. Upon the northern shore of Long Island sound, in Connecticut, &c., five other parties were engaged in the topography of the shore, which was fully executed until to the neighborhood of Stonington.

C. All that was required to furnish constantly the necessary directions for the sounding parties, that followed the shores of the sound, and the sea shore of Long island, was by all these parties always regularly provided, besides the topography; some parts of the interior within the limits of the triangulation were also surveyed in the same manner, leaving only, like in the previous works, for their future task, that filling up between these works and the interior part of the main triangulation, which the aim and plan of the works require.

11. Two hydrographical parties were again in operation last season, but they had each an additional vessel, larger than those they had before, one of which was purposely built for its aim, and employed in Long Island sound, the other a revenue cutter, which was used upon the outside coast.

12. These expenses, of building, and fitting up, of these vessels, and others, occasioned by this increase of the naval part, having not been foreseen at the time of my last report, and the forming of the estimate of the necessary appropriation, they have of course encroached upon it in a manner, and to an amount, that I could not be aware of in due time.

13. The one of these hydrographical parties continued the soundings of the outside shore of Long island, as far off as to forty fathoms sounding, from east of Fire Island beach, where the earliest outside soundings had begun, till to Montauk point, the eastern extremity of Long island, and inside of it, over Gardner's bay, which lies between the Long island shore, and the islands stretching northeasterly towards the main shore, including the southern shores of these islands.

15. It is well known that all sea charts must be provided with regular and accurate views of the aspect of the shores, upon proper scales, from the principal points of approaching harbors, and their different channels, of the light-houses, and also from any dangerous point from which the shore can be seen. To the two first of those the seaman has recourse to ascertain what land he has made, and the latter shall warn him from a shoal or a rock, upon which he may come.

17. There has been no occasion to make any alteration in the scientific means, and methods, employed for the work, from those employed in the origin; on the contrary, I had the pleasure to observe in various European accounts upon methods now used in observing, the approach made towards my methods, (explained in my papers on the earliest works of the coast survey of 1817,) in whatever they applied to the peculiar circumstances, under which the observers were. The interest taken in the coast survey by men of science in Europe has shown itself by various presents of books, and communications by letter, to me. (which I continue to receive,) treating and discussing subjects of interest for the work. Also in this country the interest in our work evidently increases with its progress, as it shows always more apparently its public utility.

18 The mechanical organization of the distribution of the works appears to be well adapted to its present state, and it will continue to be sufficient until the work may come into such parts of the country as must occasion a great increase of topographical work, and thereby perhaps an increase of the planetable surveying parties. In that proportion as this may occur, in that will on the contrary the naval, or hydrographical, parties be less occupied. This will give the proper time for the investigation of soundings, if any, at a greater distance from the coast, and of the various currents along the coast, which appear very imperfectly known by the public, and only partially so, by the local coasters, in the parts to which they are the most habituated. All these tasks being dictated by the law for the coast survey, and naturally implied in the work.

19. A considerable number of assistants will be occupied. during the coming winter, by the great mass of calculations, for which the elements are now at hand, and those which are required for the proper extension of the auxiliary tables necessary for the increased extent of the work. To

these works, I shall, however, not be able to direct them, before their work, of executing the drawings of their fieldworks of the last season, will be finished; which order dictates to be the first, and unpostponable, winter work.

20. As much as the time will allow after that, I shall direct the bringing together of the whole triangulation hitherto made, upon such a scale as might serve to prepare for the future publication, when the proper mass of work will be fully at hand; at that time I shall then have the honor to propose also the proper measures, and the necessary arrangements, to secure the accurate execution of that part, upon which so much depends, not to lose in it the accuracy and good execution given to the scientific part of the work. Last spring already a preliminary sketch of such a collection of data was begun, to serve as guide, so far as it could then be extended.

myself into the field. This year a great part of the tents have been torn up entirely by the violent storms, which have made much heavier ravages among the shipping, and even buildings; (my camp, however, received not the slightest damage.)

Eighth report of F. R. Hassler, as superintendent of the survey of the coast of the United States, and of the construction of standards of weights and measures; rendering account of the works of 1839.

Upon the survey of the coast.

1. The proper organization and course of operation in a geodical work of such extent as the survey of the coast of the United States, is dictated by the nature of the country, and the relative position of its parts; presenting a long stretch of very unequal coast, with only such a breadth as the exigences of the work required; this dictated to begin at such an approximately central part of the country as would present the most facility and best prospects for large triangles, to serve as foundation of the work, and produce the greatest quantity of data for that purpose in the shortest time; presenting, also, within its limits, a locality for a base line of proportional length, and the necessary facility for its accurate measurement,

from which the work might afterward spread in both directions of the country simultaneously, and alternately, as circumstances would dictate or allow.

4. All the survey of Long Island, as well the topographical, as the hydrographical part of its outer seashore on the south, and that of the sound to the north, had been completed the preceding years, till to Gardner's bay, of which a part of the sounding remained yet for this year.

5. The works of this year on the northern shore of the sound, include, as well the topographical, as the hydrographical surveys of Block island, the numerous islands of Fisher's sound, and others, the shore of Connecticut, and Rhode Island, with their deep inland waters, from Black Point, where the hydrographical works had ended last year, through the whole of Fisher's sound, so that the work reaches now on that side the shores and waters of the eastern States.

6. The surveys on land were carried inland as far as the nature of the coast on one side, and the time on the other, dictated or allowed; always furnishing, to the hydrographical party, which is carried on parallel with the works, on the shore, the fundamental points to ground their determinations of the points of sounding upon them: these works occupied one of the sounding parties, and a number of topographical parties.

S. A second part of the work to be executed this year, in that eastern part of the survey, was the topography of the parts, between the country near the shore, surveyed with reference to the sounding more especially, and the limit of the main triangulation, farther in the interior; the former having always been accelerated in its progress, so as to assist constantly the hydrographers in their progress on the water, it could not be carried sufficiently deep, land inward, for all the wants of the survey in general, this part of the topographical works was therefore to be completed, and it required yet some secondary triangles to complete it, besides the plain-table works. It appears, however, that the season will not serve long enough to prevent operation if it fall yet in next year's work. But this will not prevent the house works of mapping, which are intended to be done the coming winter for that part of the country.

11. Views for the guidance of the navigator approaching the shore, as mentioned in the last report, have been made last summer by one of the assistants, on the whole extent of the outside coast of Long Island, and at such places of the eastern part of the sound, as were found properly the hydrographic parties, who had of course to lead the selection of these points; these are of two kind, the one guiding, the others warning. The first are aspects of the shore from the most important points of a channel or entrance of a port, &c., by which the seaman is guided in his proper course in approaching. The second kinds are views taken from rocks, shoals, or other dangerous places in the approaches of the shore, which the view given shall warn him to avoid.

12. In extension of these principles, the views of every light-house were taken double, first from the habitual ship channel at a distance at which vessels would habitually pass it, and second from the proximity, where the light-house becomes entirely visible, and so near as to warn from nearer approaching unless special views of landing, &c.

The south shore of Long Island is well known for its dangers by the multiplicity of shipwrecks on it; therefore, special direction was given to draw views from the habitual ship channel outside, at every short interval, or in some kind of a moving panorama, by which the approaching seamen may reconnoitre the part to which he is near, and guide himself in his course by the views which he is thus shown that he shall meet in succession in his intended course.

13. From Sandy Hook southerly, the Jersey seashore, with Barnegat bay, and a certain breadth along the inner shore of the same, has also been surveyed, till down to the neighborhood of Egg Harbor river. This part of the shore is difficult of access, from the interior by triangulation, on account of the heavy wooded, but low hills which separate it from the other land of Jersey, so that it will become unavoidable to cut through the forests in various places, to get lines for triangles, joining this work to the interior parts in several places, in order to bind up with accuracy the long series of small operations, necessitated by the peculiar difficulties, presented by the nature of the locality. The hydrographical part of the same locality was also intended to be begun, but as it could not be attended to this year, it will form the first work for sounding vessels next spring.

21. The results of the whole work in triangulation, topography, and hydrography, as far as obtained, the end of last year, were last spring collected together in one map, upon the scale of $\frac{1}{100000}$, as already noticed in my last report as begun; every separate sheet of work is there numbered, as it is in the register of the works, and its limits marked, so that any execution of maps, within the limits of the work, can be guided by this preliminary in some measure tangible register of the works; the same system is, of course, to be pursued in future.

23. During the coming winter the assistants will again be occupied as in the preceding ones, only the calculations being of a somewhat different nature, principally relating to the systematic junction into one body, of the results of the trigonometric operations that have been executed; all the calculations are always to be made three-fold; being now numerous, much of the time of the assistants will be used in it, and as well this as the reduction of some of the works to ultimate maps for final execution, will occasion to keep some of the assistants engaged in these work, instead of in the field work.

24. This will make ready for any final execution for drawing, &c., the whole extent of the coast and country adjacent, from the New Jersey shore to the end of Rhode Island shore, in the topographical and in the hydrographical parts.

This part of the coast, forming, in some measure, a whole work by itself, containing about three thousand square miles, will therefore be taken in hand immediately, for final execution upon two different scales, for the different purposes, to which they must naturally serve in future.

26. A provision of the best quality of large drawing paper, appropriated to our work from the manufactory of Annonay has just been announced as having arrived in New York for our use.

27. With the view to prepare for engraving maps, copperplates have been ordered in Vienna from Hungarian copper, on account of its best quality: these have just been announced as being under preparation, and that they may be expected in a few months: they will, therefore, certainly arrive before actual use will press for them.

[illegible] begin to engrave. If the final appearance of the maps, when published, shall do justice to the trouble and expense incurred in the survey, the whole must come out of one systematic establishment, from which nothing should go out without the stamp of the establishment.

1840 Regularly ask for $100,000

3. The projection, and reduction of the map of New York, was begun upon the scale of 1 to 30,000, in duplicate, by two assistants separately, both equally reducing from the original topographical maps, resulting from the plane-table works; these two original reductions will verify each other, and prevent accidental errors, each of them will have its particular useful destination, which will appear in future.

4. The detail topography of the surveys in the field being grounded upon the triangulation, it is proper that the reduction of the results of it be again grounded upon the same, whenever any part of the work shall be brought into execution, for the construction of a map. To obtain this aim I adopted the following new method: all the triangle points being placed in the projection, made for the map, by their latitude and longitude resulting from the accurate calculations, just mentioned, by their rectangular ordinates, referring to the nearest sides of the respective quadrilateres of the projection, the lines of triangles therefrom resulting upon the map, are used as abscisses, to which every detail point is referred by its rectangular ordinate, referred to the triangle sides.

5. This operation is very satisfactorily executed by rules and rectangular triangles, divided one set upon the scale of the original, the other set upon that of the map to be executed. By this means the union of the great number of detail maps, which in a large work concur in a reduced map, is obtained with the greatest accuracy, and the most ease, therefore also celerity.

I make this detailed statement, because the indication of this method may be of service to gentlemen, who may have similar works to execute.

6. The copper-plates for this map, which had been ordered in Vienna (Austria) have arrived in due time, by the kind assistance of the United States consul Schwarz at that place.

8. This latter part of the season in which I am now engaged at the main triangulation, has hitherto been very favorable, and promises to continue so still onwards; this is so much more desirable as the nature of the country presents considerable difficulties by its configuration. If the weather of the coming season will allow it, I shall keep the field for the measurement of angles for the main triangles as long as ever possible, after which I intend still, under the favor of the woods being free of leaves, to reconnoitre myself for the discovery of more southern points for the main triangulation.

9. The elevations on either side of the valley of the Delaware, through which the main triangulation must necessarily pass, as has been already stated in my first plan of operation, are so little prominent, the one over the other: that it is difficult to find such as are elevated enough over the others, to afford a view to a sufficient distance, clear from intervening interruption. This occasions of course frequent cuttings of wood upon many hills, which are not always easily acceded to by the owners.

valley of the Delaware; and the further continuation of the survey of the Jersey shore, as well for the topography, as for the hydrography, will be grounded upon them in the next operations of that kind, as well on the side of the Atlantic, as on the side of the Delaware.

The absence of all prominent elevations, and the wooded state of all except the lower valleys, renders these operations very tedious and time-consuming.

28. In the view of these circumstances it is evident, that there will be no just comparison possible to be established between the results of the present survey, and the older ones, made at different epochs, the certitude which the results, to be obtained by the present survey shall give, will therefore be the most important result; establishing a determined state of the river, at a determined epoch of time; perhaps the comparison of it with the older works may lead to, or at least furnish some data for, what might be called the history of the changes of the river, from which conclusions might be drawn advantageous for the future.

29. The special principles upon which the instruments used in the coast survey have been constructed, have continued always to be very advantageous and appropriate; the shop established in the office, necessary to maintain them constantly in good serviceable order, has furnished besides a number of instruments, and implements, of much superior accuracy, and adaptedness than would have been obtainable in any other way, besides that being always at hand, and every minute ready for such calls as cannot fail to occur constantly in such a work; the gain in time is an additional advantage of great economy, it is therefore of essential benefit, and continually in full activity.

1841

WASHINGTON CITY, *June*, 1841.

SIR: With the present, I have the honor to inform you of the completion of the standard ounce-weights for all the States of the Union, which form a part of the task of constructing standards of weights and measures for the custom-houses and the States, in accordance with the joint resolutions of both Houses of Congress relating to that subject, which is committed to my charge.

There are 29 boxes, numbered, and inscribed, with the names of the respective States.

Though this report of the superintendent is chiefly confined to replies to the inquiries contained in the resolution of the House of Representatives of the 24th of June, yet, as it also exhibits the present condition and the extent to which the survey has been prosecuted, it is thought expedient to lay it before Congress, under the impression that it may supersede the necessity of submitting an annual report on the subject, as heretofore usual at the commencement of each regular session.

The works of the survey of the coast cover now upwards of 11,000 square miles, with primary and secondary triangulation, topography, and soundings; from the east end of Rhode Island to the neighborhood of the Chesapeake and Cape May.

This is evidently a great progress for the time that the work has as yet lasted; particularly if it be considered that every thing was to *be created*—even the ability of the assistants, they being at first new in the business. It is actually *much more than has ever been done in any similar work before;* for it must be recorded: that since the first law of 1807, nineteen years were entirely unproductive for the work, by postponement and interruption; five years were used in procuring the necessary instruments, and in preparations, as before that time there was not a single instrument, in this country applicable to such a work. Only ten years were employed in the actual work; of which the two first, 1816 and 1817, were rendered useless, and the expenses made became a bill of loss, by the overthrow of the work in 1818; so that the whole work now producible is the result of hardly about eight years actual work.

The aim of the coast survey is, and has always been considered to be, by all the successive administrations since its existence, to furnish, with the fullest accuracy possible, all the geographical, topographical, and hydrographical data that may in any way be needed for the navigation and the defence of the coast, in their generality, and to the extent of the country in the rear of the coast, to which the valleys extend: that empty their waters into the Atlantic, and are thus separated from it by some chain of mountains, or what may be called the nearest chains of elevations separating the interior from the coasting countries; and that this work should also furnish the elements to any future map of the country desired, as it is by its nature so extensive, and so situated, as to furnish the elements of maps of all the States. In fact, some States have already united in the work, to extend these elements to the advantage of an accurate map of these States.

such a work. To bring the irregular shape of the country into the most advantageous regular mathematical figures, which is the requisite of an accurate survey, is what makes the strongest call upon the science and ability of the operator; therefore its value and labor cannot be judged by the *quantity*, but by the *quality alone*, which, to judge of, requires the same insight into the mathematical and physical sciences as the execution of the operation itself. The success in all these things depends not only upon the instruments and labor of the observer, but still more upon the perfection of the *methods* devised for the work. In this respect I have the favorable

given period, in proportion and succession as they are wanted, and not according to districts or localities. The works are contained in—

32 folio volumes of my own observations and results;

90 folio volumes and cahiers of the assistants;

30 or 40 cahiers, folio, of calculations, and tables, &c.—and upwards of 100 journals, of all sizes, of naval and tidal observations, soundings, and observations thereto belonging. To this I might be allowed to add—

17 volumes of documents of correspondence, and upon subjects of the administration of the work; and about 20 volumes of journals, calculations, and documents relating to the works for the construction of standards of weights and measures;

140 maps; and

80 charts of original works of the different assistants, upon different scales, from $\frac{1}{5000}$ to $\frac{1}{50000}$;

2 register maps, upon a scale of $\frac{1}{100000}$, keep account of all these works, and serve as guides to select the original maps of any part of the work, of which an abstract, or the execution of a map for publication or otherwise,

as the aim of the work dictates. The part of the coast now executed being from east of Rhode Island to about Cape Henlopon and the Chesapeake bay, an approximate judgment might be cast upon the question, from the

and I should like would be made, comparatively to any other works, would certainly show that never so much valuable work of that kind has been obtained, in any country, and under any known arrangement, as there has been obtained, in the same time, at a proportionally equal expense, as in this survey of the coast of the United States, under the *present organization and administration of that work.*

The results of the coast survey will furnish, for the future, regular systematic data to ground any detail surveys upon, that might be needed, thereby avoiding the double expenses hitherto so frequently occurring, from the Engineer and Navy Departments acting disconnectedly, thereby, of course, doubling the expense, and, I might say, often even *the doubts.*

Philadelphia, &c.

The plain table parties have filled up the greatest part of the ground now intended to be surveyed on both sides of the Delaware, and in other parts of New Jersey.

One of the parties has continued the sounding in the Delaware

16. Question. Are we not greatly deficient in knowledge of soundings in Buzzard's bay, Nantucket shoals, Cape Cod, and Massachusetts bay?

Answer. Yes.

17. Question. Is not a knowledge of those soundings of the greatest importance to navigation?

Answer. Yes; it is more wanted there than any where else. More tonnage passes. Most vessels from Europe, for New York and Philadelphia, come between the Gulf stream and Nantucket shoals, in addition to the navigation north of Cape Cod. Most of the coasting trade comes through the Vineyard.

Answer to question 10. The topographical drawing, as used in good style of maps in Europe, has never yet been done in this country. *I challenge positively* the exhibition of one. To make the coast survey maps in the same way as the sea charts, and the work shown under Stone's name, would be a positive disgrace to the work, and the state of the art and science in this country, thence it is not admissible for the work. Stone can only engrave cards, and such like, as I have a man in the weight and measure, works to mark the standards.

4. The make of the land decides how far the topography must go inland, to follow the windings of a creek or river costs much more time and work, therefore, also money, than the sweeping survey of the whole country in which they lie, and all the highlands, &c., that may be seen from the water in any way, must be presented by the chart to the aspect of all seamen.

1842 – addressing questions posed by Congress. Also weights an dmeasures seems to be done.

Questions of the resolution of Congress of June 24, 1841, *relating to the survey of the coast of the United States, with the answers to the same, by* F. R. HASSLER.

Ques. 1. "The progress which shall have been made in the survey of the coast."

The works of the survey of the coast cover now upwards of 11,000 square miles, with primary and secondary triangulation, topography, and soundings; from the east end of Rhode Island to the neighborhood of the Chesapeake and Cape May.

This is evidently a great progress for the time that the work has as yet lasted; particularly if it be considered that every thing was to *be created*—even the ability of the assistants, they being at first new in the business. It is actually *much more than has ever been done in any similar work before;* for it must be recorded: that since the first law of 1807, nineteen years were entirely unproductive for the work, by postponement and interruption; five years were used in procuring the necessary instruments, and in preparations, as before that time there was not a single instrument, in this country applicable to such a work. Only ten years were employed in the actual work; of which the two first, 1816 and 1817, were rendered useless, and the expenses made became a bill of loss, by the overthrow of the work in 1818; so that the whole work now producible is the result of hardly about eight years actual work.

Purpose

The aim of the coast survey is, and has always been considered to be, by all the successive administrations since its existence, to furnish, with the fullest accuracy possible, all the geographical, topographical, and hydrographical data that may in any way be needed for the navigation and the defence of the coast, in their generality, and to the extent of the country in the rear of the coast, to which the valleys extend: that empty their waters into the Atlantic, and are thus separated from it by some chain of mountains, or what may be called the nearest chains of elevations separating the interior from the coasting countries; and that this work should also furnish the elements to any future map of the country desired, as it is by its nature so extensive, and so situated, as to furnish the elements of maps of all the States. In fact, some States have already united in the work, to extend these elements to the advantage of an accurate map of these States.

Ques. 3. "The number of the stations occupied therefor, (namely, the triangulation.")

The stations occupied in 1817 were 11, forming the elements of 124 triangles. At that time I was alone in the work. Since 1833, the primary triangulation has occupied over 20 stations. The secondary triangulation has several hundred stations. In the tertiary and plane-table works the number of stations is much greater. These details can best be inspected, or inquired into, in the office of the coast survey itself.

It is here only proper to remark, that the reducing of the primary triangles to the smallest number is one of the great requisites for the accuracy of such a work. To bring the irregular shape of the country into the most advantageous regular mathematical figures, which is the requisite of an accurate survey, is what makes the strongest call upon the science and ability of the operator; therefore its value and labor cannot be judged by the *quantity*, but by the *quality alone*, which, to judge of, requires the same insight into the mathematical and physical sciences as the execution of the operation itself. The success in all these things depends not only upon the instruments and labor of the observer, but still more upon the perfection of the *methods* devised for the work. In this respect I have the favorable unanimous judgment of the most eminent men of science in Europe, distinctly expressed in publications, (see documents, vol. 1, pp. 55, 59, seq.,) so that in fact the speciality of my *methods* are not only *publicly known*, but even publicly *judged*, and *approved*, long ago.

Ques. 6. "The work done by each corps employed in the service."

The survey works are distributed by myself to the best advantage of the work, according to the time, situation, and capacity of the assistants, at any given period, in proportion and succession as they are wanted, and not according to districts or localities. The works are contained in—

32 folio volumes of my own observations and results;

90 folio volumes and cahiers of the assistants;

30 or 40 cahiers, folio, of calculations, and tables, &c.—and upwards of 100 journals, of all sizes, of naval and tidal observations, soundings, and observations thereto belonging. To this I might be allowed to add—

17 volumes of documents of correspondence, and upon subjects of the administration of the work; and about 20 volumes of journals, calculations, and documents relating to the works for the construction of standards of weights and measures;

140 maps; and

80 charts of original works of the different assistants, upon different scales, from $\frac{1}{5000}$ to $\frac{1}{80000}$;

2 register maps, upon a scale of $\frac{1}{100000}$, keep account of all these works, and serve as guides to select the original maps of any part of the work, of which an abstract, or the execution of a map for publication or otherwise,

may be desired. These two maps exhibit the works done upon the 11,000 square miles collected together; the one has 10 feet length by 4 feet breadth; the other, 5 feet length by 4 feet breadth;

4 sketch maps, showing the present state of the triangulation, and of the topography and soundings; and three or four similar ones, showing the state of the works at each preceding year. A number of triangle sketches, and preliminary reductions of the charts and maps, for the use of the register maps, &c. The map of New York is executed double, in manuscript, besides the engraving.

Regular registers of all the journals and maps keep up, to every time of return from the field work, the account of the whole work; they are constantly open in the office for inspection, as well as the works themselves.

In 1811, I was sent to London to procure the instruments for the survey of the coast, to be constructed upon my plans, previously presented to the Secretary of the Treasury and to the late Professor Patterson, and by them

The appropriations made for the coast survey, since its being taken up again, are as follows:

In 1832	$20,000
1833	20,000
1834	30,000
1835	30,000
1836	80,000
1837	60,000
1838	90,000
1839	90,000
1840	100,000
1841	100,000
Total	620,000

It is to be observed that a considerable amount of actual property exists in the coast survey establishment, which forms in fact an unexpended capital; five vessels, numerous boats, instruments, clocks, chronometers, books, tables, chairs, tools, tents, and in general all the implements necessary in the office and in the field, besides the full equipment of the vessels, &c. Some of these latter have been returned to the Treasury Department, and their amount is still due to the coast-survey fund. An abstract of an inventory of the property in hand is joined herewith, the amount of which exceeds, certainly, $120,000.

Ques. 13. "The probable length of time required to complete the survey."

It would be highly improper to answer this question by *direct numbers*. It was made to me by the President in 1835. I answered it by stating this, and entering into particulars about the state of the coast survey, its variable chances in locality, weather, &c., and upon my methods of proceeding, with the view both to accuracy and celerity, and to the *best forwarding* of the work. The ultimate answer of the President was, "that is right; that will accelerate the work," as stated in its proper place in the

These officers receive an additional pay from the coast-survey funds, but from the navy nothing different from any other service in which they might otherwise be engaged. The naval part of the work is of course the smallest division of the work, as the naval operations have nothing to do with the direct determination of any distances. These are furnished by the tri-

and I should like would be made, comparatively to any other works, would certainly show that never so much valuable work of that kind has been obtained, in any country, and under any known arrangement, as there has been obtained, in the same time, at a proportionally equal expense, as in this survey of the coast of the United States, under the *present organization and administration of that work.*

Long discussion about how similar approach was used throughout Europe – with great detail.

List of instruments belonging to the United States coast survey.

1 30-inch theodolite. Troughton & Simms.
1 24-inch theodolite. Troughton.
1 18-inch repeating circle, with 2-feet telescope. Troughton.
1 18-inch theodolite. Simms.
1 18-inch theodolite. Made in office.
1 12-inch repeating theodolite, with vertical circle. Troughton.
1 12-inch repeating theodolite. (Lent to the State of Massachusetts.)
1 10-inch theodolite. Richer.
1 9-inch theodolite. Made in office.
1 24-inch vertical circle. Troughton & Simms. Brass stand to the same, made in office.
3 repeating reflecting circles, with brass stands, horizon, and mercury flasks.
1 repeating reflecting circle, without stand.
1 5-feet observatory transit instrument. Troughton.
1 5-feet observatory transit instrument. (Lent to the Navy Department.)
1 small transit instrument and stand. Made in office.
15 sextants.
1 transportable clock of Brookbank.
1 astronomical clock of Hardy.
5 box chronometers.
12 watches.
1 three-hundredth second watch.
4 mounted barometers of F. R. Hassler.
4 mounted barometers. (Lent to the State Department.)
1 mounted barometer. (Lent to the War Department.)
1 reflecting telescope of Troughton.
1 6-feet telescope. Dollond.
1 5-feet telescope. ditto.
1 4 $\frac{3}{4}$-feet telescope. Tully.
1 3½-feet telescope. Dollond.
1 3½-feet telescope. Troughton. (Lent to the War Department.)
4 3½-feet telescopes. Frauenhofer & Utzschneider.
4 2½-feet telescopes. Frauenhofer & Utzschneider.
5 pocket telescopes.
7 large heliotropes, with brass stands.
4 small heliotropes.
14 thermometers.

10 large alhidades.
2 small alhidades.
6 complete plane tables.
3 brass motion works for plane tables.
1 brass rule of Schenck's alhidade, with magnetic needle.
1 large azimuth compass, 1 foot needle, and telescope.
1 compass, with telescope, needle, and stand.
2 compasses, with telescopes.
1 small compass, with prismatic readings.
2 2-arm protractors.
2 3-arm protractors.
1 brass circular protractor.
1 small steel protractor.
1 58-inch German silver beam compass.
1 56-inch brass beam compass.
1 32-inch brass beam compass.
1 32-inch graduated brass beam compass.
21 beam compasses of different sizes and metals.
3 steel rulers of 8 feet length.
9 steel rulers of 5 feet length.
1 brass ruler of 5 feet length.
5 steel rulers of 3½ feet length.
2 steel rulers of 2½ feet length.
12 metre scales of brass and German silver.
11 metre chains.
5 graduated triangles.
12 triangles of different sizes, brass and steel.
1 30-inch dividing plate of Bird.
1 new tracing apparatus. Made in office.
3 parallel brass ruling instruments. Made in office.
12 boxes of mathematical drawing instruments.
1 82-inch scale of Troughton, divided on silver, with microscopic comparateur.
1 scale beam and grain weights of Troughton.
1 brass metre of Lenoir.
1 iron metre of Lenoir.
1 iron toise of Lenoir.
2 subdivided kilogrammes.
2 litres modeles.
4 micrometer microscopes, with reflectors.
1 double wire micrometer of Dollond.
1 level tryer, with micrometer screws.
2 micrometer screws.
2 large artificial horizons.
3 small artificial horizons.
1 box with mounted levels.
1 box with unmounted levels.
1 box with parallel glasses.
1 box with dark glasses, sextant mirrors, lenses, reading glasses, and sets of dark glasses.
1 rectangular level arrangement from Brookbank's clock.

1 vertical circle, telescope, &c., of broken repeating circle, from which an instrument is now being constructed in the office.

The base apparatus consists of—
2 boxes with microscopes.
2 boxes with brass and steel motion works.
2 boxes with iron bars.
1 box with thermometers.
1 box with wooden legs for the microscopes.
1 long wood bar, box, and base plank.
2 large brass sectors with levels.
12 large wooden stands with screws.

There belongs to the coast survey a library of a few hundred volumes of valuable mathematical and astronomical works, a number of which are very rare; all classical in their kind.

The following vessels belong to the coast survey:
Brig Washington, with 4 boats.
Schooner Jersey, with 4 boats.
Schooner Gallatin, with 3 boats.
Schooner Nautilus, with 3 boats.
Schooner Vanderbilt, with 1 boat.
The plane table parties have 5 boats in use.
The different land parties have in use 60 tents of different sizes.
Every party has the necessary carpenter tools.

For the triangulation parties there are—
6 instrument carriages.
1 1-horse wagon.
8 horses.

The instrument maker's shop has—
1 large turning lathe, cast-iron frame, wheels, &c.
1 turning lathe, with cast-iron shears, wheels, &c.
1 small turning lathe, with cast-iron shears, wheels, &c.
1 watch maker's turning bench, with all necessary implements and tools.
The artificer's shop has a carpenter's bench, with all the necessary tools.

In the office rooms there are—
12 drawing tables, of different sizes.
9 writing tables and desk.
5 bookcases.
Stands, chairs, washstands, fenders, shovels and tongs.

List of everyone employed – civilians, naval officers,

Lengthy testimony, questioning by Congress. Of head and subordinates.

60. Question. How far in from the coast have plane-table parties gone on the survey?

Answer. I cannot say precisely. They are carried on by Mr. Gerdes, Mr. Sands, Mr. Boyd, Mr. Dickens, and Mr. Werner.

61. Question. Do the plane-table parties require much science?

Answer. They require practical skill.

62. Question. When a secondary triangulation precedes the primary, is it not a second without a first?

Answer. Technically, it is.

16. Question. Are we not greatly deficient in knowledge of soundings in Buzzard's bay, Nantucket shoals, Cape Cod, and Massachusetts bay?

Answer. Yes.

17. Question. Is not a knowledge of those soundings of the greatest importance to navigation?

Answer. Yes; it is more wanted there than any where else. More tonnage passes. Most vessels from Europe, for New York and Philadelphia, come between the Gulf stream and Nantucket shoals, in addition to the navigation north of Cape Cod. Most of the coasting trade comes through the Vineyard.

27. Question. Is the topography of the country within the coast of any importance to navigators?

Answer. It is not, except for four or five miles, or where there is any remarkable eminence or other object inland.

28. Question. Is it customary to lay down the topography of the country on the charts of navigators?

Answer. I have never seen it in any charts except of islands. In charts of the West India and other islands it is sometimes given; but in these cases it is not necessary for purposes of navigation.

Interogated everyone form engraver to ship captain to leader of teams etc.

quired by the operators, and loses the character of a systematic work.

28. Since the resolution of 24th June, 1841, so much of my time has been taken up by polemic discourse, pressed upon me first from Congress, which has, of course, other disagreements in its consequence, that actually more than one year of my work was lost, which I would, with immensely more satisfaction, have applied to the forwarding of the interesting and valuable works which I have engaged for with the Government.

F. R. HASSLER.

WASHINGTON CITY, *January* 10, 1843.

Then lots on weights and measures

1843 – Congress requests lists of all employees

Ans. [Add. As I keep a regular journal every day, since 1811, when I left Schenectady for London, for all the time that I am in public employment, I can give exact account of every event of any moment; here follows therefore the *extract from the journals* referring to this question. My work in the office has always been the most arduous and laborious task, as well in the combination of the scientific methods, devising the means, the calculations, and all the manifold parts of the administration or direction of the work. Any man of science in this practical line will see that easily.]

Upon the Question of Limitation of the Works for the Survey of the Coast.

1. The limitation to any determined distance from the Coast, would require that the mountains, which are indispensably necessary for the station-points of the Survey, be within that limited distance.

2. This is well known not to be the fact, therefore also, the limitation not adapted to the nature of the country, thence, this limitation would become impossible to be observed, if even decreed.

3. If even smaller elevations were found within these limits, which it might be said fit to substitute, instead of the greater ones, it would be improper to use them, otherwise than so as they are

8th. Upon the limitation of the work only in the *topographical part*, the same reasoning applies as to the more extensive operations; the inland bays, rivers, creeks, &c., which are navigable, are all so winding and very often hid in hardly approachable marshes, that to follow them, which often would be fully impossible, would necessarily take up much more time than to survey them by the general survey of the whole topography of the neighborhood.

9th. How far therefore this topography shall, can, or must, go, it is as impossible as improper to determine beforehand; without the special reference to any given locality nothing can be said about it in general terms.

10th. This reference to any given locality can only be decided by the operator upon the spot, and the special superintendent of the work, as has always been done hitherto.

11th. The topography has hitherto never yet been carried further than

12. Any idea of limitation and distinction, between the different parts of the works, would never be understood by the uninformed people, with whom the operators in the work must come in daily contact in the field works.

13. Thence would result that any owner of land, upon which an operator in the Survey would have to go, could explain this li-

Light-house establishment, 1842.

That some of our light-houses should be undermined by the encroachment of the sea, and have to be taken down and removed further back, is not strange; it is a circumstance they will always be liable to. It is no fault of those who selected the sites or built the light-houses. I have had an opportunity of observing the encroachment of the sea on our whole coast for thirty years, visiting every light-house in the United States once every year for sixteen years. Capes, with the ocean on one side, and the rapid current of some river on the other, as Cape Henlopen and Cape Henry, are the most liable to wash away; but your light-houses must be located at those capes, and must not be set too far back from the shore. The shore continuing to recede for a series of years will oblige you to remove some of your light-houses further back. This cannot be avoided. There

[*Swift*, p. 35.

The principle upon which the survey of the coast is conducted is, essentially, that which is known as the trigonometric method. By the relations which subsist between the sides and angles of a triangle, we are enabled, from certain known data, previously determined by actual measurement, to compute certain other parts which are unknown. For example: in a given triangle, by measuring one of the sides and the angles, the two remaining sides can be determined by computation. These computed sides then serve as bases for other triangles, and subsequently, by measuring the angles *alone* in the triangles thus formed, the work is extended *ad libitum*. This is called a triangulation, and may be made upon any part of the earth's surface upon which a line of a given extent can be measured.

WASHINGTON, *May* 30, 1842.

SIR: The unprovoked *insult* offered to me, by sending the engraver Stone to me to inspect the work of the coast survey in the map of New York, is too much, as well for the powers of the committee, as for the feelings of an honest man.

12. The letter of Mr. Mallory, requesting me to give the map of New York to Mr. Stone, *to examine*, (please consult Johnson's dictionary for the real meaning of this word)—an operation which would require, of course, a good mathematician, conversant with the principles and practice of the works of the coast survey ; I felt very hard to be subjected to the *examination* of a man whom I know incompetent for that task. I even told him directly "you are not capable to put this map upon copper;" he immediately answered "I know that very well."

THE MAP WAS, HOWEVER, SHOWN TO HIM IMMEDIATELY, in presence of several assistants, and he measured it with a two-foot rule, as if to order the coffin for it of proper size. Those of my assistants who were present at the time, were as much displeased with the circumstance as myself, and I found it necessary to state on that occasion, a limit which I had hoped would not be stepped over; Stone himself felt that he had overstepped his limits. [*Hassler.*

The works of the coast survey have, since my report of 2d December of last year, continued in all the different branches, with steadiness and assiduity, the same as has always been habitual, on the part of every one engaged in the work, notwithstanding the difficulties arising from the nature of the ground, and other causes, which have required increased attention, and from the intermittent fevers, which have more or less attacked every party of the work at different times. This latter difficulty being local, and well known to increase in proportion as the work proceeds southerly, will, in a year or two, oblige to change the time of the year to be used for the field works, approaching it always nearer to the winter season; this will, however, make but a slight difference in the general organization of the work, the nature of the changes that may arise from this, or any other accessary circumstances belonging to the detail administration of the work, are so much less to be detailed here, as they are only prospective, therefore, as yet, undeterminable.

me:" see questions 63, 64, 66—76. All that relates in any way to the actual work, I had explained in full at other places; the most remarkable defeat of their questions was, when thinking to find me not able to answer, exactly, the time of my going to the field work, and returning here, every year, since 1832. I could indicate the hour, and half hour, of my departure and arrival in every year; upon which Mr. Mallory was himself *obliged to laugh* at Mr. Aycrigg, who had proposed the question, in high hopes of a catch, if it was in any way reflected.

mitation to his fancy, or interest, and attack him, drag him to jail, and otherwise expose him to insult, and ill-treatment, at his own option, as has been too often the case already.

14. That even this accessory incident causes much loss of time, and forms an actual retardation of the work, is self-evident, as well as its expensiveness.

15. The topographical part appears by experience, to be that least objected to, by the inhabitants, to judge from the manner in which the operators have been received, in comparison with the difficulties that have been laid in the way of the other parts of the work.

16. In general, a limitation to three miles from the Coast, as has been talked of, is a virtual abolition of the work itself, as well from the side of the natural, as the moral, difficulties it would suscitate, and the impossibility of giving to the work the required accuracy; nor would any other limitation be less injurious.

17. The shore line of a coast is never seen from a ship approaching it; the picture of the elevated land, is what presents itself to the sailor; in this he is guided by so much of the topography, as can be seen at a reasonable distance at sea, and this lies back in the country at distances, which are not determinable but by actual survey, thence the only rule is, that which I have followed, and long ago stated, namely, the "topography must go to the ridge of mountains which determine the heads of the coasting rivers, or creeks, or their passage through such mountains, what is called in France, technically, *le versent de la Vallée côtiere*," or, "*le versant de la Cote*." Such it has always been understood and approved.

18. My rule of action and guide in the work, must be my contract to make the work "*honorably and permanently useful, to the nation.*" The way to obtain the aim must be left to me; if I was to be guided by any foreign direction, except mathematical principles, some of my assistants might even rise up against me, refusing to do what they might think to exceed my powers, and I would either have to dismiss them for such refusal, or the work would become impossible.

19. Hitherto the work has proceeded in harmony, and with all good willing exertions on the part of every one; if such had not been the liberal action of all in the case, not half the work would be done, which actually is done.

20. The attempts to find causes for change in my arrangement, by the resolution of the last Congress session, and the present Committee, have already caused a great damage.

60. Question. How far in from the coast have plane-table parties gone on the survey?

Answer. I cannot say precisely. They are carried on by Mr. Gerdes, Mr. Sands, Mr. Boyd, Mr. Dickens, and Mr. Werner.

61. Question. Do the plane-table parties require much science?

Answer. They require practical skill.

In conclusion, the following suggestions are submitted:

That the President be requested to take such measures as may preserve the measured base, and also the actual base, if, in his opinion, the same be practicable; and to inform this House, at its next session, of the existing condition and the prospects of the future preservation of the same, together with such suggestions as he may deem advisable.

That the Topographical bureau be directed to take all the detail surveys on land, including the military information necessary for the defence of the country, from points furnished by the general survey of the coast, and that the draughts prepared from the same be preserved in the War Department, for the exclusive use of the Government, while the navigator's chart shall exhibit no more of the inland districts than such as shall be necessary for the navigator, according to the system pursued in preparing the sea charts by the Governments of France and England.

It is also a little peculiar that our survey is calculated in French metres. (92) It is a measure not usual in the country, and, with the exception of a few metres that have strayed into this country, must in general be deduced from our foot or yard measure. The English used their own measure; but, after all the expense of constructing standards for this country, it seems that the very individual who had charge of this work rejects his own measure. These two points are of no great importance; but it is an important fact that our standard measure, as constructed by Mr. Hassler, contains nothing but yards and decimals, and has neither a *foot* nor an *inch* marked on it.

NOTE (3.)

AN ACT to provide for surveying the coasts of the United States.

SEC. 1. *Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled*, That the President of the United States shall be, and he is hereby, authorized and requested to cause a survey to be taken of the coasts of the United States, in which shall be designated the islands and shoals, with the roads or places of anchorage, within twenty leagues of any part of the shores of the United States; and also the respective courses and distances between the principal capes or head lands, together with such other matters as he may deem proper for completing an accurate chart of every part of the coasts within the extent aforesaid.

NOTE (5.)

"Survey of the coast" "must present the localities of all the passages and gorges that lead to these valleys, &c., because it must contain all that is needed for the proper defence of the coast in the case, of any attack whatsoever, just as much as the outlines of the coast and the soundings, because, like these, furnish the guide to the navigation," &c. (See this extract—military purposes, statistics, and article 47, for use of State surveys, 1834–'35, Doc. 2, page 372.) [*Hassler.*

The aim of the coast survey is, and has always been considered to be, by all the successive administrations since its existence, to furnish, with the fullest accuracy possible, all the geographical, topographical, and hydrographical data that may in any way be needed for the navigation and the defence of the coast, in their generality, and to the extent of the country in the rear of the coast, to which the valleys extend, that empty their waters into the Atlantic, and are thus separated from it by some chain of mountains, or what may be called the nearest chains of elevations separating the interior from the coasting countries; and that this work should also furnish the elements to any future map of the country desired, as it is by its nature so extensive, and so situated, as to furnish the elements of maps of all the States. In fact, some States have already united in the work, to extend these elements to the advantage of an accurate map of these States. (Doc. 28, page 3, 1841–'42.) [*Hassler.*

NOTE (9.)

Hassler's comments

1. In the last discussion upon the appropriations, it has pleased Mr. Aycrigg, and one more of the members of a committee of five Representatives in Congress, to throw out the broadcast accusation, that I was mentally and physically incompetent to that task which I have now performed for ten years, with full approbation and even praise, on the part of the men of science of Europe and of this country.

Page 46, Mr. Hassler says: "It is a curious phenomenon, that while from all the better-informed public, both of Europe and of this country equally, I receive almost daily testimonials of the interest and value put in the work in which I am engaged," &c., "the public Department under which it stands should refuse every proper means, and propose every means of destruction." Again: "Difficulties never subdued me in my life, though I can affirm that I have subdued difficulties. My means are moral and intellectual; that is, stronger than money, or money considerations."

HON. JOHN B. AYCRIGG,
House of Reps. United States.

1844 – Hassler dead

[illegible] NEAR CUMBERLAND HEAD, RHODE ISLAND,

November, 1844.

SIR: In compliance with the regulations for the survey of the coast, I have the honor to submit to you a report of the "progress and state of the work," to be "laid before the President and Congress."

The coast survey owes its present form, and perhaps its existence, to the zeal and scientific ability of the late superintendent, F. R. Hassler, who devoted the energies of a life to it; and who, but for its interruption at a period when he was in the prime of manhood, and its suspension for nearly fifteen years, might have seen its completion. The difficult task of creating resources of practical science for carrying on such a work upon a suitable scale, required no common zeal and perseverance for its accomplishment, especially at a time (1807) when our country was far from having attained her present position in scientific acquirement, and when public opinion was hardly sufficiently enlightened to see the full advantages of thoroughness in executing the work. For his successful struggle against great difficulties, his adopted country will no doubt honor his memory, as the pioneer of a useful national undertaking. In succeeding to the duties of one

The appropriation of the present fiscal year does not permit such a course. It is less by one-fifth than that of years immediately preceding; and, with these diminished means, it has been necessary to provide for operations of the more expensive class, growing out of the new circumstances of the survey; to furnish additional parties, so that the regular operations might go on, and to give additional force to the publishing department. How far this has been satisfactorily accomplished, by the arrangements of the work and the conjoined efforts of all engaged, will appear in the course of the report.

[illegible] work for the year.

The operations of the survey have, during the present year, been carried on in nine States of the Union, and will be extended soon to three others, making twelve, and probably into a thirteenth in the spring. Enumerating these in geographical order, they are—Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, North Carolina, Alabama, Mississippi, and Louisiana. The greatest force has been employed on and near the Chesapeake and Delaware bays.

I.—From Narragansett Bay, northward and eastward.

1. *The primary triangulation* has been extended northward and eastward across the State of Rhode Island and part of Massachusetts, joining the main triangulation previously made in that quarter, and resting on the base now measuring. The scheme of the triangulation is shown in the an-

was 2,753. The stations observed upon, fifteen in number, extend from Narragansett and Buzzard's bays, and Martha's Vineyard sound, on the south, to near Boston harbor on the north, and to Massachusetts bay on the east. The area included in the triangulation is about 1,100 square miles, reckoning at one-third and at two-thirds, respectively, the areas, where one and two angles of the triangles have been measured; but the sums of the areas of the different triangles measured in the observations is more than 4,000 square miles.

At three of the stations, astronomical observations were made, and at four, magnetic and meteorological observations. The number of observations for the measurement of the angles in the triangles is about 2,100, for time 359, latitude about 3,800, for azimuth 340. Vertical angles for the relative heights of the stations were measured at two of the stations.

The horizontal angles for the triangulation were measured, and observations for azimuth were made, by myself personally. The observations for time and latitude and for elevation were made by the assistants of my immediate party, Lieutenant T. J. Lee, of the United States topographical engineers, and C. O. Boutelle, Esq.; and the magnetic observations, generally, by Lieutenant Lee.

2. The *secondary triangulation* in this section has been extended to include Buzzard's bay and the greater part of the Vineyard sound, from East rock to the east chop of Holmes's Hole, Martha's Vineyard. Preliminary operations were commenced in May; and between the 12th of June and the middle of October twenty-four stations were occupied, and more than 6,600 angles measured upon sixty-eight objects, viz: 44 signals, 13 spires, 9 lights, 1 beacon, and 1 telegraph. The area covered by the triangulation, estimated, as already explained in the foregoing, is three hundred and seventy-nine square miles. It has fully prepared work for three plane-table parties next season, should so many be provided. The triangulation was planned and executed by assistant C. M. Eakin. A sketch

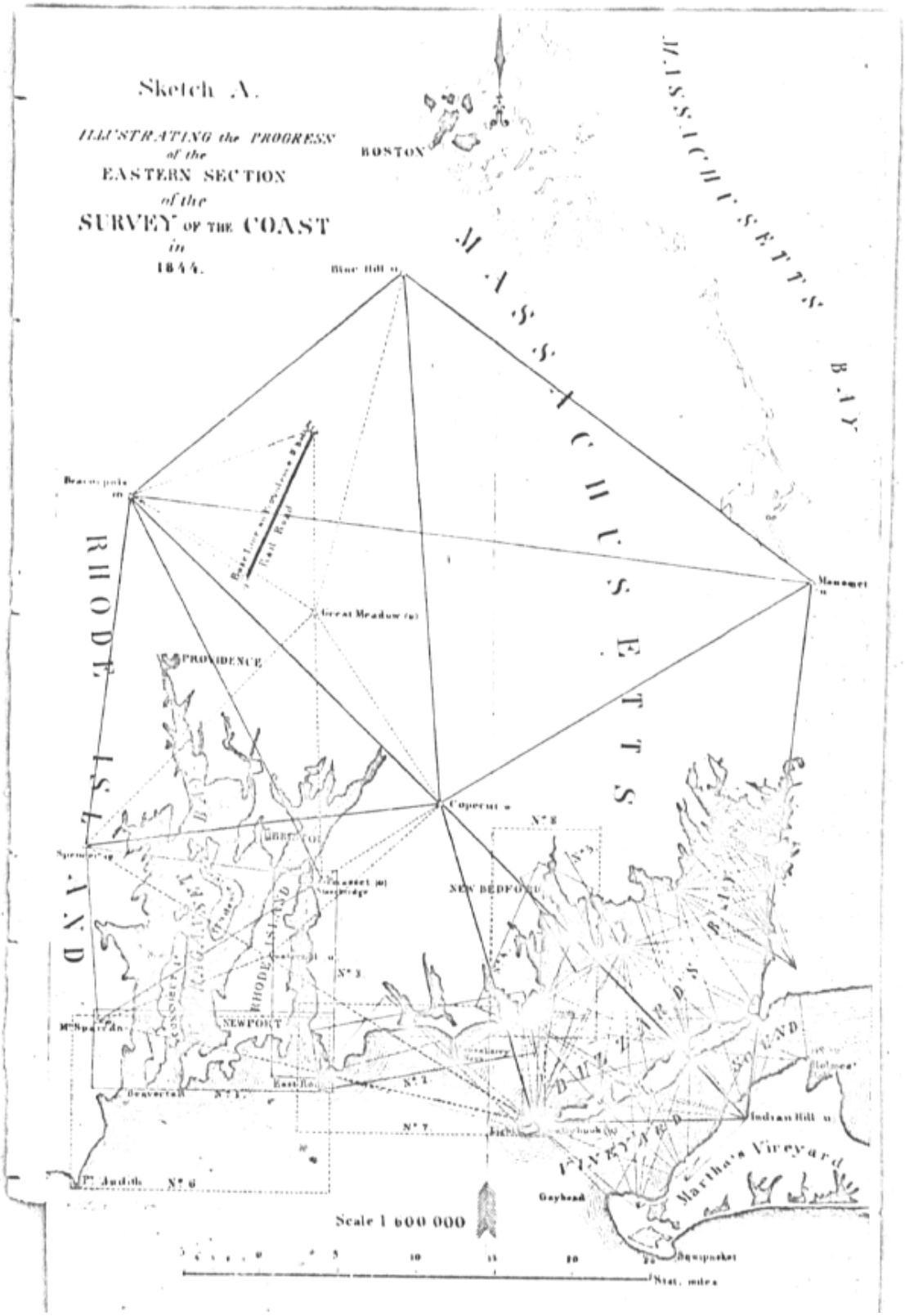
3. The *topographical work* in this section has employed two parties. The first, under charge of assistant W. M. Boyce, was in the field from the 15th of May to the 9th of November. The plane-table survey made by him extends from Beavertail light-house, on Connanicut island, Rhode Island, to Mishaum point, Massachusetts, on the western side of Buzzard's bay, including the southern shores of Connanicut and Rhode islands, and of the main in the States of Rhode Island and Massachusetts, and the harbor and town of Newport. It comprehends an area of eighty square miles, ninety miles in length of shore line, fifty-eight miles of roads, and forty-four of the shore line of ponds. The limits of the plane-table sheets are shown upon sketch A, where the sheets are numbered 1 and 2. A small vessel was hired for the use of the party, an arrangement recommended by Mr. Boyce, on the ground of economy, and of facility in moving from point to point.

Assistant H. L. Whiting, in charge of the second topographical party in this section, has nearly completed the three plane-table sheets, numbered 3, 4, and 5, in sketch A. The first sheet takes in both sides of the eastern arm of Narragansett bay, sometimes called Saughkonnet river, extending from its entrance on the south to the stone bridge connecting Rhode island and the main, near the north end of the island. The second and third extend from Mishaum point, to include the harbor and towns of New Bedford and Fairhaven. The area of the work done is about sixty square miles, the extent of shore line surveyed about sixty miles, and the length of roads about one hundred miles. The party was in the field from the 6th of May to the 25th of November.

The results obtained by these parties were furnished to the hydrographical party acting in the vicinity. The total area surveyed by them was one hundred and forty square miles, and the length of shore line determined one hundred and fifty miles.

4. The *soundings* of this part of the coast have been nearly completed from Point Judith to New Bedford harbor, inclusive. They extend (as shown in sketch A, where the sheets containing them are marked Nos. 6, 7, and 8) off the shores of Rhode Island and Massachusetts, to a line drawn from Point Judith to Gay head, as far east as the meridian of East rock, and east of this to the line Point Judith-Cuttyhunk. Observations of the currents have also been made at the entrances of Narragansett bay and in Buzzard's bay. On the completion of the soundings in the harbor of

In the report at the close of the season, Lieutenant Commandant Blake remarks: "In conclusion, I cannot forbear calling your attention to the great deficiencies in all the existing charts of the dangerous section of the coast upon which I have been employed this season. They all appear to have been founded upon the survey of Des Barres, made before the Revolution, with some occasional amendments and additions, but, even immediately off the important port of New Bedford and Fairhaven, where nearly three hundred whale ships are owned, I found dangerous single rocks near one of the main ship channels with but five feet water on them, entirely omitted in the latest publications. These rocks are not marked by buoys, and certainly not generally known. I propose hereafter to name to you certain localities where I think buoys very necessary indeed."


Sketch A.
ILLUSTRATING the PROGRESS of the EASTERN SECTION of the SURVEY OF THE COAST in 1844.
BOSTON
MASSACHUSETTS BAY
MASSACHUSETTS
RHODE ISLAND
Blue Hill
Great Meadow
PROVIDENCE
Monument
Copecut
NEW BEDFORD
NEWPORT
Indian Hill
Martha's Vineyard
Gayhead
Scale 1 600 000
Stat. miles

1845 – Report in February 1845

TREASURY DEPARTMENT,
February 27, 1845.

SIR: I have the honor to transmit, herewith, a report on the progress made in the construction of standard weights, measures, and balances, during the year 1844, under the superintendence of Professor Alexander D. Bache.

All which is respectfully submitted.

GEO. M. BIBB,
Secretary of the Treasury.

Hon. JOHN W. JONES,
Speaker of the House of Representatives.

14. The lamented decease of Mr. Hassler occurred in November, 1843; and in January, 1844, Mr. Edward T. Hassler, who had been appointed assistant to Mr. Hassler in 1835, presented to the Treasury Department a report of the progress which the work of weights and measures and balances had made up to the beginning of 1844. This report not having

15. On the 20th of January, 1844, Mr. Edward Hassler resigned his position; and the papers, of which a detailed list is appended to this report, (marked B,) were handed to me, as the archives of the department of weights and measures. These are the only papers received by me as such. At the time of the delivery of the property in the office of weights, meas-

Any diminution of the sum there asked must involve a decrease in the amount of work which is practicable, and thus, postpone the realizing of the results of the survey on some portion of the coast, and the ultimate completion of the work. Operations are proposed which may certainly be accomplished with the present scientific force, or with a very moderate addition to it. The number of parties which may be employed advan-

It is sometimes supposed that salaried officers alone constitute the working parties of the survey. It is true that the scientific chief of each party is the essential person by whom the results are obtained, and who works with his hands as well as his head; but there are also purely manual operations to be performed, requiring in each of the land parties the employment of at least from four to six, and in some cases ten and twelve men. The number of persons therefore necessarily employed in the mechanical operations of the survey is very considerable.

The increase of the appropriation for the year 1845 will enable

The following is a summary of the work done since November, 1844, the date of my last report:

In the eastern section.—The primary triangulation has been extended to Cape Ann and across the northern boundary of Massachusetts, one station observed on being in New Hampshire. The verification base, on the Providence and Boston railroad, has been connected with the primary triangulation. The secondary triangulation has been carried to the peninsula of Cape Cod. The topography of the shores of Buzzard's bay, the Elizabeth islands, and Martha's Vineyard has been nearly completed. The hydrography includes Buzzard's bay and part of the Vineyard sound. Additional observations for differences of longitude from Europe have been procured at Cambridge, Portland, and Nantucket. The work of this section has been within the limits of the States of Rhode Island and Massachusetts.

From Narragansett bay, eastward and northward, to Massachusetts bay.

If any incentive to exertion had been required in this section of the work during the past season, it must have been found in the accidents occurring within the knowledge of the different parties, from a want of information in regard to the dangers of this part of the coast. In the Vineyard sound a ship prepared for a whaling voyage to the Pacific struck, in good weather and with a fine and fair breeze, upon a shoal off Holmes' Hole, and this vessel had not entirely been released from peril, to be taken into harbor to refit, when a heavily loaded schooner struck near the same spot. The injury to the first of these vessels would have paid for the operations of the survey in this quarter more than twice over. The ship Centurion, lost on Nantucket south shoal during the summer for want of knowledge of the extent of the shoal and of the set and drift of the tides near and upon it, was insured for a sum beyond the whole appropriation for the field work of the year. These are only a part of the accidents which occurred in this region during the summer, the least dangerous portion of the year. There passed through the Vineyard sound within the last three years, (as appears from an interesting letter from William Mitchell, of Nantucket, appended to this report, appendix, No. IV,) four hundred and forty-seven ships, three thousand six hundred and sixty-four brigs, twenty-three thousand two hundred and sixty-two schooners, and nine thousand seven hundred and seven sloops; or a total of thirty-seven thousand and eighty vessels. The sound through which this trade is carried on in these vessels has many dangerous shoals, the limits of which are not defined on the existing charts. The pilots know the chan-

nels, but not the configuration of the bottom generally, and, besides this, a vessel is often without a pilot when danger is nearest. The coast survey will soon be able to supply the want of a good chart in this quarter.

1. *The primary triangulation* in this section has been carried from Narragansett bay eastward across Buzzard's bay, the Vineyard sound, and the sound between Nantucket and Cape Cod; then northward across Cape Cod and Massachusetts bays, where it meets the same work carried northward from Narragansett bay, and stretches to the hills which are near the northern boundary of Massachusetts, and into New Hampshire.

The diagram (sketch A) gives a sufficiently correct idea of the character of the triangulation, and of its connexion with the geographical features of the country. It rests upon the base measured by assistant Blunt, on the Boston and Providence railroad, as shown by the dotted lines in the diagram. It is connected with the main triangulation, and carried eastward, as indicated by the lighter full lines, the line McSparran —Quaker Hill being common to the two triangulations. Passing eastward, it gives a suitable base (Cuttyhunk—Indian hill) for the secondary triangulation; determines an important point (Cuttyhunk) at the entrance of Buzzard's bay and the Vineyard sound, a point on Martha's Vineyard, a point on the island of Nantucket, one on the ridge of Cape Cod, near Barnstable, one near the extremity of Cape Cod, one at Manomet point, near Plymouth; furnishes the base Manomet—Provincetown, for the secondary work; determines a station (Blue hill) overlooking Boston harbor, a point (Thompson's hill) near Cape Ann, and other stations suitable for carrying the work along the coast of New Hampshire and Maine.

The character of the country, in proceeding northward and eastward from Massachusetts, admits of a triangulation with sides of very considerable length, tending to accuracy in the scientific results, and to economy and rapidity in the practical ones. At the same time, by adopting intermediate points, a series of triangles is formed, furnishing, directly or by easy subsidiary operations, frequent bases for the secondary work, in addition to the constant checks presented by the positions of the primary points themselves. Thus, for example, the quadrilateral formed by Blue hill, Wachusett, and Thompson's hill in Massachusetts, and Unkonoonuc mountain in New Hampshire, has sides of from thirty to fifty-eight miles, one of these being immediately in the direction of the coast, and the stations at the other extremities overlooking the whole coast and country adjacent to it, to the northward and eastward, while by the intermediate station of Holt's hill a chain of lesser triangles is carried forward, of which the angular points overlook the adjacent waters and islands. In the case used for illustration, the stations Blue hill and Prospect hill overlook Boston harbor, its islands, and dependencies. The larger triangulation is marked on the diagram by the broader full lines, and the minor one by the narrower lines.

This part of the work will be connected immediately with the observatory at Harvard University, Cambridge, and when completed will render directly available the accurate determinations for the longitude and latitude of that point, which have been the accumulation of many years of the labors of the Cambridge and Boston astronomers, and are especially valuable to the survey in reference to the difference of longitude between this and European observatories. The triangle Blue hill, Prospect hill, Harvard observatory, makes this connexion.

Seven stations, marked 1845 in the sketch, were occupied this year between the 6th of May and the 19th of October, when the party was transferred to North Carolina. Those stations, upon which observations were made without occupying them, are marked (u). The stations at Nantucket and Provincetown were not occupied, because they are not used in carrying the work forward, and the results, with the instrument employed, proved, by the test of summing the angles in the triangles of which all three of the angles were measured, that a due degree of accuracy in the positions of those points was attainable without the necessity for measuring the third angle for verification.

The work especially intended for testing the main triangulation, by joining it with the base of verification through Pocasset station, was shown in the sketch accompanying the report of 1844, and has on that account been omitted in the one now presented.

The number of points observed upon has been as follows: primary stations 11; from the station first occupied 7; from the second 6; from the third 4; from the fourth 5; from the fifth 4; from the sixth 7; from the seventh 8; other stations and objects observed upon from the seven stations, 16. The number of angles measured was 55, and the number of observations used in their measurement was 4,436.

The area of the polygon covered by the season's work is 2,840 square miles. In making this estimate, the area of the triangles, of which two angles only have been measured, has been estimated at two-thirds of its real extent, and those where one angle only has yet been measured at one-third. Work has been prepared for a secondary triangulation party for at least two years.

Astronomical observations were made at four of the stations: Great Meadow hill, between Providence, Rhode Island, and Taunton, Massachusetts; Indian hill on Martha's vineyard; Shootflying hill, near Barnstable; and Blue hill, near Boston. At the first, the eclipse of the sun of May 6th, and the transit of Mercury on May 8th, were observed, the local time being carefully obtained. At the others, observations for latitude and azimuth were made, requiring of course the determination of local time as an auxiliary. The number of observations for time was 1,125; for latitude, 6,362; for azimuth, 937. The azimuths were obtained, as during last year, by the elongations of the pole star.

Vertical angles for the heights of the stations were measured at all the stations upon nearly all of the others in sight, so that reciprocal angles have been measured from most of the stations occupied in 1844 and 1845. One of the heights above the level of the sea was also measured by the barometer.

Magnetic observations were made at five primary stations, and, in addition, at a secondary station near New Bedford, the last named observations being required for the chart of that harbor now preparing for publication. The observations were as follows: of variation or declination, 269; of dip, 264; and of absolute horizontal intensity, 90.

A meteorological journal, recording twice a day the temperature and moisture of the air, the direction and force of the wind, the character of the clouds, and proportion of sky covered, and once a day the pressure of the air, was kept at all the stations but three. The number of observations was, of the thermometer, 154; hygrometer, 154; barometer and attached thermometer, 82; other observations, 451.

The instruments employed were as follows: the Troughton and Simms theodolite of three feet diameter, for measuring the horizontal angles of the triangles and the azimuths; the two feet vertical circle, originally accompanying the theodolite and the six inch Gambey theodolite for the vertical angles; a thirty-two inch transit kindly loaned by Major Graham, of the United States topographical engineers, and a twenty inch transit, for which we are indebted to S. C. Walker, Esq., of Philadelphia, for time; the two feet Troughton and Simms circle, and the six inch Gambey theodolite for latitude; a set of Riddell's portable magnetic instruments by Jones, of London, for variation and horizontal intensity; a dip circle by Patten, of Washington, and Hassler barometers.

The Troughton and Simms two feet repeating circle has not been used in the survey for many years, and the trials made with it in the summer of 1844 showed many important defects in the instrument. Some of these were remedied by Mr. William Würdeman, mechanician in the Coast Survey office, during the summer of 1844, so that on further trial in the autumn the results were sufficiently encouraging to induce further changes, and the construction of a stand (in part of the materials of one formerly used,) expressly for the instrument. Further changes were made last spring and summer, and the instrument has rewarded the labor expended upon it, and promises, with comparatively slight additions, to become available for the work.

The measurements of horizontal angles of the triangles, the observations for azimuth, a small part of the observations for height and for time, and the observations of the eclipse and transit in May, were made by myself personally. The observations for time and for latitude were generally made by Lieutenant Thomas J. Lee, of the United States topographical engineers, assistant in the party; and the vertical angles generally were measured, and a part of the observations for time taken by assistant Charles O. Boutelle. The reconnaissance for the work was made under my immediate direction by assistant C. O. Boutelle, at such times during the season as he could be spared from duties in camp. In September the reconnaissance was carried across the northern part of Massachusetts into New Hampshire, and a range of stations beyond those represented in the sketch selected, carrying forward the triangulation very satisfactorily.

During the early part of the season, astronomical and magnetic observations were made by Lieutenant Lee on the Chesapeake, the notice of which will be found in another part of this report.

The assistants of my party were occupied during the last winter in calculating the observations of the previous season.

The astronomical observations already made in this quarter, at points connected by the triangulation, bring seven neighboring local determinations of latitude and azimuth to bear in establishing the position of any one of the station points, or the direction of the lines joining them, for the map of this part of the coast now in preparation.

In addition, the geographical position of Nantucket will be determined by a continuous series of observations, which will be communicated for the use of the survey. These were commenced this season by Professor Elias Loomis, of the University of New York, who has communicated the results of observations of moon culminations, and for latitude, made during parts of July and August. They will be continued by William Mitchell,

Esq., of Nantucket, who will probably add prime vertical observations for the latitude to those in the meridian, and will observe the occultations computed by R. T. Paine, Esq., of Boston, as well as moon culminations with the almanac stars. The instruments used this summer for this purpose were a two feet transit belonging to Mr. Mitchell, and the West Point Troughton circle, loaned to the coast survey by the engineer department on the recommendation of Professor Bartlett. A transit for use on the prime vertical has been kindly loaned by Professor T. H. Perry, United States navy. Besides the importance of this station in a nautical point of view, it is of high practical and scientific interest, from occupying the southern extremity of an arc of the meridian passing near Portland, in Maine, the determination of the length of which will furnish the essential elements for the final computation of the work in this quarter, and the data for the figure of this portion of the earth's surface.

2. The connexion of the base line measured last year, upon the Boston and Providence railroad, by assistant Edmund Blunt, with the primary triangulation, was this year completed; the *angles at the extremities of the base* having been measured by Mr. Blunt, with the twelve inch Simms theodolite.

The peculiar position of this line, parts of which are in the trough formed by the cuttings of the railroad, rendered the measurement tedious, from the variable and considerable effects of lateral refraction. No pains were spared in rendering it as perfect as possible, and the test by the sum of the angles in the triangles, part of which had been measured by me and part by Mr. Blunt, proved both sets of results to be satisfactory.

3. *The secondary triangulation* in this section of the survey has been carried eastward to include the Vineyard sound and the island of Martha's Vineyard, the sound between Nantucket and the main, (Nantucket sound,) the island of Nantucket, the main between Buzzard's bay and Massachusetts bay, and part of Cape Cod. The most westerly station occupied was Falmouth, near the eastern shore of Buzzard's bay. The most easterly station was Sancoty head, and the most northerly was Hyannis. The stations observed upon extend as far east as Sancoty head, and as far west as Mishaum point. The work was retarded considerably during the months of July and August, in consequence of the long lines included in it, across the shoal water between Nantucket and the main; and the thickly wooded country between Falmouth and Sandwich, on Cape Cod bay, which it was deemed desirable to cross, offered at a later date considerable obstacle to rapid progress. The amount of work has, however, notwithstanding the detentions, been satisfactory. The area embraced in the work is 818 square miles, and the survey of the parts of it immediately adjacent to the coast will occupy two topographical parties more than one season. A diagram of the triangulation is given upon sketch A.

The reconnaissance for this work, and the triangulation itself, have been made by assistant C. M. Eakin, assisted by Mr. James E. Shiras. The party commenced their field operations on the 10th of May, and closed them on the 13th of October. The number of stations occupied was 17; the number of objects observed upon was 244, viz: 177 stations, 26 lighthouses, 30 spires, 6 telegraphs, 3 lightboats, and 2 beacons; and the number of angles measured was 4,392.

Assistant Eakin was occupied during the last winter in the computa-

Topo Work on MV

tion of the work of the previous season, in making duplicates of the calculations, a diagram of the triangulation, descriptions of the stations, and in completing the drawing of a sheet containing a topographical survey formerly made by him.

4. *The topographical work* in this section has included the head of Buzzard's bay, the eastern shore of the bay, the Elizabeth islands, and part of Martha's Vineyard island. It has covered an area of one hundred and seventy-eight square miles, determined one hundred and thirty-two miles of shore line, and one hundred and seventy-one miles of roads. This is a considerable increase on the work of last year in the same quarter.

Two sheets, marked Nos. 2 and 3 on sketch A, have been surveyed by assistant W. M. Boyce, assisted by Lieutenant H. C. Pratt, of the United States army. The area of the two is about ninety-three square miles, and they include more than one hundred and forty miles of shore line, sixty-six miles of roads, and thirty-two miles of shore line of ponds. The coast embraced in them is rugged and broken, with alternations of rocky, sandy, and marshy shores. The face of the country is undulating and irregular, with but little wood upon it, and requiring much labor to represent it accurately. The season has been generally favorable for work, but high winds and fogs have prevailed at times, during which the use of the plane table is difficult; at such times the compass and chain have been used with good effect in advancing the work.

This party was not able to take the field until the beginning of June, owing to circumstances not necessary to be detailed here, but by great diligence the amount of work done has been satisfactory. Through the liberal views taken by the Hon. Secretary of the Navy, in reference to the progress of the coast survey, and under authority of the act of Congress of 1807, the party has had the use of the schooner Wave belonging to the United States navy, and the facility thus afforded must be enumerated among the reasons for the amount of work done. The party was transferred to Neapeague beach, on the eastern end of Long island, for the survey of an unfinished space there, on the 20th of October, and to Philadelphia, for the measurements of the wharves, &c., left unfinished there, about the middle of November.

Assistant Boyce was engaged last winter in the office, in putting in ink the topographical work of the preceding season.

Three sheets, marked No. 1, No. 1½, and No. 4 on sketch A, have been surveyed by assistant H. L. Whiting, aided by Mr. W. E. Greenwell. The area included in these is about eighty-five square miles, and one hundred and five miles in length of roads and one hundred miles of shore line are laid down upon them. The work on the main was done between the 8th of May and the close of September, and about the 1st of October the party was removed to Martha's Vineyard island, remaining in the field until the latter part of November. The face of the country on the main has already been described, and that on the Vineyard upon the immediate shore is similar; the country embraced in the interior of the sheet is, on the contrary, level, and covered with woods of scrub oak, interspersed with pines.

The sickness of Mr. Whiting during one part of the season, and of a number of his party at another, has in a degree retarded the work, but

During the winter Mr. Whiting was occupied in the office in finishing the drawings of his sheets of the previous season, and in reducing for publication the map of New Bedford harbor, the style of the execution of which was very satisfactory. He also assisted in preparing the projections of the plane table sheets of the season.

the progress has, notwithstanding, been satisfactory, and the amount of work done considerably exceeds that of the last year.

During the winter Mr. Whiting was occupied in the office in finishing the drawings of his sheets of the previous season, and in reducing for publication the map of New Bedford harbor, the style of the execution of which was very satisfactory. He also assisted in preparing the projections of the plane table sheets of the season.

It appears that, in general, from the beginning of May to the middle of November may be profitably used in this region for the topographical surveys.

The shore line determined by these parties has been furnished to the hydrographical party working in their vicinity.

5. *The soundings* in Buzzard's bay have been completed, and considerable progress made in those of the Vineyard sound, by the party under the command of Lieutenant commanding George S. Blake, United States navy, in charge of the surveying schooner Gallatin. Some supplementary work off the coast of Rhode Island has also been completed for the chart of the entrance to Long Island sound, now preparing for publication. Other observations have been made in Long Island sound by this party, belonging to the next section of the work. Preparations for the season's work were begun on the 23d of April, and the work itself on the 7th of May, continuing until the close of October.

The limits of the sounding sheets are shown by the dotted lines on sketch A, the sheets being five in number. The work of this season will afford means for the immediate publication of charts of two important harbors of refuge on the Vineyard sound, Tarpaulin Cove on the south-east side of Naushon, and Holmes' Hole on the north side of Martha's Vineyard. Combined with the work of last year, it gives the greater part of the hydrography for a chart extending from Point Judith to Cape Pogue, and embracing the entrances to Narragansett bay, and the whole of Buzzard's bay, and the Vineyard sound. The materials for this chart, from the astronomical and geodetic observations, the topography and hydrography, will be collected immediately so as to commence the chart at the earliest possible date, leaving the remaining part of the hydrography to be completed while the chart is in progress. One of the most interesting parts of this will be the determination of the velocity and set of the tides in the Vineyard sound—a subject of not less practical importance than scientific interest.

The area included in the work is about 350 square miles; but the statement of it hardly gives an idea of the work done, as searching for detached rocks occupied much time, and was of paramount importance. Lieutenant commanding Blake's efforts in this search have been rewarded by the discovery of three rocks, very dangerous while their positions were unknown or unmarked, but which are rendered comparatively harmless when known and marked. The positions of these rocks are thus described in his report:

"A dangerous rock, having but fifteen feet water upon it, was discovered northwesterly a mile and a half from Cuttyhunk light-house, with very deep water in all directions immediately around it. This danger lies very much in the way of ships bound to and from New Bedford, many of which, when loaded, draw from sixteen to eighteen feet. Another very dangerous rock has been discovered about a mile and three-quarters southwest-

erly from Mishaum point, also very near the main channel into New Bedford. The Gallatin draws but 9½ feet, and her larboard bilge struck heavily upon this rock, the lead on the starboard side giving at the time a quarter less four, and deepening immediately to six and seven fathoms. * * * * * At the request of the collector of New Bedford, I have recently indicated the proper position for a buoy near this danger."

"A very dangerous single rock, having but ten feet of water upon it at low water, was found in mid-channel off the harbor of Mattapoisett, a whaling port on Buzzard's bay, second in importance to New Bedford."

"In regard to the rocks off Cuttyhunk and Mishaum, I am informed by experienced Vineyard pilots, that although dangers were generally believed to exist in the vicinities named, the precise situations of them were not known. In regard to the one off Mattapoisett, I am informed that nothing has heretofore been known of it. A very dangerous ledge was found off Ragged Neck, near the head of the bay, a quarter of a mile *within* which is a buoy, and which I am likewise assured was entirely unknown before."

A more technical description of the positions of the rocks off Cuttyhunk and Mishaum point, and of the ledge off Scraggy Neck, will be found in the appendix, (No. I.)

Besides the occasional observations for the tides at different points, for the reduction of the soundings, regular observations for the times of high and low water, and the height of the tide, have been kept up during the whole season at Point Judith and Newport.

The views required for illustrating the sailing directions, and desirable for entering New Bedford harbor, were prepared this season by assistant John Farley, under the advice and with the co-operation of Lieutenant commanding Blake.

During the last winter the unfinished reduction of the work of this party for the previous season, which was, however, small in amount, was completed. It consisted chiefly of the reduction of observations of tides and currents and the copying of journals.

The hydrography of New Bedford harbor was reduced for publication, and a copy made of the original chart on the working scale; a general reduction of the season's work was also made on the publication scale. The sailing directions, and other unfinished parts of the New Bedford chart, have since been supplied, and the work has been put into the hands of the engraver.

My attention has been repeatedly called by Lieutenant commanding Blake to the necessity for thorough repairs to the schooner Gallatin—repairs which are entirely beyond the limits of expenditure permitted by the ordinary appropriation for the coast survey. In his report at the close of the season, he says: "The vessel is nearly thirteen years old, has never received a thorough repair, and is now in such a state that the mere patching, which is constantly needed to preserve her efficiency, is extravagant Her frame is believed to be sound, though it cannot continue so long if the repairs named in the estimate are not attended to."

As it is impossible, without serious diminution in the quantity of work, to furnish these thorough repairs, I have felt it my duty to call the attention of the Treasury Department to the subject in a separate communication, believing that the vessels belonging to the survey should be put in

thorough order before another season's work, and that a special appropriation should be asked from Congress for that purpose.

Another subject of importance to the progress of the hydrography of the coast survey, referred to in the law for its reorganization, and in regard to which no advance whatever has been made or can be made without aid from Congress, is thus referred to in Lieutenant commanding Blake's report:

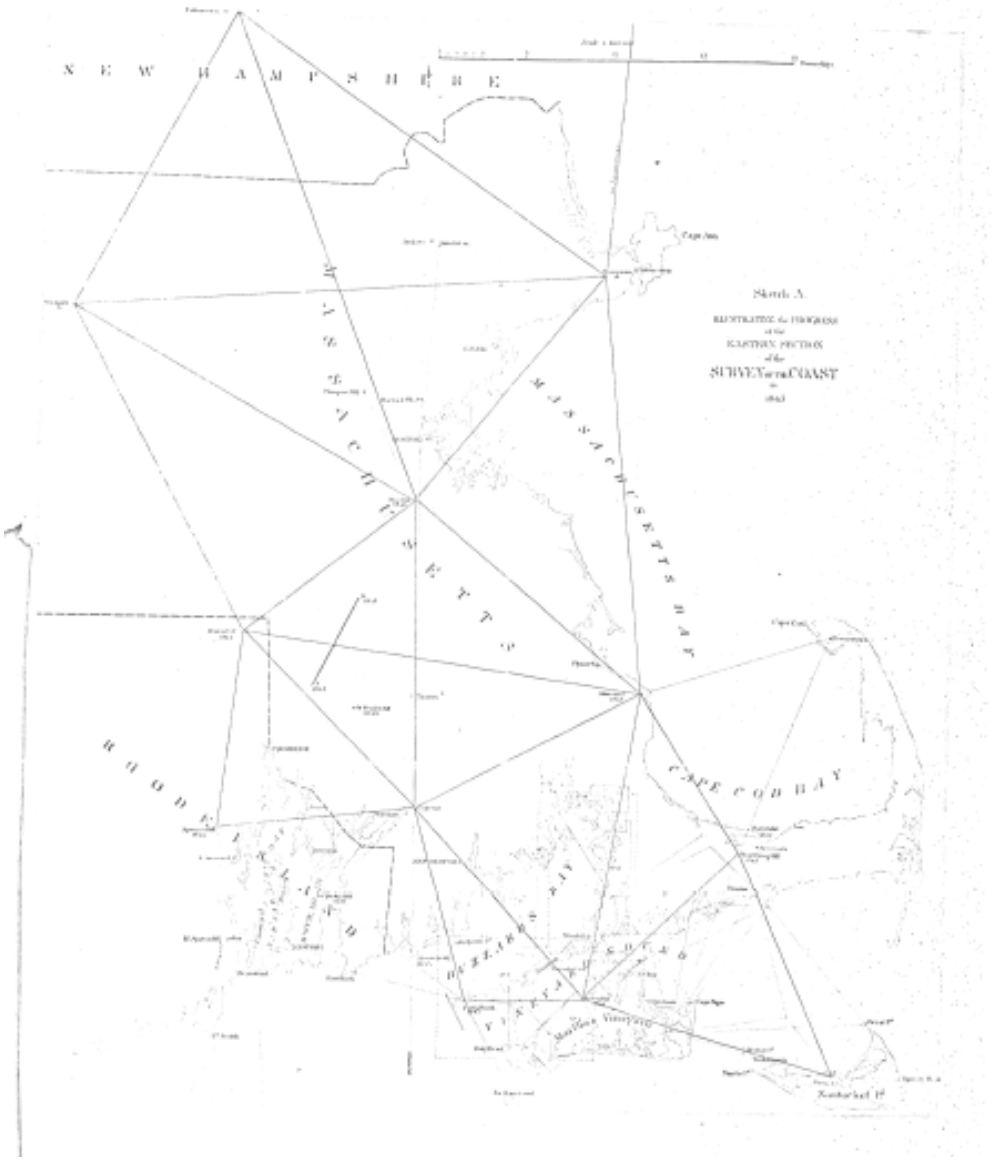
"In regard to the use of steam vessels in the survey, upon which you request my views, I would observe, that the employment of such vessels, of *suitable construction and equipment*, would in my opinion conduce very much to accuracy, despatch, and economy. To accuracy, because the rate of running would be more uniform than that of sailing vessels; the lines of soundings could be run with more system, and a vast amount of useless labor thereby be avoided. To despatch, because in light winds and calms, which prevail much upon our coast in summer time, where sailing vessels can do little or nothing, steamers could work with perfect success. They could also work with much more success, under all circumstances, than sailing vessels, being independent, in a great measure, of the direction of the wind and of tides. To economy, because a very much greater amount of work could be performed by a steamer in a given time, than by a sailing vessel, and with fewer men. I am convinced, in short, that steamers are as much to be preferred for surveying as for any other purpose whatever. It is proper to add, that I speak from experience on this subject, steamers having occasionally been attached for short intervals to my command."

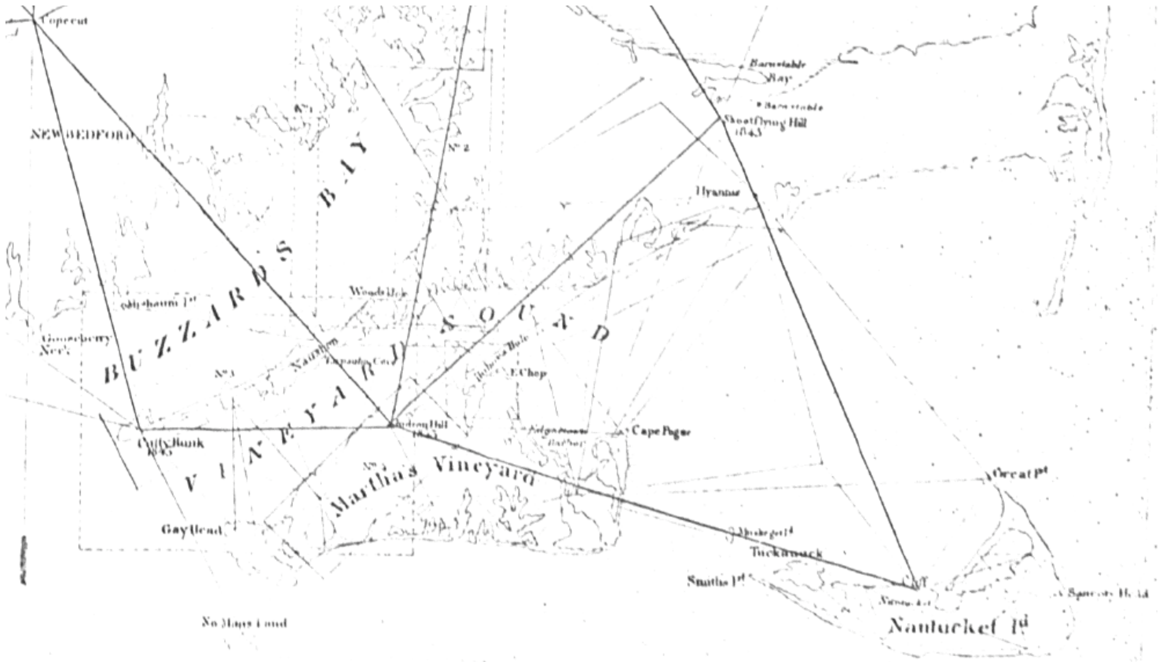
6. My attention has been repeatedly called this summer to certain dangerous obstacles to navigation off the coast of Massachusetts, requiring but little time to determine their places. Lieutenant commanding Davis brought these before me particularly, at a time when the surveying brig Washington, under his command, was necessarily waiting the repairs of instruments required for his work. A rough or approximate determination of such dangers is certainly better than none, and public utility sometimes requires that ideas of precision should be sacrificed to secure other objects. The determinations can by no means replace the accurate ones which will be made in the course of the coast survey, but they will be useful to navigators, in the absence of them. I directed, therefore, Lieutenant commanding Davis to make the search suggested by him for a ledge of rocks off Brandt point, Massachusetts bay, and the shoal to the west of George's bank. The rock, or rather ledge, is about three-quarters of a mile E. N. E. of Phillips' ledge, which has a buoy upon it, and has but eight feet of water on two different spots at low water, spring tides. It lies in the track of vessels bound into and having a fair wind for Plymouth and the lower part of Barnstable bay, and of coasting vessels beating in Massachusetts bay. An extract from a letter of Lieutenant commanding Davis in the appendix, (No. II,) gives the approximate position of this ledge, which is known to the fishermen from the adjacent shore as "Howland's ledge." It should undoubtedly have a buoy to mark it, as several vessels are reported to have struck upon it, and the buoy on Phillips' ledge tends to give false assurances of safety to the eastward of it.

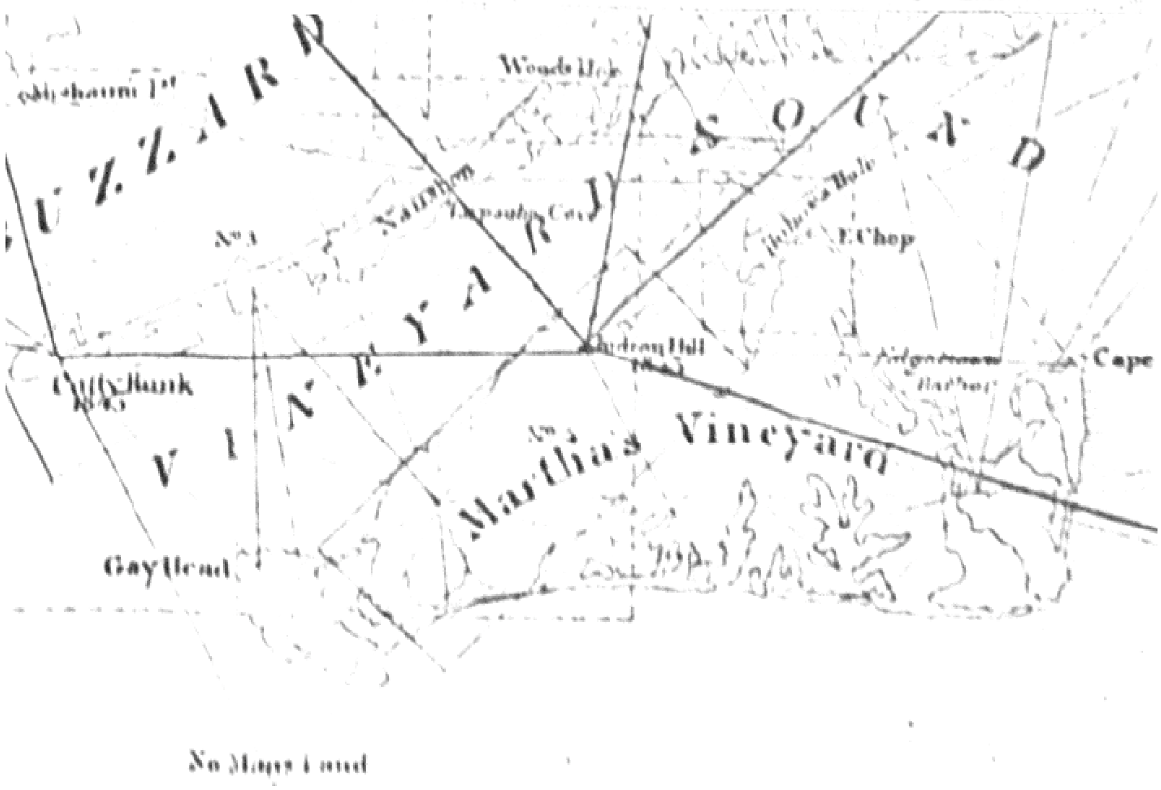
The season has not permitted a thorough exploration of the shoal west of George's, known as Clark's bank, but a line of soundings, &c. has been run upon it, and an early opportunity will be taken to examine it further.

Soundings were made by Lieutenant commanding Davis in ten fathoms, upon a bank not laid down upon the charts, in about latitude 41° 17′, longitude 68° 36′, or about sixty miles southeast of Nantucket. This bank, it is believed, was not before known, and the credit of its discovery may be claimed for the coast survey.

7. The work of triangulation conducted by me personally being in this section of the survey, I was enabled at intervals when changing stations to visit the different parties employed in this quarter, in some cases to inspect the results of their work, and in others both the results and operations.


N E W H A M P S H I R E
Sketch A.
SURVEY of the COAST
1843
MASSACHUSETTS BAY
CAPE COD BAY
Nantucket


NEW BEDFORD
BUZZARDS BAY
VINEYARD SOUND
Woods Hole
Hyannis
Barnstable Bay
Cape Poge
E.Chop
Martha's Vineyard
Gay Head
Tuckanuck
Nantucket Id
No Mans Land


BUZZARD
SOUND
VINEYARD
Woods Hole
E.Chop
Cape
Martha's Vineyard
Gay Head
No Mans Land

Again; the enlightened co-operation of the heads of the War and Navy Departments with the Treasury Department, and the general good feeling towards the survey of the officers of the army and navy, would enable us, under the directions already issued by Congress in regard to the employment of officers of the army and navy, to organize new parties if we had the means to fit them out and supply them with laborers, transportation, vessels, and other appliances for surveying which they require. We should thus be able to make such an impression on the public, by the extension of the work and the speedy publication of its results, as would repay by a rich harvest of popular approbation the fostering care of the Executive and Congress.

The present state of the work in the different sections will admit of the following progress during the next year.

1. *Eastern section.*—The primary triangulation may be extended across the northern line of Massachusetts into New Hampshire, and some progress made upon the coast of New Hampshire. The secondary triangulation may be carried across Cape Cod and Massachusetts bays, and as far north as Plymouth. The topography of Martha's Vineyard and Nantucket may be completed, and that of the main be carried from Wood's Hole eastward to Monomoy point. The hydrography of the Vineyard sound and of the sound between Nantucket and the main (Nantucket sound) may be completed, and the dangerous shoals off Nantucket seaward be examined.

7. *Office work.*—The office work should consist, 1st, in the copying, reducing, and computing of the observations of the previous season, and in making drawings and projections of past or for future work; the arrangement of the observations of the past year for publication; the verification of calculations made by the field parties. 2d. The preparation of the materials for a map to extend from Point Judith to the east chop of Holmes's Hole, Martha's Vineyard, to include Buzzard's bay and the Vineyard sound, properly so called, and the commencement of the map itself. 3d. The reduction of the chart of the harbors of refuge of Tarpaulin cove and Holmes's Hole, on the Vineyard sound, and the engraving of the charts. 4th. The engraving of the second sheet of Long Island

Very respectfully submitted by

ALEXANDER D. BACHE,
Superintendent United States Coast Survey.

Hon. R. J. WALKER,
Secretary of the Treasury.

APPENDIX NO. I.

Extract from a letter addressed by Lieutenant Commanding Blake, United States navy, coast survey service, to Professor A. D. Bache, Superintendent Coast Survey, containing a description of the position of a rock off

APPENDIX No. IV.

Extract from a letter addressed by William Mitchell, of Nantucket, to Professor A. D. Bache, Superintendent of the Coast Survey, containing an account of the trade through the Vineyard sound for the last three years, and of the Nantucket south shoal.

"MY DEAR FRIEND: I have at length obtained the information I desired relative to the number of vessels which annually pass through the sound. Knowing that thou wouldst prefer a modern account, I applied to the captain of the light boat, with whom it has been somewhat difficult to communicate. To his politeness I am indebted for the following particulars:

In 1842 there were	144	ships,	1,295	brigs,	7,551	schooners,	3,616 sloops.
In 1843 there were	151	"	1,194	"	8,228	"	3,525 "
In 1844 there were	152	"	1,175	"	7,483	"	2,566 "
	447	"	3,664	"	23,262	"	9,707 "

and to July, 1845, there were 122 ships, 805 brigs, 4,847 schooners, 1,796 sloops, passed Nantucket light-boat, (an immense amount of property indeed,) and yet there is no chart of this thoroughfare in existence that is worthy of the name.

1846 – Report from December 1846, so two field seasons.

COMMUNICATING

A report from the Superintendent of the Coast Survey, showing the progress of the survey during the year ending November, 1846.

DECEMBER 10, 1846.

Read, and ordered that it be printed; and that 500 copies, in addition to the usual number, be printed—250 copies thereof for the use of the superintendent of the coast survey.

TREASURY DEPARTMENT, *December* 10, 1846.

SIR: I have the honor to transmit, herewith, a report made to the department by Professor A. D. Bache, superintendent of the coast survey, showing the progress of the work during the year ending November, 1846.

All which is respectfully submitted.

R. J. WALKER,
Secretary of the Treasury.

Hon. GEO. M. DALLAS,
Vice President of the United States,
and President of the Senate.

SECTION I—EASTERN SECTION.

From Passamaquoddy bay to point Judith, including the coast of Maine, New Hampshire, Massachusetts, and Rhode Island.

The work in this section has been vigorously prosecuted; and, though the season has been remarkably unfavorable, the combined efforts of the different parties have produced a satisfactory progress; and, indeed, have pushed the work farther, in parts of the section, than was anticipated.

The labors of the hydrographic party have been rewarded by the discovery of a shoal to the southward of that known as the Nantucket South Shoal; and of a shoal spot in the Vineyard sound, where it was supposed there was deep water. They have thus rendered, in one season, important service to the commerce between Europe and the United States, and to the coasting trade; the dangers discovered being, as it were, in the highway of each. A particular reference to these and other details of the survey will be made under the head of the several operations of which it is composed.

1. *Primary triangulation.*—The general scheme of this triangulation was stated in the report of last year. It has been extended, by a reconnaissance, into the States of New Hampshire and Maine, by the occupation of two triangulation stations, the lines of sight from which pass into Maine and New Hampshire, and by astronomical and magnetic observations.

The reconnaissance was made, under my immediate direction, by assistant C. O. Boutelle, during part of June, July, and August, and resulted in the choice of Gunstock mountain, in New Hampshire, and of Agamenticus, in Maine, as stations in the principal chain of triangulation, and of Pattuccawa and of the Isle of Shoals for the minor chain. The bases Gunstock-Agamenticus, Gunstock-Pattuccawa, and Pattuccawa-Agamenticus, furnish the requisite facilities for extending the work along the coast of Maine. The stations and connecting sides are marked upon sketch A. Those unoccupied are marked (u.)

As the primary triangulation in this section is considerably in advance

Finished MV topography

last report.

4. The *topographical work* of this section has embraced the northern

shore of the Vineyard and Nantucket sounds, from Wood's Hole eastward, to include Hyannis harbor, Martha's Vineyard, the small island of No Man's Land, and Nantucket. The topography of the shores of Boston harbor has also been commenced. The work is shown in sketch A; where the plane table sheets are marked 5, 6, 7, 8, 9, 13, 14, and 15. It has included, omitting the topography near Boston harbor, an area of more than 220 square miles, a length of 438 miles of shore line, including the shore line of ponds, and of 215 miles of roads. The area surveyed is one fifth greater than that executed last year in this section. The shores of two important harbors of refuge and of one commercial port are included in the surveys.

Sheets numbered 5, 13, 14, and 15 were assigned to assistant W. M. Boyce, and the first three have been completed during the season. The country embraced in these sheets is of varied aspect, that of No. 5 being undulating, and without wood; on Nos. 13 and 14 generally flat and wooded, and cultivated only in the vicinity of the villages. The area of the work executed between the 17th of June and 1st of October, when the report was made, is about 81 square miles; upon which 191 miles of shore line and 63 of roads have been chained. Assistant Boyce was occupied during the winter in putting in ink his work of the previous season.

The work done in section second, by assistant Boyce, at the close of 1845, has been referred to in my last report. He took the field on the 13th of May of this year, in the same section, for work, which will be stated in its proper place; and, closing his work on the coast of Massachusetts on the 8th of November, transferred his party to the North Carolina section, (No. 4.)

Assistant Boyce has had the use of a small vessel during the season.

Lieutenant E. O. C. Ord, United States army, was assigned to this party; but, before taking the field with it, was detached from the survey and ordered to duty with the army.

Sheet No. 4, commenced last year, has been finished, (see sketch A,) and Nos. 6, 7, 8, and 9 commenced and finished, by assistant H. L. Whiting, aided by Mr. Samuel A. Gilbert, and during the latter part of the season by Mr. W. E. Greenwell. The shore upon the Vineyard sheets, Nos. 6 and 7, is described as generally level and sandy, and cut up by numerous ponds; the interior is wooded. That embraced in the Nantucket sheets is more varied—the north shore being high and irregular, and ending in sand bluffs; the south shore level, and intersected by ponds. The work, generally, has not required the same amount of detail as that of the north side of the Vineyard; it has, however, included the towns of Edgartown and Nantucket.

Assistant Whiting took the field in May; but the early part of the season proving unpropitious, the work was not actually begun until about the first of June, between which time and the 20th of October the following progress was made:

Area surveyed, 139 square miles; extent of shore line, 145.5 miles; of shore line of ponds, 102.5 miles; of roads, 182 miles. The immediate party of assistant Whiting was transferred to Boston harbor in November, leaving Mr. Greenwell to complete the work on Nantucket.

5. The *topography* of Boston harbor was begun, according to an arrangement with the commissioners of the Commonwealth of Massachusetts, in November, by assistant Whiting, aided by Mr. Gilbert. The portion including the shore at South Boston, the city wharves, the shore near Charlestown and East Boston, will be completed before Mr. Whiting leaves the field.

The work of this party in the Vineyard sound has led them to the discovery of a shoal, having but thirteen feet water upon it, about 2½ miles S. by E. ½ E. from Tarpaulin cove light-house, in a part of the sound where not less than seventeen feet was believed to exist before, and where it is supposed that the ship Addison struck some thirteen years since. The fact that the depth of thirteen feet was not known to exist at that place is proved by the letter from three experienced pilots, addressed to Lieut. Com. Davis, and placed in the appendix No. 2.

Two rocks were also determined by Lieut. Com. Davis, which will find their places on the chart of Tarpaulin cove, the engraving of which is nearly finished.

Again; the enlightened co-operation of the heads of the War and Navy Departments with the Treasury Department, and the general good feeling towards the survey of the officers of the army and navy, would enable us, under the directions already issued by Congress in regard to the employment of officers of the army and navy, to organize new parties if we had the means to fit them out and supply them with laborers, transportation, vessels, and other appliances for surveying which they require. We should thus be able to make such an impression on the public, by the extension of the work and the speedy publication of its results, as would repay by a rich harvest of popular approbation the fostering care of the Executive and Congress.

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In section No. 1, the primary triangulation has extended its lines into New Hampshire and Maine. The stations occupied being the most northerly ones in Massachusetts, one astronomical station has been occupied, and magnetic observations have been made at suitable points of the coast. The secondary triangulation of the southern part of Cape Cod has been completed, and the lines extended over the cape and the western shore of Massa-

chusetts bay. The secondary triangulation of Boston harbor has been commenced. The topography of Martha's Vineyard, the island of No Man's Land, of Nantucket, and of the main from Wood's Hole, to include Hyannis, has been completed. The survey of the shoals south of Nantucket, and of Nantucket sound, has been commenced. The harbors of Edgartown and Nantucket have been surveyed. Further observations, for differences of longitude from European observations, have been obtained at Portland, Cambridge, and Nantucket.

The labors of the hydrographic party have been rewarded by the discovery of a shoal to the southward of that known as the Nantucket South Shoal; and of a shoal spot in the Vineyard sound, where it was supposed there was deep water. They have thus rendered, in one season, important service to the commerce between Europe and the United States, and to the coasting trade; the dangers discovered being, as it were, in the highway of each. A particular reference to these and other details of the survey will be made under the head of the several operations of which it is composed.

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Drawing, &c.—The maps of assemblage and record, and of progress, for the work of 1845, have been completed by Mr. Morven McClery.

Twenty-four sheets for plane table parties, and for the hydrographic parties of the Chesapeake, which require the projection of the meridians and parallels, have been prepared by Messrs. Fairfax, Glück, and McClery.

The following maps have been drawn: a map of Holmes's Hole harbor, on a scale of $\frac{1}{10000}$, was reduced and drawn by Mr. Morven McClery; the drawing of the hydrography being furnished by Lieutenant Commanding George S. Blake.

A map of Tarpaulin cove, on a scale of $\frac{1}{10000}$, was reduced and drawn by Mr. McClery; the drawing of the hydrography being furnished by Lieutenant Commanding George S. Blake.

The map of New Haven harbor, on a scale of $\frac{1}{10000}$, was completed by assistant John B. Glück.

One of the large sheets of the map of Long Island sound, and another of the river Delaware, are receiving the finishing work; and the chart of New London harbor, the completion of which was deferred for some work of verification, must be ready for printing in a few weeks. The chart of New Haven harbor, engraved in New York, requires merely the last finishing work to make it ready for printing. Oyster bay, or Syosset harbor, an important harbor of refuge on the north side of Long Island, will be completed in less than three weeks; and nearly the same progress has been made in the engraving of the charts of Holmes's Hole and Tarpaulin cove. These three charts are executing by Messrs. Sherman and Smith, in New York. All these charts, except perhaps the last named, will be published in the course of the winter.

In section No. 1, the eastern section.—The primary triangulation, and astronomical and other observations connected with it, may be continued in New Hampshire and part of Maine. The secondary triangulation of Cape Cod, the shores of Massachusetts bay and of Boston harbor, and its vicinity, may be completed. The topography of Cape Cod, and part of the southern and western shore of Massachusetts bay, may be executed. The hydrography of Nantucket sound may be extended seaward, and further progress made in that of the shoals south and east of Nantucket. Further progress may be made in the hydrography of Boston harbor. Charts of the harbor of Nantucket, and of the harbor of refuge of Edgartown, may be reduced. The map of the coast from Point Judith eastward to Martha's Vineyard, inclusive, may be reduced, and the engraving be commenced.

The operations of the surveying parties include: 1st. *Reconnoissance*, general or particular, by which the plan of the work is laid down, or the stations actually to be used, determined. 2d. *Triangulation* of different orders for determining the relative positions of stations; primary or main, in which the positions are fixed with great accuracy, and control the work; secondary or tertiary, by which with less perfect means, numerous points are determined. 3d. *Astronomical observations*, by which the positions of the most important main points are fixed upon the surface of the earth. 4th. *Topographical work*, by which the coast line, the position of objects, and character of ground, and land communications are determined, so as to be represented on a map. 5th. *Hydrographical operations*, including sounding, determination of the character of the bottom, observations of tides and currents. 6th. *Magnetic observations*, to give the variation of the compass.

The work executed by the field parties passes to the office, where computations are revised, and independent computations made. The field work is assembled and reduced to a scale for publication; the maps resulting from it are drawn, engraved, printed, and published.

SECTION I. The *primary triangulation* has been extended into the southern part of Maine; the stations in New Hampshire remaining to be occupied; it is yet considerably in advance of the secondary work. *Astronomical* and *magnetic* observations have been made at one station in New Hampshire, and one in Maine. At the latter, the performance of new and approved instruments has been compared. This important department of the survey has been put on a new and more perfect basis within the last eighteen months, by the introduction of astronomical instruments of a superior class. Differences of longitude from Europe, by chronometers, have been obtained, and astronomical observations for latitude and longitude at Cambridge and Nantucket. The *reconnaissance* for the primary work has extended north beyond Portland, Maine. The *secondary triangulations* of Cape Cod and Boston harbor and its vicinity have been completed, and that near Plymouth has been commenced. The *topography* of Boston harbor and its vicinity, from Scituate light on the south to Nahant Neck on the north, has been completed. The *topography* of the southern shore of Cape Cod has been carried eastward. The *hydrography* of Boston harbor and of its approaches has been completed; that of the shoals near Nantucket has made considerable progress. The *views* necessary for the charts of Edgartown, Nantucket, and the general coast chart, have been taken, and drawings sent to the office. The work in Boston harbor has been done according to an arrangement with the commissioners of the Commonwealth of Massachusetts, requiring its completion during the present season, and extending certain aid necessary to insure it.

All the arrangements for the immediate *reduction* of the work in Boston harbor, and the preparation of manuscript maps to be delivered in the spring, are made.

The *reduction* of the chart of Edgartown harbor has been made, and that of Nantucket is nearly completed.

The reduction of sheet No. 1, of the eastern series of coast charts, from Point Judith to Cape Cod, (to be completed in three sheets,) has been commenced. The *engraving* of the chart of Edgartown harbor is nearly completed. The chart of the harbors of refuge of Holmes' Hole and Tarpaulin cove, (Martha's Vineyard sound,) has been *published*.

SECTION II. *Verification* work required at one station in connection

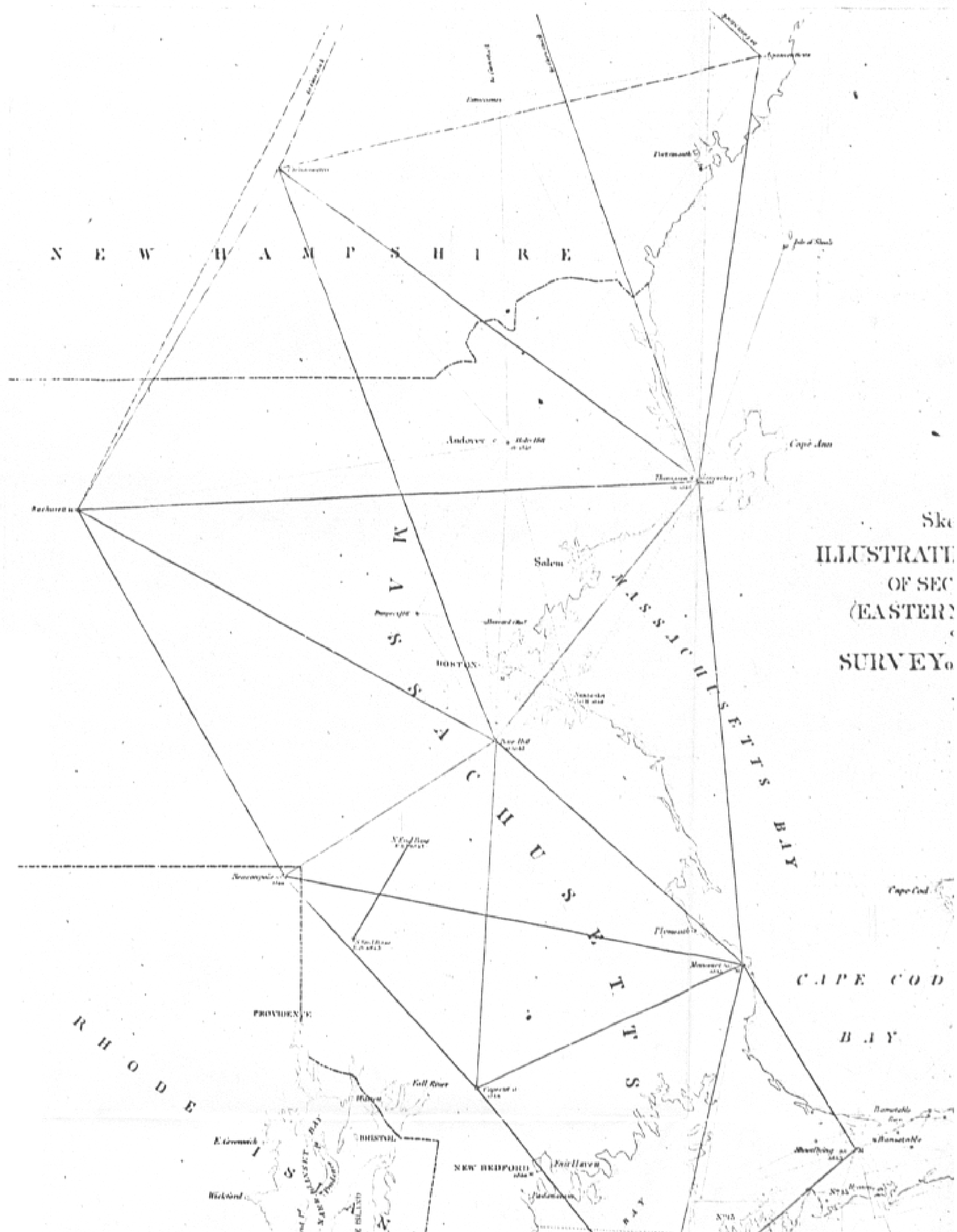
1848

The chart of *Edgartown* harbor (Martha's Vineyard) has been published. A sketch of the Nantucket shoals has been engraved and published, for distribution.

The hydrography of Nantucket south shoals has made excellent progress, and has realized, in new discoveries, the fruits of the zeal and perseverance of those engaged in it. Muskeget channel, an important avenue to and from the Vineyard sound, and one which was very imperfectly understood, has been sounded out.

7. *Topography.*—The topography of Cape Cod has employed two parties, and has embraced sheets Nos. 28, 31, 32, 33 of sketch A. The first party was under the general charge of Assistant H. L. Whiting, and the work was executed by him and by Sub-assistant S. A. Gilbert, the number of hands of the party being doubled. Up to the close of September, sheets Nos. 31, 32, 33 had been completed by this party, an area had been surveyed of 73½ square miles, an extent of shore line of 103 miles, shore lines of creeks and ponds 38½ miles, and roads 210½ miles. The topography of the shores of Wellfleet harbor, of South Wellfleet or Blackfish creek, and of Parmet river harbor in Truro are included in No. 31. This sheet alone contains 184 miles of roads, and the character of the natural features of the country included in it is very complex. Mr. Whiting remarks: "The hills in Truro will average from 100 to 140 feet high, and in Wellfleet and Eastham from 120 to 80 and 60. These are all of the most abrupt and irregular character, with alternate hollows and peaks." "In six *consecutive* square miles there are not less than 300 separate peaks of hills, and some 510 holes or hollows, all requiring and having separate and distinct curves of contour and elevation."

Mr. Whiting took the field in June, and, after preliminary reconnaissance, commenced his plane table operations on the 8th of July. He was joined by Mr. Gilbert on the 20th of July, since which time two instruments have been employed. The party expected to finish this part of Cape Cod during the present season; but I have been obliged to direct the closing of the work in October, for important verifications in section II. of the survey, and a re-survey of Sandy Hook, to ascertain its increase. The topography in this section is sufficiently in advance of the hydrography to permit a short season's work without detriment to the general progress of the section.



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Portsmouth
Isle of Shoals
Cape Ann
Andover
Salem
BOSTON
Plymouth
Cape Cod
PROVIDENCE
Fall River
BRISTOL
E. Greenwich
Wickford
NEWPORT
NEW BEDFORD
Fair Haven
Beavertail
Pt. Judith
BUZZARDS BAY
VINEYARD SOUND
Barnstable
Cape Poge
Gay Head
No's Mans Land

has been carried eastward. The *hydrography* of Boston harbor and of its approaches has been completed; that of the shoals near Nantucket has made considerable progress. The *views* necessary for the charts of Edgartown, Nantucket, and the general coast chart, have been taken, and drawings sent to the office. The work in Boston harbor has been done according to an arrangement with the commissioners of the Commonwealth of Massachusetts, requir-

The *reduction* of the chart of Edgartown harbor has been made, and that of Nantucket is nearly completed.

The reduction of sheet No. 1, of the eastern series of coast charts, from Point Judith to Cape Cod, (to be completed in three sheets,) has been commenced. The *engraving* of the chart of Edgartown harbor is nearly completed. The chart of the harbors of refuge of Holmes' Hole and Tarpaulin cove, (Martha's Vineyard sound,) has been *published*.

In conformity with the request of a committee of the citizens of Nantucket, a very careful examination has been made of the bay inside of Great Point, with a view to ascertain what changes, if any, have occurred since former surveys. The channel between the island of Muskeget and Martha's Vineyard has also been carefully sounded; and Lieutenant Commanding Davis recommends that a chart be prepared, embracing this channel and the harbors of Edgartown and Holmes's Hole—a recommendation which meets my entire concurrence. He is of opinion that this channel may be useful, if properly buoyed, as vessels passing through Nantucket sound would have the choice of passing out by this channel or by the Vineyard sound, and "at certain times of the tide the current is unfavorable in one place, while it is favorable in the other; and, owing to the different directions of the two channels, the same wind may be fair in one that is ahead in the other. After passing the outer bar, about eight miles distant from the southeast point of Chappaquiddock, over which there is good beating space of three fathoms, vessels are clear of danger. Muskeget channel, however, promises to be principally useful as a means of entrance to the sound in threatening weather, when the object will be to reach a harbor of refuge."

The recommendations of a light on Sankaty head and of a beacon on the new South shoal, are again renewed by Lieutenant Commanding Davis in his report of this year, in the following terms:

"It will be highly gratifying to you, however, to know that our labors in this field have already proved useful to the coasting trade, in pointing out the safe and expeditious route clear of the shoals to the southward of Nantucket; this has been made known chiefly through the pilots and others employed in this branch of the coast survey. I have never seen so many vessels in this track as during the past season. But the valuable knowledge collected by the coast survey in this region will become much more conspicuous and generally useful when the light is established on Sankaty head. If this light is, as it undoubtedly should be, one of great power, distinctly visible in clear weather at a distance of thirty miles, not only will the domestic commerce derive great ad-

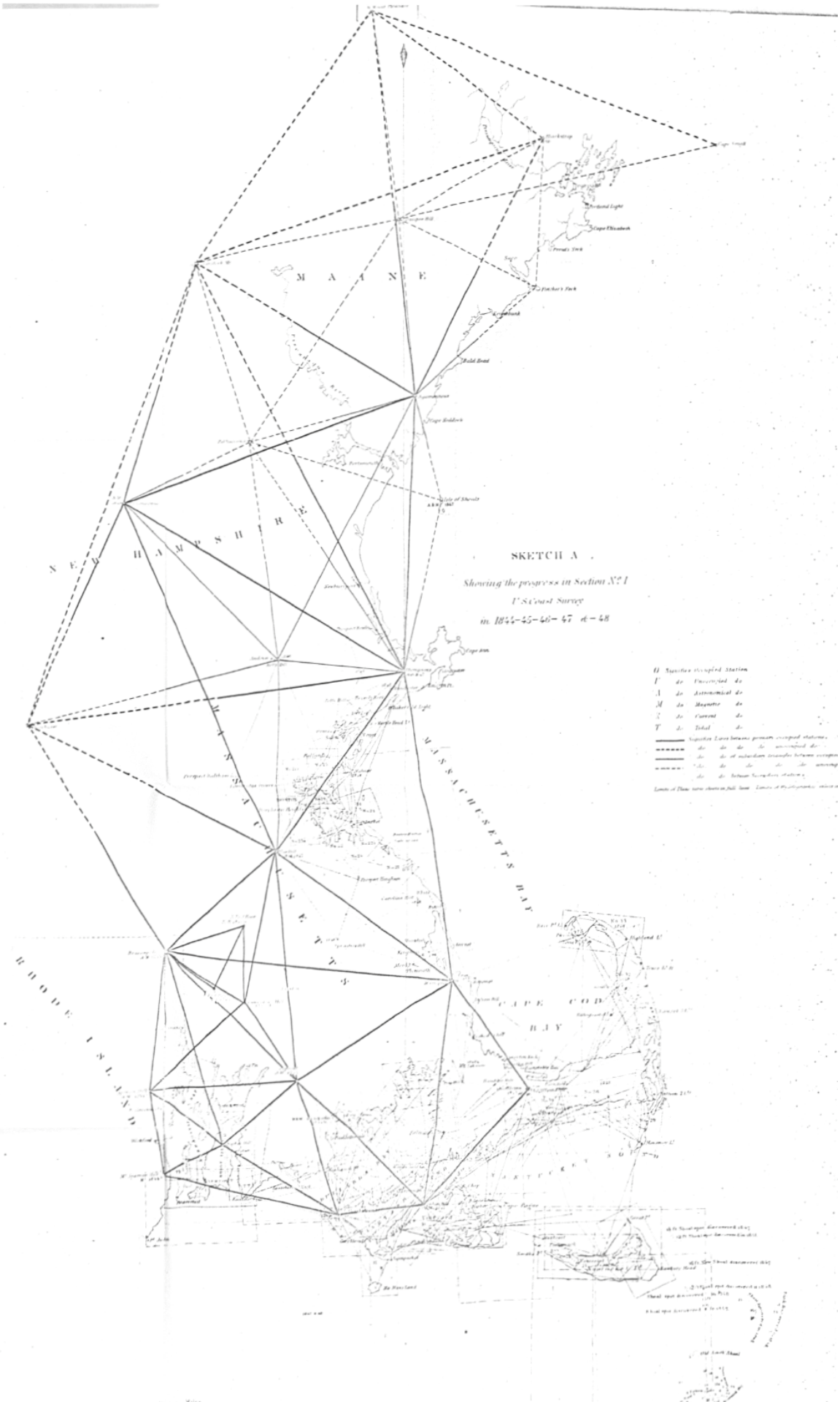
Engraving.—Assistant W. M. C. Fairfax has had charge of the engraving, in addition to the duties before enumerated under the head of drawing. The engraving of the harbor map of Edgartown, by Messrs. Dankworth, Lawson, and W. Smith; of New London, by Messrs. Rolle and Knight; of Black Rock and Bridgeport, by

Printing.—Since the 1st of November, 1847, there have been printed the following numbers of the maps newly published. Of Delaware bay and river, (complete in three sheets,) 1,967; of Long Island sound No. 3, 25 sheets; of the harbor of New London, 770 sheets; of the harbor of Edgartown, 974 sheets; of Black Rock and Bridgeport harbor, 898. Of maps published in former years there have been printed the following numbers within the present year: of Holmes' Hole and Tarpaulin Cove, (harbors of refuge,) 100; of New Bedford harbor, 315; of Little Egg harbor, (harbor of refuge,) 255; of New York bay and harbor, (scale $\frac{1}{80000}$,) 441; of the large map of New York bay, (scale $\frac{1}{30000}$,) 277 sheets; of Fisher's Island sound, 841; of New Haven harbor, 350; of Annapolis harbor and the Severn, 262; making in all 7,475 sheets. Besides the above there were 1,200 sketches for the yearly report, 200 proofs of maps for the superintendent, 1,100 copies of the sketches of Nantucket new South Shoal, Cat Island harbor, and entrance to Mobile bay, and the usual 25 monthly proof sheets, amounting in the year to 300 sheets

Publishing.—At the date of my last report, sixteen sheets of coast survey maps had been published, since which time five have been added, making a total of twenty-one; besides these, three sheets are engraved and nearly ready for publishing. Since November 1, 1847, 301 copies of each of the maps of New London, Holmes' Hole and Tarpaulin Cove and Oyster Bay, 306 copies of each of the maps of Black Rock and Bridgeport and Edgartown, 161 copies of the small map of New York bay and harbor, and 7 copies of the six sheet map of New York bay and harbor have been distributed to scientific and literary institutions in the United States. These distributions are chiefly made on the nominations of members of the two houses of Congress. Seventy-six copies of each of the maps of New London, Holmes' Hole and Tarpaulin Cove, Oyster Bay, Black Rock, and Bridgeport and Edgartown, have been distributed to foreign governments and to the departments of our own government. By direction of the Treasury Department and for use on the survey, 31 copies, 186 sheets, of the large map of New York, 70 copies of the small map of New York, 34 sheets of the map of Delaware bay, 63 copies of the chart of Fisher's Island sound, 34 copies of the map of Annapolis, 40 copies of the map of Little Egg

harbor, 60 copies of the map of New Haven, 70 copies of the map of Holmes' Hole and Tarpaulin Cove, 47 copies of the map of New Bedford, 67 copies of the map of Oyster Bay, 60 copies of the map of New London, 8 copies of the map of Long Island sound, 43 copies of the map of Black Rock and Bridgeport, and 43 copies of the map of Edgartown have been distributed. The whole number of sheets distributed is 2,923. During December, the maps of Delaware bay and river, (in three sheets,) Nantucket harbor and Huntingdon bay will be distributed; and in January, one sheet of the map of the south side of Long Island, the map of Cawkin's and Sheffield islands, and the mouth of Chester river.

There have been turned over to the disbursing officer of the coast survey, to be placed with agents for sale, 300 sheets of the large map of New York bay and harbor, 212 sheets of the small map, 1,743 sheets of the map of Delaware bay and river, 550 copies of the chart of Fisher's Island sound, 265 copies of the map of Annapolis, 155 copies of the map of New Bedford, 360 copies of the map of New Haven, 155 copies of the map of Little Egg harbor, 400 copies of the map of Holmes' Hole, and Tarpaulin Cove, 220 copies of the map of Oyster Bay, 300 copies of the map of New London, 228 copies of the map of Edgartown, and 128 copies of the map of Black Rock and Bridgeport, making, in all, 5,016 sheets of maps. These are sold at prices which about defray the cost of the paper and printing, namely, fifteen cents for each of the small sheets, and for the large sheets, from twenty-five to forty cents each.


MAINE
NEW HAMPSHIRE
MASSACHUSETTS BAY
CAPE COD BAY
RHODE ISLAND
SKETCH A
Showing the progress in Section № 1
U.S Coast Survey
in 1844-45-46-47 & -48

Each Report includes sections:

General report by section (region); reconnaissance; primary triangulation, secondary triangulation, topography; hydrography; office work; computations, manuscript charts, drawing, engraving, printing, next year's activities;

1849

The capacity of the geodetic method of survey for rapid progress is very great wherever the country is at all favorable to it. I have visited parts of the coast of fifteen of the nineteen States on the Atlantic and Gulf of Mexico, and have a more or less minute acquaintance with the character of most of the other parts of the coast, through the operations of the survey and the reports of the assistants. In nearly the whole extent the facilities for the application of the geodetic method are remarkable. On the coast of Maine, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, and a part of New Jersey, are lofty hills, rising in some cases to mountains, just such as invite triangulation. On the coast of Connecticut, New York, part of New Jersey, North Carolina, Florida, and Mississippi, there are wide sounds between the main shore and the ocean beaches, which are particularly favorable for the work. Off the coast of Massachusetts, Florida, Mississippi, and Louisiana, there are numerous islands at distances from the main which exactly adapt them to a continuous chain of triangles connecting them with the shore. Indenting the coast of Maine,

The topography of the northern shore of Cape Cod has been carried to Harwich; the topography east of Boston has been carried from near Lynn to beyond Salem.

The hydrography of Nantucket shoals has been continued. That of Bass river and Wellfleet harbors has been completed. The position of Cashe's ledge has been determined. Tidal and current observations have been made in the Vineyard sound. *Four* new shoals (McBlair's shoals) have been discovered in the "main ship channel over the Nantucket shoals."

The usual *computations* of the work of the year have been made in this and the sections generally.

Drawing.—The manuscript maps of Boston harbor have been completed, including additional work to that originally designed, which renders the hydrography more perspicuous. The map of Boston harbor, on a smaller scale for engraving, is more than half done. The chart of Muskeget channel is two-thirds done.

UNITED STATES SCHOONER NAUTILUS,
Wood's Hole, October 25, 1849.

SIR: It becomes my pleasing duty to report to you the noble and generous conduct of Acting Master E. C. Stout, Passed Midshipman D. P. McCorkle, and the crews of the cutter and whaleboat belonging to this vessel, in the following instance:

Late in the evening of the 24th instant, it being quite dark, the wind blowing a gale from the northward and westward, intelligence reached me from our tidal observer at Nobska light, through Mr. Fish of this place, that a sloop, in beating through the Vineyard sound, had been suddenly struck by a heavy squall of wind and capsized. I immediately despatched Acting Master E. C. Stout in the cutter, and Passed Midshipman D. P. McCorkle in the whaleboat, to her assistance. Upon reaching her they discovered she had drifted ashore upon the middle reef in the sound, the sea making a heavy breach over her, and her captain and crew lashed upon her side and bottom. The whaleboat under Passed Midshipman McCorkle happened to reach her first, and succeeded in rescuing (not without great effort and risk to himself and crew) the lives of the unfortunate persons upon her—three in number. She proved to be the Mount Prospect, of Falmouth, bound to this place. One of the persons on board was Mr. Bourn, postmaster of Wood's Hole.

I take great pleasure in bringing to your notice the spirited and meritorious conduct of these officers, together with the crews of the cutter and whaleboat of this vessel; by their timely aid, in all probability, a melancholy loss of life was prevented.

I am, very respectfully, your obedient servant,

J. R. GOLDSBOROUGH,
Lieutenant Commanding, United States Navy.

A. D. BACHE, LL. D.,
Superintendent U. S. Coast Survey, Portland, Maine.

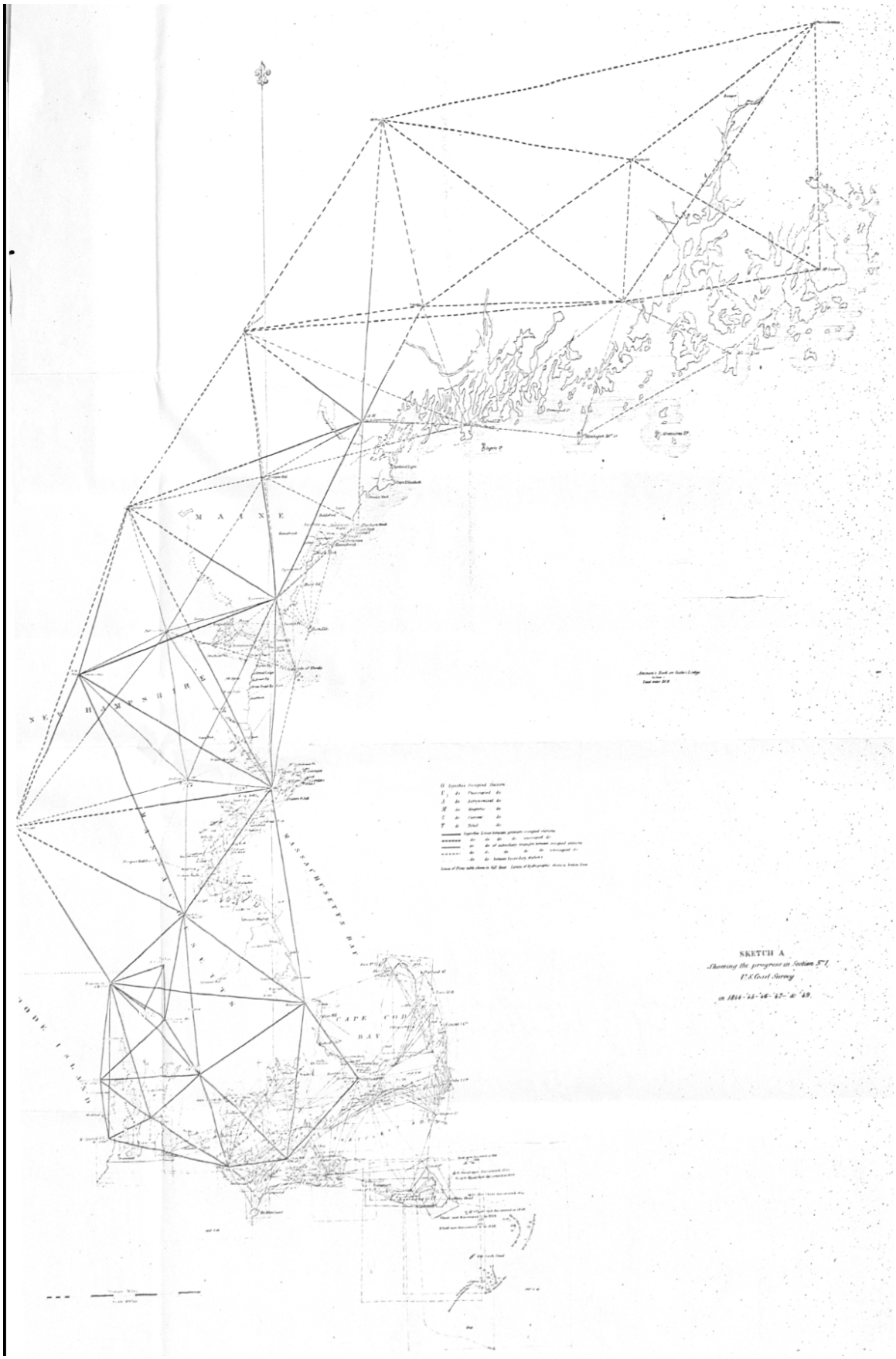
1849. More or less detailed instructions have been given by me to each of the chiefs of parties on commencing the work of the season, and have been followed up from time to time by others, as the monthly reports or correspondence showed their necessity in executing the plan for the section, in which the operations of several persons and parties employed are combined. Each party keeps a daily journal, an abstract of which is transmitted to the superintendent at the close of the month, with the reports of work done in the different branches of the office. At least once during the quarter, the proof-sheets of the engravings in progress are also sent for inspection. The work in the office, the drawing, engraving, and printing, and, as far as practicable, the instrument making and publishing, proceed according to a programme previously arranged. On closing his season's work, about the first of October, the chief of each party makes a report which contains a summary of his year's work. Personal examinations of the operations of the parties have been made by me where it was practicable, and such verifications by me personally, or by one of the assistants, as time and opportunity have permitted. The amount and character of the work executed appear to me highly creditable to the officers of the survey, and in general there has been great economy in the expenditures. High testimony has been borne both at home and abroad to the character and progress of the work, and the comparisons made by your predecessor of the relative expenditures and results of the survey and of similar ones in other countries, (Ex. Doc. No. 26, 30th Congress, 2d session,) showed a very decided difference in favor of our economy. A comparison which I had occasion to institute in my report of last year with the land surveys, showed that in the matter of actual cost per linear mile surveyed, converting our topographical areas into equivalent linear surveys in order to produce similarity of operation, our topographical surveys had the advantage.

The general progress of the coast survey may be thus summed up. In the first section, sketch A, (Maine, New Hampshire, Massachusetts, and Rhode Island,) the primary triangulation and astronomical and other observations connected with it have reached Portland, Maine, the minute reconnaissance extending to the Kennebeck, and the general reconnaissance to the Penobscot. One party, uninterruptedly engaged in this work, could finish it to the boundary in two to two and a half seasons. A base of verification has been measured on the Boston and Providence railroad. The secondary triangulation has reached New Hampshire, and the preparation of putting up signals has been carried to Kennebunk, in Maine. The topography has reached Cape Ann, with an interval to be filled on the eastern side of Massachusetts bay, from Harwich to Scituate. The hydrography of the south shore of Massachusetts is complete to Nantucket sound, embraces nearly the whole of Nantucket shoals, and has been completed in Hyannis, Bass river, and Wellfleet harbors of refuge, and in Boston harbor and its approaches. The rest of the work in this section, except the topography and hydrography of part of Narragansett bay, is complete. Observations for difference of longitude, by chronometer, between Cambridge and Europe, are in progress. The charts of New Bedford, Holmes' Hole, Tarpaulin Cove, Edgartown, and Nantucket harbors, have been published. That of Hyannis is engraved. The "general coast chart" from Narragansett bay to Cuttyhunk, is engraving. So also the chart of Boston harbor, Muskeget channel, and the second sheet of the coast chart, are in the hands of the draughtsmen. Two manuscript charts, on a large scale, of Boston harbor and its approaches, have been prepared for the commonwealth of Massachusetts and the city of Boston. Preliminary sketches and notices of dangers, and facilities to navigation, developed by the survey, have been published.

The reconnaissance for the primary triangulation has been carried to the Penobscot, and the triangulation has reached Portland, leaving one station in Maine and one in New Hampshire to the south of it to be occupied, and being still in advance of the secondary triangulation which has reached Saco, Maine, with its reconnaissance, and the New Hampshire line, with measured angles. The topography of Cape Cod has been in progress, and that of Massachusetts bay has advanced eastward, so as to include Salem harbor. While the instruments and my party were transferred from the first station which I occupied to the second, I visited all the land parties east of Boston, and inspected their operations and progress.

The hydrography of the Nantucket shoals has been continued with two vessels, (one a steamer,) and Bass river and Wellfleet harbors of refuge have been sounded out. The observations of tides and currents in Martha's Vineyard sound have been in progress. The soundings required to complete the chart of Muskeget channel have been made, and the chart itself nearly completed. The chart of Hyannis harbor has been engraved. Two to three seasons would suffice for completing the primary triangulation in this section, if the time of one party were entirely devoted to it; but, as I have before pointed out, if it is kept in advance of the secondary triangulation and other parts of the survey, all is done that is required—the pushing of it, to the exclusion of my work in other sections, and at periods of the year not best adapted to operations in this region, is not desirable. At the present rate, and with two parties, the secondary triangulation may be completed in about six years. When the large and intricate space about Nantucket is sounded out, the hydrography will make much more rapid progress along the coast. It should be remarked, however, that Boston harbor and its approaches have been carefully surveyed, in addition to the work southward of it. The harbors and other sheltered parts of the coast admit of work earlier and later than the open coast. Experience has shown that there are not more than eight to ten weeks, during the summer, when it is profitable to attempt sounding on the Nantucket shoals—that is, during which it is profitable to have the party ready for the kind of work, and in a neighboring harbor, prepared to run out and survey whenever the weather permits.

The phenomena of the tides in the Vineyard sound are of considerable practical interest, and the investigation was commenced towards the close of the season, by the party under the command of Lieutenant Commanding J. R. Goldsborough, U. S. N., assistant on the coast survey. Part of the scheme laid down in my instructions for combined tidal and current observations has been successfully carried out, and I expect to derive from the results valuable indications for the farther prosecution of the work. The tidal stations were occupied for one lunation. Three of these were on the north side of the Elizabeth islands, within the influence of the tides of Buzzard's bay, (see sketch A,) and three in the Vineyard sound itself, two of the stations being respectively at the entrance of "Quick's Hole" and "Wood's Hole," from Buzzard's bay, and two others at the Vineyard sound entrance of the same passages. The tide gauges were attached to tripods, placed in between five and six feet of water at low tide. Meteorological observations were made in connexion with those of the tides.



SKETCH A

Shewing the progress in Section 5th of
U.S. Coast Survey

in 1844-45-46-47 & 48.

It is sometimes forgotten, that though the land work yields no discoveries, it is the basis of the whole, and that without it the results on the water would be uncertain in their character. The positions on the water can only be determined by reference to fixed points upon the land, and the places of these on the surface of the earth must be given by the operations of geodesy. Without the land work a geodetic survey, such as was planned by Jefferson, Gallatin, and Hassler, and such as has been well declared, within the year, to be the only survey admissible in the present state of science, would dwindle into a nautical reconnaissance. Nearly or quite four fifths of the whole work, and two thirds to three-fourths of the out-door work, is on the land—the appropriate work of landsmen, of trained scientific men, and of such only. When a pursuit is, in the highest sense of the word, a profession, it is ever true that devotion to it unfits the man for a different profession.

The reorganization of the coast survey, under legislative authority, in 1843, embodied all the experience obtained up to that date, both of trials which had succeeded and of others which had failed; it confirmed and gave the force of law to the union in one corps, which had gradually grown up, of civilians, officers of the army, and officers of the navy, serving under a neutral department, under which alone they could be united—namely, that having control of matters relating to commerce and navigation. It is easy to see that without a permanent nucleus for such a work, the objects and aims must be wavering and unsteady, the methods wanting in uniformity from year to year and from party to party, and the results heterogeneous in kind and in form. Confusion and waste would result from such an organization, and the survey would in time be abandoned. The scientific parts of such a work require diligent study and devotion to mathematical and physical science, to grasp them in their various bearings; and it is not too much to say, that, unless such a work came up to the demands of science and scientific men of the country, it could not long stand. That the theoretical knowledge acquired at the Military Academy should be reduced to practice in the survey, by those officers of the army who have an inclination to similar pursuits, to its advantage as well as to their own, will readily be seen; and up to the point where details would interfere with the duties of the arm to which the officer belongs, Congress has conferred upon the work a right to seek his services. The War Department judges whether they can be granted or not.

The law of 1843 very properly limited the services of officers of the navy to the hydrographic parts of the work—the portions which have a professional bearing, and towards which the inclination of a nautical man may turn with professional pride. Experience has fully shown the advantages of this organization in general. The tendency resulting from the variable elements (the army and navy,) is nevertheless at times to lessen the results produced, by the necessity for turning aside from actual work to give instruction, and from the loss of the experience acquired at the expense of the survey by the removal of officers—caused, no doubt, by the exigencies of their proper service, and yet reacting severely upon the survey. The experience and knowledge of Humphreys, Johnstone, and Prince, of the army, and of Davis, Patterson, and Porter, of the navy, cannot readily be replaced; a detail may be filled, but the knowledge immediately available is not supplied.

The injunction of the law to employ as many officers of the army and navy as practicable in the coast survey, I have never lost sight of. On the breaking out of the Mexican war, five staff and nine line officers were upon the work. The number of hydrographic parties has been increased from two in 1843 to eight in 1850.

SECTION I. *Field work.*—To extend the primary triangulation in *Maine* eastward, and to make the reconnaissance and astronomical and magnetic observations connected with it; to extend the secondary triangulation of the coast of *Maine* to the eastward to *Portland;* to continue the topography of the western shore of *Massachusetts bay*, and of the eastern and northern shores of *Cape Ann;* to commence that of *Casco bay* (Portland harbor;) to complete the hydrography south of *Martha's Vineyard* and *Nantucket*, and to continue that of *Nantucket shoals* and of the ocean near *Nantucket;* to complete that of *Salem* and *Gloucester* harbors, Massachusetts, and of *Portland* harbor, Maine; to complete the observations of tides and currents in the *Vineyard sound*, and to commence those in *Nantucket sound*, including the cost of ordinary repairs to steam vessel and engine, of fuel, and of the hire of a vessel to aid in the soundings. *Office-work.*—To make the reductions and computations for the section; to complete the drawing of the general coast chart No. 2, from *Cuttyhunk* to *Cape Pogue;* to commence that of No. 3; to continue the drawing of charts of *Salem* and *Gloucester* harbors; to continue the engraving of the chart of *Boston harbor;* to complete that of *Wellfleet harbor*, of *Mukeget* channel, and of *Bass river*—will require - - - - $35,000

SECTIONS X AND XI.

The coast of California and Oregon.

The officers despatched to this coast in 1849 have met with great difficulties, arising from the high rate of wages and subsistence there, and their consequences. It was not possible to keep the hands together with the means usually deemed adequate for the support of similar parties.

The remarks appended to this report in regard to the trade of Oregon, and to the cutting of timber from the public lands, are of interest. I extract the former, referring to the appendix No. 35 for the latter:

"Traffic is very much on the increase in Oregon; and while it must be admitted that the great increase has been on the Columbia river, yet it has also much improved in the sound. Lumber has become an extensive article of export, and it is quite probable that there is no country on the face of the globe where it is so abundant, so good, and so convenient."

II.—*Sketches for location of light-houses, &c.*

1. Holmes's Hole.
2. Beacon ranges, New York.

The secondary triangulation was completed to Casco bay, and the reconnaissance carried over the bay. The topography of the vicinity of Chatham and Wellfleet, Massachusetts; of Cape Ann, from Beverly farms to the northeast point of the cape; and of Newburyport harbor, Massachusetts, was executed. The hydrography of the Nantucket shoals was continued. The hydrography of Muskeget channel was completed; off-shore soundings were made off Block island and Gay Head; the limits of soundings on Great Rip and Davis's bank extended; and the position of Fishing Rip determined. Tidal and current observations were made in Buzzard's bay and the Vineyard sound, and in the passages connecting them. Chatham harbor was examined; the hy-

mouth, New Hampshire, have been made. Reports were made on light-houses, &c., at Naraguagus bay and the mouth of the Kennebec, Maine; in Boston harbor; off Chatham; in Holmes' Hole harbor, Massachusetts; and off Brenton's reef, Rhode Island. The difference of longitude of Bangor, Maine, and Cambridge observatory, Massachusetts, has been ascertained by telegraph, (November 25;) and Cambridge has been connected in the same way with a station of the British survey of Nova Scotia. A second chronometer expedition, for difference of longitude of Greenwich and Cambridge, has been in progress, and is nearly brought to a close.

completed to Portland. The topography of Cape Cod, Cape Ann, and Newburyport harbor, in Massachusetts, was nearly completed. The hydrography of Nantucket shoals was continued; that of Salem, Chatham, Portsmouth, and Newburyport harbors completed; off-shore work off Block island and Gay Head was executed; and tides and currents were observed near the Elizabeth islands, in the Vineyard sound and Buzzard's bay, at Holmes' Hole, Salem, Newburyport, and Portsmouth. The permanent tidal station at Charlestown, Massachusetts, has been kept up, and observations for several lunations have been made in Salem, Portsmouth, and Newburyport harbors. The office-work has made corresponding progress.

reference to a junction with it.

The tides, and currents resulting from them, in the passages between the Elizabeth islands are altogether peculiar, and require close investigation. On one side of the islands the rise and fall belongs to Buzzard's bay; and on the other side to the Vineyard sound. The Buzzard's bay tide is propagated through the entrance between Cuttyhunk and Saghkonnet Point. (See sketch A.) The two chief passages used by vessels between the Vineyard sound and Buzzard's bay are Wood's Hole and Quicks' Hole. The plan which I sketched for determining the facts in regard to the tides was the establishment of three tide-gauges, to be observed during the same period on the north side of the Elizabeth islands at Wood's Hole, Kettle cove, and Quicks' Hole; and on the south side at Wood's Hole, Tarpaulin cove, and Quicks' Hole. These observations would give the corresponding phenomena and their progress between the two passages, and, being completed satisfactorily, the gauges from Kettle and Tarpaulin coves were to be removed to points nearly midway, or, better, at or near the point of meeting of the tides from the bay and sound, between the two gauges in Wood's and the two in Quicks' Hole, so as to determine the relation of the movement in these passages. This plan has been satisfactorily carried out during the present season, except that three days of simultaneous hourly observations, which I considered essential to its completeness, could not be made on account of the boisterous character of the weather.

After the date of my report of last year, assistant C. O. Boutelle completed his work connecting the secondary triangulation of the coast of Massachusetts with that of New Hampshire and Maine, erecting the necessary signals and measuring the angles, between the 1st of October and 8th of November. The number of stations occupied was 12, and 156 angles were measured, upon 154 objects, by 950 observations. Vertical angles were also measured upon 38 objects, 59 zenith distances being determined by 578 observations. The instrument used in both

Lieutenant Commanding Swartwout, in the brig Washington, was detached, for a part of the season, in this section, upon the survey of No-Man's-Land channel, between the island of that name and Martha's

Vineyard island, and also upon off-shore soundings, between the meridians of Gay Head and Beaver Tail.

The survey comprised an area of 14 square miles, in which 1,200 soundings were made, and 81 angles observed, the depth of water varying from 8 feet to 11 fathoms. The off-shore work consisted of 160 soundings, over 3 lines, the total length of which was 176 miles.

In execution of his instructions, Lieutenant Commanding Woodhull, United States navy, assistant in the coast survey, in the schooner Madison, has occupied 8 stations in the Vineyard sound, (see sketch A,) and 2 at the entrance of the passages between Buzzard's bay and the sound, for currents, and 9 stations for tides. The tidal observations, during two lunations, were made at eight points as nearly identical as practicable with those at which partial results were obtained last year, and after this period two of the gauges were removed to points near the middle of the length of the passage, Quicks' and Wood's Holes, and simultaneous observations were again made.

Lieutenant Commanding Woodhull states, in his report:

"During the observations I had all due care and attention paid to the regulation of the time. I visited the stations frequently, to see that the duty was faithfully and carefully performed. The books have been well kept; observations of wind and weather have been made at all the stations. The barometer and thermometer have also been recorded with great care, both at Quicks' and Wood's Holes; in fact, I feel satisfied, as far as I could control circumstances, nothing has been neglected to insure favorable results. The tidal observations have been conducted agreeably to your directions in every respect, save observing them every hour for three consecutive days. I made all my arrangements to comply with your instructions in this particular, but did not succeed, owing to the constantly unfavorable state of the weather during nearly the whole of the time comprised in the two lunations."

nlled up and perfected as the work advances.

The divisions of the office-work are as follows: 1. Computing; 2. Drawing; 3. Engraving; 4. Electrotyping; 5. Printing; 6. Publishing, distribution, and sale; 7. Instrument making; 8. Archives and library.

"There are now eighteen engravers—five employed on a salary, one on a *per diem*, nine on contract, and three apprentices. Much of the work can best be done by contract; all the lettering and figures, views, sands, swamps, and even hills. Only one letterer is now employed on a salary; and to him is assigned the most difficult work, as titles and general lettering.

It is due to the efficiency of the drawing and engraving departments that nearly the whole work of the past year is presented in sketches, with this report, to Congress. Major Stevens observes: "Our arrangements now are such that the work, as fast as it comes in, can be given to the public in preliminary sketches. Its effect will be great, both as an incentive to parties in the field, who see at once the fruits of their labor, and to the office force, in affording a better opportunity to train the younger members and prepare them for the finished charts. These sketches will, in most cases, be the finished charts, simply by the addition of the ornamental work.

"So the system of preliminary sketches and finished charts will actually hasten the publication of the latter, besides being the best system to apply, men having different degrees of skill; all, however, gradually rising to the highest excellence.

"The electrotyping department has improved so greatly the past year in all its arrangements and processes, that at my request its chief, Mr. Mathiot, has made a general report on the subject of electrotyping, (Appendix No. 55,) which I respectfully commend to your consideration.

"The advances which have been made through the agency of the Coast Survey have scarcely been equalled in the history of any art. Not a single failure has yet occurred in Mr. Mathiot's process. A single plate has again been reproduced from the junction of plates with complete success.

"The time for reproducing a plate has been greatly abridged. Time has been saved, and a greater certainty given to the process, by a heating apparatus, which is described in Mr. Mathiot's paper, and which is exhibited on the sketch accompanying his report. The work of this department the past year is not to be estimated by the number of plates made—16, all that were required by the wants of the survey—but by the great improvements that have been introduced—improvements necessary to meet the wants of the department the ensuing year. The sale of maps will, undoubtedly, soon be greatly extended.

"The time has come to call into action agencies for special sale of Coast Survey maps. They should be carried to each man's door having an interest in commerce, navigation, geography, and science. Mr. Mathiot can with certainty, in the present state of the art, reproduce his first basso in eight, and every subsequent basso in four days. These times may be reduced to six and three days. A plate has actually been made the past year, and returned to the engraving department, in sixty-five hours from the time the alto was sent to the electrotyping rooms. Certainly in fifty days the plates can be made for 16,000 sheets of any Coast Survey map, however large and elaborate

it may be: this shows the great practical utility of the process in the operations of the coast survey.

"Many of the plates will require three to four years' work of an engraver, and will cost from three to six thousand dollars. By the electrotyping process we can reproduce them in eight days, and at a comparatively trifling expense of some two hundred dollars."

A hydraulic press for map printing, intended to remedy the distortion which is now unavoidably produced, in a greater or less degree, by the copper-plate printing press, has been devised by Mr. Saxton, and is now in the course of construction under his direction.

The results obtained in the instrument shop, both in reference to the quality and economy, are very encouraging.

The arrangement of the archives has been much improved during the past year, in reference to registering, to completeness of detail in them when returned, and to facility of reference. Major Stevens again calls attention to the necessity for improved accommodations for the office of the survey. He remarks: "I again beg leave to call your attention not only to the pressing necessity of more extended accommodations for the safe-keeping of the archives, and for a probable increase in the business of electrotyping, printing, publishing, and sales, but to the unfitness of the present quarters for the purposes of drawing and engraving.

"I would recommend a suitable building as calculated to give a better tone to the whole establishment; making supervision more effective, giving better facilities for the furtherance of work, and abridging many expenses in the way of heating the rooms, and of repairs and attendance."

[illegible] instruments repaired.

ARCHIVES AND LIBRARY.—Mr. C. B. Snow, in charge of the archives and library, has re-registered the original and duplicate geodetic work, securing simple and convenient reference; separated the hydrographic and topographic reductions of original maps into their appropriate sections, and opened a new register, arranged chronologically, with an alphabetical index; superintended the binding of the original and duplicate sounding and angle books; nearly finished arranging the hydrographic and topographic sheets in single tubes; superintended the force employed in copying sounding and tidal observations required to correct errors and complete duplicates, which duty will soon be completed; examined the returns of the permanent tidal observers, and reported as to completeness; and placed the library in condition for convenient use.

MISCELLANEOUS.—The foregoing office-work has been generally under

U. S. Surveying Steamer Bibb,
Nantucket Bar, July 16, 1851.

Sir: In obedience to your instructions, I have carefully examined Holmes' Hole harbor, for the purpose of ascertaining what additional lights are necessary, and the most suitable locations for them.

I would respectfully recommend the establishment of three harbor lights of the smallest class, to be placed on the sites indicated by the accompanying sketch. The houses might be frame structures, similar to those erected for the small lights called bug lights of this port. Buildings of this description would be most economical, and answer every purpose. They would be placed in such immediate vicinity to the village, that a dwelling for the keeper may not be necessary.

It is not important that the lights themselves should be visible over four miles. The greatest danger encountered in entering this harbor proceeds from the rocks and shoals lying near Low Point. The skirt of wood occupying the higher ground, at some distance from the beach, is sometimes mistaken at night for the shore line, leading vessels to double Low Point too closely to clear the shoal or rocks. Frequent disasters arise from this circumstance.

The lights placed as proposed, furnish two well-defined ranges, the object of one of which is to guard against this danger, while the other shows the mid-channel and best water along the entire harbor.

Holmes' Hole is used as a port of refuge by vessels navigating the sound, on occasion of head winds and tides and storms; and the adoption of these or similar improvements would add security to life and property.

If the lights suggested are established, it will be necessary to modify the present sailing directions. I have prepared the following, and present them to you in full at the present time, as the best means of exhibiting the value of the ranges referred to.

Entering this harbor from the westward, east chop well open with west chop light-house, clears you of the middle ground. Give west chop a berth of half a mile, until you bring on the western range of the harbor lights, when, with the chart for your guide, bear up for your anchorage in the outer roads. If you want to stand into the inner harbor, bring on the eastern range of the harbor lights, and follow it.

Approaching from the eastward, give east chop a berth of half a mile, and bring on the eastern range of the harbor lights; following which, you may cast anchor either in the outer or inner harbor.

Ships may anchor in three and a half fathoms, muddy bottom; west chop light just open, with woods on Low Point.

Small vessels may anchor immediately off the town.

You can beat in with safety, the shores being bold and clear. West chop light is fixed, elevated sixty feet above the level of the sea, and visible sixteen miles.

Respectfully,

C. H. McBLAIR,
Assistant Coast Survey.

The detail of officers of the army for the work which had been interrupted by the Mexican war was resumed in 1850, and it has been my endeavor to obtain the services of as many of those whose studies and disposition lead them to desire to be detailed for the work, as could be spared by the War Department. There are now six officers of the two corps of Engineers on the survey, and eight officers of the line; and as fast as the necessary preparatory training in the practical parts of the work is had, they are placed in positions of responsibility adapted to their particular qualifications. A list of the army officers attached to the work will be found in the Appendix No. 2, *bis*.

The wants of the naval service have rendered it difficult to obtain the number of officers required for hydrographic work of the survey, especially during the past two years; and when officers have been detailed, they have, as a rule, been relieved at such short periods as to prevent them from acquiring the necessary experience to render effective service. The chiefs of parties, only, have been

SECTION I.—FROM PASSAMAQUODDY BAY TO POINT JUDITH, INCLUDING THE COAST OF MAINE, NEW HAMPSHIRE, MASSACHUSETTS, AND RHODE ISLAND. (SKETCH A.)

In this section there have been engaged during the season five land parties and two hydrographic parties; one of the land parties engaged in primary triangulation, one in secondary, one in secondary triangulation and reconnaissance, and two in topography, one of which latter was a double party. Both of the hydro-

been made by this party.

Lieut. Com. McBlair recommends the placing of two buoys in the channel between Gay Head and No-Man's Land—one on Lone Rock, and the other on Old Man's Ledge. He remarks that "this channel is a good deal used, and the guides suggested are indispensable to the safety of passing vessels."

with my own to the department, may be found in appendix No. 20.

The party under the command of Lieut. Com. Maxwell Woodhull, U. S. Navy, assistant in the Coast Survey, was charged, during the early part of the season, with the observations of tides and currents in Buzzard's bay and Martha's Vineyard sound. Gauges were put up and hourly observations made at Wood's and Quicks' Holes, and Kettle and Tarpaulin coves, to verify the results obtained there during the previous season. A series of observations on the north and south sides of the Vineyard sound was commenced about the middle of July and completed at the end of August, to ascertain the movement of the tide wave through the Vineyard sound. The stations occupied were Cuttyhunk, Nobsque, Hyannis, Monomoy, Menamsha Bight, Holmes' Hole, Edgartown, Nantucket, and Great Point—nine in all. At two of the stations—Hyannis and Nantucket—self-registering gauges were used. A part of these observations will require repetition.

Views.—Lieut. A. A. Gibson, U. S. Army, assistant in the Coast Survey, after taking the views in Section V, of Charleston harbor, &c., joined Lieut. George H. Preble, U. S. Navy, assistant in Coast Survey, in command of schooner "Gallatin," and during the month of September took views of the north and south entrances

to Wood's and Quicks' Holes, east entrance to Vineyard sound, Holmes's Hole, Tarpaulin cove, Mattapoissett and Sippican harbors, and of Muskeget channel, Billingsgate light, including Wellfleet, and seven views of Boston harbor.

3. ENGRAVING.—This department has since December last been under the supervision of Mr. A. W. Tinkham, assistant in the Coast Survey.

An amount of work has been accomplished during the year equal to the constant employment of twelve or thirteen engravers.

The additions to the list of finished, elaborately-engraved charts have amounted to three in number during the year: 1. General chart of the coast from Gay Head to Cape Henlopen, by Messrs. J. Knight, F. Dankworth, and G. McCoy; 2. Entrance to Mobile bay, by Messrs. H. M. Knight and G. McCoy; 3. Hell Gate and its approaches, by Messrs. J. Knight and G. McCoy. Besides the above,

1853

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Topography.—Assistant H. L. Whiting, after the close of his work of revision on the Patapsco, noticed in my report of last year, was engaged in inking several sheets of his previous field-work (in Sections I, III, and V) until the 24th of May, when he received instructions for the season's operations in Section I. These were commenced at Cuttyhunk (see Sketch A, No. 5) on the 4th of June, for the purpose of showing, in detail, the topography of the southern part of the island and the "Sow and Pigs" rocks, upon which it is proposed to erect a light-house, and to furnish the shore-line and positions to the hydrographic party charged with the minute examination of the rocks and selection of a site for the light-house. This work was completed on the 14th of June; after which, until the 24th of that month, the party was occupied in the re-establishment of points on the south side of Martha's Vineyard (see Sketch A, No. 1) for the use of the hydrographic party, rendered necessary by the rapid wear of the cliffs there by the ocean.

Mr. Whiting says, in regard to the Nashaquitsa (or Wequobsky) cliffs: "The highest cliffs on Martha's Vineyard are the 'Wequobsky cliffs,' called by Mr. Eakin 'Nashaquitsa cliffs,' on the highest point of which he put his triangulation station. This part of the south shore of the island is rather remarkable, from the fact that these cliffs draw in and form quite a *cove*, showing that the shore is washed away more at this point than any other, although the cliffs are one hundred and fifty feet high.

"When the signal was first put up in 1844 or '45, it was placed twenty-five feet from the edge of the cliff. Last year I went with Lieut. McBlair to show him where the signal was, and found it had been washed away. I noted a large rock, some ten or twelve feet back from the edge of the cliff, as a landmark at the time, and I now find this stone has been reached and has rolled down the cliff. My new station is about sixty feet inside the old point, and thirty-eight feet from the present edge of the cliff, making the encroachments of the sea upon these cliffs, of one hundred and fifty feet in height, some *fifty feet* (50) in *nine years*. This encroachment continues for some miles to the westward on the south side of the island. I found the beach washed in at 'Chilmark Pond station' about twenty or twenty-five feet, but this becomes less and less, until at the extreme southeast end of the island the shore seems to have increased, if anything; there is, however, not much change.

"As these and the Gay Head cliffs are quite known landmarks in this section of our coast, I thought these changes quite interesting facts."

It may be worth inquiry whether some effective means should not be adopted to preserve these landmarks.

Thence the party proceeded to the survey of the vicinity of Gay Head, (see Sketch A, No. 1,) which was finished on the 14th of July. On the height of Gay Head cliffs Mr. Whiting remarks:

"I find the Gay Head cliffs not so high as supposed. Prof. Hitchcock calls them one hundred and fifty feet, which they are generally considered, but they are only from one hundred and twenty to one hundred and thirty-five feet high. There is one small knoll, not on the edge of the cliff, which is one hundred and forty-five feet. The lantern of the light-house I make about one hundred and sixty-seven feet. All these heights are from mean low water. The highest land is near the middle of the Head, and is about one hundred and eighty-five feet."

Upon the completion of this work Mr. Whiting transferred his party to the

APPENDIX No. 5.

List of Coast Survey maps, sketches, and preliminary charts, engraved and engraving.

1. LIST OF MAPS ENGRAVED.

No.		
1.	Richmond island	$\frac{1}{20000}$
2.	Wellfleet harbor	$\frac{1}{20000}$
3.	Nantucket harbor	$\frac{1}{20000}$
4.	Hyannis harbor	$\frac{1}{20000}$
5.	Harbor of Edgartown	$\frac{1}{20000}$
6.	Harbor of Holmes' Hole and Tarpaulin cove	$\frac{1}{20000}$
7.	Harbor of New Bedford	$\frac{1}{40000}$
8.	General chart of the coast from Gay Head to Cape Henlopen	$\frac{1}{400000}$
9.	Fisher's Island sound	$\frac{1}{40000}$
10.	Harbor of New London	$\frac{1}{20000}$

1854

Mr. Whiting's office-work consisted in the preparation for office use of the following topographical sheets, viz:

Cuttyhunk	scale $\frac{1}{50000}$
Gay Head and No Man's Land	scale $\frac{1}{10000}$
Essex, Cape Ann, (part of sheet)	scale $\frac{1}{10000}$
Ipswich, Cape Ann	scale $\frac{1}{10000}$

The details on these maps are minute.

appeared to require.

One of the most interesting results first developed was, that the whole difference in time of four hours occurred between the West Chop of Holmes' Hole and Menemsha Bight, (see Sketch A *bis*,) a distance of but twelve miles; then, that on the west side of the point or West Chop, the time of high water was the same nearly as inside, and that nearly the whole difference occurred between Cedar Tree Neck (see Sketch A *bis*,) and the West Chop, only six miles apart; and finally, that a difference in time of high water of three and a half hours actually occurred along the strait-shore of Martha's Vineyard island in a distance of four miles. In the same way, on the

1855

1856

Charts of two hundred and thirty-five harbors, inlets, shoals, sounds, bays, and portions of the coast and rivers, have been drawn, engraved, and published. The number of maps, charts, and sketches drawn within the year, or now in progress, (as will be seen by reference to Appendix No. 22,) is ninety-five; and the number engraved, or yet in hand, is eighty-four. Of these, twenty-nine are first class maps, twenty-six are preliminary charts, and twenty nine are sketches and diagrams.

The list of published maps, charts, and sketches, (Appendix No. 22.) shows that one hundred and forty-eight sheets may be had of the general disbursing agent of the Coast Survey, and of local agents in the principal marts of commerce. Within the year seventy sheets have been published, including those with the report of 1856. The number of copies distributed under the act of Congress and regulation of the Treasury Department within the year is nineteen thousand seven hundred and ninety-five.

Additional hydrography done in MV

has been executed in Martha's Vineyard sound. The tidal observations at Boston navy yard have been continued, and the currents have been specially investigated in Nantucket and Martha's Vineyard sounds.

Resurvey on shores of Vineyard sound and Muskeget channel.—In order to ascertain the extent of changes known to have been occasioned by the action of the sea in the southeastern part of the Vineyard sound, an examination has been made by Assistant H. L. Whiting in that vicinity, including also the shores of Muskeget channel. His resurvey commenced as early as the nature of the season would admit, and was carried on at intervals of favorable weather until its completion on the 8th of May.

The natural changes which were found to have occurred were at once reported to the office, with the sheet containing the revised shore lines, and have been presented in the new edition of the chart of Muskeget channel (Sketch No. 6) accompanying my report of last year.

I subjoin entire in the Appendix (No. 13) the report of Assistant Whiting in reference to the character of the changes developed in his resurvey. He was previously engaged in the verification of work in Section III, and is now employed in the execution of topography for the Commissioners on Harbor Encroachments, to be noticed under the head of Section II.

Three topographical sheets of work executed last season have been sent to the archives by Assistant Whiting, viz: vicinity of Hyannis and Bass river; north shore of Cape Ann, including Essex river and Rowley river, with part of Plum island, to Newburyport. These maps are on the scale $\frac{1}{10000}$.

1857

The coast-line is now generally known with sufficient accuracy to render it practicable to prepare projects for a general series of maps according to the scales, and for the objects heretofore adopted. These projects have been taken up from time to time, and laid down again for want of more precise materials to be furnished in the progress of the survey, or for more thorough and mature study after preliminary examinations and discussions.

The three classes of maps and charts, of which the study has been resumed, are the preliminary seacoast charts on the scale of $\frac{1}{600}$; the general coast charts or off-shore charts on the scale of $\frac{1}{40000}$, and the finished coast maps (in-shore) on the scale of $\frac{1}{80000}$. The first and second named series have been approved, subject merely to alteration in the details, and the third, after modification, has been retained for further study. The several sheets of these different classes of maps and charts form, of course, part of the series. The series of harbor charts is additional to those just referred to. The general classification of the maps and charts resulting from the survey has been given in my report for 1856.

GENERAL COAST CHARTS, OR OFF-SHORE CHARTS.

This series has been the subject of repeated study by different assistants, and the last project of Mr. Boschke has seemed to me so successful that I have adopted it for general guidance in the office, subject to such modifications in details as the progress of the work may require. It gives the coast of the Atlantic and Gulf of Mexico in sixteen sheets. Of these, the Atlantic series is comprised in nine sheets, for which there are materials for beginning the whole in the office, and I propose to publish on this scale, and as preliminary with the reports of the year, by lithography, stone engraving or transfer, such portions of these charts as are finished from time to time, referring them by their numbers to the complete charts. The limits of the Atlantic series and its progress are as follows:

No. I. *Quoddy Head to Cape Cod*, Eastport to Provincetown, (seacoast of Maine, New Hampshire, and part of Massachusetts.)

II. *Cape Ann and Jeffries Bank to Gay Head and Davis Shoal*, including George's Bank and the Nantucket shoals, (seacoast of Massachusetts and part of Rhode Island.)

III. *Gay Head to Cape Henlopen*, including Long Island Sound and New York bay, (seacoast of part of Massachusetts and Rhode Island, Connecticut, New York, New Jersey, and part of Delaware.)

OFFICERS OF THE ARMY.

The names, rank, and date of attachment to the survey of officers of the army serving upon it is given in Appendix No. 2. Captain M. L. Smith, U. S. Topographical Engineers, and

OFFICERS OF THE NAVY.

The number of officers of the navy attached to the Coast Survey on the 1st of November, 1857, was thirty-one, being twenty-two less than at the same date of the year before, (1856,) and twenty-eight less than on the 1st of September, 1855. The number of assistant engineers was but five; and notice was given in July of the intention to withdraw the whole of the naval engineers from the work, in consequence of the exigencies of the naval service.

Scituate to Nausett, $\frac{1}{80000}$; and the general coast chart from Cape Ann to Point Judith. In the engraving division, plates have been completed of seacoast of Massachusetts, No. 1, as preliminary; Plymouth harbor; Boston harbor, (new edition,) and Monomoy shoals; and the following plates are in progress: seacoast of Massachusetts, as a finished chart, Ipswich and Annis Squam harbors, Muskeget channel, and eastern series, Nos. 1 and 2.

APPENDIX No. 23.

List of original topographical sheets registered in the archives of the United States Coast Survey, geographically arranged.

4. Compared with those of other nations, the surveys undertaken by the United States have been on a moderate scale of expenditure.

The trigonometrical survey of England alone had cost up to 1856 five millions of dollars; that of Ireland, five millions three hundred thousand dollars; that of Scotland, one million four hundred thousand dollars; making, for the United Kingdom, eleven and a half millions of dollars. This is for the land work. Besides this, over ten millions of dollars were expended in hydrography. The total cost of the field and office work of the United States Coast Survey from 1843 to the middle of the year 1857, including the estimated facilities furnished by the Navy Department, and deducting the estimated value of public property then on hand, (omitting the original maps and charts,) was less than four and a quarter millions of dollars.

Topography between Scituate and Plymouth harbor, Mass.—Assistant A. M. Harrison, having last season finished the plane table survey of the shores of Plymouth harbor, took the field immediately after his return from duty in Section V, and on the 12th of July resumed work near Green Harbor river. The sheet projected for the present season (Sketch No. 2) now contains the details of the shores of North river, several tributary streams, and the western shore of Massachusetts bay from the mouth of that river northward to the limits of former work near Scituate.

"The general character of the country surveyed does not differ materially from that of the shore of the State elsewhere, the topographical details, as represented on the sheet, embracing marsh, creek, hills, forest, cultivated fields, &c." The ordinary statistics are thus stated by Mr. Harrison:

Shore-line, (outside)	5.75	miles.
River shore-line	16.25	"
Creeks	13.50	"
Roads	13.50	"
Marsh line	19.00	"
Area in square miles	7.75	

Sub-Assistant W. H. Dennis was attached to the party, and used the plane-table constantly until the close of the season at the end of September. The surveying schooner Peirce, which was employed for transportation, had previously been in the service of this party in Section V. Under that head other plane-table work, executed by Assistant Harrison, will be described.

Mr. Sengteller has completed the topography of Provincetown harbor; coast chart, No. 4, $\frac{1}{80000}$; and commenced that of coast chart, No. 12, $\frac{1}{80000}$; *Mr. Metzeroth* has finished the topography of Annis Squam and Ipswich harbor; Beaufort harbor; and also engraved a portion of Rappahannock river; Pensacola harbor; and Monterey bay charts; *Mr. Blondeau* has been employed the entire year in engraving the topography of San Francisco bay and harbor map; *Mr. Phillips* has engraved a portion of the topography coast charts, Nos. 91 and 92, $\frac{1}{80000}$; *Mr. E. A. Maedel* has engraved a portion of the topography of Wood's Hole harbor, and Biloxi, and titles, notes, soundings, and general lettering upon the plates of Provincetown harbor; Rappahannock river; seacoast of the United States, Nos. 3, 4, 11, 14, and 31, $\frac{1}{200000}$, series, and other miscellaneous work; *Mr. Throop* has engraved soundings and miscellaneous lettering upon the maps of Beaufort

SECTION I. *From Passamaquoddy bay to Point Judith, including the coast of the States of Maine, New Hampshire, Massachusetts, and Rhode Island.*—The primary triangulation is carried to the northeastern boundary of the United States, requiring merely the occupation of certain stations passed by in order to advance the coast work, to complete the original scheme from Point Judith (Rhode Island) to the limits of Maine.

Three secondary triangulation parties will finish the triangulation in six years, and the progress will show whether this is the best course, or to press on the topography, employing only occasionally a third triangulation party, so as to complete the triangulation in seven and a half to eight years. The completion of the primary work of this section will give means from the estimates to furnish the additional topographical parties needed to keep fully up with the secondary triangulation. Two hydrographic parties with steam vessels and one with a sailing vessel will keep the hydrography close upon the triangulation and topography. The progress made this season shows that there will be no difficulty in this respect.

Allowing a margin of two years brings us to the estimate of my report for 1856–'57, namely, "ten to twelve years" from that date, or eight to ten from this, even without the additional year already referred to.

A map has been marked off with the limits of average progress, as determined by the statistics of the survey, to be expected in the triangulation of this part of the coast, and will enable me to regulate the progress accordingly. In two years the same may be done for the topography and hydrography.

port harbor. Progress has been made in the drawing and engraving of general coast chart No. II, from Cape Ann to Gay Head, and of preliminary coast chart No. 3, from Cape Small Point to Cape Cod; in the drawing of coast maps and charts No. 7, from Muscongus bay to Portland harbor; Nos. 9, 10, and 11, from Cape Neddick to Hyannis harbor, and No. 14, from Cuttyhunk island to Block island; also in the engraving of coast maps and charts Nos. 12 and 13, from Monomoy to New Bedford; the views for these charts, the finished maps of Kennebec river and Lynn harbor, and the new edition of the chart of Muskeget channel.

The application of photography to the regular reduction of our maps and charts has made good progress. It is estimated that the cost of reducing one of our sea-coast charts by photography is but about one-fourth of that by the pencil and pen. The questions yet unsolved in this application are merely questions of detail, and it is to be considered as one of the processes fully applicable to the reduction of our maps and charts for engraving, no important difficulty in relation to which remains to be mastered. The report of the assistant in charge of the office, and of George Mathiot, esq., in charge of the photographic operations, give many important particulars in this matter, (Appendix No. 17.) Prints have been produced of reduced maps in which the severest tests could detect no error beyond the tolerated limits.

Office-work.—The drawing and engraving of additions to the chart of Boston harbor have been completed, as also the drawing of those of Portland harbor, Lynn harbor, and a new edition of that of Muskeget channel, and the engraving of the preliminary charts of Kennebec river and Rockport harbor. Progress has been made in the drawing and engraving of general coast chart No. II, from Cape Ann to Gay Head, and of preliminary coast chart No. 3, from Cape Small Point to Cape Cod; in the drawing of coast maps and charts, No. 7, from Muscongus bay to Portland harbor; Nos. 9, 10, and 11, from Cape Neddick to Hyannis harbor, and No. 14, from Cuttyhunk island to Block island; also in the engraving of coast maps and charts, Nos. 12 and 13, from Monomoy to New Bedford; the views for these charts, the finished maps of Kennebec river and Lynn harbor, and the new edition of the chart of Muskeget channel.

1860

limit of uncertainty of two years. A continuous triangulation stretches from Passamaquoddy bay to the boundary between North and South Carolina, and another season will make it continuous from Winyah bay to a point below Matanzas river, south of St. Augustine. There remains, in fact, less than one-eighth of the Atlantic coast not covered by one of the classes of triangulation.

Barnstable harbor. A special plane-table resurvey has been made of the more exposed portions of the islands and shores of Boston harbor, for the city of Boston, and of the neck between Buzzard's bay and Cape Cod bay, for the State of Massachusetts. The in-shore hydrography

pleted for the $\frac{1}{10000}$ scale of our coast maps and charts. As the photographic system supersedes the elaborate and elegant drawing of the former drawing school, coloring is introduced to show varieties in cultivation, wood, marsh, and the like. The generalization is made on a tracing on the full field scale. It is reduced one-fourth and studied, correcting any imperfections before they are so far reduced as to make them difficult of detection. Then reducing one-half again, coloring the reduced photograph, and sharpening such of the details as need it, completes the engraver's pictorial copy. The photographic reduction is also made on glass, so that the distances may be measured, and the outlines taken, free from the expansion of paper.

1889

RESURVEY OF THE NEW INLET INTO COTAMY BAY, MARTHA'S VINEYARD.

In the Annual Report for 1886, Appendix No. 9, was published an account of the changes in the shore-line and beaches of Martha's Vineyard, as derived from comparisons of recent with former surveys. This paper was prepared by Assistant Henry L. Whiting with special reference to the new opening through Cotamy Beach, which occurred during a violent storm, accompanied by a very high tide, on the night of January 9–10, 1886. The conclusions drawn by Mr. Whiting respecting the probable eastward movement of the new opening were based upon a comparison of surveys made by himself in 1846, 1856, 1871, and 1886. These conclusions have been verified by two later surveys, one by Assistant Vinal, in 1887, and the other by Mr. Whiting, in June, 1889. It appears from these later surveys that there has been in fact more change than was anticipated, although those changes that have taken place have been in accord with the predictions based upon a knowledge of former changes, and the laws which appear to govern the normal *set* of the tidal currents along the south coast of Martha's Vineyard, and to produce the prevailing sea-dash.

In Mr. Whiting's detailed report of the results of the latest resurveys, published as Appendix No. 14 to this volume, he observes that it is reasonable to predict that the easterly point of the inlet will move eastward past the Wasque Hills, leaving a long canal passage-way between an outer beach so formed and the fast land of Chappaquiddick; and that perhaps this long pas-

Supervision and inspection of topographical resurveys on Martha's Vineyard, No Man's Land, Naushon, in the vicinity of Wood's Holl, and on the southeasterly part of Long Island.—The report submitted by Assistant H. L. Whiting of his duties of supervision and inspection of the topograhical resurveys on Martha's Vineyard and adjacent islands, and on the main-land at Wood's Holl and vicinity, presents some interesting and valuable results of the comparison of old and new surveys in localities which are of interest to navigation as defining the important waterway of Vineyard Sound. The report closes with a notice of the resurvey on the south coast of Long Island in the vicinity of Westhampton, about fifty miles to the west of Montauk Point.

Upon Martha's Vineyard and No Man's Land, the resurveys were executed by Assistant John W. Donn; upon Naushon and the Falmouth shore, by Assistant W. Irving Vinal, and on Long Island by Assistant C. T. Iardella.

For the details of the work of these several parties, the time occupied during the season of 1888, and the statistics, reference may be made to the reports of their chiefs, which will be found under separate headings in this and the next section.

Space is not available for more than a few extracts here from Mr. Whiting's very full description of the features, geological and topographical, of the localities under survey, and account of the changes due to natural causes in the shore-line. With regard to Martha's Vineyard he observes:

"The formation and material of the northerly part of Martha's Vineyard is of much the same character as that of Long Island and Block Island. This part of the Vineyard is marked by a succession of irregular hills, which, with the exception of the Manomet Hills near Plymouth, are the highest in southeastern Massachusetts, the highest summits being from about three hundred to three hundred and ten feet. In approaching Vineyard Sound from the southwest, the conical top of Prospect Hill is the first land seen from the sea.

"The territory of Gay Head, formerly an Indian reservation of Massachusetts, has an area of between five and six square miles, terminating at its western extremity in the curiously variegated clay cliffs which give the name to this remarkable head-land. The land of the peninsula of Gay Head is generally hilly; Molaska Hill, near the center, is about one hundred and eighty-five feet high. The southwest and northeast points of the peninsula, however are of beach formation. The highest land at Nashaquitsa is about one hundred and fifteen feet, and at Squipnocket about sixty-five feet.

"The triangulation executed by Assistant R. A. Marr in 1887, has furnished, as was intended, sufficient basis for the topographical resurveys which have been made during the past season of 1888 by Assistant J. W. Donn. I need hardly say that the accuracy and style of Mr. Donn's work has been of the first order in every respect, and more in detail than was the custom to follow in the earlier survey.

"The agreement in geographical position of the main features of the two surveys is, however, so far satisfactory that the comparison of them gives a reliable basis for measuring the changes effected by time and other natural causes during the interval of forty-three years since the first survey was made.

"From the physical peculiarities of Gay Head, and the importance of its position as one of the main promontories of the coast marking the entrance to Vineyard Sound * * * it was deemed desirable to make the resurvey of the special features of the cliff on a larger scale than that usually given to the field work of ordinary shore topography. For this purpose a sheet was projected on a scale of 1–2500, or about 25.3 inches to a statute mile. On this sheet Mr. Donn made a very elaborate survey of the features of this remarkable cliff, which is the only one of its kind in the whole extent of our Atlantic coast.

"Owing evidently to the tenacious character of the clay of which the Gay Head Cliffs are composed, they have held their own much more firmly than might have been expected against the attacks of the sea, which at times dashes against their base with the violence of the heaviest storm breakers. the most apparent cause of the giving away of the base of the cliffs, which occasionally happens in slides of greater or less masses, seems to be the insidious action of springs and quicksands at their base.

"Although this head-land is exposed, as before remarked, to the full sweep of the ocean, the immediate shore and beach is guarded by the bed of bowlders which extend well out beyond the water-line. It was on one of these sunken bowlders that the ill-fated steamer *City of Columbus* struck. These 'rocks' as they are locally called, undoubtedly mark the former ground of the original head-land. The 'Devil's Bridge,' so called, confirms the theory and fact that the greater mass of them was deposited along the higher and more northerly part of the original drift.

"The waste of this remarkable head-land has already reached a line beyond its original summit, so that all future loss will lower its elevation, and that of the first order light, now not far from the crest of the cliffs, unless in the next retreat (one has already been made) a higher light-house structure is erected.

"Owing to the comparative smallness of the scale of the survey of 1845, and the worn condition of the older map and change in the position of the light-house as a main point of reference, it is difficult to make a close comparison and measurement of details. The very elaborate survey made by Mr. Donn will, however, preserve the record of the exact position of the cliffs, with all their varied physical and topographical features, from which a closer and more interesting knowledge of future changes can be obtained.

"The best comparison that can now be made shows, near the northwest point of the head-land, for a lateral distance of about three hundred and fifty feet, a slide or giving way of the summit line of the cliff, the greatest amount of waste of which is about ninety feet. From the same point eastward along the shore of the Sound for a distance of about fifteen hundred feet, the summit line of the bank has fallen back irregularly in various places. A former spur, nearly opposite the light-house, has given away a distance of about one hundred and twenty feet. Along the line of the Government land surrounding the light-house, there has been an average waste of from eighty to ninety feet. There has not been much apparent change in the position of the high-water line along this front of the head-land."

With regard to the resurvey of the shore topography of the small island of No Man's Land, lying about five and a half miles south a little east from Gay Head Light, Mr. Whiting observes that the scale of resurvey was 1–5000. Being so far outside of the larger islands, it is open to the action of the sea from all directions, and the earthy material of which it is composed makes it an easy prey to the consuming power of the waves. Full details of changes in the configuration of the shores since the first survey are given in Mr. Whiting's report.

Referring to Mr. Vinal's resurvey of Wood's Holl and vicinity, an account of which is given under a separate heading in this section, Mr. Whiting states, as a general result, after reviewing the detailed resurvey, which was executed on a scale of 1–5000, that no important change has taken place in the main features of the topography during the last forty-three years. This he deems somewhat surprising, particularly in the features of Wood's Holl, in view of the strength of the currents that are constantly rushing through its narrow and tortuous water-way, and it suggests an interesting field, he thinks, for physical investigation as to the power of imbedded bowlders and shingle, where no actual ledges seem to exist, to resist the forces of tidal currents of such high velocities.

Additions of topographical details to the original surveys of Nantucket and Martha's Vineyard Islands.—In furtherance of his assignment to the general charge and supervision of the topographical resurveys on the islands of Nantucket and Martha's Vineyard, Assistant Henry L. Whiting has submitted a report of the work executed by him under instructions issued early in July, 1888. This work has consisted mainly in adding to the topographical sheets the several county and town roads which have been laid out and opened on Martha's Vineyard since the original survey was made, in 1845.

The fact of the loss of most of the early triangulation points made it possible to locate these new features in harmony with the original work only by the use of such of the old plane-table points as could be identified, such as the chimneys of conspicuous houses, etc. Much time and labor were required to do this, more than would at first appear, because of the discrimination needed to ascertain by various tests which of the old points were used as bases in the original survey.

Mr. Whiting states that the results in the main have been more satisfactory than he anticipated, and that he has been even surprised at the general coincidence of the old and new work, considering the scanty supply of the early triangulation points, the original survey of the central part of the island having been based on but two points, Prospect and Indian Hill, and these so far apart that they can not be used together in any given section of work. The compass and chain of the early surveys have long been superseded by the plane-table and the telemeter.

The lines of the new roads have been imposed upon the original sheet in red ink without changing or erasing any of the older work, thus affording a comparison of the lay-out of new roads where they follow in whole or in part the directions of former by-roads, farm roads, etc. All of the road resurveys west and north of the central villages of West and North Tisbury were completed; unfavorable weather compelled a postponement of the resurvey of the two new roads in the northeasterly part of the island.

Under a preceding heading in this section reference is made to special surveys for the State of Massachusetts carried on under Mr. Whiting's direction.

Hydrographic resurvey of the approaches to Martha's Vineyard and Nantucket, and resurvey of Muskeget Channel.—The hydrographic surveys executed by the party in charge of Lieut. J. F. Moser, U. S. N., Assistant Coast and Geodetic Survey, commanding the steamer *Bache*, in the summer and autumn of 1888, were a continuation to the eastward of the surveys made by the same officer during the preceding season. In 1887 work was closed on a line thirteen miles west (true) from No Man's Land; thence south (true) to the twenty-fathom curve. From these limits the off-shore hydrography was continued to the eastward and a resurvey made of Muskeget Channel. The limit to seaward was the twenty-fathom curve, provided that this curve connected the deep-sea lines run by the steamer *Blake;* if they did not connect, then the work was continued seaward until a proper connection was made.

The off-shore work was executed on a scale of 1–40000; the Muskeget Channel work on a scale of 1–20000.

For the off-shore hydrography the system of execution is similar to that of the previous seasons, namely, normals half a mile apart from the shore to a distance of six or seven miles, and thence to the limit a mile apart. This system is crossed by lines beginning at the shore and half a mile apart, this distance being increased seaward until the outer limit is reached, where the lines are about one and one-half miles apart. The boat system connecting the ship lines with the shore varies as the coast demands. Where the coast is rocky, or, rather, has scattered over it great numbers of bowlders, as in the vicinity of Squipnocket Point, the lines are run very close so as to make the development full. From Squipnocket to Muskeget Channel the shore is bold and clear and the system of boat-work more open.

Between the fogs which frequently visit this exposed coast during the summer months, the prevailing winds, which are strong from the southwest, and the usual course of New England weather, the number of working days on this coast are not very many, as a general rule, but the season of 1888 was an unusually bad one, notable for the frequency of high winds, rains, and heavy seas. During July and August fog prevented work for several days at a time.

About the middle of August, as the southwest winds continued to blow very hard, preventing outside work, Lieutenant Moser decided to go to Edgartown and begin work on the resurvey of Muskeget Channel. The limits of the projection for this work were from Muskeget Island to Cape Poge and Wasque Bluff and thence to seaward. Having previously informed himself as fully as possible in regard to the locality by communicating with people who were familiar with it, he was prepared to encounter great natural difficulties in the execution of the survey, and he found the accounts given of these difficulties not at all exaggerated, and that the work was always accompanied by more or less danger.

From Muskeget Island to Wasque Bluff is a distance of over five miles, between which no signal can be erected; a line of shoal water extends between these two points and beyond; Cape Poge is distant from Wasque Point about four miles, and the time of high and low water between these last two points is more than four hours, or more than two-thirds of a tide. The force of the current running to the southward, not only with the velocity of the Sound current (which is very

great) but with rapidly increasing force as it approaches Skiff's Island, can be imagined. It gains its impetus from the difference of water level, further accelerated by the funnels through which it is drawn. In such a current it was found impossible to keep a regular system of lines. A boat would start on a regular line, and before a second position could be plotted she would probably be swept by the current on an adjoining line. The current is not the same in direction over all the work; on the same tide it will vary eight points on different parts of the field. Hence the lines could not be carried continuously; the work had to be done according to the conditions of the weather; when this was exceptionally good the more dangerous portions of the work were done, and the rest at other times as the conditions seemed favorable.

Lieutenant Moser gives in his report full details in regard to the channels, currents, shoals, and other data of interest to the navigator and of value for the Coast Pilot within the limits included in his survey, devoting a large part of his report to the peculiarities of Muskeget Channel, respecting which he observes that few vessels ever use it, and none without a pilot unless by accident. His recommendations for additional buoys at its southern entrance will be duly reported to the Light-House Board.

Referring to the scarcity of aids to navigation on the southern coasts of Nantucket and Martha's Vineyard, Lieutenant Moser remarks that there is no coast light from Sankaty Head to Gay Head, a distance of forty miles, and that the only buoys in the same distance are one on Mutton Shoal, Muskeget Entrance, and three marking the channel between No Man's Land and Martha's Vineyard. He asks why there is not a first-order light on No Man's Land instead of Gay Head, the island just named being one of moderate elevation, admirably situated for a sea-coast light, as it is six miles farther seaward than Gay Head. A light could be placed on the island that would send its rays over the European steamer track. At Gay Head, all that he deems necessary is a fourth-order light as a guide for the entrance to the Sound. Instead of the second-class can buoy now at the Devil's Bridge he recommends a whistling buoy.

It had been Lieutenant Moser's intention to run all the north and south lines to a point on the southeastern side of Nantucket, and then from the above range and angle at No Man's Land, cover the north and south system, but the work at Muskeget occupied the party much longer than had been expected, and it was deemed preferable to finish the work on that sheet, the changes there, from year to year, being probably very great.

The principal tide-gauge was established at No Man's Land, and day tides observed there from July 6 to October 30. A comparison gauge was used at Wasque Bluff, which confirmed the data in the office tide-tables—that the times and heights were approximately the same at these two points. Comparisons of time and height at Wasque Bluff, with data derived from the observations at Cape Poge, made by the party under Lieut. S. C. Paine, U. S. N., Assistant Coast and Geodetic Survey, showed a difference in tide of four hours, with an inappreciable difference in height. At Cape Poge high water was four hours later than at Wasque Bluff or at No Man's Land. For the work off Martha's Vineyard but one tide-gauge was used—that at No Man's Land. For the Muskeget Channel work, owing to the great complication of tides to be dealt with, a system of blocks was employed, the details and limits of which are stated in Lieutenant Moser's report.

Of this exceedingly comprehensive report (B) the foregoing is but a limited extract; the information it gives relative to all of the hydrographic characteristics of the areas under survey will be of great value in the preparation of a new edition of the Coast Pilot for the approaches to Nantucket and Vineyard Sounds.

To the officers and crew of the *Bache* Lieutenant Moser expresses his acknowledgments for their diligent efforts to forward the work. The following named officers were attached to the party during the season: Ensigns W. M. Constant, H. A. Bispham, J. E. Shindel, W. H. G. Bullard, and S. M. Strite, U. S. N.; Passed Assistant Surgeon J. M. Steele, U. S. N., and Assistant Engineer S. H. Leonard, U. S. N. Messrs. Geo. R. Jones and J. L. Dunn served as recorders.

Ensign Bispham had charge of all tidal computations under Lieutenant Moser's direction.

Topographic resurvey of parts of the north and south shores of Martha's Vineyard.—Also of the shore line of No Man's Land.—In pursuance of instructions issued early in July, 1888, Assistant John W. Donn organized a party for the resurvey of the north shore of the Island of Martha's Vineyard from Tashmoo (or Chappaquonsett) Pond to Menemsha Bight, thence to Gay Head, and from Gay Head along the south shore to Wec-quobska Cliffs, taking in also the outlying island of No Man's Land. At Tashmoo Pond and Wec-quobska, the extremities of the projected shore line work, junction was to be made with the resurveys of Assistants Whiting and Vinal, which had been previously completed.

Work was begun July 12 at Indian Hill, and advanced east and west along shore, including a margin of topography of varying width, averaging about a quarter of a mile. Upon finishing this work between Tashmoo and Menemsha, the party was moved in August to Gay Head, and an elaborate survey of the cliffs and eastward slope of that locality was made upon a scale of 1–2500, or 25.34 inches to the statute mile. Contour lines were run for every five feet of elevation, thus thoroughly developing the surface. As the weather was generally fair and free from high winds during the progress of this survey, the conditions were very favorable for the completion of a map of Gay Head, which will serve as a true basis for future comparisons.

The heights of several prominent objects were determined by lines of levels connecting them with the bench-mark established by Assistant Henry Mitchell, in 1857, at Menemsha Bight. The base of the light-house tower upon the cliff, and the tops of two large bowlders at the northwest and southwest curves of the shore around Gay Head were the principal points. These bowlders were selected for the purpose of discovering the degree of subsidence of bowlders by the action of the sea, in connection with the receding of the shore.

Upon the transfer of the party to No Man's Land, the shore and cliff-lines of the island were surveyed, and the heights of the principal cliffs were determined, but no resurvey of the interior was made, contours having been carried over the surface by Assistant Whiting in his survey of 1855. The island is entirely bare of trees and covered with grass, so that little or no surface degradation occurs by reason of winds or waves.

After the work on Gay Head cliffs had been finished, the shore line resurvey was taken up from Menemsha around the Head, and along the south coast, together with the cliff work at Squibnocket, Nashaquitsa, and Wec-quobska. This done, the widening of the margin of topography between Menemsha and Tashmoo was begun, with the intention of reaching the tops of the highest hills and ridges overlooking the sound and the sea. But the allotment of funds for the survey having become exhausted by the 20th of October, the work was brought to a close.

Following are the statistics:

Topography:

Area surveyed in square statute miles (scale, 1–10000)	7
Lengths of shore-line in statute miles (scale, 1–10000)	29
Length of shore-line of ponds in statute miles (scale, 1–10000)	4
Length of shore-line of creeks in statute miles (scale, 1–10000)	5
Length of roads in statute miles	10

For the more detailed surveys on the Gay Head cliffs and on No Man's Land, the statistics are:

At Gay Head:	
Length of instrumental contour lines in statute miles (scale, 1–2500)	50
At No Man's Land:	
Length of shore-line in statute miles (scale, 1–5000)	5
Area (approximate) in statute miles	1

After returning from Martha's Vineyard, Mr. Donn received instructions to execute a topographical resurvey of Annapolis Harbor and approaches. Notice of this work will be found under a heading in Section III.

Topographical resurvey of shore line and adjacent details in Wood's Holl and on the islands in its immediate vicinity.—Reference was made in the last Annual Report to the assignment of Assistant W. I. Vinal to duty on the coast of Massachusetts under the general direction of Assistant Henry L. Whiting. Having reported to Mr. Whiting, he was directed to take up a topographical resurvey of the vicinity of Wood's Holl, and organized his party for that purpose immediately upon reaching the working ground, June 18, 1888.

This resurvey was to be executed upon a scale of 1–5000, to show the shore-line with adjacent details both inside and outside of high-water mark, and to include the village of Wood's Holl, the islands of Uncatena and Nonamessett, and part of Naushon Island, with the positions of outlying rocks, whether detached or in reefs.

Some delay was encountered at the outset, owing to the disappearance of important stations of the old triangulation in the course of the many changes and improvements since the original survey. The weather was less favorable than usual, the summer being rainy and the months of September and October more than ordinarily stormy and cold. On September 26 occurred a storm which was said to be the most violent and destructive experienced in that region in over forty yers.

The very swift current of the straits, locally known as "The Hole," between Nonamessett Island and the main shore, obliged Mr. Vinal to work with the tides, and thereby often involved delays on days when the weather and tides were favorable for passing through and returning. This current has abraded the north side of Pine Island and the points of Long Neck and Devil's Foot Island to a marked extent.

Field operations were closed November 5, the work not having been quite completed owing to the many drawbacks encountered throughout the season.

A descriptive report has been submitted by Mr. Vinal to accompany his topographical sheet. In this report reference is made to the geological features, the roads, bridges, growth of forests, and other details of interest relating to the region under survey.

Encroachments of the sea, and consequent serious changes in the shore-line on the Buzzard Bay side of Long Neck, and on the mainland, particularly between the Bay and Great Harbor, are prevented by three short breakwaters or walls of stone, built along the high-water ridge.

The low-water line is distinctly defined on the sheet, but, as Mr. Vinal observes, it may be slightly modified in outline when the soundings are plotted.

Following are the statistics of the season:

Topography:

Area surveyed in square statute miles	6
Length of general coast in statute miles (high water 22, low water 23)	45
Length of shore-line of creeks and ditches, in statute miles	9
Length of roads and railroads, in statute miles	28

Topographical resurvey of the Elizabeth Islands, off the coast of Massachusetts.—During the month of June, 1889, Subassistant E. L. Taney took the field in pursuance of instructions issued May 31, and began a topographical resurvey of the Elizabeth Islands, forming a part of the eastern shores of Buzzard's Bay, Massachusetts.

Between June 8, when he reached the locality of work, and the end of the fiscal year, he was occupied chiefly in a search for and recovery of old triangulation points, putting up numerous signals, and making a plane-table triangulation to determine their position on his topographical sheet.

Further account of his progress will appear in the next Annual Report.