37TH CONGRESS, } HOUSE OF REPRESENTATIVES. { EX. DOC.
3d Session. } { No. 70.

REPORT

OF

THE SUPERINTENDENT

OF THE

COAST SURVEY,

SHOWING

THE PROGRESS OF THE SURVEY

DURING

THE YEAR 1862.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1864.

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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IN THE HOUSE OF REPRESENTATIVES, *January* 9, 1863.

On motion of Mr. CLARK, from the Committee on Printing—

Resolved, That there be printed three thousand extra copies of the Report of the Superintendent of the United States Coast Survey for the year 1862; two thousand of which shall be for distribution by the Superintendent, and one thousand for the use of the members of the present House.

Attest: EM. ETHERIDGE, *Clerk*.

ERRATA.

IN COAST SURVEY REPORT FOR 1861.

Page 152, last line, for "Coquilla" read "Coquille."
Page 232, line 15 from bottom, for "41°" read "43°."

IN COAST SURVEY REPORT FOR 1862.

Page 12, line 5 from bottom, for "1861-'62" read "1860-'61, and is much diminished from those of 1861-'62."
Page 178, line 13, for "sketch No. 50" read "sketch No. 48."
Page 182, line 10 from bottom, for "sketch No. 50" read "sketch No. 48."
Page 272, line 17 from bottom, for "of Sergus" read "Las Sergas." The full title of the book is "Las Sergas del Mey Esforzado Cabalero Esplandian hijo del Excelente re Amadis de Gaula."
Page 272, line 13 from bottom, for "Sergus" read "Sergas."
Page 275, line 7, after the word "pages" insert "45-49."
Page 285, line 7, after the word "page" insert "15."
Page 286, line 16 from bottom, before the word "side" insert "NW."
Page 288, line 10 from bottom, for "12".9" read "11".6."
Page 290, line 9, for "10".2" read "09".8."
Page [illegible], line 17 from bottom, for "bend" read "trend."
Page 29[illegible], line 12, for "58".1" read "51".8."
Page 297, line 5, for "17"" read "11"."
Page 299, line 6, for "55" read "5.5."
Page 299, line 21, for "of Point" read "off Point."
Page 299, line 8 from bottom, for "undergo is" read "undergoes."
Page 299, line 5 from bottom, for "presents" read "present."
Page 301, line 11 from bottom, for "10".0" read "03".7."
Page 302, line 23, for "56".9" read "50".5."
Page 303, line 8, for "37".4" read "31".0."
Page 303, line 2 from bottom, after "southward" insert "of Point Lobos."
Page 303, line 1 from bottom, for "Point Lobos" read "it."
Page 304, line 12, for "intimated" read "ascertained."
Page 307, line 18, for "straight" read "strait."
Page 316, line 15 from bottom, for "moon" read "noon."
Page 323, line 14, for "$12,000,0000" read "$12,000,000."
Page 325, line 8, for "are formed" read "is found."
Page 327, line 7, for "37 59 39.4" read "37° 59′ 39".4."
Page 327, line 2 from bottom, for "levated" read "elevated."
Page 328, line 21 from bottom, for "31.6""" read "31".6;" for "54.9""" read "54".9."
Page 328, line 11 from bottom, for "islet" read "islets."
Page 329, line 4, for "4½" read "3½."
Page 329, line 19, for "four" read "three."
Page 344, line 16 from bottom, for "Oregon," read "Oregan."
Page 355, line 8 from bottom, for "127° 58′" read "123° 58′."
Page 359, line 12, for "after" read "before."
Page 360, line 10, for "311-315" read "44-48."
Page 362, line 19, for "channel one," read "channel, one —."
Page 363, line 2, for "norhernmost" read "northernmost."
Page 364, between lines 21 and 22, insert—

"The two bars bore from each other SE. by E. and NW. by W., and their distance apart was 2¼ miles, with the seaward extremity of the Middle Bank in line between them.

"The Middle Bank between the north and south channel was about a mile wide, and regular up to the cape, except the off-shoot to connect with Sandy island, which bore E. by S. ½ S. 3⅓ miles from Disappointment, and NW. ¾ N., two miles from Adams. N.NE. from it the Chinook shoal stretched southward within less than a mile.

"The western tail of the great Middle Shoal, eastward of Point Adams, lay NE. $\frac{3}{4}$ N. $1\frac{3}{4}$ mile from that point.

"The channels north and south of this bank had changed very much, but to them we shall not again refer.

"We note the following changes since the survey of 1841 :

"That the south sands, then stretching 6 miles westward from Point Adams, had been cut through at a point half their distance out by a wide channel, with deep water, running S. by W. from Sandy island, but the bar of this channel was not yet fairly cut through, having less than 3 fathoms upon it. This channel was therefore running at right angles to the one of 1841, and over the very spot marked bare in 1839.

"That the north channel retained the same general features, but had moved to the southward ; its southern part cutting away over a mile of the west end of the south sands of 1841. It still had over a fathom more water than the south channell Inside of Cape Disappointment it retained the same general direction as in 1839 and 1841, but was more contracted.

"That the Middle Bank was much changed, but its northern portion similar to that of the two previous surveys. The eastern point had moved N.NW. three-quarters of a mile since 1841. Sandy island had much increased in size, and apparently moved with it.

"That a long sand bank had made out over a mile NW. from Point Adams, and was called the Clatsop spit.

"That the western tail of the great Middle Shoal, eastward of Point Adams, had been cut away three-quarters of a mile.

"SURVEY OF 1852.

"This was the second examination by the United States Coast Survey, founded upon a complete triangulation and the topography of Point Adams, Sandy island, and Cape Disappointment.

"Two channels remained as in 1850. The south had become more defined, having $3\frac{1}{2}$ fathoms across the bar, which was three-quarters of a mile wide, and the general direction of the channel N. $\frac{1}{2}$ W. From Point Adams it bore SW. $\frac{3}{4}$ S., distant $3\frac{1}{4}$ miles, and from Cape Disappointment S.SE , $5\frac{3}{4}$ miles. It was $2\frac{1}{2}$ miles distant from the beach south of Point Adams.

"The north channel was S. $\frac{1}{2}$ W., 3 miles from the cape, and W. $\frac{1}{3}$ S., $4\frac{1}{2}$ miles from Point Adams ; it had $4\frac{1}{2}$ fathoms upon it toward the southern side, and its width was three-quarters of a mile. The midchannel course for $1\frac{1}{2}$ mile was NE. by N , then N. by W. towards the cape, turning to the east half a mile before reaching it, and after a mile on this course running E SE. past the north side of Sandy island ; or, continuing past the cape within a quarter of a mile, then steering E NE. one mile, in from 8 to 5 fathoms, changing to SE. by E. through a 3-fathom channel, past the NE. side of Sandy island. The old Spit bank of 1792 had made out half a mile nearer the cape than then existing, but having a 3-fathom channel across it."

Page 364, line 29, for "bank" read "shoal."
Page 364, line 9 from bottom, for "bank" read "shoal
Page 365, line 6, for "is" read "are."
Page 365, line 11, for "bank" read "shoal."
Page 367, line 18, for "Columbia" read "Columbia's."
Page 370, line 22 from bottom, add "from the south bar."
Page 371, line 12, for "which" read "it."
Page 376, line 14, for "377" read "110."
Page 376, line 18 from bottom, for "is" read "are."
Page 379, line 4 from bottom, insert "110" in the blank.
Page 383, line 4 from bottom, for "ow" read "low ;" for "findl" read "find"
Page 387, line 2, for "refitted their ships here" read "were refitted here."
Page 387, line 30, for "and ———" read "136–148."
Page 389, line 4 from bottom, "for good withholding" read "with good holding."
Page 392, line 3, for "northwest" read "northeast."
Page 396, line 17 from bottom, delete "first."
Page 399, line 16, in blank space insert "distant."
Page 402, line 8 from bottom, for "Cordowa" read "Cordova."
Page 404, line 18 from bottom, for "sweeps" read "sweep."
Page 408, line 24, for "the shore" read "the eastern shore."

LETTER

FROM

THE SECRETARY OF THE TREASURY,

TRANSMITTING

THE REPORT OF THE SUPERINTENDENT OF THE UNITED STATES COAST SURVEY.

TREASURY DEPARTMENT, *December* 19, 1862.

SIR: I have the honor to transmit, for the information of the House of Representatives, a report made to this department by A. D. Bache, LL.D., Superintendent of the United States Coast Survey, stating the operations and progress in that work during the year ending November 1, 1862, and an engraved sketch showing the general progress which has been made in the survey of the Atlantic, Gulf, and Pacific coasts; also, the manuscript map of progress, brought up to the same date, in accordance with the act of Congress approved March 3, 1853.

I have the honor to be, very respectfully,

S. P. CHASE,
Secretary of the Treasury.

Hon. GALUSHA A. GROW,
Speaker of the House of Representatives.

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ABSTRACT OF CONTENTS OF REPORT.

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REPORT.

COAST SURVEY STATION,
Near West Cheshire, Connecticut, November 7, 1862.

SIR: I have the honor to submit my report for the surveying year ending November 1, 1862, as required by law and the regulations of the Treasury Department. With it is an engraved map showing the general progress of the survey, and a manuscript map prepared at the Coast Survey office, in accordance with the act of Congress of March 3, 1853.

The survey has been in progress, in its field or office work, in all the States of our coast—Atlantic, Gulf, and Pacific, though upon the diminished scale required by the diminished appropriations for the fiscal year. The officers and the work have rendered essential service to the fleets and armies of the Union. A brief and general statement of both these classes of operations will be given in the prefatory chapter (Part I) of this report, and a more detailed account in Part II.

The estimates for the next fiscal year, upon the same reduced scale as those of the past year, are contained in Part I.

The experience of the usefulness of the survey in the various war and blockade operations of the coast was hardly needed, to show that it ought to be pushed forward as rapidly as the means of the government will permit, if we would be prepared in those sections where danger may at any moment be imminent. The flows and ebbs of public feeling on that subject during the past year demonstrate the necessity of such preparation.

I have taken the opportunity, presented by the visits of inspection of the chief engineer, General Joseph G. Totten, to inform myself personally, through the kindly official and personal relations between us, of the progress and direction of the plans for defences on the coast, with a view to special reference thereto in the progress of the surveys. I was much gratified to find that as far as we had advanced the progress was in the right direction, though I could not but recognize that the information obtained would enable me in the future to make the connexion even more intimate than in the past, when no such exigencies as are now probable seemed to be among the possibilities of the times. I would be glad to make rapid provision for these exigencies, could adequate means be furnished. Perhaps some opportunity may yet occur to carry out such a purpose. It is certain that accurate maps must form the basis of well-conducted military operations, and that the best time to procure them is not when an attack is impending, or when the army waits, but when there is no hindrance to, or pressure upon, the surveyors. That no coast can be effectively attacked, defended, or blockaded without accurate maps and charts, has been fully proved by the events of the last two years, if, indeed, such a proposition required practical proof. The persons employed upon the various coasts being in the service of the government, their personal experience has been available in the various and complicated duties of pilotage, for lighting, for placing beacons, buoys, &c., in times of exigency, and during the derangement of regular modes of supply and inspection.

The honorable Secretary of the Navy has mentioned in his report the services of the Superintendent of the Coast Survey, as a member of the commission, in reference to plans of blockade, &c., and has since, with your approval, placed him on an important commission for selecting a site for a navy yard for iron clads and iron vessels, in order to lay the foundation of an iron navy. The indispensable usefulness of the Coast Survey results to these two commissions was generously acknowledged by votes of each without dissent. The resolution passed by the second board, transmitted to me by its president, Admiral Stringham, will be found in the Appendix No. 37. The communication from the president of the first board, Admiral DuPont, was given in the Appendix of my last annual report.

It will be observed that though general publications of maps and charts are made, the government has always more advanced and fresher information than other parties, whether domestic or foreign, and that due discretion has guided us in the mode of publication and distribution of new maps and charts and of new information.

The zeal with which the Coast Survey officers have thrown themselves into such service as the government required is truly commendable, and has procured for them the praise of the distinguished army and navy officers under whose immediate direction they have served.

GENERAL STATEMENT OF PROGRESS.

The general sketch of progress (No. 45) shows that the triangulation, primary or secondary, of the Atlantic coast is continuous from our northeastern boundary to south of the line between North and South Carolina, and, with an interval of about sixty miles, from Winyah bay, S. C., to Matanzas inlet, south of St. Augustine, Fla.

This year three triangulation, six topographical, and two hydrographic parties have worked upon the coast of Maine. The triangulation (Sketch No. 2) includes Eastport harbor, and that of the sea-coast is complete from Machias bay to Mount Desert, and from the entrance and approaches of Isle au Haut bay, including Penobscot bay, to Kittery, Me. The topography is about two seasons behind the triangulation, and the hydrography is proportionately advanced. This season's topographical work on the coast of Maine has been in the neighborhood of Eastport, at Frenchman's bay, below Rockland harbor, along the water passages which connect the Sheepscot and the Kennebec, in the upper part of Casco bay, and near Portland, (a reconnaissance for defensive purposes.) The hydrography has been that of the water connexions between the Sheepscot and Kennebec rivers, including also Wiscasset bay, the upper part of Casco bay, including Yarmouth and Freeport rivers, and supplementary work near Portland.

The work on the coast of New Hampshire and Massachusetts (Sketch No. 3) is nearly completed. During the past season a hydrographic party has added to the previous work. The special surveys in Boston harbor have been continued. Two topographical and one hydrographic party have worked on the coast of Rhode Island, one of each class co-operating in the examination by the navy yard commission. The tidal and magnetic observations have been kept up at Eastport, and the tidal observations at Boston. Two triangulation parties, one also making astronomical observations, have been working on the coast of Connecticut (Sketch No. 3) near New Haven, and on the Connecticut river below the head of tide.

Two triangulation, one topographical, and one topographical and hydrographic party have worked on the coast of New York and New Jersey; on Hudson river, (Sketch No. 11,) near Rhinebeck and Poughkeepsie, and above Tivoli; near the western end of Long Island, and on the ocean shore of New Jersey, (verification survey.) Tidal observations have been kept up at Brooklyn, New York. Examinations of hydrographic changes have been made in the Delaware river, near Fort Delaware, and near the mouth of the Schuylkill, in Delaware, New Jersey, and Pennsylvania. Magnetic observations for the secular change of the declination and intensity have been made in New York and Pennsylvania, (Sketch No. 47.) The rate of progress on the coast of Sections I and II, (Maine to Maryland,) has quite equalled the estimates made in my reports for 1857 and 1859. Five parties triangulating and sketching in shore-line and the topography of the banks of the Potomac, (Sketch No. 13,) and co-operating through one chief, have finished the preliminary survey of that river from Blakistone island up to Georgetown. These, while at work, were in part protected by the Potomac flotilla, in part by the army detachments on the banks, and in part worked freely without need of protection. A hydrographic party is still engaged and will complete the soundings of the Potomac below Indian Head. The same party had previously rendered good service in the North Atlantic blockading squadron, in the York, Pamunkey, and Mattaponi rivers. An additional hydrographic party has sounded the Potomac between Alexandria and Georgetown, there being great need for a chart of the river near Washington.

Two topographical parties have mapped the environs of Williamsport, Maryland, for the use of the army; another was for a short period employed in the topography of military defences near Fort Lincoln; one is now engaged in the vicinity of the District line near Bladensburg in plane-table work for military purposes; a survey was made by another of the rebel position and works at Manassas; a fifth party is now engaged in mapping the western approaches of Fort Marcy, in Fairfax county; another party surveyed the north bank of the Rappahannock at Fredericksburg, and sketched the roads leading to the Potomac; and a seventh made reconnaissances and surveys on the Peninsula, between the York and James rivers. These parties worked under the immediate direction of the chief topographical engineers of the armies of the Potomac and Rappahannock.

Two topographical parties with the army of Maryland worked on the eastern shore of Virginia, near Drummondtown and Norfolk, and one of them made a hydrographic resurvey of Metomkin inlet.

There are now (November 7) four topographical parties surveying with the different corps of the army under General McClellan along the line of the Potomac. Observations have been made at the Washington magnetic station, and the tidal observations have been continued at Old Point Comfort, Va.

On the coast of North Carolina (Sketch No. 21) a resurvey was made of Hatteras inlet at the opening of the present surveying year, and it was in part re-examined subsequently, and service in marking by buoys and stakes rendered there, in connexion with the North Atlantic blockading squadron, by a second Coast Survey party. Oregon inlet was completely surveyed by a third party, which also made examination of the tides and currents and of their action upon the site of Fort Hatteras. The same parties, last named, made a reconnaissance of the Neuse river to a point above Newbern, and placed channel stakes and buoys on the middle ground. Service was rendered in the attack upon Roanoke island. As soon as Beaufort, N. C., was taken by our forces, a hydrographic party was sent there and made a resurvey, tracing anew portions of the shore line, and sounding the bar, the entrance, and the interior of the harbor. Some useful observations were communicated to us, by permission of the Navy Department, by one of the officers of the blockading squadron, who had been supplied with instruments from the Coast Survey office. These parts of the coast had been recognized as changeable in our operations of previous years.

On the coast of South Carolina, (Sketch No. 25,) Georgia, and Florida, acting under the immediate direction of the flag officer of the South Atlantic blockading squadron, were four parties, one of which had officers for all the surveying operations and a steam vessel; another for topography and hydrography, and two for topography, which were led by officers of experience upon this part of the coast—co-operating with each other through one chief and under the orders of Flag Officer DuPont. The operations of these parties, which received much commendation, will be given in detail under the head of Section V, only the surveying service being referred to here. Stono inlet and river, and parts of Folly and Kiawah rivers were sounded out, the bar having entirely changed. The banks of those streams were traced and mapped. Part of North Edisto river was resurveyed; part of St. Helena sound, and part of Port Royal sound, including Broad and Beaufort rivers and their tributaries, and also Skull creek and Calibogue sound; part of Tybee Roads, Ga.; part of Wassaw sound; part of St. Simon's sound, and the bar at Fernandina, Fla. Buoys were placed and sailing directions furnished to the flag officer. In connexion with the hydrography, the shore-lines were also traced of parts of John's, James', Cole's, Kiawah, and Folly island; of the inside of Port Royal island, and of parts of Broad river, S. C., and its tributaries. Officers were furnished to reconnoitring expeditions afloat and ashore.

The survey of the Florida reef (Sketch No. 32) was continued by a hydrographic party with a steamer, one triangulation, and one topographical party; and magnetic observations by photography were kept up at Key West.

On the coast, from Mobile entrance to New Orleans, (Alabama, Mississippi, and Louisiana—Sketch No. 35,) a very strong party with a steam vessel lent by the Navy Department, including assistants familiar with the different operations of the survey and with this part of the coast, made reconnaissances; determined the best channels of the mouths of the Mississippi, and buoyed that of the Southwest Pass; gave positions and distances for stationing the mortar boats near Fort Jackson, and other useful services which have been acknowledged by the flag officer of the western Gulf blockading squadron, and by Commodore D. D. Porter, under whose immediate direction they acted. The same party made examinations of localities designated by General Butler, U. S. A. One of the surveying officers was immediately connected, for some time, with Flag Officer Farragut in the Hartford. Two topographical parties were detailed, at the request of General Halleck, and under orders of his aide-de-camp, Colonel R. D. Cutts, Assistant in the Coast Survey, to make military surveys of the ground occupied and commanded by the defensive works erected at St. Louis in 1861. These surveys are nearly completed.

Arrangements are now making for the detail of parties to accompany the expedition of General Banks to the coast of Texas, and Commodore Porter's to the Mississippi.

On the Pacific coast, in Sections X and XI, (Sketches Nos. 37, 38, and 42,) one triangulation party, one triangulation, topographical, and hydrographic, two topographical, one of them a double party, and one hydrographic party, have been employed. The triangulation of San Clemente island (one of the Santa Barbara islands) and of the main between San Pedro and Point Duma, has been completed. The topography of Bodega bay has been completed in connexion with the coast adjacent south to Tomales, and several miles north of Bodega entrance. Soundings for verification have been made in Karquines strait, opposite to Martinez; also at the junction of the strait with the channel to Mare Island navy yard, and off Point Wilson, in San Pablo bay. The hydrography of Bodega bay has been completed, including the roadstead and that of the coast between it and Tomales entrance. Tidal observations have been continued at San Diego and San Francisco, besides those in connexion with the hydrography. The steamer Active has assisted in guarding the navy yard at Mare island in time of emergency.

The hydrography of Koos bay, Oregon, (Sketch No. 43,) has been extended; and the bar and entrance of Gray's harbor, W. T., have been sounded. Tidal observations has been continued at Astoria.

The diminished appropriation for the western coast has required the withdrawal of one of the parties. The steamer Active being much out of repair, a favorable opportunity was taken to dispose of her. She will require to be replaced when a proper opportunity occurs.

OFFICE-WORK.—The regular work of computing, drawing, photographing, lithographing, engraving, and electrotyping has gone on in the office. Many of the charts for the memoirs for distribution to officers of the army and navy connected with coast expeditions have been executed in a preliminary way by lithographing. Some, of which but a few copies were required, have been photographed. Photography, as a mode of reduction of field-work to the publication scale, has become a part of the regular routine of the office.

It will be necessary soon to make some reduction in the number of persons employed in the office; in fact, it has been commenced, but it is hoped that it may not be necessary to extend it much further, as the work requires thorough training to be effectively executed, and it will be difficult to recover our trained computers, engravers, and others, should they once become engaged in other offices.

The titles are here appended of drawings for maps and charts and of the engraved plates worked on during the year which ended on the 1st of November:

Section I.—The drawing for a finished chart and the engraving in a preliminary form of Barnstable harbor have been completed; the engraving of Portland harbor as a finished chart, with additions to the hydrography, has been nearly completed; and a preliminary chart of Mount Hope bay has been drawn and engraved. Progress has been made in the drawing and engraving of coast charts No. 8, Seguin island to Kennebunkport, Me.; No. 9, Cape Neddick to Cape Ann, Mass.; and No. 11, Plymouth to Hyannis, Mass.; and of the chart of Sheepscot and Kennebec rivers, Me. The drawing of general coast charts No. I, Quoddy Head, Me., to Cape Cod, Mass.; No. II, Cape Ann to Gay Head, Mass.; and of coast chart No. 7, Muscongus bay to Portland, Me., has been continued; and the engraving of coast chart No. 7, Muscongus bay to Portland, Me., and the drawing and engraving of No. 10, Cape Ann to Plymouth, have been commenced. Additions have been made to the chart of Salem harbor and to coast charts Nos. 12 and 13, Nantucket sound and Vineyard sound, as also to the progress sketches of the section; and a new progress sketch of the coast of Maine has been drawn and engraved.

Section II.—The engraving in outline of the new edition of coast chart No. 21, New York bay and harbor, has been completed, and the chart issued in a preliminary form; the drawing of the same as a finished chart has been continued. Progress has been made in the drawing and engraving of the Hudson river, (sheet No. 1,) from New York to Haverstraw, and in the drawing of sheet No. 2, Haverstraw to Poughkeepsie; the engraving of the latter has been commenced; and additions have been made to the progress sketch of the section.

Section III.—The engraving of coast chart No. 35, Chesapeake bay, (sheet No. 5,) from Pocomoke sound to York river, has been completed; progress has been made in the engraving of coast chart No. 36, Chesapeake bay, (sheet No. 6,) mouth of York river to entrance of bay; and of Patuxent river, lower sheet, as a finished chart. The drawing of Potomac river chart in four sheets, and the engraving of general coast chart No. IV, Cape May to Currituck sound, and of Potomac river, (sheet No. 3,) from Lower Cedar Point to Indian Head, have been commenced. Additions have been made to coast charts No. 31, head of Chesapeake bay to Magothy river; No. 32, Magothy to the Hudson river, Md.; No. 33, from the Hudson to the Potomac river; and to the progress sketch of the section. The following preliminary charts and maps have been lithographed and issued to meet the immediate wants of the public service, viz: Atlantic coast, from Chesapeake entrance to Ocracoke inlet; Chincoteague bay; Hampton roads; James river, up to City Point, (new edition;) reconnaissance of Pamunkey and Mattaponi rivers; Potomac river, up to Georgetown, in four sheets; road map of District of Columbia; plan of wharves at Alexandria; military reconnaissance map of southeastern Virginia, in nine sheets; and a general map of Virginia, in colors.

Section IV.—The engraving of coast chart No. 37, Atlantic coast, from Cape Henry to Currituck sound, has been commenced; and preliminary charts of Hatteras inlet (resurvey of 1861) and of Beaufort harbor, N. C., (resurvey of 1862,) have been drawn and lithographed.

Section V.—The engraving of Sapelo sound, Ga., Ossabaw sound, Ga., and of St. Simon's sound, Brunswick harbor, and Turtle river, as finished charts, has been completed. The drawing of general coast chart No. VII, Atlantic coast, from Winyah bay, S. C., to St. John's river, Fla.; and that of Calibogue sound and Skull creek, forming the inland passage from Tybee roads to Port Royal sound; and the engraving of Savannah river as a finished chart, have been in progress. Additions have been made to the progress sketch of the section. The following preliminary charts have been drawn and lithographed for immediate use, viz: Sea-coast of South Carolina; sea-coast of Georgia and Florida to St. Augustine; Port Royal entrance, with Beaufort, Broad, and Chechessee rivers; Calibogue sound and Skull creek; Wassaw bar; St. Helena sound; the addition of James island and Stono river to the chart of Charleston harbor; and a chart of Stono inlet, with parts of Stono, Folly, and Kiawah rivers, from the survey of the present year.

Section VI.—The drawing and engraving of the chart of St. Augustine harbor, and the engraving of St. Mary's river and Fernandina harbor, have been completed. Progress has been made in the drawing and engraving of general coast chart No. X, Florida reef, from Key Biscayne to Marquesas keys, and coast chart No. 71, New-found harbor key to Boca Grande; the engraving of coast chart No. 70, Garden key to Lower Matecumbe key, has been commenced; and the annual additions to the progress sketches of the section have been made. A preliminary chart of the vicinity of the Tortugas, Fla., has been lithographed.

Section VII.—A sheet showing the entrance to Santa Rosa bay, and a general chart of the northeastern part of the Gulf of Mexico, in two sheets, have been drawn and lithographed for the use of the blockading squadron. The engraving of the chart of Maria de Galvez bays, Fla., has been completed.

Section VIII.—The engraving of coast chart No. 93, Lakes Borgne and Pontchartrain, has been commenced. Additions have been made on coast chart No. 92, western part of Mississippi sound, and to the progress sketch of the section; and a hydrographic sketch of the southwest pass of the Mississippi has been lithographed. Drawings and photographs have also been made of the approaches to Fort Jackson and Fort St. Philip, below New Orleans, and of a survey of Fort Jackson after the bombardment.

Section IX.—The drawing of coast chart No. 108, Matagorda and Lavaca bays, Texas, and of general chart No. XVI, Gulf coast, from Galveston bay to the Rio Grande, has been continued; progress has been made in the engraving of chart No. 106, Gulf coast, from Galveston bay to Oyster bay, Texas; and the annual additions to the progress sketch of the section have been made. A general chart of the northwestern part of the Gulf of Mexico, in two sheets, has been drawn and lithographed for the use of the blockading squadron.

Section X.—The drawing of Napa creek and Petaluma creek, as finished charts, and the engraving of the same in preliminary form, have been completed; and a preliminary chart of Tomales bay has been drawn and engraved. The engraving of the chart of San Pablo bay is nearly completed, and progress has been made in the drawing and engraving of that of Drake's bay. The drawing of the lower part of San Francisco bay, and of a chart of the Pacific coast from Point Pinos to Bodega Head, has been commenced. Additions have been made to the progress sketches of the section, and to plates of charts previously engraved.

Section XI.—A preliminary chart of Koos bay, Oregon, has been drawn and engraved; and the drawing and engraving of a new edition of the chart of Washington sound, W. T., and the engraving of that of Coquille river entrance, Oregon, have been completed. Additions have been made to the progress sketch and other plates of the section.

COAST SURVEY SERVICE WITH BLOCKADING SQUADRONS AND WITH ARMIES IN THE FIELD.

Though the statements of the use made of the Coast Survey parties in different important military and naval expeditions will be given in the body of my annual report, with the acknowledgments made by their chiefs, it will conform to the general plan of this report to make a brief abstract of them here. The services at Port Royal and in the Lower Mississippi, where the survey gained so much credit, were only a fractional part of those rendered.

Three Coast Survey steamers have been kept at work during nearly the whole season—the Corwin, the Bibb, and the Vixen—being, when not actually employed by the survey, used by the Navy Department. The services of the Vixen, under command of Assistant C. O. Boutelle, were acknowledged by Admiral DuPont in his official report of the action at Port Royal. The familiarity of her commander with that part of the coast made his personal services of the greatest importance.

The Sachem, lent to the Coast Survey by the Navy Department, in place of the Hetzel, was also officered and manned by a surveying party. She accompanied the expedition to the Lower Mississippi, and there rendered services which have been warmly acknowledged by Admiral David D. Porter.

The Corwin, when not engaged in her regular work—as at Hatteras and in the Potomac—was under the orders of Admiral Goldsborough, and performed good service in York river and its tributaries—the Pamunkey and the Mattaponi. Reference to these several localities, in full detail, will be made under the heads of Sections III and IV, Section V and Section VIII, and in the first of these will also be stated the service of topographical parties for military purposes in the State of Virginia. No opportunity has been lost to furnish for the public service officers familiar with the parts of the coast which have been visited by our fleets and military expeditions.

The operations here alluded to have, in general, been executed by the civil assistants, sub-assistants, and aids of the Coast Survey; all the naval officers but one, and all the officers of the army, having been detached from the work and returned to their respective services.

Six of the civil officers of the survey have, under your authority, received furloughs, without pay, to join the volunteer service, and have shown great capacity in their several positions. Another, formerly an officer of the corps of engineers, has been absent from the office temporarily, and is yet under the orders of the chief engineer.

Sixteen officers of the survey, of different grades, have been detailed for service, chiefly topographical, with the army of the Potomac, near Washington, in the Peninsula, and on the Upper Potomac; with the army of the Rappahannock, near Fredericksburg and at Manassas; with the army of Maryland and Virginia, on the Eastern Shore and at Norfolk; and with the army of North Carolina, at Hatteras, Roanoke island, Newbern, and Beaufort, N. C.

The regular work has gone on upon the Florida reef, and parties were at and near Key West, ready to co-operate with the army if active operations had been deemed advisable on the western coast of the Florida peninsula.

The regular work on the Pacific coast has gone steadily forward.

Of seventeen assistants, fourteen sub-assistants, and eighteen aids, serving in the field or afloat, fifteen assistants, eleven sub-assistants, and fifteen aids have devoted the whole or a part of the year to the regular progress of the survey; and eight assistants, ten sub-assistants, and fourteen aids (thirty-two officers) have rendered service in connection with the operations of the army and navy, generally in addition to their regular duties. This last-named service was, of course, not without its special dangers. Sub-Assistant Dorr narrowly escaped when the lamented Wagner and a soldier of Mr. Dorr's plane-table party were mortally wounded in front of Yorktown. The plane-table which Mr. Dorr was using was shattered to pieces. Sub-Assistant Oltmanns was badly wounded in the breast by a Minie ball during the reconnaisance of Pearl river, while attached to the steamer Sachem, which was then under command of Assistant F. H. Gerdes, and serving with the flotilla of Commodore (now Admiral) D. D. Porter.

The bravery of Mr. J. S. Bradford, Mr. C. H. Boyd, and their comrades, of the party of Assistant Boutelle, alone saved them from capture on James island, S. C., and put in their hands several prisoners, who were delivered to the custody of the flag-officer of the squadron.

Of the officers who have thus served, the chiefs of parties—Assistant Charles O. Boutelle, under Admiral DuPont, and Assistant F. H. Gerdes, under Admiral D. D. Porter—have made themselves especially useful, and have won the special commendations of the gallant officers under whom they served. A more satisfactory view of the *p rsonnel* of the service alluded to will be found in the Appendix, (Nos. 28 and 29,) showing the details made during the year when the changes were the greatest, as in the months previous to June, compared with those between June and November.

MAPS AND CHARTS.

In my general reports for 1856, 1857, and 1858, I gave an account of the several series of sheets intended to show the topography and hydrography of the Atlantic and Gulf coast. These were one hundred and thirteen coast or in-shore maps and charts, in forty-two series, on a scale of $\frac{1}{80000}$; sixteen general or off-shore charts, on a scale of $\frac{1}{400000}$; and harbor maps and charts on various scales, from $\frac{1}{5000}$ to $\frac{1}{60000}$. In advance of these was a preliminary series, thirty-three in number, upon a scale of $\frac{1}{200000}$, intended to provide for the publication of the coast hydrography as soon as possible, when the number of sounding parties was at the maximum, and without the addition of the details of topography. Several of these were published in previous years; but of late it has been found more expedient to issue charts on either of the scales, as preliminary, or with only the shore-line, it not being in all cases practicable to continue the hydrography with strict reference to the completion of sheets which might be in progress in the drawing and engraving divisions.

Of the series first mentioned (in-shore maps and charts) twenty-five have been published, representing the most important parts of the coast, and fourteen are yet in the hands of the engravers. The same topography and hydrography, reduced to one-fifth and generalized in details, are used for the general coast charts, four of which are now in progress and advancing towards completion as the material applicable to the localities which they represent comes in.

The whole number of charts which have been engraved upon copper for publication, and which are now in use, is three hundred and eight. This is exclusive of twenty-three copperplates, containing the progress sketches, and thirty-two plates of diagrams. The number of maps, charts, and sketches lithographed in the office, in addition to the engraved ones, is one hundred and twenty-nine.

In the Drawing Division seventy-one sheets have been worked on within the year which ended on the 31st of October. In the classification which has been referred to, ten of these were maps and charts intended to be in full detail, and seventeen others of the same kind, but not connected with the coast series, their scales being various. Ten others are preliminary charts, and twenty maps and sketches for lithographic transfer. Besides twelve of the progress sketches to which additions were made, and two sheets of diagrams, thirty-five of the drawings have been completed and twenty-two are now in hand.

In the Engraving Division six first-class maps and charts have been brought to completion within the year, and supplementary work has been added to four others which had been published. Five second-class charts and sketches have also been engraved, and three diagrams for my last annual report. Twenty-eight plates are now in progress, of which thirteen were commenced within the present year. This gives a total of forty-six plates worked on, the details of eighteen of which were completed. There are, in addition to these, in the division, the plates of seven charts in various degrees of forwardness. Several of them have received all the material which the field-work has as yet furnished, and others, engraved in parts, are about to be joined and put in hand for completion.

In order to supply new maps and charts as rapidly as they were wanted for military and naval use, we, last year, established lithographic rooms in the office for ordinary lithography, engraving on stone, and transfer printing. The demand having greatly increased, all the persons attached to this branch of the office have been very closely employed. Two lithographic presses are yet kept in use. Color printing has been introduced for maps of the seat of war, and has proved very acceptable, the sale of the maps more than reimbursing the cost of their production.

Of the charts printed within the year, which have greatly exceeded in number the issue of previous years, 25,925 have been furnished to the active superintendent of the Hydrographic office of the Navy Department to be distributed to our naval vessels. Two hundred and twenty-three captains and pilots of vessels in government service, who have made application in person at the Coast Survey office, have received in the aggregate 1,863 copies of various charts. It will be seen by the report from the Miscellaneous Division, (Appendix No. 11,) that a total of 44,195 copies has been distributed during the year, of which by far the greater part were for the use of the navy and the army.

In addition to the ten memoirs descriptive of the coast, mentioned in my report of last year as lithographed and bound up with charts, and distributed to officers of the navy and of the army in command of expeditions, two other memoirs have been completed, and copies issued in like manner. Of the twelve which were prepared by the Superintendent and Assistants specially for the use of naval and military commanders, an aggregate of three hundred and eighty-five copies have been furnished since August, 1861, when the first was ready for issue. All the details in regard to the distribution of maps, charts, memoirs of the coast, &c., will be found in the Appendix before referred to.

The following list contains the titles of the maps, charts, and sketches which accompany this report. They are arranged in geographical order, as usual, and marked with numbers corresponding to the numbers in the margin of the list:

1. A.—Progress sketch, Section I, (primary triangulation.)
2. A *bis.*—Progress sketch, Section I, northern part, (secondary triangulation, topography, and hydrography.)
3. A *bis.*—Progress sketch, Section I, southern part, (secondary triangulation, topography and hydrography.)
4. Kennebec and Sheepscot rivers, Maine.
5. Portland harbor, Maine.
6. Barnstable harbor, Massachusetts.

7. Bristol harbor, Narragansett bay, Rhode Island.
8. Newport and Coasters' harbor, Narragansett bay, Rhode Island.
9. Dutch Island harbor, Narragansett bay, Rhode Island.
10. Connecticut river and New Jersey coast triangulation.
11. B.—Progress sketch, Section II.
12. Hudson river, No. 3, Poughkeepsie to Glasco.
13. C.—Progress sketch, Section III.
14. Coast chart No IV, Cape May to Currituck.
15. Chesapeake bay, sheet No. 6.
16. Metomkin inlet, Virginia.
17. Potomac river, No. 1—entrance to Piney Point.
18. Potomac river, No. 2—Piney Point to Lower Cedar Point.
19. Potomac river, No. 3—Lower Cedar Point to Indian Head.
20. Potomac river, No. 4—Indian Head to Georgetown.
21. D.—Progress sketch, Section IV.
22. Oregon inlet, North Carolina, survey of 1862.
23. Hatteras inlet, North Carolina, survey of 1861.
24. Atlantic coast from Nantucket to Cape Hatteras.
25. E.—Progress sketch, Section V.
26. Port Royal entrance, with Beaufort, Broad, and Chechessee rivers, South Carolina.
27. Calibogue sound and Skull creek, South Carolina.
28. Ossabaw sound, Georgia.
29. Sapelo sound, Georgia.
30. St. Simon's sound and Brunswick harbor, Georgia.
31. St. Mary's river and Fernandina harbor, Florida.
32. F *bis*.—Progress sketch, Section VI, Florida keys and reef.
33. St. Augustine harbor, Florida.
34. Coast chart, No. 71, Florida reef from Newfound harbor to Boca Grande key.
35. H.—Progress sketch, Section VIII.
36. Southwest Pass, Mississippi river, 1862.
37. J.—Progress sketch, Section X, Pacific coast from San Diego to San Luis Obispo.
38. J *bis*.—Progress sketch, Section X, Pacific coast from San Luis Obispo to Bodega Head.
39. San Francisco, upper bay, California.
40. Coast from Point Pinos to Bodega Head, California.
41. Bodega bay and roadstead.
42. K.—Progress sketch, Section XI.
43. Koos bay, Oregon.
44. Gray's harbor, Oregon.
45. General progress sketch, Atlantic, Gulf, and Western coast.
46. Cotidal lines in the Gulf of Mexico.
47. Magnetic map of Pennsylvania and part of New York.
48. Diagrams illustrating discussions of magnetic horizontal force observations.
49. Diagrams illustrating experiments in length of standard bar.

NOTE.—Those of the above maps and charts which represent portions of the coast under blockade at the time of publication of this report will not appear.

ESTIMATES FOR THE FISCAL YEAR 1863-'64.

The estimates now submitted are intended to provide for the usual progress on the coast from Passamaquoddy to the capes of Virginia, and the progress which seems most probable from thence to the Rio Grande. They also provide for parties to aid the fleets and armies operating on the coast, in pursuance of the plan which you have fully approved, and which has, under your direction, proved so useful. Flexibility, in a work like this, is a most important feature, and that you have successfully impressed upon it. If I have erred in the estimates, it is in restricting them too much, the safest side upon which to err under the circumstances.

I suppose that one more appropriation, of about the amount now asked, will enable us to complete the survey of the Florida reefs and keys. There is now a gap in the hydrography of this dangerous part of the coast, which I expect to be able to have completed this season. It may require the application of the small appropriation for the triangulation across the peninsula, which cannot be used, under present circumstances, for completing the work for which it was designed, for this purpose. All these matters of detail will be set forth in my annual report.

The estimates include, as usual, separate items for the Atlantic and Gulf coast, Florida reefs, and western coast of the United States, without, however, the facilities formerly extended by the War and Navy Departments by the detail of officers.

ESTIMATES IN DETAIL.

For general expenses of all the sections,* namely, rent, fuel, materials for drawing, engraving, and printing, and ruling forms, binding, transportation of instruments, maps, and charts; for miscellaneous office expenses, and for the purchase of new instruments, books, maps, and charts $19,000

SECTION I. *Coast of Maine, New Hampshire, Massachusetts, and Rhode Island.* FIELD-WORK.—To complete the primary triangulation in this section, and to continue the astronomical and magnetic observations connected with it; to continue the triangulation of *Passamaquoddy bay;* to extend the secondary triangulation over *Machias bay, and eastward;* to complete that of *Penobscot bay* and the *Fox islands,* and to extend it over *Bluehill bay* and up the *Penobscot river;* to continue the topography of *Passamaquoddy bay,* and to complete that of *Eastport harbor, Me.;* to commence that of *Goldsborough harbor, Me.;* to continue that of the approaches to *Penobscot bay,* and to complete that of *Rockland, Rockport, and Camden harbors, Me.;* to continue that of the *Kennebec river to Augusta* and of the *Sheepscot river, Me.,* and of the *passages connecting them;* to complete that of *Cape Cod bay, Mass.;* to continue that of *Bristol Neck, Mount Hope, and Prudence and Connanicut islands and main of Narragansett bay, in R. I. and Mass.;* to continue the in and off shore hydrography of the coast of Maine, including *Passamaquoddy, Muscongus, and Penobscot bays,* and the ledges off the coast; to continue the tidal and magnetic observations at *Eastport and Portland,* and to make tidal observations in connexion with the hydrography. OFFICE-WORK.—To make the computations required by the field-work; to commence the drawing of coast chart No. 6, *Isle au Haut bay to Muscongus bay; Casco bay, Me.; Damariscotta entrance, Me.; Narragansett bay, R. I.;* to continue *Eastport harbor, Me.;* general coast chart No. I, *Quoddy Head, Me., to Cape Cod, Mass.;* coast chart No. 7, *Muscongus bay to Portland, Me.; Rockland harbor, Me.;* coast chart No. 8, *Seguin island to Kennebunkport, Me.;* coast chart No. 9, *Kennebunkport, Me., to Cape Ann, Mass.;* coast chart No. 10, *Ipswich to Green harbor, Mass.;* coast chart No. 14, *Buzzard's bay to Block island sound, R. I.; Bristol harbor and approaches;* to complete *Sheepscot and Kennebec rivers, Me.;* to commence the engraving of *Eastport harbor, Me.;* general coast chart No. I, *Quoddy Head, Me., to Cape Cod, Mass.; Damariscotta entrance, Me.; Rockland harbor, Me.; Bristol harbor and approaches, R. I.; Narragansett bay, R. I.;* to continue *Rockland harbor, Me.;* coast chart No. 7, *Muscongus bay to Portland, Me.;* coast chart No. 8, *Seguin island to Kennebunkport, Me.;* coast chart No. 9, *Kennebunkport, Me., to Cape Ann, Mass.;* coast chart No. 10, *Ipswich to Green harbor, Mass.;* coast chart No. 14, *Buzzard's bay to Block island sound, R. I.;* to complete *Sheepscot and Kennebec rivers, Me.;* and general coast chart No. II, *Cape Ann to Gay Head, Mass.,* will require 61,000

SECTION II. *Coast of Connecticut, New York, New Jersey, Pennsylvania, and part of Delaware.* FIELD-WORK.—To complete the connexion of the bases in sections I and II; to continue the triangulation of the *Connecticut river to Hartford, and of the Thames above New London to Norwich,* and the verification of the triangulation on the sea-coast of *New Jersey,* south and west of *Long Branch;* to continue the topography of the shores of *Connecticut river;* to continue that of the *Hudson;* to commence that of the sea-coast of *New Jersey,* (verification;) to continue the hydrography of the *Hudson river from Coxsackie* northward, and the verifi-

* Viz: of all included in this item, inclusive of Sections I to IX, and exclusive of Section VI.

cations off the coast of *New Jersey;* to make further surveys for changes in the *Delaware* at points important for defence; to continue the tidal observations in the section. OFFICE-WORK.—To make the requisite computations; to commence the drawing of *Hudson river* No. 4, *Hudson to Troy;* coast chart No. 22, *Sandy Hook to Jones river bay, N. J.;* to continue *Hudson river* No. 2, *Haverstraw to Poughkeepsie;* to complete *Hudson river* No. 3, *Poughkeepsie to Hudson; Hudson river* No. 1, *entrance to Haverstraw;* coast chart No. 21, *New York bay and harbor;* coast chart No. 25, *Delaware bay and river,* (new survey;) to commence the engraving of *Hudson river* No. 3, *Poughkeepsie to Hudson;* to continue that of coast chart No. 21, *New York bay and harbor; Hudson river* No. 2, *Haverstraw to Poughkeepsie;* to complete *Hudson river* No. 1, *entrance to Haverstraw;* and coast chart No. 25, *Delaware bay and river,* (new survey,) will require.......................... $17, 500

SECTION III. *Coast of part of Delaware and that of Maryland, and part of Virginia.* FIELD-WORK.—To continue the astronomical and magnetic observations required in the section; to examine and preserve the more important triangulation stations; to continue, if practicable, the topography of the shores of the *Potomac;* to complete the surveys of the *District of Columbia and approaches,* and, if practicable, of *James river* and the lower part of *Chesapeake bay;* and to continue the off-shore hydrography of the section; to continue the topography of the *Eastern shore of Maryland and Virginia and of the Rappahannock.* OFFICE-WORK.—To make the reductions and computations required; to continue the drawing of coast chart No. 30, *Chincoteague inlet to Great Machipongo inlet, Va.;* general coast chart No. IV, *Cape May to Currituck, Va.;* to complete *Potomac river* No. 1, *entrance to Piney Point; Potomac river* No. 2, *Piney Point to Lower Cedar Point; Potomac river* No. 3, *Lower Cedar Point to Indian Head;* and *Potomac river* No. 4, *Indian Head to Chain bridge;* to commence the engraving of coast chart No. 30 *bis,* between *Great Machipongo inlet and Cape Henry;* to continue general coast chart No. IV, *Cape May to Currituck, Va.;* to complete *Potomac river* No. 1, *entrance to Piney Point; Potomac river* No. 2, *Piney Point to Lower Cedar Point; Potomac river* No. 3, *Lower Cedar Point to Indian Head;* and *Potomac river* No. 4, *Indian Head to Chain bridge,* will require........... 13, 500

SECTION IV. *Coast of part of Virginia and of part of North Carolina.* FIELD-WORK.—To complete, if practicable, the primary triangulation of *Pamplico sound,* and the secondary triangulation connected with it; to make the necessary magnetic observations; to commence the triangulation of the *Neuse and of the Pamplico rivers;* to complete the topography of the outer shore of *North Carolina* south of *Hatteras to Core sound;* to continue the in and off shore work of the sea-coast of *North Carolina,* and of the sounds, and the observations of tides and currents, and of the *Gulf stream.* OFFICE-WORK.—To make computations from field data; to commence the drawing of coast chart No. 44, *Cape Hatteras to Ocracoke inlet, N. C.;* to continue coast chart No. 46, *Cape Lookout to Bogue inlet, N. C.;* to complete *Oregon inlet, N. C.;* to continue the engraving of coast chart No. 37, *Cape Henry to Currituck sound, N. C.;* and complete *Oregon inlet, N. C.,* and *Beaufort harbor, N. C.,* (resurvey,) will require.. 15, 000

SECTION V. *Coast of part of North Carolina, and that of South Carolina and Georgia.* FIELD-WORK.—To execute such work of triangulation, topography, and hydrography as may be practicable in the section, filling up the places not yet embraced in the surveys. OFFICE-WORK.—To continue the computations from field records; to commence the drawing of *Wassaw sound, Ga.; Doboy sound, Ga.; St. Catharine's sound, Ga.;* coast chart No. 57, *Sapelo sound to St. Andrew's sound, Ga.;* to continue coast chart No. 53, between *Stono inlet and Fripp's inlet, S. C.;* coast chart No. 54, *Fripp's inlet, S. C., to Ossabaw sound, Ga.;* general coast chart No. VII, *Winyah bay, S. C., to St. John's river, Fla.;* to complete *Savannah river, Ga.,* (additions;) *Port Royal sound, Beaufort and Broad rivers, S. C.;* and the chart of *Skull creek and Calibogue sound, S. C.;* to commence the engraving of *Wassaw sound, Ga.; Doboy sound, Ga.; St. Catharine's sound, Ga.;* and coast chart No. 53, between *Stono inlet and Fripp's inlet, S. C.;* coast chart No. 54, *Fripp's inlet, S. C., to Ossabaw sound, Ga.;* to complete *Savannah river, Ga.,* (additions;) *Port Royal sound, Beaufort and Broad rivers, S. C.;* and the chart of *Skull creek and Calibogue sound, S. C.,* will require.. 16, 000

SECTION VI. *Coast, keys, and reefs of Florida.*—(See estimates of appropriations for those special objects.)

SECTIONS VII, VIII, and IX. *Part of the western coast of Florida, northern coast of Florida, coasts of Alabama, Mississippi, Louisiana, and Texas.* To continue such portions of triangulation, topography, and in and off shore hydrography, as may be practicable in filling up the portions unsurveyed of these coasts, (contemplates the employment of one steamer and two sailing vessels.) OFFICE-WORK.—To make computations; to continue the drawing of coast chart No. 84, *Ocilla river to Crooked river, Fla.;* coast chart No. 88, *Choctawhatchee bay to Pensacola bay, Fla.;* general coast chart No. XIII, *Waccasassa river to Choctawhatchee river, Fla.;* general coast chart No. XIV, *Choctawhatchee river to the Mississippi delta, La.;* coast chart No. 93, *Lake Borgne to Lake Pontchartrain, La.;* coast chart No. 96, *Delta of the Mississippi, La.;* coast chart No. 100, *Point au Fer to Marsh island, La.;* to commence coast chart No. 110, *Aransas bay to Corpus Christi bay, Texas;* to continue general coast chart No. XVI, *Galveston to the Rio Grande, Texas.* To commence the engraving of coast chart No. 84, *Ocilla river to Crooked river, Fla.;* coast chart No. 85, *St. George's sound,* (eastern part;) to continue coast chart No. 81, *Chassahowitzka river to Cedar Keys, Fla.;* to commence general coast chart No. XIV, *Choctawatchee river to the Mississippi delta, La.;* to continue coast chart No. 93, *Lake Borgne and Lake Pontchartrain, La.,* will require $36,000

Total for the Atlantic coast and Gulf of Mexico 178,000

The estimates for the Florida coast, keys, and reefs, and for the western coast of the United States, are intended to provide for the following progress:

SECTION VI. *Coast, keys, and reefs of Florida.* FIELD-WORK.—To continue, if practicable, the surveys of the eastern coast of the peninsula from the present limits; to complete the triangulation and topography of the southern keys and coast of the peninsula from *Card's sound* to the work at *Cape Sable;* to complete the hydrography of the reefs, by connecting the work at *Key Rodriguez and Upper Matacumbe,* and to run off-shore lines from the reef and coast of the section; to continue the magnetic observations at *Key West.* OFFICE-WORK.—To compute results from field records; to commence the drawing of *Charlotte harbor, Fla.;* to continue general coast chart No. X, *Florida reefs and keys, Key Biscayne to Marquesas key;* coast chart No. 70, *Long key to Big Pine key, Fla.;* coast chart No. 69, *Garden key to Lower Matacumbe key.* To commence the engraving of *Charlotte harbor, Fla.;* to continue general coast chart No. X, *Florida reefs and keys, Key Biscayne to Marquesas key;* coast chart No. 70, *Long key to Big Pine key, Fla.;* coast chart No. 69, *Garden key to Lower Matacumbe key,* will require $11,000

SECTION X. *Coast of California.* FIELD-WORK.—To continue the triangulation from the *Santa Barbara base* northward and westward towards *Point Conception,* and to complete that of the islands off *Santa Barbara channel;* to continue the triangulation from *Bodega* northward; to continue the topography in connexion with the *Santa Barbara and San Francisco* triangulations; and to extend that north from *Bodega.* To continue the hydrography off and in shore from *Point Bolsena to Point Piedras* between *Monterey* and *San Francisco bays;* to execute verification work off *Point Wilson in San Pablo bay,* for changes; lines of approach northward and westward from *Point Reyes, Drake's bay,* approaches to *Crescent City harbor* from westward, southward, and southwestward; to continue the tidal observations at *San Diego and San Francisco.* OFFICE-WORK.—To continue the computations and reductions of the field-work; to commence the drawing of general coast chart from *San Diego to Point Conception;* soundings off *Humboldt bay, Cal.;* to complete topography of *Tomales bay, Cal.;* sea-coast chart from *Bodega Head to Point Pinos,* including the bay of *San Francisco,* $\frac{1}{200000}$; and *San Francisco bay, lower part;* to commence the engraving of general coast chart from *San Diego to Point Conception;* to continue *San Francisco bay, lower part;* sea-coast chart from *Bodega Head to Point Pinos,* including the bay of *San Francisco,* $\frac{1}{200000}$; to complete topography on that of *Tomales bay, Cal.*

Also for the operations in—

SECTION XI. *Coast of Oregon and Washington Territory.* FIELD-WORK.—To complete the topography and hydrography of *Gray's harbor, Washington Territory;* to extend the topography and hydrography up *Admiralty inlet;* to continue the tidal observations required in the section. OFFICE-WORK.—To compute results; to commence the drawing of *San Juan island; Gray's harbor, W. T.;* soundings off *Cape Blanco, Oregon;* soundings off *Port Orford, Oregon; Admiralty inlet and Puget's sound;* to continue *Washington sound, W. T.;* to complete topography on that of *Koos bay, Oregon.* To commence the engraving of *Gray's harbor, W. T.; Admiralty inlet and Puget's sound;* to continue *Washington sound, W. T.;* and to complete topography on that of *Koos bay, Oregon,* will require.. $100,000

The other items of appropriation asked for are small; the items for the line across the Florida peninsula, and for fuel and quarters of army officers are omitted; that for the pay of engineers, according to the reduced scale of four steamers, is reinserted.

Those items are:

For publishing the observations made in the progress of the survey of the coast of the United States, by act of March 3, 1843 4,000

For repairs of steamers and sailing schooners used in the survey, by act of March 2, 1853..... 4,000

Both these items are less than those appropriated for the same objects last year.

For pay and rations of engineers for four steamers to be used in the hydrography of the Coast Survey, and no longer supplied by the Navy Department 9,000

The amounts thus estimated for the fiscal year 1863–'64, and the appropriations for the present year and 1861–'62, are given in parallel columns.

Object.	Estimates for fiscal year 1863–'64.	Estimated for fiscal year 1862–'63.	Appropriated for fiscal year 1861–'62.
For survey of the Atlantic and Gulf coasts of the United States, including compensation of civilians engaged in the work, per act of March 3, 1843	$178,000	$178,000	$230,000
For continuing the survey of the western coast of the United States, including compensation of civilians engaged in the work, per act of September 30, 1850	100,000	100,000	110,000
For continuing the survey of the Florida reefs and keys, including compensation of civilians engaged in the work, per act of March 3, 1849	11,000	11,000	25,000
For completing the line to connect the triangulation on the Atlantic coast with that on the Gulf of Mexico, across the Florida peninsula, including compensation of civilians engaged in the work, per act of March 3, 1843	....	....	5,000
For publishing the observations made in the progress of the survey of the coast of the United States, including compensation of civilians engaged in the work, per act of March 3, 1843	4,000	5,000	5,000
For repairs of steamers and sailing schooners used in the survey, per act of March 2, 1853	4,000	5,000	10,000
For fuel and quarters, and for mileage or transportation, for officers or enlisted soldiers of the army serving in the Coast Survey, in cases no longer provided for by the quartermaster's department, per act of August 31, 1852	....	....	*5,000
For pay and rations of engineers for seven steamers used in the hydrography of the Coast Survey, no longer supplied by the Navy Department	†9,000	....	†12,800
Total	306,000	299,000	402,800

* Formerly included in estimates of War Department.
† Formerly included in estimates of Navy Department.

The amount of these estimates is but about six per cent. more than half those of 1861–'62, as shown by the comparative table. All the items are either the same as, or less than, those appropriated last year, except the one for the pay of engineers for the steam vessels, which was omitted last year, as there was a sufficient surplus, from the reduction of the previous year in the number of steamers, to last until the close of the year 1862–'63.

DEVELOPMENTS AND DISCOVERIES.

The general list of developments and discoveries, containing the items arranged in geographical order, is given in Appendix No. 4. Those connected with the work of the present year are here appended, and will hereafter take their places in the general list.

The difficulty of finding rocks, of which we have had so many instances, cannot be better illustrated than by the fact that two should have been discovered in and near the entrance of so well surveyed and so well known a harbor as that of Newport. The particulars in regard to position, &c., of these, which stand first in the appended list, are stated in Appendix No. 6.

For the notice given in Appendix No. 7, in reference to a shoal spot supposed to exist to the eastward of the Winter Quarter shoal, (coast of Maryland,) I am indebted to G. W. Blunt, esq., of New York city.

1. Two rocks discovered in the approaches to Newport harbor, R. I; one with fourteen and a quarter feet of water on it at mean low tide, the other with seventeen feet at mean low water. Ten other rocks in the vicinity (previously known) were determined in position.

2. The shifting of the bar of Metomkin inlet, Va., and changes of shore-line, but without alteration of depth on the bar.

3. Determination, by close soundings, of the best line of water for crossing the Kettlebottom shoals, Potomac river, there being no well defined channel over the shoals.

4. Changes in depth and outline at Oregon inlet, N. C.

5. Special examination of the tides and currents, with reference to the hydrographic and shore-line changes at Hatteras inlet, N. C.

6. Development of the alteration in outline and depth at the entrance of Beaufort harbor, N. C.

7. Re-examination, by soundings, of the Rattlesnake shoal, coast of South Carolina.

8. Stono entrance, S. C., sounded, and channel found half a mile to westward of its former position, with slight increase of depth.

9. The shoaling of North Edisto entrance from its former depth, giving now only nine feet of water.

10. St. Helena entrance, S. C., examined, and a new channel from the eastward found, giving sixteen feet at mean low water.

11. The south channel of Port Royal sound developed, and nineteen and a half feet found to be the least depth in it.

12. The channel of the inland passage thoroughly sounded, leading from Port Royal sound into Tybee roads, through Skull creek and Calibogue sound.

13. The bar and entrance of St. Simon's sound, Ga., examined, showing no material change of depth within the past two years.

14. The shifting to southward, and shoaling by several feet, of the channel into Fernandina harbor, Fla., having now only eleven feet at mean low water.

15. The further encroachment of the sand spit at the confluence of Karquines and Mare Island straits, upon the channels which branch towards the navy yard and Benicia.

SPECIAL SURVEYS.

The maps and charts for the United States commissioners on the harbor of Boston, called for by the city in the study of means for the preservation of the harbor, have made good progress in Mr. Boschke's hands, and it is expected will be finished soon after the opening of the new year.

Special surveys of the shore-line of Prudence Island, of Taylor's cove, Connanicut, Dyer's Island harbor, and of Dutch Island harbor, in Narragansett bay, were promptly made for the navy yard commission by Assistants A. M. Harrison and Henry Mitchell and their parties, and the maps needed for the use of the commission were rapidly drawn and furnished. A special survey, also, of Coasters' Harbor island and of the adjacent shore was made by Assistant Henry L. Whiting, and the drawing promptly returned. This is on a large scale, and upon it the study of the suitableness of the island as a site for the Naval Academy may readily be made. Mention of these surveys will be found under the head of Section I.

The levellings required by the navy yard commission at League island, and Red Bank, opposite to it, in New Jersey, were made by Assistant George Davidson, and notice of his work in that vicinity will be given under Section II.

One of the naval officers, who has in former years served acceptably in the work of the Coast Survey—Lieut. Commander D. L. Braine, U. S. N.—addressed me, last summer, offering, if means were supplied from the office, to determine the condition and capacity of the western channel at the Cape Fear entrance. This was to be incidental to his duties in command of the U. S. steamer Monticello, then, as now, in service on the blockade of the coast of North Carolina. After consulting the Navy Department, the instruments and projection needed were furnished, and the promise of Lieut. Commander Braine as promptly fulfilled. In the channel over the bar of the western entrance he found some improvement in depth. This channel had but nine feet at mean low water in 1856. In reference to the examination which he made in September of the present year, Lieut. Commander Braine states that he "is led to believe that there is a depth of fifteen feet at high water, which would give in the channel ten and a half feet at mean low water."

This survey was, of course, made under many disadvantages, and will be further pushed by the commander of the Monticello as opportunity occurs. Its difficulty and danger are apparent from the fact that the soundings were made at night, and almost immediately under the guns of the enemy's batteries. In allusion to this, it is remarked in the report that "the sentry's hail on his post could be distinctly heard on the deck of the Monticello."

On hearing of the raid into Pennsylvania, in October last, I volunteered the services of Coast Survey officers (the Secretary of the Treasury approving) for any military reconnaissances which might be desired, and for making the maps which I thought might be desirable. The presence of Assistant George Davidson near the city of Philadelphia would have rendered immediate service practicable. This offer was communicated to the committee of councils on defence by the mayor, Alexander Henry, esq.

TIDE TABLES FOR MARINERS—TIDES AND CURRENTS.

An edition of the tide tables, revised by Assistant L. F. Pourtales, is printed in Appendix No. 8. In it a few errors which had heretofore escaped detection have been corrected.

The tidal stations, with two exceptions on the Atlantic coast, and all those upon the Western coast, have been kept up; but it has been necessary to abandon, for the present, those on the Gulf of Mexico. The self-registering gauge left by Mr. Donegan at New Orleans, in the summer of 1861, has been recovered; that at Fernandina, Fla., is believed to have been destroyed by the rebels. The one which was formerly used near Pensacola was, in all probability, destroyed by the burning of the navy yard. Nothing has yet been heard of the self-registering gauge which was on board of the schooner Twilight at the time of her seizure at Aransas.

TABLE OF DEPTHS.

The table containing a statement of the depth of water at the entrances of all the considerable harbors and inlets of the United States, which was published in my annual report for 1859, has been revised in the Hydrographic Division of the office, and will be found in Appendix No. 5. The table contains several entries which were not given at the previous date.

INFORMATION FURNISHED.

The information furnished under authority of the Treasury Department during the past year is stated in the form of a list, in Appendix No. 2, to which are also added the tracings from the orginal sheets needed by the military and naval officers in command of expeditions. The list does not contain a large amount of information communicated for their use by other modes, as the compilation of geographical data for parts of the coast not regularly surveyed, and the preparation and distribution of special notes and photographs of special surveys.

Great care has been taken to discriminate in regard to the applications for tracings, &c., for the purposes of civil life.

STATISTICS.

The table of statistics has been added to, so as to bring it up to the present surveying year, and is given in Appendix No. 3.

Up to 1861, inclusive, the triangulation had embraced an area of nearly fifty-four thousand two hundred square miles, within an area of nearly sixty-two thousand square miles covered by reconnaissance; and had developed a general extent of coast of over four thousand five hundred miles, and a shore-line of about twenty-three thousand miles, determining nine thousand four hundred and fifty-two geographical positions.

For longitude determinations, eighty-five stations had been occupied; for latitude, one hundred and twenty-seven, and for azimuth, eighty-four stations.

The topography had extended over an area of nearly seventeen thousand square miles, having a general coast line of four thousand miles, and over forty-two thousand two hundred miles of shore-line, measuring the indentations.

The hydrography extended over an area estimated at forty-six thousand square miles, in which one hundred and ninety-six thousand miles were run in sounding; six million three hundred and ninety-eight thousand soundings were made, and over eight thousand four hundred specimens of the bottom obtained.

The number of manuscript maps and charts constructed was two thousand one hundred and eighty-one, and of engraved maps, charts, and sketches there had been produced four hundred and ninety-three plates.

DISTRIBUTION OF ANNUAL REPORTS AND MAPS.

It has been judged expedient during the past year to hold still in abeyance the usual foreign distribution of the printed annual reports through the Smithsonian Institution, as was done during the year which ended with October, 1861, as was stated in my last annual report.

During the past year 4,028 copies of reports of various years have been distributed to institutions and individuals in the loyal States of the Union, leaving on hand a limited number of copies for the years from 1851 to 1860, inclusive. Of those remaining on the 1st of November there were of the report for 1851 two hundred and twenty copies; of that for 1855, four hundred and twenty copies, and of that for 1857, three hundred and twenty-eight copies left. Of the dates 1853, 1856, 1859, and 1860, the copies disposable for general distribution is larger. This decidedly unequal number of copies of the reports of various back years makes it necessary to discriminate carefully in their issue. It is also to be remembered that for the years 1859 and 1860 no copies have been sent to the States which now disavow their allegiance to the government of the Union, but which will at some future day feel interested, in common with the others, in the information which they embody. To provide for the best issue of these remaining reports (1851 to 1860) a circular has been sent to the principal libraries in the more important cities of the north, and to those of universities, colleges, and other institutions, to ascertain what reports may be needed in order to complete their series, so that entire sets may in future be within reach for purposes of reference in all the States to which they are now sent.

As already stated under the head of maps and charts, upwards of forty-four thousand copies of printed maps, charts, and sketches have been sent from the office since the date of my last report—a number more than double the distribution in the year 1861, and upwards of five times the average annual distribution of former years. This large and increasing issue of charts within the past two years has been due to the constant demands of the Navy and War Departments, every effort to supply which still continues to be made.

Besides the printing of charts by the transfer process, the production of the hydrographic memoirs of the coast with facility offers further proof of the advantage of establishing a lithographic division at the office, though induced as it was by the emergency of last year for copies of charts. The course taken in the preparation of the hydrographic notes was mentioned in my report of last year, and has also been alluded to in this, under the head of maps and charts. The testimonials from the different commanding officers as to their value have been numerous and emphatic.

A summary of the details of distribution of the annual reports, maps, charts, &c., is contained in the report from the miscellaneous division of the office, Appendix No. 11.

RECORDS AND RESULTS.

I call attention again to the fact that this publication is postponed for more auspicious times, as I have repeated applications for copies. The present appropriation merely enables us to prepare the materials for publication, but not to publish.

LONGITUDES.

The history of the determination of longitudes in connexion with the survey of the coast, from the law and plan of reorganization of 1844 to 1858, was given in my report for 1858, including the methods by astronomical observations, by the transportation of chronometers, and by the electrical telegraph. The problem of longitudes by occultations of the Pleiades is described in the appendix of my report for 1856. Professor Peirce has been engaged since 1854 in stimulating observers to a new series of observations, by preparing predictions and charts of the occultations, as explained in my report for the year 1858. These observations were collected during the period from 1857 to 1861, or until the moon's path ceased to pass among those stars. While this new series of observations was in progress with modern instruments and methods, Professor Peirce was occupied in recomputing the older series, for the period 1838 to 1842, by the aid of the new lunar tables. The results are given in his report, which was printed as Appendix No. 17 in my report of last year. "The conformity of the observations with theory is quite remarkable, and shows that this, the most delicate of all the observations of the moon, demands and justifies the utmost precision of calculation. The final determination of the longitude will, undoubtedly, surpass all others in precision."

Some of the particulars of this interesting series of results are stated in the professor's report, Appendix No. 12. Certain of the occultations which were observed both in Europe and America will serve to determine the errors of the tables, and hence to compute with suitable corrections those which were observed only in America, and to obtain a second determination of the longitude. Professor Peirce remarks that "the various observations will also serve the subsidiary purpose of determining the relative longitudes of the different places which are upon the same continent either of Europe or America, and also to correct the places of the stars, and, finally, to determine the value of the lunar semi-diameter, and the necessity of having regard to the protuberances of the moon in the complete solution of the problem."

Professor Peirce has addressed to me a special letter in relation to the tables of the moon used in the reduction of the observations of the Pleiades, (Appendix No. 13.) The Professor gives his reasons for using Hansen's tables in the computations, and, referring to the "full and generous" statements of Mr. Lubbock, in the thirtieth volume of the Memoirs of the Royal Astronomical Society, in praise of the American tables prepared by Professor Peirce for the Nautical Almanac under the direction of Captain Davis, U. S. N., corrects some historical statements in reference to the labors of mathematicians who have been occupied with the important task of improving the lunar tables.

The observations made by telegraph for the difference of longitude between Macon, Ga., and Eufaula, Ala., in the working season of 1859–'60, have been discussed by Dr. B. A. Gould. He reports that the difference in time between the astronomical stations is, Eufaula 6*m.* 3.02*s.* west of Macon; which result, he adds, cannot be erroneous by more than five-hundredths of a second of time.

The detailed report on the results of the observations made in Georgia and Alabama is in course of preparation. I have placed in the Appendix No. 14 Dr. Gould's report on the progress which has been made in computing the results for all the stations between Calais and New Orleans.

MAGNETISM.

The publication of the results of a discussion of the Girard College observations, from the Smithsonian Contributions to Knowledge, commenced in my reports of 1859 and 1860, is continued in this, embracing the discussion of the observations of horizontal magnetic force. The difficulty which stands at the threshold of the discussion of these observations is the correction for temperature, the magnetic bars changing in their own intensity of force with changes of temperature. The attempts to obtain the value of this correction are fully stated, and their application is shown and verified in various ways, in Part IV of the memoir, (Appendix No. 15.) Tables of the results, reduced to a standard temperature of 63° Fahrenheit, are then obtained, and corrected for the progressive change in the readings of the magnets. The observations are next separated into regular and disturbed readings by the aid of Peirce's criterion, and the disturbances being taken out, there remain the normal results for the hour, day, and year. These show the same period of ten or eleven years in number and extent of disturbances which was deduced from the declination observations, corresponding with the period of change in the solar spots. The results agree very well with those obtained at Toronto, Canada. The curves of daily change of horizontal force come out very perfectly in each year's result, the curves showing two maxima and two minima in the course of the day, and the day changes being much more considerable than those of the night.

The next part of the memoir, Part V, (Appendix No. 16,) contains the investigation of the diurnal and annual variations of the horizontal magnetic force, from the means of the results for the five years of observation. The normal value of the horizontal intensity for the several hours of the day and months of the year of the five years is deduced, applying all the required corrections. The summer and winter results are compared in formulæ, and by curves, with the mean for the whole year. At 6 a. m. there is scarcely any change of horizontal force throughout the year, and at 11½ a. m. it is also nearly constant. Two other points of the same sort occur at 7½ p. m. and at 11 p. m.

From this discussion results a series of curves (Sketch No. 48) which show the horizontal force at every hour of the day of every month of the year. These correspond to the curves of declination referred to in my report of 1860. Both have been beautifully represented, by modelling, by Mr. F. Engel, of the Coast Survey office.

Part VI of the memoir (Appendix No. 17) shows the influence of the moon on the magnetic horizontal force. The magnetic tide, so to speak, has two ebbs and flows in the lunar day. The times of maxima are two hours, and of the minima seven and a half hours after the culminations. The influence of the relative positions of the sun and moon on the horizontal magnetic force, though small, is distinctly perceptible, and the same is true of the moon's declination changes. When the moon is nearest the earth the horizontal magnetic force is decidedly lessened, and when at the greatest distance from the earth is increased.

At Eastport, Me., the magnetic observations intended chiefly to furnish results bearing on the study of the secular change have been continued. Besides the change of the three magnetic components, these observations will also give the means of tracing the connexion of the diurnal range of the declination with the relative frequency of solar spots, and furnish, in addition, standard annual means for the general discussion of magnetic observations which have been made along the entire northeastern coast of the United States.

At Key West the observations, both differential and absolute, have been continued, and the former now present an unbroken series of daily records. The photographic records of the three elements are revised regularly at the office, and have been tabulated with a view to their general discussion in a form somewhat similar to that used in the treatment of the Girard College series, of which mention has been already made. Though strictly scientific in character, these investigations will give ready means for tracing the secular changes that are now going on in the eastern part of the Gulf of Mexico.

In the years 1840 and 1841 I made a detailed magnetic survey of the State of Pennsylvania and of adjacent parts of New York, Ohio, and Maryland, to which other observations were added in 1843, while on a tour through Western New York, Canada, New Jersey, and Pennsylvania. These observations have recently been worked up and prepared for the press, having been made with the best instruments then available. An abstract of the discussion of them is given in Appendix No. 19. The declination was determined at sixteen stations, and the dip and intensity at forty-eight.

In July and August, 1862, six of the stations in my series were reoccupied by Assistant Charles A. Schott, (Appendix No. 18.) The expense incurred for the three which fell outside of the limits of Coast Survey operations was defrayed by the Smithsonian Institution, and this co-operation has added greatly to the expected value of the results. This is believed to be one of the earliest systematic surveys, that includes the three magnetic elements, as yet made in any of the States. Its object is intimately connected with an important part of the operations of the Coast Survey. In Appendix No. 19 I give an abstract of the individual results, as well as a general account of the discussion and of the expressions deduced for the distribution of magnetism over the area surveyed. The subject is further illustrated by Sketch No. 47, which shows the isomagnetic curves for the epochs 1842 and 1862.

The regular biennial publication of results found for the magnetic declination, dip, and intensity, at stations which have been occupied by Coast Survey parties within the last two years, is contained in Appendix No. 20. This comprises twenty-two stations, numbered in continuation of those given in Appendix No. 28 of my annual report for 1860.

SOLAR SPOTS.

The record of solar spots which was kept at the Coast Survey office by Assistant Schott with considerable regularity until the close of the year 1861 has since been only partially kept up, in consequence of the pressure of routine duties. Appendix No. 21 gives a continuation of the records which were published in 1860 and 1861 as Appendix No. 25 in my reports for those years. European observations, made regularly and published every year, will supply the place of the omitted records in the discussion of magnetic observations.

EARTHQUAKE WAVES.

The renewed interest awakened on this subject by the presence in our country of Captain Lessoffsky, of the Russian navy, who was in command of the flag-ship Diana, Admiral Pontiatine, wrecked by the effects of the earthquake of December 23, 1854, in the harbor of Simoda, Japan, has called my attention to errors, some of them typographical, in the printing of my paper on earthquake waves, and the depth of the ocean as deduced therefrom, in the Coast Survey report for 1855. As the best mode of correction, I have included the paper for reprint with the appendix matter of this report. It will be found in the Appendix, No. 24.

FLORIDA REEF.

Captain E. B. Hunt, of the corps of engineers, has contributed for this report an interesting paper on the origin, growth, substructure, and chronology of the Florida reef, which will be found in the Appendix, No. 25. Its conclusions will meet with examination and criticism from those who have been occupied in these and similar studies. The practical part referring to soundings, currents, winds, &c., is of decided interest to navigators.

HEIGHTS.

The collection of data, from all available sources, for heights over the continent of North America has been continued during the past year; and the preparation of a map to form a basis for the projection of contour lines has been carried on as far as the time of the Assistant charged with this subject would allow from other pressing calls.

This collection of heights has been placed at the disposal of the chief topographical engineer of the army of Washington.

EXPERIMENTAL INQUIRIES.

The experiments for determining the length and expansion by heat of the standard bar, referred to in my report for 1860 as being in progress, were completed early in 1861, under the direction of Assistant J. E. Hilgard, by Mr. W. L. Nicholson, aided by Mr. J. R. Gilliss and Mr. Thomas McDonnell; but, owing to the pressure of business in the office, a complete discussion of results was not made until the present year. An abstract of the experiments and results is given in Appendix No. 26, from which it will appear that complete success has attended these delicate operations.

A special mode of construction of the axle of the magnetic dipping-needle, admitting of its being turned in its arbor, in order that observations may be made with the needle resting upon different parts of the pivots, has been devised and put in practice by Assistant Hilgard. A description of the new arrangement and an abstract of experiments are given in Appendix No. 23.

In my last report a comparison of the relative change by atmospheric moisture in the dimensions of maps drawn on "parchment" paper and on drawing paper backed with muslin was stated to have resulted in favor of the latter. Specimens of an improved quality of parchment paper having been submitted, similar comparisons were again made, but with a like result, as will be seen by reference to Appendix No. 27.

AIDS TO NAVIGATION.

The lists which have appeared in my previous annual reports, giving the recommendations of the Assistants of the Coast Survey for aids to navigation in special localities in which the need for them was open to observation, are this year almost entirely represented by one, (Appendix No. 36,) showing the number of buoys set by the working parties at the port and harbor entrances of the southern States for the use of the blockading squadrons. All of the sailing marks seem to have been taken up and destroyed or secreted early in 1861. In some cases the buoys belonging to a channel were found at the nearest town, but in other instances new ones were required. They were all replaced with reference to the hydrographic changes which have occurred since they were first put in place.

DIRECTORY OF THE PACIFIC COAST.

I have availed myself of the convenient access which Assistant George Davidson at present has to the office, having returned two years since from the Western coast, to invite him to prepare a second edition of the Directory of the Pacific coast, which was published in my annual report for 1858. It is to be understood that this embodies the information collected in our archives by the labors of the Assistants in the Coast Survey since 1849, as well as the researches into historical and other matter by the author, and his personal experience and observation. Thus are embraced the astronomical determinations of Assistants R. D. Cutts and George Davidson, and Sub-Assistant J. S. Lawson; those from triangulation by Assistants Cutts, Davidson, Rodgers, Greenwell, and Lawson; the topographical by Assistants Cutts, Harrison, Rodgers, and Johnson; and the hydrographic by Lieut. Com'g W. P. McArthur, the pioneer of the hydrography; by

Lieut. W. A. Bartlett; by Captain James Alden, the able commander for nine years of the well-named surveying steamer Active; by Lieut. R. M. Cuyler; and by Captain B. F. Sands.

The directory, as revised and extended by Assistant Davidson, is given as Appendix No. 39.

OFFICERS OF THE ARMY AND NAVY.

The very acceptable aid which we have in former years received from the officers of the army and navy, and which was returned to the government by the experience acquired in the various operations of the survey, has necessarily been withdrawn from us, the war placing us in the position of giving aid instead of receiving it. Lieutenant Commander Phelps is at this time the only officer of the navy left with us, and we have not a single army officer on full duty with us. Captain Elliot, of the corps of engineers, is still, however, permitted to examine and send to us the tidal observations from the Western coast.

OBITUARIES.

Assistant Alexander S. Wadsworth died, suddenly, in the city of Washington, on the 9th of August, 1862. He joined the survey in 1848, and, opportunity and his merit concurring, rapidly rose to the position of Assistant, which he occupied at the time of his death. His triangulation and plane-table work on the coast of North Carolina were among the most rapid and successful works of their class.

Sub-Assistant Wyllys S. Gilbert, of Zanesville, Ohio, died of pulmonary disease on the 12th of January, 1862, at Wakatomaka, within a few miles of his home. He was an excellent topographer, having been trained carefully by his accomplished brother, Assistant Samuel A. Gilbert, (acting brigadier general, second brigade, second division, army of Kentucky.) Although but little exposed to the rigors of a northern climate, Sub-Assistant Gilbert contracted, a few years ago, the disease of which he died; and notwithstanding efforts made to save him by assigning continuous service in the southwest, his strength gradually wasted, and he was added to the victims in our corps, of consumption of the lungs.

General Isaac I. Stevens had so thoroughly identified himself with the Coast Survey, during his four years of service as Assistant in charge of the office, that those with whom he had zealously and ably served could not suffer his death, upon the field of Chantilly, to pass unmarked by the deepest tokens of their respect and regret, and met to give expression to their feelings towards their former associate and chief, and of condolence with his bereaved family, in the resolutions and remarks which are given in the Appendix, No. 40.

Major William R. Palmer, U. S. topographical engineers, brevet lieutenant colonel U. S. army, remained on service in the Coast Survey while aid to Major Geneial McClellan, until the army moved forward into Virginia last spring, when it was necessary to accompany the general's staff. The same zeal which made him so serviceable in the office displayed itself in the field; and the hardships of the Peninsular campaign, acting upon a somewhat delicate constitution, laid him open to the attack of typhoid fever of which he died, on the 18th of June. He was able to return home to the care of his devoted wife, but so much enfeebled by disease as not to rally, and on the day after his arrival in Washington he breathed his last, mourned by a large family circle to whom he had been always deeply attached, and regretted by numerous friends who had shared his hospitality and good offices. The officers of the Coast Survey expressed their regret in the resolutions given in Appendix No. 40. My own relations to Major Palmer were such as are due to a proved, true, and life-long friend.

Captain John R. Smead had left the Coast Survey office, on the breaking out of the war, to command the Washington Rifles, and after the campaign, in which they were so much distinguished for discipline and readiness of service, had returned to his position in the fifth regiment of U. S. artillery. He perished in the bloody fight near Manassas, on Saturday, August 30, leaving a young and helpless family to the care of his country, for which he had laid down his life. The Appendix already referred to contains the resolution passed by his recent associates in the office on the occasion of his death.

Brigadier General William R. Terrill, of Virginia, was in charge of a Coast Survey party on the western coast of the peninsula of Florida when the rebellion broke out. He promptly disentangled his party and the government property from the hands of the rebels, when seizure became imminent, and, returning north, ranged himself unflinchingly on the side of the whole country, seeking at once service of the most active kind with the army. By nature morally, as he was also physically, dauntless, he resisted every effort of his relatives who sided with the State of Virginia, and declared himself a soldier of the Union. After service in drilling the earlier companies that arrived in Washington, he joined his regiment, (fifth regiment of artillery,) having been promoted to a captaincy. His marked intrepidity in the battle near Pittsburg Landing, in Tennessee, and before Corinth, in Mississippi, won for him a commission as brigadier general of volunteers.

In the summer campaign he was in service with the army of Kentucky, under General Buell, and was mortally wounded in the battle which was fought at Perryville on the 8th of October. The genial memories which his name would have elicited at all times amongst his former associates in the work of the survey are turned to sadness by the early death of this truly upright and patriotic officer.

By an accident at the Mare Island navy yard, on the night of April 2, which caused the death, by drowning, of William F. Sands, the survey has lost the only hydrographic aid then attached to the work. His naturally good abilities had been developed to a promise of great usefulness by his father, Commander B. F. Sands, U. S. N., with whom the deceased had served from early boyhood in the practical details of hydrography. Remarkable for an amiable and teachable disposition, he had gained proficiency in hydrographic drawing, and was fully qualified to make return for the high expectations which had been formed in his training. At the time of his death Mr. Sands was acting master in the hydrographic party, and was engaged in the prosecution of the survey in Section X.

PART II.

The brief summary of progress in the field and office already given will be represented in this part of the report by the details of work done in each section of the coast to which parties have been assigned. As usual heretofore, the statements will be given in geographical order, the work of triangulation being described first, as preceding the other operations in order of time, and the topography as preceding the hydrography in the order of execution, in each section.

SECTION I.

FROM PASSAMAQUODDY BAY TO POINT JUDITH, INCLUDING THE COAST OF THE STATES OF MAINE, NEW HAMPSHIRE, MASSACHUSETTS, AND RHODE ISLAND.—(SKETCH A, NOS. 1, 2, and 3.)

Under this head abstracts will be given from the reports of Assistants on the following field operations:

1. Triangulation of the coast of Maine from Machias bay southward and westward to Pleasant bay, including Englishman's bay, Moose-a-bec reach, Indian river, and islands in the vicinity of each.
2. The triangulation of Eggemoggin reach, and of the northern part of Isle au Haut bay, Me. This work connects with the triangulation of Penobscot bay.
3. The triangulation of Belfast bay, Winter harbor, Searsport bay, and Mill cove, in the upper part of Penobscot bay, including, also, the lower part of Penobscot river.
4. A shore-line survey of part of Passamaquoddy bay, Me., embracing West Quoddy bay, the shores of Eastport harbor and Johnson's bay, and the western side of Campobello island.
5. Detailed topography of the eastern side of Frenchman's bay, Me., including Jones's cove, Bunker's cove, Hammond's cove, the islands opposite, and the shores of Winter harbor.
6. A topographical survey of the western side of the entrance to Penobscot bay. This includes the shores of Tennant's harbor and Wheeler's bay, and, in detail, the islands and reefs of the Muscle Ridge channel.
7. Plane-table work, nearly completing the survey of the steamboat passages between the Sheepscot and Kennebec rivers.
8. The detailed topography of Yarmouth river, Freeport river, and Wolf's Neck, in the upper part of Casco bay.
9. A reconnaissance, relative to purposes of military defence, in the vicinity of the city of Portland, Me.
10. A special topographical survey of Coasters' Harbor island, Coddington cove, and the shore of Rhode Island above Newport.
11. Detailed surveys of parts of Connanicut island, Dutch island, including Taylor's cove, and Dutch Island harbor, for the use of the navy yard commission; and shore-line survey of Providence, Patience, Dyer's, and other islands in Narragansett bay.
12. Soundings nearly completed in the several channels which connect Wiscasset bay and Sheepscot river with the Kennebec.
13. The hydrography of the upper part of Casco bay, including that of Yarmouth and Freeport rivers. The same party made supplementary soundings near the entrance of Portland harbor.
14. A special examination in Cape Cod bay for the determination of questions before the commissioners of the Cape Cod ship canal.
15. Supplementary soundings to complete the chart of Barnstable harbor, Mass.
16. The hydrography of the eastern and middle passages of Narragansett bay, joining completed work at Half Way rock and below Goat Island light. This includes Newport harbor, in the approaches of which several points of rock were developed.
17. Magnetic observations at Eastport, Me.
18. Tidal observations at Eastport, Me., and at the Charlestown navy yard, Mass.

OFFICE-WORK.—The drawing for a finished chart, and the engraving, in a preliminary form, of Barnstable harbor has been completed; the engraving of Portland harbor as a finished chart, with additions to the hydrography, has been nearly completed; and a preliminary chart of Mount Hope bay has been drawn and engraved. Progress has been made in the drawing and engraving of coast charts No. 8, Seguin island to Kennebunkport, Me.; No. 9, Cape Neddick to Cape Ann, Mass.; and No. 11, Plymouth to Hyannis, Mass.; and of the chart of Sheepscot and Kennebec rivers, Me. The drawing of general coast charts No. I, Quoddy Head, Me., to Cape Cod, Mass.; No. II, Cape Ann to Gay Head, Mass.; and of coast chart No. 7, Muscongus bay to Portland, Me., has been continued; and the engraving of coast chart No. 7, Muscongus bay to Portland, Me., and the drawing and engraving of No. 10, Cape Ann to Plymouth, have been commenced. Additions have been made to the chart of Salem harbor, and to coast charts Nos. 12 and 13, Nantucket sound and Vineyard sound, as also to the progress sketches of the section; and a new progress sketch of the coast of Maine has been drawn and engraved.

Triangulation of Machias bay, Englishman's bay, Moose-a-bec reach, Indian river, and adjacent islands, Me.—This is in continuation of work which has been pushed, by the same party under Sub-Assistant F. P. Webber, from Mount Desert island to the northward and eastward along the coast of Maine. The secondary and tertiary work is kept in close connexion with the primary triangulation, as may be seen by reference to Sketches Nos. 1 and 2.

The triangulation of this year was taken up on the 8th of August, previous to which date Mr. Webber had been employed in Section III. From the entrance to Little Machias bay signals were set up to the southward and westward in positions proper for defining the numerous indentations of the coast. The angular measurements made at them in September and October furnish points for the topographical survey of Machias bay, Howard's bay, Little Kennebec river, Englishman's bay, Chandler's River bay, and Moose-a-bec reach, and of the islands which lie off their entrances. At eight of the stations vertical angles were measured on thirty-six signals by three hundred and ninety observations. Mr. Webber used the ten-inch Gambey theodolite, No. 63, and the six-inch Brunner, No. 52, in the determination of angles. His party worked with the schooner Hassler until the beginning of November, when operations closed for the season in this section. The following is a summary of the field statistics:

Signals erected	35
Stations occupied	17
Angles measured	318
Objects observed on	309
Number of observations	2,718

Fifty-three points were accurately determined for topographical purposes.

The schooner Hassler was laid up at Portland.

Duplicates of the records of observations have been completed and sent to the office. The computations of the work have also been finished and turned in.

Triangulation of Eggemoggin reach, Me.—In continuation of his work of last year which connected stations in Penobscot bay with others to the eastward in Great Blue Hill bay, Assistant G. A. Fairfield resumed work on the 7th of August at Blake's Point. A signal was erected there, and in the course of the month points were selected and signals set for the triangulation of Eggemoggin reach, the location of which may be seen by reference to Sketch No. 2. Observations with the theodolite (ten-inch, No. 91, by Blunt) were commenced on the 3d of September and closed at the end of that month, when Mr. Fairfield proceeded to Blue Hill primary station and observed on such of the signals of his triangulation as were within view from it. The islands in the expanse which lies north of Isle au Haut bay and west of Eggemoggin reach are included in the triangulation of this season. The following are the statistics of work:

Signals erected	5
Stations occupied	9
Points determined	23
Angles measured	113
Number of observations	2,208

Assistant Fairfield continued the observations necessary for connecting the secondary with the primary triangulation until the middle of November. The schooner James Hall, which was used by his party, was then taken to Portland and laid up for the winter.

Triangulation of Penobscot bay, Me.—This work has been nearly completed by the extension of a system of triangles above the line which joins Dickey's bluff with Cape Rosier. It now includes Belfast bay, (Sketch No. 2,) Searsport bay, and Winter harbor, on the western side of Penobscot bay; Mill cove, at the mouth of the Penobscot river; and Castine bay. Sub-Assistant S. C. McCorkle, working with a party in the schooner Torrey, resumed this duty on the 8th of July, and, as it advanced, erected in all nine tripod signals, some of which were set up so as to include the lower part of the Penobscot river in the scheme of triangulation. Before returning from the section he made a reconnaissance northward to Bangor and selected stations for continuing the preliminary survey. A summary of the general statistics is here given:

Signals erected	9
Stations occupied	13
Angles measured	185
Number of observations	1,879

The angular measurements were made with the Gambey theodolites—ten-inch, No. 15, and six-inch, No. 29. Mr. McCorkle concluded his work on the 18th of October, and laid up the schooner Torrey at Portland. He then joined Assistant Fairfield, whose party was still at work to the eastward, and concerted means with him for perfecting the connexion between the triangles of Great Blue Hill bay and those of the upper part of Penobscot bay. Four of the stations, the signals of which have been observed on from other stations, will be occupied for the final completion of the work in Penobscot bay.

Shore-line survey of Eastport harbor and of West Quoddy bay, Me.—Sub-Assistant W. H. Dennis resumed the survey of Passamaquoddy bay on the 1st of August, and prosecuted that work until the 6th of November. The three sheets which he has returned contain the western shore-line of Campobello island, from East Quoddy Light to a point opposite to West Quoddy Head; the western shore of West Quoddy bay, including the Head; the peninsula of Lubec, and in connexion with it the shores of Johnson's bay; the entire shore-line of Moose island, including the town of Eastport; the south end of Deer island, and the numerous small islands lying between it and Campobello. Taken together the plane-table sheets give the outlines in connexion of West Quoddy bay, Eastport harbor or Friar road, and both shores of the St. Croix river to Pleasant Point. Part of the details were traced in the work of last season. The limits comprised in this year's survey (Sketch No. 2) fully provide for the hydrography of Eastport harbor and its approaches. Sixty-four miles of shore-line were traced, exclusive of thirteen miles of low-water shore-line which required to be surveyed separately. Details were filled in to cover an area of three and a half square miles.

Sub-Assistant Dennis had passed the winter and spring in topographical service connected with the naval expedition of Commodore (now Admiral) Du Pont on the coast of South Carolina. He is now making preparation to rejoin the expedition and continue the survey in Section V.

Topography of Frenchman's bay and Winter harbor, Me.—The topography of the coast of Maine, east of Mount Desert island, was begun on the 1st of September by Mr. Cleveland Rockwell, the basis for it being the triangulation made by Sub-Assistant Webber in 1860. The sheet, which was completed by the 18th of November, takes in West Goldsborough harbor or Jones's cove, Bunker's cove, Hammond's cove, Winter harbor, and the lesser indentations of the eastern side of Frenchman's bay, together with Stave island, Jordan's and Iron-bound islands, and many smaller ones in the bay. Sketch No. 2 shows the locality. Mr. Rockwell's plane-table work is continuous in shore-line and surface details from Hall's Point southward to and inclusive of Winter Harbor entrance. The statistics are as follows:

Shore-line surveyed	44 miles.
Roads	14 "
Area of topography, (square miles)	12¾

The earlier part of the working season was employed by Mr. Rockwell in Section V, as will be stated under that head.

Topography of Seal harbor, Wheeler's bay, and Tennant's harbor, and of islands in Penobscot bay, Me.—This work is comprised on two plane-table sheets which connect with each other, and, to the northward, with a survey made last year of Rockland harbor and Owl's Head bay. The upper sheet (see Sketch No. 2) shows in detail the Muscle Ridge islands, and has marked on it in position the very numerous rocks, reefs, and shoals in their vicinity. This part of the duty of the season was accomplished by means of a boat in calm weather, the points not being approachable under other conditions. Careful intersections were made with the plane table so as to fix in their relative places the isolated rocks of the group.

Sub-Assistant Charles Ferguson resumed this work on the 18th of July with a party in the surveying schooner Bowditch. His sheet containing the survey of the Muscle Ridge group extends from Munroe island, in Owl's Head bay, southward and westward to White Head light-house. The islands lie off the western shore of Penobscot bay, which was surveyed last year, and from two to three miles distant. Of the group the principal ones shown on the map are Andrew's island, Dix island, High island, Pleasant, Grafton, and Crow islands, Great Two Bush, and Little Two Bush. The reef which stretches about half a mile from the north end of Great Two Bush island is also delineated on the sheet. This part of the survey defines the shape and limits of two small harbors in the Muscle Ridge group: Dix harbor, between Dix island and High island, and Horne's harbor, near the north end of Pleasant island.

At the island last named the second sheet executed by Mr. Ferguson connects with the former and continues the survey of the lower part of the western shore of Penobscot bay from the limit reached last season. It shows the outlines and topographical character of the shores of Seal harbor, Wheeler's bay, Long cove, Tennant's harbor, and Mosquito harbor, besides minor indentations and numerous islands, the plane-table work being continuous on it from north to south. Of the islands represented on this sheet Sprucehead is noted for its extensive quarries of granite, as is also Dix island, which is shown on the adjoining sheet. The numerous buoys and stakes marking the entrance to Seal harbor were determined in position by Mr. Ferguson, and are included as part of the details of his survey.

Field-work was continued until the 27th of October, when the vessel was taken to Portland and there laid up. The following summary of statistics is given in the field report:

Shore-line surveyed	72 miles.
Roads	22 "
Creeks	5 "
Area of topography, (square miles)	16

During the early part of the present surveying year Sub-Assistant Ferguson was employed in Section III.

Topography of Back river, Little river, Robin Hood's cove, &c., Me.—The plane-table survey of the neck between the Sheepscot and Kennebec rivers, below Wiscasset and Bath, was resumed on the 1st of August, and has been nearly completed. The party detailed for this service was in charge of Sub-Assistant C. T. Iardella. Shore-line was furnished to the hydrographic party which worked in the channels between the two rivers at the same time. The water passages defined by the topographical sheet of Mr. Iardella are known as Little river, Hall's bay, Riggs's cove, Long or Robin Hood's cove, and Little Sheepscot river, all of which are marked in a general way on Sketch No. 2.

Before taking up this survey Sub-Assistant Iardella had been employed in Section VI.

The plane-table work on the Woolwich peninsula was completed on the 25th of November, with the exception of a small portion of details of surface. A summary of the statistics is appended.

Shore-line	59 miles.
Roads	45 "
Creeks and marsh line	40 "
Area of topography, (square miles)	22

Mr. Iardella is now employed in inking his topographical sheets.

Topography of Yarmouth river, Freeport river, and Wolf's Neck, &c., Casco bay, Me.—The shore-line of the upper part of Casco bay was traced last year from Drinkwater Point to the entrance of Maquoit bay, by Assistant A. W. Longfellow. This season he filled in the topographical details within the same limits, and traced, in addition, thirteen miles of shore-line.

"Yarmouth river was surveyed from its mouth and confluence with Cousin's river, at Parker's Point, two miles upwards, to the falls, where are the wharf and ship-yards; and thence on, under the name of Royall's river, it was traced upwards a mile and a half further, to the crossing of the Atlantic and St. Lawrence railroad.

"Yarmouth village was surveyed from the wharves at the head of tide three-quarters of a mile back, to include the railroad depot. South Freeport village was a growth from the ship-building interest on the shores of the Freeport or Harriseeket river. Here, as at Yarmouth, vessels of fourteen hundred tons have been built. This estuary is included in the survey as far as the narrows, where, at the edge of the plane-table sheet, the channel passes up to Harriseeket Landing. Part of the village of Bartol's Point Landing is also embraced in the detailed work, the in-shore boundary of which is the main country road, running generally about a mile from the shore."

The detailed survey off-shore includes Lane's island, Great and Little Moges islands, Trenche's and Bustin's islands, and the group known as the Silver islands, all lying in the upper part of Casco bay. The location of the work is shown on Sketch No. 2.

Assistant Longfellow commenced work in this section on the 18th of July, and continued in the field until the middle of October. He had been engaged during the early part of the summer in Section III. His party used the schooner Meredith for transportation and quarters while prosecuting the topography of Casco bay. The following is a synopsis of the plane-table statistics:

Shore-line traced	13	miles.
Roads	23½	"
Area of topography, (square miles)	9¼	"

Reconnaissance of the environs of Portland, Me.—This service was called for with reference to purposes of military defence, and was executed by Sub-Assistant F. W. Dorr, who had passed through the peninsular campaign in plane-table surveys for the army of the Potomac, mention of which will be made under the head of Section III. Mr. Dorr commenced work on the 10th of September, and consulted freely at Portland with Captain Casey, of the corps of engineers, in regard to the direction and extent of his reconnaissance. The best county map being taken as the basis, its scale was enlarged and the roads were traced on the reconnaissance sheet. To these were added the curves of elevation, sketched by the eye, and such other details as were wanting in the map, but which the experience of Mr. Dorr with the army surveys of the present and the working season of last year suggested to be of moment for military purposes. The field-work was concluded on the 9th of October. The compilation of the material was then taken up and nearly completed before the close of the month. Meanwhile application had been made to me by the tax commissioners appointed for Florida for the services of a topographer. Mr. Dorr's local knowledge of that coast being extensive and his qualifications ample, he was assigned to accompany them, and, in accordance with directions, reported in person to the commissioners at New York in November previous to their departure for Fernandina.

Mr. H. W. Longfellow aided Mr. Dorr in the field-work near Portland. The reconnaissance map, which is now at the office, contains the following among other details of surface:

Roads	176	miles.
Outline of woods	223	"
Marsh line	28½	"
Area, (square miles)	70	

Topography of Narragansett bay, R. I.—Assistant Henry L. Whiting commenced a special plane-table survey of Coaster's Harbor island and its vicinity on the 26th of June. Its surface was carefully contoured, and that of the adjacent part of Rhode Island, from Coddington cove nearly to the environs of Newport, and eastward, to include Miantonomy Hill.

This survey was executed at the request of the Navy Department, and in order to furnish data for deciding the question at issue, Mr. Whiting made close soundings between the southwest face of Coaster's Harbor island and the Gull rocks. The work was closed on the 12th of July. Assistant Whiting then took up topographical duty in Section II. He had, before taking up duty in Narragansett bay, made several surveys in the vicinity of Washington city, in Section III.

The plane-table work in Narragansett bay was continued, between the 16th of August and the 1st of November, by the party of Assistant A. M. Harrison, who had also been, during spring and summer, engaged in field duty in Section III.

For the special use of the United States board which was appointed to examine and report on sites for navy yards, and which met in Narragansett bay early in September, a survey had been directed of parts of Connanicut island, including Taylor's cove, Dutch island, and Dutch Island harbor. This was executed by Mr. Harrison, on the scale of $\frac{1}{10000}$, and met all the requirements of the commission. The other topographical duty of the party was confined to the determination of shore-line and of the principal points needed for the correct plotting of the hydrographic work of the present season. These results were supplied to the party under Assistant Mitchell.

During the entire working season in Narragansett bay, Assistant Harrison was aided by Mr. H. W. Bache, and during part of it by Mr. F. A. Lueber. The following are statistics of the plane-table survey:

Shore-line surveyed	44	miles.
Roads	8½	"
Creeks and ponds	5¼	"
Marsh line	8¼	"
Area of topography, (square miles)	9	

Besides the special localities already referred to, the additions this year to the regular survey of the shores of Narragansett bay comprise the shore-line of Prudence, Patience, Dyer's, Gould, and other islands, and the western side of Rhode Island, from a point opposite to Coaster's island and northward, to limits of previous work. Only a few of the smaller islands in the bay remain to be traced in outline.

Hydrography between Wiscasset and Bath, Me.—The water passages which intersect the Woolwich peninsula, and which connect the Sheepscot and Kennebec rivers, have been sounded out by a party in charge of Assistant F. H. Gerdes. Most of the shore-line had been previously traced. The concluding portion was supplied for the use of the party by Sub-Assistant Iardella.

Mr. Gerdes took up the hydrography at Wiscasset (Sketch No. 2) on the 23d of August, and in sounding Wiscasset bay connected his work with the survey of the Sheepscot made in 1858 by Lieutenant Commanding Moore. Thence in a direction southward and westward he sounded Back river, Montseag bay, Hoakomoak bay, and Little river, which, taken together, afford a continuous water passage between the Sheepscot river at Wiscasset and the Kennebec at a point about seven miles below Bath. The character of the other passage between the two rivers, made up of Upper Hurl Gate, the Rapids, and Great Hurl Gate, was also developed. These connect the Kennebec at Bath with the Sheepscot opposite to Mahan's island. Measured together, and including Robin Hood's cove, which was also sounded, these channels make an aggregate of thirty-four miles in length. The peninsula traversed by them is from five to ten miles in breadth.

Sub-Assistant Clarence Fendall assisted Mr. Gerdes. Mr. T. C. Bowie and Mr. F. H. Gerdes, jr., were attached to his party as aids. The schooner G. M. Bache was used for transportation.

Tidal observations were commenced at Wiscasset when the hydrography was taken up, and were continued at that station until the end of September, when the work was completed. During each day the state of the tide was noted every ten minutes, as were also the high and low waters that occurred at night. Observations for shorter periods were in like manner made on the tides in Little river and in Upper and Great Hurl Gates.

The party of Assistant Gerdes determined about seventy points for hydrographic purposes, and used above twenty others which were furnished by Sub-Assistant Iardella.

The general statistics of the work are as follows:

Miles run in sounding	160
Angles measured	1,167
Casts of the lead	11,000

Both of the passages referred to in this notice are navigable. A steamer passes semi-weekly from Bath to Boothbay through Upper and Great Hurl Gates. Excepting Little river at low tide, the water is quite deep in all the passages between the Sheepscot and the Kennebec.

After the completion of the service assigned, the schooner was laid up at Wiscasset. The soundings were plotted by Mr. A. Strausz, and the sheet containing them is now on file in the office.

Assistant Gerdes and his aid, Mr. Bowie, had been previously engaged in Section VIII. Mention will be made of their employment there under the corresponding head of this report. In October Mr. Bowie was detailed for plane-table duty in Section III.

Hydrography of Casco bay, Me—Hydrographic operations were resumed in the upper part of Casco bay on the 3d of August by a party in the surveying schooner Caswell. The charge of the work was given to Mr. Edward Cordell, of large experience and qualification as a hydrographic draughtsman, who had previously served with a number of the regular hydrographic parties on all parts of the Atlantic coast. The soundings made were in continuation of the work of last year by Assistant Schott, which had stopped on a line running east from the north end of Cousin's island to Harpswell Neck, (Sketch No. 2,) and, south of the Neck, on a line from the lower end of Jewell's island eastward to include Drunken Dick ledge. North of the first-mentioned line Mr. Cordell sounded Yarmouth river, Cousin's river, and Freeport river, and from their entrances the body of Casco bay eastward to Harpswell. He completed also the hydrography north of the line last mentioned, comprising that part of the bay which lies between Bailey's island and Crotch island. This survey includes Mericonig sound, Harpswell harbor, and the channel between Harpswell Neck and Great Whaleboat island.

On the tides, day and night observations were made at three stations, one of which was at South Freeport, where the record was continued until the 13th of October. Those at Harpswell and at Little Moges island were kept up until the end of September.

Six current stations were occupied in different parts of the bay while soundings were in progress.

In the vicinity of Portland harbor Mr. Cordell made supplementary soundings near Trundy's reef, and others in a resurvey of White Head passage, between Peak's and Bangs's islands. He also determined in position a rock off the southeast end of Little Jebeig island. This rock has only nine feet of water on it at mean low tide.

The channel which has been artificially made across the Middle Ground since the date of the survey of Portland harbor was sounded out by the party of Mr. Cordell, and will be represented on a new edition of the engraved chart.

The soundings made in the upper part of Casco bay this season show depths of from one to forty fathoms.

A summary of the statistics of work is here appended:

Miles run in sounding	663½
Sextant angles	5,237
Number of soundings	30,894
Area sounded, (square miles)	27

Mr. Cordell has plotted and sent to the office the sheets containing the hydrographic work of the season, together with the records of angles, soundings, and tidal and current observations, in duplicate. He was aided in duty afloat by Messrs. L. L. Nicholson, L. A. Sengteller, and J. A. Sample, and makes special mention in his report of the ready and intelligent service rendered by them.

Physical survey of Cape Cod bay, Mass.—In the early part of the present year I directed Assistant Henry Mitchell to make some experiments in Cape Cod bay, with a view of furnishing information required by the committee on the Cape Cod canal appointed by the Massachusetts legislature. This committee had under discussion the question whether the proposed canal and artificial harbor would be obstructed by ice during the winter months.

During a previous season's work we had discovered that a sub-current from the deeper portion of Cape Cod bay *cropped out* in the neighborhood of Scussett at one of the proposed sites for the breakwater and basin. In this region the temperatures were quite at variance with those of the surface of the sea elsewhere; they were very uniform, and corresponded with the thermal conditions observed at the depth of fifteen fathoms wider out in the bay. Our observations had been made in the summer, and could not, therefore, furnish more than a guess as to the conditions which should obtain in winter.

On the 9th of February Mr. Mitchell reported upon a new set of experiments made during a cold period earlier in the same month, and I sent his manuscript immediately to the committee.

In the course of this report it is stated that a specimen of the Cape Cod bay water began to freeze at 28½° Fahrenheit, and that, after being for eleven hours exposed in air at 16°, one-third of its bulk became a spongy ice, the residue still remaining in a liquid state at 27°. This ice, though quite fresh itself, held some salt water suspended in its cells. At each attempt to freeze the residuum water there was obtained a lower temperature and a higher specific gravity for that still remaining liquid.

The water off Scussett was observed to fall as low as 32°—that is, within about four degrees of its freezing point—and this at the end of a period of severe cold.

Mr. Mitchell concludes from his study that, while the natural circulation of the currents is unobstructed, no sea-water ice can actually form in the particular district off Scussett, although he believes that *bottom ice* may be found in localities where fresh springs are welling from the sands.

Hydrography of Barnstable harbor, Mass.—In October the party of Assistant Henry Mitchell made supplementary soundings in the vicinity of Barnstable, and completed the hydrographic sheet which was turned in last winter. The engraved chart, in preliminary form, accompanied my annual report for 1861.

Hydrography of Narragansett bay, R. I.—In continuation of the work of last year, Assistant Mitchell, with a party in the schooner Bancroft, took up soundings at the south end of Prudence island, (Sketch No. 3,) and extended the hydrography of Narragansett bay southward in the Middle Passage to a point about a quarter of a mile below Goat Island light. Soundings comprised within an area of about a square mile were made also in the Western Passage, in the immediate vicinity of Dutch island.

This party resumed the work on the 1st of August and continued duty afloat until the end of September, when the vessel was returned to New York. She had previously been in use by the party of Assistant Mitchell in Section IV, under which head mention will be made of other service.

The statistics of the hydrographic work in Narragansett bay are as follows:

Miles run in sounding	212
Angles observed	1,322
Casts of the lead	5,729

The currents were observed at three stations while the party was engaged in sounding.

In the course of this season's work Mr. Mitchell developed the positions of ten hidden rocks, and found in the approaches to Newport harbor two others, the existence of which was unknown. These are all marked on the hydrographic sheet which is now in preparation, and which will be turned in before the close of the year. In Appendix No. 6 a copy is given of the notice issued to mariners at the time of the discovery.

Messrs. C. L. Bixby, C. P. Dillaway, and Persifer Frazer, jr., were attached as aids to this party.

The work done by Assistant Mitchell was directed with a view to the requirements of the navy yard commission which met in Narragansett bay in the first week of September.

Magnetic observations.—The observations near the middle of each month of the year have been continued at the Eastport station, in Maine, without interruption. These now furnish a well-conducted series of determinations of the magnetic declination, dip, and intensity, extending over a period of nearly three years.

Mr. Samuel Walker had charge of the instruments at Eastport until March of the present year. His services being then needed at Key West, the station was put, and still remains, in charge of Mr. R. H. Talcott.

Before leaving Eastport Mr. Walker determined the value of the coefficient of temperature, and the moment of inertia for the magnets A and C.

Early in November Mr. Talcott was relieved by Assistant Edward Goodfellow, and was attached to the topographical party of Sub-Assistant W. H. Dennis, to work in Section V.

Tidal observations.—The tidal station at Eastport, Me., remained in charge of Mr. Samuel Walker until March last, when the observations were intrusted to Mr. R. H. Talcott, the services of Mr. Walker being needed at Key West, in connexion with the magnetic station at that place.

A substantial staff-gauge has been set up at Eastport for comparing results with the self-registering tide-gauge, the tape or band heretofore used having proved unreliable from irregular expansion.

Mr. Talcott also continued the magnetic and meteorological observations at Eastport until November.

At the Charlestown navy yard, Mass., the tidal observations have been kept up by Mr. T. E. Ready with his accustomed punctuality. The Boston harbor commissioners having put in his charge a self-registering gauge for an independent series of observations, and provided a building for its protection, the occasion has been improved by setting up in the same a substantial box-gauge, from both of which observations are recorded, in addition to those at the permanent station.

SECTION II.

FROM POINT JUDITH TO CAPE HENLOPEN, INCLUDING THE COAST OF THE STATES OF CONNECTICUT, NEW YORK, NEW JERSEY, PENNSYLVANIA, AND PART OF DELAWARE.—(SKETCH B, No. 11.)

Statements of the work done in this section will be noticed in the following order:

1. Geodetic, astronomical, and magnetic observations at primary stations in Massachusetts and Connecticut. The triangulation work is for connecting the primary base on Epping Plains, Me., with that on Fire Island, N. Y.

2. Triangulation continued along the course of the Connecticut, between Goodspeed's Landing and Higganam.

3. Triangulation on the eastern side of Hudson river, near Rhinebeck and Poughkeepsie.

4. Supplementary triangulation for revising work on the coast of New Jersey, near Shark river and Manasquam river.

5. A detailed topographical survey east of Brooklyn and between Flushing and Jamaica. This work completes the material needed for finishing the new chart of New York harbor.

6. The plane-table survey of Hudson river, continued from Tarrytown to Croton river, embracing the eastern shore of Tappan bay, the village of Sing-Sing, and other villages.

7. Shore-line survey from Tivoli upwards to Coxsackie, and hydrography of the Hudson river extended from Tivoli to Four-Mile Point.

8. Hydrographic examination of the vicinity of Pea Patch island, in the Delaware river. Levellings were made by the same party at League island and Red Bank for the use of the board appointed to examine sites for navy yards.

9. Magnetic observations in New York and Pennsylvania.

10. Tidal observations in New York harbor.

Office-work.—The engraving in outline of the new edition of coast chart No. 21, New York bay and harbor, has been completed and the chart issued in a preliminary form. The drawing of the same as a finished chart has been continued. Progress has been made in the drawing and engraving of the Hudson river sheet No. 1, from New York to Haverstraw; and in the drawing of sheet No. 2, Haverstraw to Poughkeepsie. The engraving of the latter has been commenced, and additions have been made to the progress sketch of the section.

Geodetic observations at Mount Tom and Sandford, (Mass. and Conn.)—The party under my immediate direction was organized early in June, to continue the primary triangulation on the coast of New England, for connecting the Fire island and Epping bases.

The preliminaries required in the erection of signals and posting the heliotropers were attended to by Assistant G. W. Dean and Sub-Assistant R. E. Halter, while the preparations required for occupying the stations were made, as usual, by Mr. Thomas McDonnell.

Station Mount Tom, in the township of Northampton, Hampshire county, Massachusetts, was first occupied. The measurement of horizontal angles at this point was commenced on the 11th of July, but the atmosphere during the months of July and August proving unusually hazy, and the distances to several of the signals being more than fifty miles, these observations were not completed until the 16th of August. Meanwhile the requisite latitude and magnetic observations were made by Assistant Edward Goodfellow, aided by Mr. S. H. Lyman.

On completing the observations at Mount Tom, the instruments and camp equipments were transferred to Station Sanford, in the northwestern part of the township of Hampden, New Haven county, Connecticut. The operations at this station were similar to those at Mount Tom.

The measurement of horizontal angles at Sanford was begun on the 9th of September, but the weather during that and the following month proving still less favorable for geodetic operations than July and August, the observations were not completed until the 11th of November.

At Station Mount Tom eight hundred and twenty-six observations were made with the thirty-inch theodolite C. S. No. 1, upon five signals and an elongation mark. The heights of the several stations were determined from three hundred and ninety measurements of vertical angles, with the eight-inch Gambey vertical circle C. S. No. 57.

At Station Sanford twelve hundred and seventy-nine observations were made with the thirty-inch theodolite, upon eight signals and an elongation mark, and the elevations of the several trigonometrical points were ascertained from five hundred and twenty-eight measurements of the vertical angles, with the vertical circle No. 57.

At Mount Carmel the angle between Stations Tashua and Sandford was measured with the Gambey theodolite C. S. No. 57.

The most distant signals which were observed on during the season were those at Mount Tom and Station Sanford, being about fifty-six miles from each other in a direct line. Two other signals were more than fifty miles distant, and two were about forty-three miles from the point of observation. The relative positions of the several stations may be seen by reference to Sketch No. 1.

The area within the limits of the triangulation completed during the season—estimated in the usual manner—is thirteen hundred and seventy-five square miles. The geodetic observations were chiefly made by Assistant G. W. Dean and Sub-Assistant R. E. Halter.

Latitude.—At Mount Tom one hundred and seventy-two observations were made with the zenith telescope C. S. No. 5, upon thirty-six sets of stars, and the arc value of the micrometer was obtained from one hundred and twenty-two observations upon Polaris, near its eastern elongation. The local time was obtained from one hundred and thirty-two observations upon twenty-four zenith and circumpolar stars, with the twenty-four-inch transit C. S. No. 10.

At Station Sanford the latitude was ascertained from one hundred and sixty-one observations with the equal altitude instrument C. S. No. 5, upon thirty-five sets of stars, and one hundred and twenty-two observations were made upon Polaris, near its eastern elongation, for ascertaining the arc value of the micrometer divisions. The arc value of the level divisions upon the zenith telescope was carefully determined, both at Station Mount Tom and Station Sanford, from several series of readings of the micrometer, the pointings being made in the usual manner upon the cross threads of a small collimator, which was adjusted a few feet from the telescope. The local time was ascertained from one hundred and twenty-two observations upon nineteen zenith and circumpolar stars with the twenty-four inch transit C. S. No. 10.

The observations for latitude and time were made by Assistant Edward Goodfellow, aided by Mr. S. H. Lyman.

Azimuth.—The astronomical meridian and bearings of the trigonometrical lines from Stations Mount Tom and Sandford were determined with the thirty-inch theodolite by the usual methods of the survey. At Mount Tom eighty-four observations were made upon δ Ursæ Minoris, near its upper culmination, and eighty observations upon Polaris, near its eastern elongation, in connexion with one hundred and fifty readings on the elongation mark, which was established in a favorable locality near the summit of Mount Holyoke, about four and a half miles from the geodetic station at Mount Tom.

At Station Sandford the azimuth observations consisted of ninety readings upon Polaris, near its eastern elongation, and eighty-two readings upon λ Ursæ Minoris, near its upper culmination, in connexion with one hundred and sixty-two observations upon the elongation mark, which was favorably located upon the summit of a small hill, about one and a half miles in a westerly direction from the station-point at Sandford.

These observations were made by Assistant Dean, who was assisted by Sub-Assistant Halter. The field operations were closed on the 11th of November.

Magnetic observations.—The geological formation of Mount Tom being chiefly of trap rock, (green stone,) no reliable magnetic results could be obtained near the geodetic station, although, by way of experiment, the magnetic declination and dip were approximately ascertained at several localities near the summit. For this purpose four complete sets of observations were made by Assistant Goodfellow with the dip circle C. S. No 4, at two points, the results of which differed ten degrees. The results obtained for declination were still less satisfactory than those for dip, as it was soon ascertained that the needle of a land surveyor's compass would take any indicated direction by changing the position of the instrument only a few inches. The same phenomenon was also observed by Mr. Dean at the summit of Mount Holyoke, the geological formation of that mountain being similar to that of Mount Tom.

Experimental observations for ascertaining the magnetic declination and dip were made within the enclosed grounds of Williston Seminary, near the centre of the village of Easthampton, about two and a half miles in a northwesterly direction from the station at Mount Tom. No unusual local disturbances were noticed at this locality; and Mr. Williston, with the other gentlemen connected with the seminary, kindly offering to extend to the Coast Survey every required facility, a complete set of magnetic observations was made near the seminary buildings. These consisted of one hundred and sixty-five observations, on three days, for ascertaining the declination, and four sets for determining the dip of the needle. The horizontal intensity and moment of inertia were deduced, from three sets of vibrations and deflections, on two days.

At Station Sandford experimental observations were made at several points in the immediate vicinity of the geodetic station, but no indications of local attraction were discovered; accordingly, a complete series of magnetic observations were made near the summit of the hill. For this purpose, one hundred and seventy-five observations were made, on three days, for determining the declination, and four sets, with three needles, were observed for ascertaining the inclination of the needle at two points. The horizontal intensity and moment of inertia were obtained from three sets of vibrations and deflections, on two days.

The magnetic observations were made by Assistant Edward Goodfellow and Mr. Lyman.

Meteorological observations.—The usual meteorological journals were kept by Mr. H. M. Dewees, who was attached, as geodetic recorder, to my party during the season. Two hundred and ninety readings of the barometer, and the wet bulb and dry bulb thermometers, in connexion with the direction and force of the wind, were noted in the journals.

Mr. C. P. Bowditch was attached as volunteer aid in my party during the five weeks of his college vacation in July and August, and his efficient services were appropriately acknowledged by Assistant Dean.

All the original records were duplicated, and the reductions of the latitude, azimuth, and magnetic observations were completed before the party left the field.

The number of volumes of records and reductions deposited in the archives at the close of the season was forty-nine.

Triangulation of Connecticut river.—This work was again taken up at Goodspeed's Landing, and has been extended northward and westward to include the course of the river to the vicinity of Higganam. Sketch No. 10 shows the extent of the river embraced in the work of this and the previous season. Sub-Assistant W. S. Edwards resumed the triangulation soon after his return from Section V, his service in which will be stated in another place in this report.

The points furnished by the triangulation work done this year are sufficient to enable a plane-table party to define twelve miles of the course of the Connecticut. Mr. Edwards continued with his party until the 30th of September. Just previous to that date application had been made, through me, by the late Brigadier General Terrill, for the services of Sub-Assistant Edwards, who had been his recent associate in the work of the Coast Survey. The request was promptly met. Mr. Edwards left the party in charge of his aid, Mr. F. H. Dietz, and hastened to Kentucky, but reached Perryville only in time to take charge of the remains of the deceased general.

The following summary of statistics is taken from the report sent in by Sub-Assistant Edwards previous to his departure for the west:

Signals erected	19
Stations occupied	8
Angles measured	157
Number of observations	1,080
Area of triangulation, (square miles)	44

On the 1st of November Mr. Edwards resumed work on the Connecticut, and continued the triangulation until the end of the month. He then made preparation for resuming duty in Section V.

Triangulation.—In the vicinity of the boundary line between the States of Connecticut and New York, and in connexion with his triangulation of the Hudson river, Assistant Edmund Blunt occupied eight principal stations between the 16th of August and 21st of October. He was aided in the field and in office work by Mr. A. T. Mosman, who had previously been employed in Section XI, and more recently in the presen season in Section VI, and also by Mr. A. R. Fauntleroy. The following are the statistics of this triangulation:

Stations occupied	8
Angles measured	31
Number of observations	3,702

After the completion of the office-work Mr. Mosman was assigned to duty in the longitude party in charge of Dr. B. A. Gould.

Triangulation of the coast of New Jersey.—The revision commenced last year at Sandy Hook, and extended to the vicinity of Shark river, (Sketch No. 10,) was resumed in July by Assistant John Farley. Observations were completed at the stations selected last year. Other stations were chosen, chiefly along the beach above and below the mouth of Shark river, and most of the signals erected at them were observed on. The most southern stations occupied are about a mile below the entrance of Manasquam river. Mr. Farley continued the work during August and September, having visited fifteen stations in the course of the season. Including the preliminary measurements made last year, the number of observations with the theodolite was two thousand one hundred and fifty.

Supplementary topography between Flushing and Jamaica, (Long Island,) N. Y.—The final field-work required for the completion of the new chart of New York bay and harbor was taken up, at the end of July, by the party of Assistant H. L. Whiting. The space requiring to be filled with detailed topography on the plate lies eastward of the city of Brooklyn, and between Jamaica and Flushing, as was shown by the preliminary chart which accompanied my report of last year. Mr. J. W. Donn aided Mr. Whiting in the field.

This work occupied the party until the 25th of October, when it was transferred to another locality in this section.

The following are the statistics of the plane-table work near Flushing:

Outline of creeks and ponds	81 miles.
Marsh line	8¼ "
Roads	92¼ "
Area of topography, (square miles)	15

Assistant Whiting and Mr. Donn had passed the earlier part of the working season in Section III.

Topography of Hudson river, N. Y., near Sing Sing.—The regular plane-table survey of the banks of the Hudson was resumed by Assistant Whiting on the 28th of October. Near Tarrytown he joined the work of Sub-Assistant Mechan of 1859–'60, and from thence extended the detailed survey of the eastern side of Tappan bay up to the mouth of Croton river. The sheet worked on embraces the village of Sing Sing and others on the bank of the river above and below it, including, in addition, all the surface features between the old post road and the river. In some places the average breadth, for the sake of symmetry, was stopped at the Croton aqueduct, the fringe of topography being about half a mile in width. Mr. Donn aided in this work, and his efficiency and judgment in the execution of intricate details of contour is specially mentioned in the report of Assistant Whiting. A synopsis of the statistics is appended:

Shore-line surveyed	6 miles.
Roads	30 "
Croton aqueduct	6 "
Area of topography, (square miles)	3

This party is still in the field, and will probably continue plane-table work until the close of November.

Assistant Whiting had previously executed a survey, which has been noticed under the head of Section I. Further mention of the work of his party and of the previous service of Mr. Donn will be made with the statements of work done in Section III.

Topography and hydrography of Hudson river above Tivoli, N. Y.—At the limit which he had reached last year Sub-Assistant John Mechan, with a party in the schooner Arago, took up work near Tivoli on the 1st of August, having previously been engaged in field duty, which will be stated under the head of Section VIII.

For the joint operations on the Hudson Mr. Mechan divided his party, himself running the shore-lines of the river twenty-three miles upwards to Coxsackie, and extending the hydrography to Four-Mile Point, about midway between Hudson city and Coxsackie. Mr. W. W. Harding, one of his aids, took angles and assisted in plotting them for the chart. Mr. C. S. Hein recorded the soundings as they were made, and duplicated the hydrographic records and journals. Mr. Persifer Frazer, jr., also served as aid to Sub-Assistant Mechan during the latter part of the season.

The work of this party is comprised on three sheets, two of which are filled with soundings and the third partly filled.

The following statistics show the progress of the present season:

Miles of shore-line traced	49
Miles run in sounding	210
Angles measured	1,674
Number of soundings	14,675

The work on the Hudson was discontinued for the season on the 15th of October. Sub-Assistant Mechan and Mr. Harding were soon after assigned to topographical service for the 6th army corps in Section III. The schooner Arago was laid up at Poughkeepsie.

Hydrographic examination in Delaware river.—In March last instructions were given to Assistant George Davidson to make a special and detailed examination of the vicinity of the Pea Patch, in Delaware river, for purposes of defence, and to proceed in that duty under the direction of Captain C. F. Pendergrast, U. S. N., commandant of the navy yard at Philadelphia.

From his examinations of the previous year Mr. Davidson was enabled to determine immediately the locality which required examination. The work was reduced at once, and tracings from the sheet were placed in the hands of the commandant. The original sheets and traced copies were also forwarded to the office.

In fitting out his party for service at very short notice, Assistant Davidson acknowledges the aid cheerfully rendered by Captain T. Turner, U. S. N., at the navy yard.

Tracings also of parts of the survey made last year were furnished to Captain A. A. Gibson, U. S. A., commanding at Fort Delaware, and duplicates of all the sheets of work from Newcastle to Reedy Point were sent to General Totten, chief of the corps of engineers, who has specially acknowledged the importance of the developments. The original sheet of 1861 and duplicates of the sounding and tidal registers have been filed in the office.

A comparative chart of the Delaware river, between Newcastle and Reedy Point, was made in the office last spring, to represent, together, the hydrographic surveys of 1841 and 1861. This sheet exhibits great and important changes that have occurred within the space of twenty years. Their nature was clearly stated in a special report made by Assistant Davidson soon after closing his survey. The changes appeared of such moment to the commerce of Philadelphia that I placed the map before the Board of Trade, and, at their request, Mr. Davidson gave the members full and clear oral explanations in regard to the alterations that had taken place, and of the importance of the developments which are yet in progress. Resolutions were passed by the board thanking him for the statements.

Assistant Davidson was occupied during the summer with a party in Section VI, to the operations of which allusion will be made further on in this report. In the autumn he executed levellings at League island and Red Bank for the use of the navy yard commission, and made himself useful, besides, by his special knowledge of localities.

Magnetic observations.—In some of my previous annual reports charts have been given showing approximately the direction of the lines of equal magnetic variation traced seaward and inland from stations along the coast at which the elements have been from time to time well determined. Those alluded to may be found in the report for 1856, Sketch No. 61, and in that for 1861, Sketch No. 30, and they show the present state of our knowledge on the subject.

With a view to greater precision in the direction of the lines given for the coast of the middle States, in which I had personally determined the magnetic elements in 1840–'41, Assistant C. A. Schott was directed to reoccupy seven of the stations in July and August of the present year. The observations at the coast stations were made at the expense of the Coast Survey, and those of the interior ones at the cost of the Smithsonian Institution. Mr. Schott commenced at Harrisburg, Pa., and on the 28th and 29th of July determined the declination, dip, and horizontal intensity of the magnetic needle in the grounds of the State capitol. Proceeding westward he made similar observations on the 31st at the position which I had previously used, on the national road, about five miles east of Brownsville, in Fayette county. At Erie, Pa., the elements were determined in like manner, on the 6th and 7th of August, on Seventh street near French. At Bath, N. Y., the station in the public park, opposite to the post-office, was occupied in the same way on the 11th; and on the 13th of August the position near Dickinson seminary, in the borough of Williamsport, Lycoming county, Pa. Two stations in the grounds of the Girard college, Philadelphia, were occupied on the 15th and 16th of August.

The observations at each of the places comprised: for declination, three sets to ascertain the time and azimuth, of six readings each, and frequent readings of the scale of the declination magnet, continued for several hours.

For the magnetic dip two sets of observations were recorded from two needles, and the same number with the polarity reversed.

The intensity was ascertained by two sets of vibrations and two sets of deflections. Six sets of observations were made in determining the time of one hundred and fifty vibrations.

For all three of the magnetic elements the various processes, either in full or in part, were repeated, so as to have one set of observations recorded in the forenoon and the second set in the afternoon.

The instruments used were magnetometer, No. 3; the Barrow Dip Circle, No. 8; and mean time chronometer, Hutton 211. Determinations of the instrumental constants and also of the magnetic elements were made at Washington, further notice of which will be seen under the head of Section III.

Taking into account the interval of time between the series of observations in 1840–'41 and that of the present season, it is reasonable to expect that comparison of the results will give much information in regard to the secular change of the magnetic elements. The discussion of the observations is nearly completed, at my own expense, and will probably be published in the Smithsonian Contributions to Knowledge.

Assistant Schott was accompanied by Mr. P. H. Donegan, who recorded the observations and duplicated the registers. Both sets, as well as the detailed computations, have been placed in the office. The results found are given, in tabular form, in Appendix No. 18.

Tidal observations.—The permanent self-registering tide-gauge at Governor's island, in New York harbor, has continued in operation during the year, under the charge of Mr. R. T. Bassett. Observations for comparison have also been made at the dock of the Atlantic Ferry Company, in Brooklyn.

I am indebted to the courtesy of the superintendent of the Union Ferry Company, who has replaced the small building which covered the tide-gauge at Brooklyn by a better one, after it had become necessary to remove the old structure for repairs to the wharf.

SECTION III.

FROM CAPE HENLOPEN TO CAPE HENRY, INCLUDING THE COAST OF PART OF DELAWARE, THE COAST OF MARYLAND, AND PART OF THE COAST OF VIRGINIA.—(SKETCH C, No. 13.)

All the work done in this section was in furtherance of military or naval operations, and under orders of the War and Navy Departments, through authorized officers. It will be described under the following heads:

1. Complete triangulation of the Potomac river from Blakistone island to Georgetown. This laid the basis for a chart of the Potomac, which was specially requested by the Navy Department.

2. The topographical survey of the immediate banks of the Potomac from Blakistone island to Washington city. All the rebel works erected in 1861 are shown on the sheets of this survey.

3. A plane-table survey of Williamsport, Md., and of its environs, including the opposite bank of the Potomac, for the use of the sixth corps of the army of the Potomac.

4. Detailed topography, for military purposes, near Bladensburg, and in the vicinity of the northeastern part of the District of Columbia.

5. Topography of the vicinity of Fort Lincoln and other defensive works near the Capitol.

6. Additions to the details of the military map of Fairfax county, Va. These include the topography between Fort Marcy and Falls Church.

7. Minute survey, embracing the contour of ground about Manassas Junction, with the lines of rebel intrenchments, barracks, sites of ruins, roads, &c.

8. A plane-table survey of the ground opposite to Fredericksburg, Va., and mapped reconnaissance of roads leading from the Potomac to the Rappahannock river.

9. Surveys and reconnaissances for the army of the Potomac on the peninsula between the York and James rivers. The party assigned to this duty was actively employed during the whole of the campaign.

10. Verification of topography between Chincoteague bay and Pocomoke sound, across the northern part of Accomac county, Va. This work was done incidentally by a party assigned to make surveys for military purposes.

11. Topography of the middle part of Accomac county, Va., for the use of the army of occupation, stationed in the vicinity of Drummondtown.

12. Plane-table surveys, including the rebel works erected for the defence of the approaches to Norfolk, Va., and survey of the navy yard at Gosport, showing its condition when evacuated by the insurgents.

13. A hydrographic survey of the Potomac river, complete from the limit of former work near Blakistone island, to Indian Head, and from Alexandria up to Georgetown and to the Washington navy yard. The chart which this survey furnishes was specially called for by the Navy Department, to replace the hydrographic reconnaissance chart of last year.

14. Operations of the Coast Survey hydrographic party in York river and its tributaries, under the orders of the flag-officer of the north Atlantic blockading squadron.

15. Hydrography of Metomkin bar and inlet. Buoys were permanently set to mark the bar and entrance. This work was for the use of the army of occupation in eastern Virginia.

16. Magnetic observations at the station near the Coast Survey office, in Washington, D. C.

17. Tidal observations at the station near Fortress Monroe, Va.

OFFICE-WORK.—The engraving of coast chart No. 35, Chesapeake bay, (sheet No. 5,) from Pocomoke sound to York river, has been completed; progress has been made in the engraving of coast chart No. 36, Chesapeake bay, (sheet No. 6,) mouth of York river to entrance of bay; and of Patuxent river, lower sheet, as a finished chart. The drawing of the Potomac river chart in four sheets, and the engraving of general coast chart No. IV, Cape May to Currituck sound, and of Potomac river, (sheet No. 3,) from Lower Cedar Point to Indian Head, have been commenced. Additions have been made to coast charts No. 31, head of Chesapeake bay to Magothy river; No. 32, Magothy to the Hudson river, Md.; No. 33, from the Hudson to the Potomac river; and to the progress sketch of the section. The following preliminary charts and maps have been lithographed and issued to meet the immediate wants of the public service, viz: Atlantic coast, from Chesapeake entrance to Ocracoke inlet; Chincoteague bay; Hampton roads; James river, up to City Point, (new edition;) reconnaissance of Pamunkey and Mattapony rivers; Potomac river, up to Georgetown, in four sheets; road map of District of Columbia; plan of wharves at Alexandria; military reconnaissance map of southeastern Virginia; and a general map of Virginia, in colors.

Triangulation of the Potomac river.—At the end of the surveying season of 1860 this work had reached Blackistone island, (see Sketch No. 13.) where its further progress from the entrance of the river was stopped for a year by the hostilities which broke out in the spring of 1861. In order to meet the demand consequent upon the war, a rapid hydrographic reconnaissance was ordered at once, the particulars of which were stated in my report of last year. The resulting sketch was much in demand during the ensuing twelve months, and was largely distributed for the use of the navy.

On the opening of the spring campaign of 1862 special request was made by the Navy Department for a minute hydrographic survey of the Potomac, and steps were at once taken for resuming the triangulation at Blackistone island. By the authority of the Hon. Secretary of the Treasury, Professor Fairman Rogers, of Philadelphia, was made acting Assistant in the Coast Survey, and was put in charge of the general field and office arrangements of this survey. Sub-Assistants F. P. Webber and Charles Ferguson were assigned to assist in the preliminary work, and competent topographers were detailed to make the plane-table survey, as will be stated at more length presently.

A reconnaissance was made by Professor Rogers early in May, and a preliminary base line of 1.188 metres measured by him at the west side of the mouth of Port Tobacco river, with the slide contact wires Nos. 5 and 6. From the stations at the ends of the base the triangulation was extended down the river to Blackistone Island light, and from the base up the river as far as Occoquan, by the 19th of June, when Professor Rogers was called away by other duties and relinquished the service, which, it is here in place to remark, he had undertaken to prosecute for a limited period as a volunteer. At the date mentioned the very considerable stretch of sixty miles of the course of the Potomac had been triangulated, and the topographical survey, which was commenced soon after the triangulation, was in progress.

On the 19th of Ju y the triangulation was resumed at Occoquan by Mr. Charles Hosmer, and in the following thirty days was pushed quite up to Georgetown, and to a connexion with the triangulation of part of the District of Columbia, made by himself and by Sub-Assistant Ferguson in the winter of 1861–'62.

In the me surement of the preliminary base Professor Rogers was assisted by Messrs. Longfellow and Halter, of the topographical party.

The statistics of the triangulation of the river from Blackistone island to Georgetown are as follows:

Signals erected	70
Stations occupied	68
Angles measured	353
Number of observations	6,456

One hundred and nine points were determined for the use of the plane-table parties.

In the work below Occoquan three theodolites were used, viz: the Gambey ten-inch, No. 82; the Würdemann eight-inch, No. 86; and the six-inch Brunner, No. 64. The angles above Occoquan were measured with the six-inch Gambey, No 65.

Professor Rogers bears testimony to the cordial disposition manifested by the officers on duty at the Washington navy yard to assist him in the work by all means in their power. For the reconnaissance the steamer Powell was lent by Lieutenant Commander Wyman.

Sub-Assistants Webber and Ferguson, who had worked assiduously in the triangulation of the Potomac, took up field duty in Section I early in July.

The theodolite stations used for the survey of the Potomac were marked by small wooden posts, and those below Occoquan were set in hydraulic cement.

Topography of the Potomac river.—The full provision made for this work has been referred to in a previous notice in this chapter. Four experienced topographers—Assistants H. L. Whiting and A. W. Longfellow, with Sub-Assistants John Mechan and R. E. Halter—were assigned for the survey. Two schooners were furnished for the use of the parties. Soon after the work commenced Mr. Charles Hosmer replaced Sub-Assistant Halter, who had been taken ill. The topography was begun on the 19th of May. Eleven plane-table sheets were turned in by the 25th of June. Of these one was executed by Mr. Whiting, showing the Virginia shore of the Potomac from Persimmon Point to Metomkin Point, and, on the Maryland side opposite, the shores of Port Tobacco river. Four sheets were turned in by Mr. Longfellow, containing surveys of the Maryland shore from Swan Point to the "Trunk," above Pasquehanna creek; also from Upper Cedar Point to Smith's Point, and from Budd's Ferry to Indian Head. Mr. Mechan returned three sheets, giving the Virginia shore from Lone Locust Point to Persimmon Point; also from Metomkin Point to Aquia creek, and from Quantico creek to High Point, including also the mouth of the Occoquan river. A fourth sheet sent in by him contains the shore-line survey of Nanjemoy river, on the Maryland side. Mr. Hosmer traced the Maryland shore from Cob Point to Swan Point, and, on a second sheet, the Virginia side from Aquia creek to Quantico creek.

The length of river-course included in the sheets above referred to is about sixty miles, and the aggregate of shore-line traced was one hundred and twenty-nine miles. The mouths of the principal creeks which empty into the Potomac were followed, and careful surveys were made of the immediate sites of all the rebel batteries that had been erected on the Virginia shore of the river during the year 1861.

Mr. Hosmer, after completing the triangulation of the Potomac between Indian Head and Georgetown, as mentioned in a previous notice, took up and completed the survey of the remaining thirty miles of shore-line, closing the topography on the 30th of August, on the plan adopted for the sheets below Occoquan.

The lateness of the season and restriction in time making it impracticable to take in the usual breadth of shore, so as to permit the issue of a full chart of the river this year, the plane-table survey of the immediate shores only was executed. The total of shore-line traced by the parties is one hundred and fifty-nine miles.

Mr. Hosmer's closing work in August joins near Mount Vernon with a reconnaissance made in the previous year by Sub-Assistant Mechan. On the Maryland side he traced twenty-one miles of shore above Indian Head.

Before the close of August a chart of the Potomac was issued in three sheets, showing the banks and channel, the buoys and lights, and the sailing lines, from the entrance of the river to the mouth of the Occoquan. The fourth sheet, making the chart of the river complete to Georgetown, was issued in September. These contain the preliminary soundings determined by the reconnaissance made in 1861. I will state further on, the details of hydrography, done on the basis of the recent plane-table surveys.

The topographers who worked on the lower part of the Potomac were in June assigned to duty in Sections I and II.

Plane-table surveys at Williamsport, Md.—This work was done at the request of Major General Franklin, who occupied the vicinity of Williamsport in October with the sixth corps of the army of the Potomac. Mr. Charles Hosmer was detailed to execute the required topography on the 2d of October, and on the 15th was joined by Mr. F. A. Lueber. The principal roads leading out of the town towards Hancock, Hagerstown, and Sharpsburg were, respectively, traced to the distance of three miles. At the end of the month the party was further increased by the assignment of Sub-Assistant John Mechan and Mr. W. W. Harding, and in the course of the first week of November the ground around Williamsport was surveyed in detail. The working sheets show the general contour of surface of about fifteen square miles, with about five miles of the course and banks of the Potomac at Williamsport.

Mr. Hosmer moved at the end of October with the corps of General Franklin into Virginia, and continued reconnaissance duty. He has since received instructions to report to Major General Banks for special topographical service on the coast of Texas, for which his local knowledge promises great usefulness.

The previous duty of the parties employed with the sixth corps will be stated in other parts of this chapter. Mr. Harding had passed the greater part of the working season in Section V, as will be mentioned under that head.

Sub-Assistant Mechan remained near Williamsport until the 14th of November, and completed the survey of the environs. He forwarded the topographical sheet to the office, and then was placed under orders for duty with the army division of General Franklin.

Topographical survey near Bladensburg, Md.—A map of the country lying just outside of the District of Columbia, and north and east of Bladensburg, was commenced in the middle of October by Sub-Assistant C. M. Bache. This, like similar work done last year, was under the immediate direction of Lieutenant Colonel J. N. Macomb, of the topographical engineers. Details of hands and means of transportation were furnished by the military department. Mr. Bache is still engaged with the plane-table in the vicinity of the northeastern corner of the District, and has already mapped about five square miles of area, within which over twenty-five miles of roads have been traced and nearly four miles of water-course. The tract on which he is employed will probably occupy the party until the end of November. His map, like others of the environs of Washington of which mention will be made, shows the contour of the ground and the surface details generally.

Mr. T. C. Bowie has been assigned to duty in this party.

Topography near the military defences of Washington.—At the request of General Barnard, U. S. Engineers, Sub-Assistant J. G. Oltmanns was detailed in the latter part of September to make close topographical surveys of the sites and surroundings of Fort Lincoln and other defensive works to the north and east of the city of Washington. Mr. Oltmanns commenced work and for a short period prosecuted it, under the immediate direction of General Barnard. He was, however, soon compelled to close field duty, not having sufficiently recovered from the effects of a rifle-shot by which he was wounded in the lungs while engaged in Section VIII. Being still anxious for such field service as he might find practicable in a climate milder than that of this section, he has been directed to report for general duty on the southwestern coast, in the performance of which he will be under the immediate orders of Major General Banks.

Topography of Fairfax county, Va.—This work was additional to extensive plane-table surveys made last year of the entire ground which was occupied by the army of the Potomac. As stated in my last annual report, the topography was executed under the direction of Lieutenant Colonel J. N. Macomb, then chief topographical engineer of that army. The maps made and photographed last summer at the office showed a vacant space of several square miles, corresponding to ground which was then occupied by the enemy, to the north and east of Falls Church. The topography along the Potomac shows on the same sheets a breadth of only a mile and a half between Fort Marcy and Bailey's Cross-roads.

On the 4th of October, and after the completion of much service of the same kind, which will be stated in geographical order in this section, the survey of the ground alluded to was commenced by Mr. T. W. Robbins. Details of men and facilities for transportation were furnished, as before, by Colonel Macomb. Points requisite for the topographical adjustment were supplied from the office.

From Falls Church Mr. Robbins extended the survey towards Lewinsville as far as was deemed needful by Colonel Macomb, and then along the District line, taking in a breadth of three miles and including Minor's hill and its vicinity. Late in October the party moved to the neighborhood of Fort Marcy, and at the date of this report is engaged in prosecuting the survey in the vicinity of Langley and towards Lewinsville.

This work, as before stated, is in full detail, and adapted to all the requirements of military operations or defence. The roads, bridle paths, and contour of the ground are shown, as was done by the plane-table parties which worked in Fairfax county last year.

Topography of Manassas junction, Va.—After the evacuation of this important position by the rebel army in March last, Assistant H. L. Whiting was directed to make a minute plane-table survey, so as to meet any possible military contingencies that might arise in the future. He proceeded, as in making similar surveys in the section, under the special order of Colonel J. N. Macomb, chief of topographical engineers. Sub-Assistant C. M. Bache assisted Mr. Whiting in this duty, and details of men for the work were made from the 88th Pennsylvania and 101st regiment of New York volunteers. The survey was begun on the 27th of March, and embraced the contour of a belt a mile in breadth, mostly on the south side of the Orange and Alexandria railroad. Three miles of the track to Alexandria, and nearly as much of the branch leading from the junction towards Centreville, with the wagon roads and numerous intersecting tracks, were traced and carefully mapped. The contour lines were drawn in for successive elevations of ten feet. All the intrenchments were sketched in position, including an extensive detached work, about two miles east of the junction; also the positions of the ruined structures at the junction, and the extensive barracks found at three points on the south side of the railroad.

The map of the locality was drawn on a large scale, and was at once photographed at the office, so as to meet possible requirements.

This work occupied the party until the 6th of May. Mr. Whiting left Manassas a few days before, for field service on the shores of the Potomac, and was afterwards employed in Sections I and II. Sub-Assistant Bache at once took up topographical duty for the army of the Rappahannock.

Topographical service on the Rappahannock river, Va.—The advantage, for transportation and other military uses, of correct maps of the ground occupied by his army had been fully appreciated by Major General McDowell in the campaign of 1861. At his request, which was made known to me through Colonel J. N. Macomb, A. D. C. and chief of topographical engineers in the army of the Rappahannock, the services of Coast Survey topographers were continued after the arrival of the staff at Fredericksburg, Va. Sub-Assistant C. M. Bache and Mr. T. W. Robbins, being assigned to duty, reached headquarters on the 9th of May, and reported to Colonel Macomb. On the 12th a general topographical reconnaissance was made; the stations used in the survey of the Rappahannock in 1853 were visited, and means were taken for connecting the new work with the points then determined.

The centre line and grades, requisite as data in the reconstruction of the railroad bridge across the river, were furnished by the party, as were also the points for locating a side track to lead from the main line to the foundry, near the middle of the city of Fredericksburg.

On the 26th, direction was given by Colonel Macomb for a survey from the right bank of the Rappahannock below the city, the topographers to report to Brigadier General King, the staff officers having been recalled to meet at Manassas. The working force necessary to the efficiency of the two parties was detailed by General King, and, after consultation with General McCall, the railroad was understood as the line on which the working parties should join, Sub-Assistant Bache intending to take the tract west of it, and Mr. Robbins that lying eastward. This service, however, was soon deemed too hazardous, in the judgment of the military governor, Brigadier General Reynolds, the pickets on the south side of the river having been driven in on the 30th of May. The parties were accordingly removed to the north bank, and commenced work, one opposite to Fredericksburg and the other near Falmouth, on the 2d of June. Field-work with the plane-table, compass, and chain was continued by both parties until the 7th of July. The contour of the ground and all details, as roads, streams, &c., of importance for defensive purposes, on the left bank of the Rappahannock, were mapped on two sheets, which show the country from Falmouth to a point nearly a mile below the railroad bridge, and several miles back from the river, towards Aquia creek and Potomac creek. On a third sheet Mr. Robbins traced in from reconnaissance the line and topography of the main road from Fredericksburg to Belle Plain, at the mouth of Potomac creek, and, from a point higher up that stream, the Fredericksburg railroad and the main wagon road to a junction with the survey of Sub-Assistant Bache, near the head of Claiborne's creek.

The details of men required for this work were furnished by Brigadier General Augur, from the 24th regiment New York volunteers.

As soon as practicable after their completion the plane-table sheets were inked and turned in at the office in Washington. The results were there reduced in scale and combined at once into a single map, of which, at the request of Colonel Macomb, copies were made by the photographic process and furnished to him for the use of the army. An area of about ten square miles is represented by the map, exclusive of the lines of road which connect the environs of Fredericksburg with the waters of the Potomac.

After inking his sheet Sub-Assistant Bache was assigned to plane-table duty in Section II; but, a call having reached me very soon after for topographical service in another division of the army, himself and Mr. Robbins were recalled, and held subject for duty in any emergency that might arise.

Topographical service between York and James rivers, Va.—Mention was made in my last annual report of the connexion of Coast Survey parties with the army of the Potomac, in the summer of 1861, in the vicinity of Washington. The high testimony then given by the military authorities as to their usefulness led to the assignment of Sub-Assistant F. W. Dorr and Mr. J. W. Donn for special field duty in the campaign which was begun in March last by Major General McClellan. In order to secure conformity to all the requirements of the military department, the services of Mr. Dorr and Mr. Donn were placed at the disposal of Brigadier General A. A. Humphreys, chief of topographical engineers in the army of the Potomac, to whom the two topographers reported for duty on the 20th of March.

On the way to Fortress Monroe the party engaged in the compilation of a map of the peninsula between York and James rivers, and completed it several days after their arrival at the fortress on the 8th of April.

The next duty assigned and executed was a plane-table survey of the road and adjoining country from Half-way House to headquarters, or within five miles of Yorktown. Subsequently the survey was extended to the outer lines of the army when distant only about three-quarters of a mile from the rebel intrenchments. The positions of important points were determined from a base of which one end rested at the building known as the "White House," the other end being the furthest point reached in the survey of the main road. Besides these, determinations were made of prominent houses lower down, on the river shore. The positions thus ascertained sufficed for connecting the work with the topographical survey of the shore of York river made in 1857 by Assistant Seib.

On the 15th and 16th of April, Messrs. Dorr and Donn surveyed the Warwick road, from Harward's mill to Warwick Court-House, and connected their work with a plane-table survey, made from the Court-House to Lee's mill, by Sub-Assistant P. C. F. West, who was then on furlough from the Coast Survey and serving as aid to Brigadier General W. F. Smith. On the following day, while Mr. Dorr was connecting Mr. West's survey with that of the main road, his plane-table was struck by a shell from a rebel battery near Wynn's mill and entirely destroyed, together with a part of the working sheet. The part, however, on which were represented the positions of the batteries and the desired connexion was fortunately uninjured. Lieutenant Orlando G. Wagner, of the topographical engineers, standing near by at the time, was mortally wounded, as was also one of the soldiers, Private Jerry Luther, of the second Rhode Island regiment, attached to the surveying party. One of the pickets was killed outright and several were wounded. The alhidade was blown from Mr. Dorr's hand and the sleeve of his coat torn away, but he received no personal injury except a slight scratch on the hand. He resumed the survey at once with a compass and chain, and completed it from York river to Lee's mill and Warwick Court-House on the 18th of April.

Another plane-table, to supply the place of the one destroyed, having been promptly forwarded from the office by request of General McClellan, Mr. Dorr carefully surveyed Wormley's creek and its branches, making a junction with the survey of Mr. Seib, previously referred to, as well as with his own surveys. That work was closed just previous to the evacuation of Yorktown. A short interval before had been employed in making tracings from the completed surveys, for military use.

After the retreat of the enemy up the peninsula, Sub-Assistant Dorr surveyed the works which had been erected by the insurgents between the main road and Lee's mill, and that service was not quite complete when the party was ordered to move on after the army. Sub-Assistant West had made a careful plane-table survey of the battle field of Williamsburg, to accompany a report of the battle, by Brigadier General Smith. Three miles west of the town that survey was again taken up on the 10th of May, and continued by the party uninterruptedly to New Kent Court-House, including also the road leading thence nearly to Eltham, and that to Cumberland on the Pamunkey river. Mr. Dorr reached "White House," on the Pamunkey, on the 16th of May. Mr. Donn next day surveyed the wagon road and line of railroad leading out from that point westward, as far as Tunstall's Station. On the 18th a general reconnaissance was ordered by various routes to the Chickahominy river. The line of railroad and country adjacent to it were allotted to the party of Mr. Dorr. By nightfall he had advanced seven miles, and had sketched a belt of about a mile in breadth. The reconnaissance was pushed forward to the railroad bridge across the Chickahominy, and its condition was reported. Returning, the road was run which leads from Turner's mill southward to Baltimore Cross-roads, a point on the main road passing from New Kent Court-House to Bottom's bridge.

Immediately after the movement of the army to the Chickahominy, which took place on the 21st and and 22d of May, Mr. Dorr surveyed the road from Despatch Station to Coal Harbor, sketching in the topographical features between the road and the river, and making careful examinations with reference to suitable positions for bridges. His survey was then connected near Dr. Gaines's house with plane-table work by Sub-Assistant West, which took in details between the same road and the river, but higher up, and to a point within three miles of Mechanicsville. All the roads diverging from Mechanicsville, excepting the one which leads to Meadows's bridge, were run by Messrs. Dorr and Donn, and contour lines of twenty feet elevation were traced around the village and to the distance of several miles in all directions.

Sub-Assistant Dorr mapped the vicinity of the railroad, from the Chickahominy to Fair Oaks Station, on the 28th of May, and then surveyed the Williamsburg road from Savage Station westward to the outer line of pickets. Mr. West at the same time made a plane-table survey of the west bank of the Chickahominy, between Sumner's upper bridge and the upper trestle bridge. Contour lines also were run with great care by the party for each ten feet of elevation of most of the ground in front of General Sumner's position. The road from Tyler's house to Savage Station, across Sumner's lower bridge, was traced and mapped by Mr. Donn.

South of the railroad and west of the Chickahominy the ground generally, including the minor roads near Fair Oaks and the various roads leading to the White Oak Swamp, were examined and traced by the party of Mr. Dorr.

When the flank movement of the army had been decided on in the latter part of June, the party was ordered to examine all the roads branching from the Williamsburg stage road in the direction of the swamp. This was promptly done, and of a number examined and reported on, one practicable route, in addition to the one in previous use, was found. Near midnight of the 28th of June, Messrs. Dorr and Donn were detailed as guides for General Sykes's division, which had been ordered to pass through to the James river. The intense darkness and heavy rain made the service somewhat difficult, but the entrance of the road was soon found, and the division reached Woodbury's Ford early on the following morning.

Mr. Donn returned to the Coast Survey office on the 3d of July, and near the end of that month joined the party of Assistant Whiting in Section II.

Sub-Assistant Dorr remained with the army and made a survey of the ground of occupation in the vicinity of Harrison's Landing, on the James river. He was detached from duty with the army on the 14th of July, and reported at the office on the following day. During the autumn he executed a field reconnaissance and made a map of the environs of Portland, Me., for military defence, which has been more fully referred to under the head of Section I. He is now under orders for duty in Section VI.

Verification of topography.—Assistant A. M. Harrison ran a line with the plane-table for connecting the survey of Chincoteague bay with that of Pocomoke sound, across the northern part of Accomac county, after the completion of work which will be referred to further on in this chapter. "The line was started at Snead Station on Chincoteague bay, (see Sketch No. 13,) with two other triangulation points, for obtaining a correct position, and then a series of courses was run in the same general direction with the plane-table and chain for a distance of 15.41 miles, to the head of Pocomoke sound, which had been surveyed by Assistant Seib." The number of courses was forty, the longest being nearly a mile and the shortest about a hundred and fifty yards in length. The station marks on the Chesapeake side being lost, made it impracticable to connect the two surveys at any intermediate point, without triangulation, or to verify the topographical survey which had been carried nearly across the head of the peninsula in the vicinity of the boundary line, in the surveying season of 1859–'60.

On closing with the Chesapeake shore-line, Assistant Harrison found a difference of fifty metres, which may properly be regarded as due to the error of the plane-table, when worked without occasional reference to points of triangulation as checks.

Mr. Charles Hosmer, who had completed an extensive survey for military purposes, aided Mr. Harrison in this duty. Mr. H. W. Bache was attached to his party as aid, and was employed in this and other duty in the section.

Topography of Accomac county, Va.—At the request of Major General Dix, a party, in charge of Mr. Charles Hosmer, was assigned in December, 1861, for the survey of the vicinity of Drummondtown, that part of Accomac county being then occupied by United States forces under Brigadier General Lockwood, as was stated in my last annual report. Mr. Hosmer, aided by Mr. F. A. Lueber, commenced, on the 17th of December, a survey (see Sketch No. 13) which joins on the east with one of the topographical sheets of the Atlantic coast, and on the west with a sheet of the survey of Chesapeake bay. All the roads, woods, and other surface features within a breadth of about eight miles north and south, and passing quite across the middle of the county, were mapped.

Assistant A. M. Harrison, who had been, during the same period, employed in sounding out Metomkin bay and inlet, when that work was done, joined Mr. Hosmer with his own party, and assisted in the plane-table survey. Mr. Hosmer had previously assisted in the work at Metomkin bay, to which further allusion will be made in this chapter. The topographical survey was closed on the 21st of May.

From the sheet of the approaches to Drummondtown, including the soundings in Metomkin inlet, a careful tracing was made at the office and forwarded to Brigadier General Lockwood. The following are statistics of the topography:

Creeks, &c., surveyed	34 miles.
Roads	132 "
Area of country, (square miles)	51

For this survey General Lockwood made details of men from the second Delaware regiment, and, towards the close of the season, from the second regiment of Maryland volunteers. Means and facilities for transportation were supplied by Captain Tyler, brigade quartermaster, to whose courtesy and obliging disposition the working parties were much indebted.

Although generally level the country around Drummondtown is much intersected by roads, and these, with other features, present a large amount of detailed work on the topographical sheet.

After completing this survey, Mr. Hosmer assisted Mr. Harrison in revising the topography at the head of the peninsula, near the Virginia boundary line. The parties returned to the office in the latter part of May, and made immediate preparation for other field duty. During the summer Mr. Hosmer was employed on the shores of the Potomac.

Plane-table surveys near Norfolk and Portsmouth, Va.—An early opportunity was taken, after the possession of Norfolk was regained to the government, in May last, to trace on the original plane-table sheets of the Coast Survey the numerous batteries which had been erected in its vicinity by insurgents during the course of the previous year. This service was performed by Assistant A. M. Harrison, in June, the requisite facilities for working having been furnished by Major General Wool and Brigadier General Viele.

In the immediate vicinity of Elizabeth river the rebel forts and the entrenched camp on Sewell's Point were surveyed and mapped, as were also the fortifications on Craney island, besides thirteen, mostly of small size, at various points along the shores, and the Gosport navy yard, with a battery directly opposite to it on the river bank.

The survey of the navy yard was made on a large scale, to show its condition after the destruction of the buildings and shipping by the insurgents. Mr. Harrison says: "It presented a sad picture of devastation. Excepting the officers' quarters and one or two other buildings, all the edifices were burnt. The dry dock and the granite lumber dock were not materially injured, though an attempt had been made to blow up the masonry which held the gate hinges of the dry dock. The gates were destroyed."

Bastions which had been erected near the wall, to command the approaches to the navy yard from the south, were also surveyed, and the positions determined of the remains of several vessels of the navy which had been burnt in the harbor.

General Viele furnished a steam tug and hands to aid in making the surveys. Mr. Harrison mentions, also, his indebtedness to Lieut. S. Lee Perkins, 2d regiment New York volunteers, acting engineer to General Viele, for sketches of several of the batteries on Elizabeth river.

The positions of two other intrenched camps, designed to guard the approaches to Norfolk from north or south, were marked on an engraved sketch, so as to admit of being transferred to the topographical sheets.

Mr. H. W. Bache and Mr. F. A. Lueber assisted in field duty in this section, and also accompanied Assistant Harrison when he resumed topographical work in Section I, in the latter part of July.

The special surveys made by the party in the vicinity of Norfolk are on two sheets containing the details of the numerous intrenchments. Their positions have been laid down on the original topographical sheets of the survey of 1854. All of these are now on file in the office.

Hydrography of the Potomac river.—The hydrographic reconnaissance which was made last year in order to meet the exigencies of the naval and military service, and which was then reported on, has been replaced by a thorough survey of the greater part of the Potomac below Georgetown.

Lieutenant Commander T. S. Phelps, U. S. N., Assistant Coast Survey, with a party in the steamer Corwin, took up the regular hydrography on the 29th of July. Abreast of Britton's bay and St. Clement's bay (Sketch No. 13) he joined work with the soundings which had been made in 1860, and thence upwards extended the hydrography towards Indian Head. At the Kettlebottom shoals the soundings were made more than usually close, no proper channel having been developed by sounding in the ordinary way.

The triangulation and plane-table survey on which the hydrography of the Potomac was based has been noticed already in the beginning of this chapter. Lieut. Commander Phelps is still at work, and expects to complete the hydrography up to Indian Head by the close of the year. The following are the statistics of work at the present time:

Miles run in sounding	1,668
Angles measured	7,190
Number of soundings	109,794

The tides were observed at six stations. About six hundred and fifty miles were run in sounding at the Kettlebottoms alone.

Special service in which the party in the Corwin was employed during the spring will be referred to presently. Mr. Charles Junken aided in the hydrography, and plotted the chart of the lower Potomac. The results will be transferred to the sheets of the preliminary chart which was at first issued with the soundings given by the reconnaissance.

During such intervals as the duties of the office would permit, the Potomac, between Alexandria and the aqueduct at Georgetown, was carefully sounded by Captain C. P. Patterson, chief of the Hydrographic Division. He was aided, until the 11th of July, by Mr. L. Karcher, having commenced work on the 27th of May. The course of the Eastern branch and the channel passing to the navy yard are included in this survey.

After closing work, which was done at the end of August, the soundings were plotted for the upper sheet of the chart of the Potomac.

Tidal observations were made as usual while the hydrography was in progress.

The following are statistics of the work above Alexandria:

Miles run in sounding	205
Stations determined	43
Angles measured	1,342
Number of soundings	21,735

Operations of the hydrographic party in York river, Va.—At the opening of the campaign on the Peninsula, between York river and James river, the steamer Corwin, with the hydrographic party under Lieut. Comdr. Phelps, was so placed as to pass at once under the orders of Commodore (now Admiral) Goldsborough, if the exigencies of the naval or military service should so require. In the progress of the siege of Yorktown, in which the Corwin engaged as one of the flotilla, it was perceived, on the morning of the 4th of May, that the intrenchments had been abandoned by the enemy. Lieut. Comdr. Phelps at once reported the fact to the flag-ship, and was directed to start up York river in company with the steamer Currituck. Near Queen's creek a company of rebel cavalry was dispersed by shells from the Corwin, and a schooner, a sloop, and a launch were captured within a run of thirteen miles above Yorktown, with military stores and personal effects of officers.

Being so directed, the steamer joined the United States gunboat Chocura, which was then passing up, on a reconnaissance towards the head of the river. West Point was found unoccupied, though fifty prisoners from civil life had been left there by the enemy, in wretched condition and without necessary subsistence. Efforts had been made to burn the lumber stored there, and the Corwin, in consequence, remained to prevent further destruction.

A few hours before reaching West Point the party had captured a second schooner, above Bigler's wharf, and next day took possession of a third, and of the sloop Water Witch, which had been abandoned in the Pamunkey river. Much information was gained by Lieut. Comdr. Phelps respecting the movements of the rebel forces, and at once transmitted to the proper quarter.

At this time the hostile garrison which had occupied Gloucester Point was known to be retreating up the east side of York river. To cover the possibility of an attempt to pass through West Point, Lieut. Comdr. Phelps, under direction of the naval authorities, anchored near the ship-yard, on the night of the 6th, so as to command the approaches to the town. Learning, next morning, that previous measures had diverted the retreat to the east side of the Mattaponi, the Corwin started up that river, and by 3 p. m. had gone thirty-six miles above West Point, learning on the way, however, that the rebel force had crossed during the night. In the evening the steamer returned to her anchorage at the ship-yard, and by throwing shells during the night prevented the burning of the timber there by a party which had destroyed all the other public property in store.

Under permission of the senior naval officer, the party of the Corwin disabled Trice's mill, in King and Queen county, which was at work for the rebel army, leaving it, however, capable of being run for the use of the neighboring inhabitants. The party took, at the same time, three teams laden with flour, which were on their way to the rebel troops at Dunkirk.

On the departure of the senior naval officer, Commander William Smith, on the 15th of May, for the James river, Lieut. Comdr. Phelps was left in charge to protect the government property which was then accumulating at West Point and in the Pamunkey river. During this period of duty the Corwin retook several items of government property, amongst others twelve mail bags which had been the property of the United States Post Office Department, and recovered the gun of a rebel boat that had been burnt by her crew, on the 4th of May, to escape capture by the steamer.

On the 14th of June the schooner Starlight was seized by a party from the Corwin, in the Potopotank river, and sent to the fleet, the fact being made clear that her owner was then serving as lieutenant in the insurgent army at Richmond. Others had been detained, and, after due process, released. The Corwin had, just previously, made another trip up the Mattaponi, in which all was found quiet.

In the afternoon of the 21st of June the third officer of the Corwin, Mr. E. L. Taylor, was sent, with a boat's crew, to King and Queen county, and found, in mail matter which was taken in its passage between Caroline county and Richmond, intimation that strong re-enforcements had reached the rebel army on the 11th of that month. The letter containing it was immediately sent to General McClellan.

Lieut. Comdr. Phelps remained at West Point until the evening of the 1st of July, and then, in conformity with orders, dropped down to Yorktown. Before doing so, he turned back the steam transport Philadelphia, which, having passed up the river in the night with horses, had so missed notice of the evacuation of the depot on the Pamunkey.

In the course of his service in the vicinity of West Point, Lieut. Comdr. Phelps made and sent to the office a reconnaissance map of the Mattaponi river as far up as the junction of the Mantapike, and also of the course of the Pumunkey river, from West Point to the military station at White House.

On the 13th of July orders were received from the Hon. Secretary of the Navy, in accordance with which the Corwin returned to Washington, and was afterwards employed in the duty which has been referred to under the previous head.

Hydrography of Metomkin inlet and bay, Va.—This work was ordered for the use of Brigadier General Lockwood, the depth and position of the bar and course of the channel from the inlet to the public wharf on Folly creek being necessary in the water communication with his command at Drummondtown. The inlet had been surveyed in 1852, but, the character of the changes being unknown, commissary stores for the troops had been landed at Pungoteague after its occupation, and from thence carted fifteen miles. After the survey by Assistant Harrison, which will now be referred to, the stores were taken by the most direct way to the military station.

Mr. Harrison commenced the resurvey in January, and met with unusually stormy weather, which much retarded the work. He found no noticeable change in depth at Metomkin inlet, though the bar itself had shifted. Considerable changes had taken place in the shore-line. In reference to the alterations he says:

"The beach just inside of the northern point at the entrance of the inlet has washed away as much as one hundred and fifty metres; the entrance has widened; and the outer shore below the entrance has at one point been swept away for a breadth of more than three hundred metres."

Details of men from the 2d Delaware and 2d Maryland regiments, and means for transportation, were furnished by General Lockwood.

On the 6th of April Mr. Harrison placed a can buoy on the bar, with such means for security as were then available, but this was swept away a few days after by an unusually severe northeast storm. Two others, with sufficient chain, were afterwards procured at Chincoteague island. One of them, "a spar buoy, thirty feet long, painted red," was placed on the bar about a mile seaward from the entrance; and the other, "a second class can buoy, painted black and white," near mid-channel, about half a mile outside of the mouth of the inlet, and as much inside of the bar.

After completing the hydrography Mr. Harrison's party joined that of Mr. Hosmer, and assisted in the plane-table survey near Drummondtown. A tracing combining the results of both surveys has been furnished to General Lockwood.

Mr. H. W. Bache served as aid in the party of Assistant Harrison.

After the completion of the hydrographic sheet the party was assigned to topographical duty in the vicinity of the boundary line between Maryland and Virginia, of which notice has been taken in this chapter, and, later in the summer, in the neighborhood of Norfolk. Mr. Harrison has been subsequently engaged in Section I, and now has charge of the Drawing Division, at the office in Washington.

Magnetic observations.—Before taking the field for the series of observations which has been described under the head of Section II, Assistant C. A. Schott determined at the station near the Coast Survey office the constants of the instruments intended to be used.

After his return to Washington Mr. Schott observed, as at the other stations of the present season, for the magnetic declination, dip, and horizontal intensity at the station near the office. The results found are included with those of Section II in Appendix No. 18.

The instruments employed and general order pursued in regard to the observations have been referred to in the preceding chapter.

Tidal observations.—The tidal observations at Old Point Comfort have been continued successfully by Mr. M. C. King throughout the year, notwithstanding the great liability to interruption last spring. A few intervals in the series, but of no great importance, were occasioned by the jarring of numerous transport steamers in bringing up at the wharf.

SECTION IV.

FROM CAPE HENRY TO CAPE FEAR, INCLUDING THE COAST OF PART OF VIRGINIA AND OF PART OF NORTH CAROLINA.—(SKETCH D, No. 21.)

The surveys made in Section IV were for the use and chiefly under orders from the chief of the military department of North Carolina and the flag-officer of the north Atlantic blockading squadron. They comprise the following:

1. Hydrographic survey and development of Oregon inlet, N. C., and buoying of the channel into Pamplico sound. Buoys placed to mark the Middle Ground, and reconnaissance for marking the channel of the Neuse river to a point above Newbern.

2. Physical survey of Hatteras inlet, N. C. This was directed by the commander-in-chief of the army, and was prosecuted with reference to the cause of encroachment on, and the devising of means for preserving, the site of the forts from further action by the waves of the sea.

3. Hydrographic resurvey of Beaufort harbor, N. C., determining important changes in depth and in the direction of the channels. The same party traced the altered shore-line of the entrance at Beaufort. This survey was made by special request of the Navy Department.

OFFICE-WORK.—The engraving of coast chart No. 37, Atlantic coast from Cape Henry to Currituck sound, has been commenced; and preliminary charts of Hatteras inlet (resurvey of 1861) and of Beaufort harbor N. C., (resurvey of 1862,) have been drawn and lithographed.

Hydrography of Hatteras and Oregon inlets, N. C., and special service in Pamplico sound.—My report of last year contained a notice of the hydrographic resurvey of Hatteras inlet and examination of the currents, intended to facilitate the naval operations which were in progress in the fall of 1861. The result was that the new chart of the inlet only made more apparent the natural difficulties of the passage. Tracings from it were furnished for the use of the second expedition, which was preparing in the winter, under the command of Major General Burnside and Commodore (now Admiral) Goldsborough, to move in the waters of Pamplico and Albemarle sounds; and, as intimated in my last report, a party, well acquainted with the localities, was assigned to accompany the expedition, in order to render such further service as might be needed.

Assistant A. S. Wadsworth joined the military expedition of Major General Burnside at Annapolis on the 8th of January, and reported at once to Brigadier General Foster. When the fleet arrived off Hatteras inlet the weather was bad; yet the local knowledge of Mr. Wadsworth was made effective in verifying the recorded soundings, and in piloting vessels of the expedition through the intricate channel of Hatteras inlet, and in keeping the channel buoyed. Though subject to rapid changes, the shoals near the entrance were found to have only slightly altered in contour since the careful survey made by Lieutenant Commander Phelps, in November, 1861.

Tracings from all the plane-table sheets of the vicinity of Roanoke island and other quarters on this part of the coast had been made at the office on the full scale, and supplied for the use of the military and naval commanders.

Mr. Wadsworth accompanied the joint expedition in the successful attack which was made early in February on the rebel forts and intrenched lines on Roanoke island, and after its occupation supplied tracings of the environs of the forts from the topographical sheets. Fortunately, the minute topographical survey of the island was almost complete when the war commenced, the instruments with which Sub-Assistant Mechan was working at its south end, to close the survey, being seized in the spring of 1861.

Having intimate local knowledge of the shores of Albemarle sound, Mr. Wadsworth also attended the detachment sent to Elizabeth City and to other points on its north side, and returned to Hatteras on the 11th of March. He accompanied the army in the expedition to Newbern, and there took charge of the schooner Bancroft, which had arrived on the 24th of March, with facilities for executing any special hydrography that might be needed in the military operations. The party in the schooner was employed until the 5th of April in setting stakes to mark the channel above Newbern, and on completing that service returned to Hatteras, where preparations were at once made for joining the party of Assistant Henry Mitchell, who had been specially assigned in March for the survey of Oregon inlet. This work was undertaken in the hope that a practicable channel might be found to shorten and facilitate the passage of small transports to Roanoke island.

Assistant Wadsworth erected the signals and assisted in measuring the requisite angles. Returning with the party to Hatteras inlet in the latter part of May, he went with it again to Newbern, and assisted in sounding the Middle Ground and in setting buoys. This service having been completed he returned to the inlet soon after, and reached Philadelphia with the Bancroft on the 14th of June.

In his report (Appendix No. 30) Assistant Mitchell gives details of his own operations, and refers to special work performed for the military authorities, which, however, lay quite within the scope of his instructions. This embraced a reconnaissance of a portion of the Neuse river and the buoying out of the Middle Ground.

Sailing directions were furnished for the use of the military department as soon as Oregon inlet was buoyed, which was done under the direction of Mr. Mitchell a few days after the arrival of his party. Tracings of the finished chart were sent at once to Major General Burnside and Commodore Goldsborough, the service being completed on the 20th of May.

The sounding out of the bar and seaward approaches of Oregon inlet was the work of only four days; but the survey of the Swash, where the winding channels are narrow and traversed by strong tidal drifts, proved a very slow and arduous undertaking. Assistant Mitchell says:

"Oregon inlet has worked to the southward since the plane-table survey of 1849, and as an avenue for commerce it has greatly deteriorated. The chart shows only six feet and a quarter over the bar at mean low tide, and the channel lies so close along the north beach that it can scarcely be regarded as safe for sailing vessels, even in the best weather."

The currents of this as of all other inlets connecting our inland sounds with the ocean are of the half-tidal class; that is, slack water occurs two or three hours before and after the high water stand, and the maximum flood and ebb drifts occur, respectively, at high and low waters.

The shallowest bulkheads of the Swash, as shown on the chart, are, by one channel, four and a quarter feet; by the other, three feet. Vessels, especially steamers, when under good headway, may force through these sand ridges with, perhaps, a foot greater draught. The recent continual passing of steamers over the Hatteras Swash has, I am informed, deepened its channel materially.

The steamer Albemarle, for the use of which Mr. Mitchell received an order from Commodore Goldsborough, having met with an accident just before his party reached Newbern, arrangements were made with Assistant Wadsworth by which the two parties were combined, as already stated, on board the schooner Bancroft. Special allusion is made by Assistant Mitchell to the cordial co-operation of Mr. Wadsworth.

Mr. Edward Cordell was attached to this party as hydrographic draughtsman, and was prompt and efficient in plotting the work and preparing the chart. Mr. C. P. Dillaway served as aid, and Messrs. Ames and Sengteller as observers.

Assistant Mitchell returned to the office at the end of May, leaving Mr. Wadsworth in charge of the vessel. He was subsequently employed in hydrographic duty in Section I.

Assistant Wadsworth remained at the office after his return in June. He died in Washington on the 9th of August.

In a letter addressed to me, dated "Headquarters Department of North Carolina, May 31, 1862," Major General Burnside says:

"I beg leave to express to you my high appreciation of the services of Mr. Henry Mitchell and party, of your department, at Oregon inlet and in the Neuse river. They have worked most faithfully, and given us very valuable charts, sailing directions, and general information."

Physical survey of Hatteras inlet, N. C.—In my report of last year I referred to the fact that I had, at the request of Major General McClellan, sent one of my assistants, Mr. Henry Mitchell, to inquire into the nature and causes of the encroachments of the sea upon Fort Hatteras, and the changes in the form of the inlet. Mr. Mitchell remained at and near Fort Hatteras until the 9th of January, when, having completed his observations and compiled his notes, he returned to the office. A short time after he furnished a full report upon the subjects of his mission, which I communicated to the War Department.

It may not be out of place to refer here to some of the more general inductions which this report contains. The long, narrow strip of sound which separates Pamplico sound from the ocean is spoken of as "a ridge made by the waves of the sea, which have disintegrated the borders of shallow flats and gradually elevated or heaped up that portion of the material which could not be dissolved or carried off by currents."

"The waves upon a beach are observed to make a selection among the earths with which they come in contact. The vegetable mould and light soils are washed out and borne away in the recoil of the sea and by littoral currents, while the gravel and coarse sands are left rolled up in ridges, near the highest reach of the rollers."

Examinations about Hatteras inlet seemed to show that at the depth of fifteen to eighteen feet below the low water plane the action of waves is not traceable, and that here the antecedent soil of the country may be found.

The report is very full upon the causes of inlets, and shows how dependent the depths of these avenues are upon the amount of outflow and the *angle at which this outflow encounters the waves of the sea.*

The tides and currents were carefully studied. "In small harbors and bays upon our coast the epochs of the tides and currents are coincident: that is, *slack* current occurs at the *stand* of the tide, at *high* water and at *low* water. But where the tide wave enters a narrow inlet, connecting with a great inland basin, the case is different. The basin, being nearly tideless, has its surface lying at about the mean level of the sea—that is at the half-tide plane—and it is upon this plane that the currents of the inlet must take the initiative. Flood currents can only commence to run in at the inlet when the surface of the ocean has risen above that of the basin; and ebb current must commence when the surface of the former falls below that of the latter. Moreover, the maximum velocities must occur when the greatest contrasts of heights between the ocean and sound obtain; that is at *high water* for the *flood* and at *low water* for the *ebb*. At Hatteras inlet the conditions described are in a great degree realized, although it would appear that the land waters which have accumulated in Pamplico sound have raised its surface somewhat above the half tide plane of the ocean, so that the flood current does not commence until three and a half hours after low water, and gives place to the outflow in less than three hours after high water.

"It is a well known paradox of Hatteras harbor that *if a tight vessel grounds on the Bulkhead at high* *water, during the strength of the flood current, she will 'cut off,' at low water, during the strength of the ebb drift.*"

An opportunity was offered Mr. Mitchell to examine into the character of quicksands of various kinds. He attributes the formation of the deeper class of quicksands to the "drifting of fine silicious dust into lagoons and slues during the prevalence of dry winds." The slues, which have been occasioned by violent storms, soon become bordered by dangerous quicksands as the wind-drifts encroach upon them. "*Sloughs* are sometimes caused by the escape of gases from the sands on the rise of the tide."

Among the diagrams accompanying this report there is one showing the variations of density and temperature of the water which occur at different stages of the tide. It was observed that during the *ebb* or *outflowing* current the water was continually freshening and falling in temperature, the least density and lowest temperature being recorded on the slack of the rising tide. On the other hand, the waters of the *flood* current came in warmer and denser, reaching their maxima on the slack of the falling tide. This warm water was evidently from the Gulf Stream. "I observed," says the report, "that the state of the atmosphere was much affected, especially at spring tides, by the currents; that it was sensibly more humid and mild during the *inflow* than during the *outflow*. A thermometer hanging on the outside of my quarters indicated the *changes* of the currents at the inlet.

The report contains specifications for building dikes and causeways, and some of the plans are new. In a locality like Hatteras, where material is limited both in quantity and variety, original methods of construction must be resorted to. Instead of using baskets of stones to protect the exterior slope of a dike, as in Holland, it is proposed to place a large number of cedar trees inclined against the fore shore slope, their butts to be loaded with pig iron, and to lie six or eight feet apart in a trench. These trees are to be connected by two parallel rows of chains, the lower chain securing the trunks, and the upper passing among the branches; thus a continuous matting may be formed which cannot be torn asunder by the breakers, but on the contrary may cause the sands to collect in permanent masses.

Every facility was offered Mr. Mitchell by the commander of Hatteras, the late Brigadier General Thomas Williams, and in a letter from the latter, dated February 4, the return of my assistant is solicited with flattering comments.

Hydrographic resurvey of Beaufort harbor, N. C.—The chart of Beaufort harbor was published in 1857, but, like all other harbors on the South Atlantic coast, its bar and channels are known to be subject to changes of very serious consequence to navigation, if not from time to time pointed out.

The capture of Beaufort and the reduction of Fort Macon by Major General Burnside, having restored the harbor to the possession of the government, a resurvey was ordered in May, so that the port might be made as available as the capacity of the channels would allow for the purposes of the Navy Department. The duty of making the examination and soundings was intrusted to Mr. Albert Boschke, and the schooner Joseph Henry was assigned for the use of his party. The vessel reached Beaufort on the 28th of May.

By natural or artificial changes most of the triangulation marks had been lost, and it was found necessary to determine thirteen stations anew. Nine of these required the erection of large tripods for observing with the theodolite. Mr. Boschke occupied eleven of the stations and observed eleven hundred and eighty angles. Mr. E. H. Courtenay served as recorder, and the work was drawn by Mr. Charles Heyne as the observations were completed at the several stations. The triangulation was completed on the 13th of June and the soundings commenced next day. For this last duty assistance was furnished by the commander of the United States gunboat Daylight.

The changes in outline noticed at Beaufort entrance made it necessary to resurvey ten miles of the shore, which was done in the usual way, with the plane-table. The nature of the changes will be again referred to. A summary given in the report of Mr. Boschke contains the following as statistics of the hydrography:

Miles run in soundings	216
Sextant angles	2, 248
Casts of the lead	16, 540
Area sounded, (square miles)	14½

Seven current stations were occupied, each during one full ebb and flood. A tide staff was set up at the government wharf, Fort Macon Point, from which the tides between the 8th of June and the 26th of July were recorded by Mr. Thomas Thompson.

As the hydrography advanced the plotting of the chart was pushed on, the sailing lines were drawn, and new positions assigned for buoys, so as to conform to the actual alterations in the proper courses. The

United States quartermaster at Beaufort furnished a steam-tug, and the engineer of the Daylight procured the temporary moorings for the buoys. The buoys belonging to the port were found in the city, where they had been deposited by the parties who removed them at the outset of the war.

The following remarks on the changes which have taken place in Beaufort harbor are extracted from the report of Mr. Boschke:

"Considerable changes have occurred on the shores of Bogue and Shackleford banks. The west end of Shackleford bank has made out three hundred and sixty yards; and from Bogue bank, at Fort Macon Point, sixty yards have washed away. To the westward of Fort Macon Point, on the seaside, and to the eastward of Shackleford Point, the shores have grown from one hundred to one hundred and fifty yards seaward.

"The present channel and bar are about a third of a mile further west than they were in 1857. The depth on the bar at mean low water has slightly improved. The former channel is obstructed and now gives only seven feet at low water, or no more than the western slue.

"The southwest breakers have changed considerably, there being now a shoal bare at low water in their place. A spot is also bare at low tide on the Middle Ground, and both shoals are at present increasing in size. The channels and shoals of the inner harbor have not materially changed."

The results of the examination made by Mr. Boschke render it probable hat the bar of Beaufort entrance will continue to move westward for some time in the direction of the main ship channel, and that the depth of water on it may further improve. From a reduction furnished by Mr. Boschke, a new preliminary chart of Beaufort harbor was lithographed at the office in August and distributed for the use of the navy and of the army transports.

The schooner Joseph Henry returned north at the end of July, reaching Boston on the 12th of August. She was at once assigned for use to the party of Assistant Harrison, in Section I. The records of observations, the duplicates, and the original chart of the resurvey of Beaufort harbor, are now at the office in Washington.

SECTION V.

FROM CAPE FEAR TO ST. MARY'S RIVER, INCLUDING PART OF THE COAST OF NORTH CAROLINA, AND THE COAST OF SOUTH CAROLINA AND GEORGIA.—(SKETCH E, No 25.)

The service performed in this section was by parties which accompanied the South Atlantic blockading squadron. Some of the orders of Admiral DuPont, under whose immediate direction the work was done, will be found in Appendix No. 31. The details are stated in the following order, after a few preliminary remarks relative to the organization of the parties, and reference to duty connected with the capture of Fort Walker and Fort Beauregard, the particulars of which were stated in Appendix No. 31 of my report of last year:

1. Rattlesnake shoal, examined by sounding, and buoys placed to mark its ends.

2. Stono river and bar mapped and sounded, including also Folly and Kiawah rivers, and topographical survey of their shores and of the islands near Stono entrance, S. C., showing the forts and rebel intrenchments. The requisite triangulation for these surveys was executed during the present working season. Stono bar and entrance was permanently buoyed by the party.

3. North Edisto entrance, S. C., sounded out. The changes of the channels were developed and buoys set in conformity with the present courses for entering.

4. St. Helena entrance, S. C., examined and buoyed. Sketches were made of the defensive works found on the shores of the sound.

5. Port Royal sound, including Broad and Beaufort rivers and Skull creek, S. C.; extended topographical and shore-line surveys and hydrography, with plans of the rebel fortifications. Buoys were permanently set to mark the channels into Port Royal, and others for the navigation of the interior of the sound.

6. Calibogue sound, S. C., and Savannah river entrance thoroughly sounded and buoyed.

7. Wassaw entrance, Ga., examined, and buoys set to mark the bar.

8. St. Simon's bar, Ga., sounded, and changes in depth developed. Buoys were placed to mark the channel into the sound.

9. Fernandina harbor, Fla., examined by soundings on the bar and in the channel. The buoys which had been removed by the enemy early in 1861 were found and replaced.

The list given in Appendix No. 36 shows the number of aids to navigation placed by the working parties in each locality for the use of the blockading squadron on the coast of South Carolina and Georgia.

OFFICE WORK.—The engraving of Sapelo sound, Ga., Ossabaw sound, Ga., and of St. Simon's sound' Brunswick harbor, and Turtle river, as finished charts, has been completed. The drawing of general coast chart No. VII, Atlantic coast from Winyah bay, S. C., to St. John's river, Fla., and that of Calibogue sound and Skull creek, forming the inland passage from Tybee roads to Port Royal sound, and the engraving of Savannah river as a finished chart, have been in progress. Additions have been made to the progress sketch of the section. The following preliminary charts have been drawn and lithographed for immediate use, viz: sea-coast of South Carolina; sea-coast of Georgia and Florida to St. Augustine; Port Royal entrance, with Beaufort, Broad, and Cheehessee rivers; Calibogue sound and Skull creek; Wassaw bar; St. Helena sound; the addition of James' island and Stono river to the chart of Charleston harbor; and a chart of Stono inlet, with parts of Stono, Folly, and Kiawah rivers, from the survey of the present year.

Coast Survey operations on the coast of South Carolina, Georgia, and part of Florida.—As stated in my last annual report, the party of Assistant C. O. Boutelle, at the end of the year 1861, was in active service with the naval and military expeditions which moved in several directions from the naval station in Port Royal sound, S. C. Two surveying steamers for a short period, but ultimately only one, (the Bibb being sent to replace the Vixen when disabled,) and two schooners, the Arago and the Caswell, were assigned to the charge of Mr. Boutelle. Several of the most active sub-assistants and aids had been attached to his party, their selection being made so as to insure the most thorough efficiency.

Under the orders of Commodore (now Admiral) DuPont, the first duty performed by the party was the temporary buoyage of the south channel into Port Royal sound, and piloting the fleet and army transports over the bar, as stated in my previous report.

After the successful naval attack of the 7th of November, by Admiral DuPont, which restored the waters of Port Royal sound to the possession of the government, the several members of the party were occupied in local surveys until the 24th of that month, or a little beyond the close of the surveying year, at which time my annual report is made up.

In noticing the further operations of the party of Assistant Boutelle reference will be made to the localities in geographical order, in accordance with the plan of previous reports, though this will, in some cases, invert the order of dates at which the work was executed. The parties proceeded from Port Royal as a centre, and worked north and south of it, but I will notice first the most northern locality of operations, and proceed with the others in the usual order, going southward.

The surveyors were repeatedly under the fire of the enemy, either while co-operating with the naval or military forces by reconnaissance, or when employed in usual field-duty in this section.

Rattlesnake shoal.—It having come to the knowledge of the flag-officer that most of the vessels which ran the blockade of Charleston had taken the advantage of local knowledge to cross the Rattlesnake shoal, Mr. Boutelle was directed to examine it, and to place buoys so that the movements of our blockading vessels might be free from danger. This was promptly done, the buoys being set on the 10th and 11th of May. The steamer Bibb was used in running the necessary lines of soundings, and the buoy vessel, which was then serving as her tender, in placing the buoys. Two first-class buoys were fixed in position, one at each end of the shoal. The result of the examination was made known to the squadron, and that, with the marks which had been set, had much effect in checking the evasions of the blockade that had become quite frequent in that quater.

Triangulation, topography, and hydrography of Stono entrance and bar, and of Stono, Folly, and Kiawah rivers, S. C.—On the 18th of May Mr. Boutelle received orders to transfer his party to Stono inlet, to examine the bar, to buoy the channel, and, if practicable, to pilot in the gunboats which had been sent there as the preliminary to an attack on the fortifications of that vicinity.

On the morning of the 19th the Stono bar was examined, and a channel found giving seven feet at low water. This was temporarily buoyed by the party at once, and permanently marked on the following morning. Assistant Boutelle, aided by Mr. J. S. Bradford, piloted in the gunboats Unadilla, Ottawa, and Pembina. The reconnaissance was extended up the Stono, above Legarèville, to a fortification known as "Old Battery," on James' island. When the gunboats were anchored for the night Mr. Boutelle and Mr. Bradford returned to the bar, the steamer Bibb, owing to her draught, being as yet obliged to anchor outside.

Some days were occupied in sounding the lower part of the Stono in the vicinity of Bird key, and the remaining part of May and the month of June in hydrographic duty, and in the preliminary work requisite for it. In that interval Assistant Boutelle made two short visits to Port Royal on public service. At Stono he was rejoined by Sub-Assistant W. S. Edwards, in the surveying schooner Arago, and by Mr. Cleveland Rockwell, these parties having completed extensive surveys for military purposes near Port Royal. Mr.

Edwards rendered able assistance in the survey of the rivers connected with Stono inlet, and Mr. Rockwell by tracing the shore-line of the adjacent islands.

The resurvey of Stono bar and inlet revealed great changes which had occurred in the direction of the channel, and in the depth of water. All of the hydrography was, of necessity, done in boats, though the heat of the weather was extreme. The Stono, Folly, and Kiawah rivers were sounded. Mr. Edwards, taking the upper part of the Stono, extended the soundings to Newtown Cut, above which his progress was stopped by a strong rebel battery.

By the untiring industry of Mr. Rockwell the shore-line survey of Coles, Folly, Kiawah, and James's islands, and that of Bird Key, was ready for the use of the hydrographic party when called for.

The triangulation of this part of the coast of South Carolina was executed in 1855. Some of the stations then used being necessary for the topography and hydrography, the duty of restoring the signals, a work attended with danger, was assigned to Mr. C. H. Boyd. This was done in armed boats, and in one instance (Big Sandy Pt. station,) it was necessary to have aid from one of the gunboats stationed in the river. Captain J. B. Creighton, of the Ottawa, kindly sent his first cutter, in charge of Master R. K. Duer, to accompany the cutter of the Bibb, which was in charge of Mr. Bradford. No reconnaissance had been made previously. Mr. Bradford reset the signal, and his party returned in the afternoon. Other signals were in like manner set up, and the positions of the buoys and hydrographic points were determined from them.

The position of Fort Pemberton, a rebel intrenchment on Wappoo creek, and of other batteries, and of lookout stations erected by the enemy in the neighborhood of "Secessionville," was determined in the same way. The exact distance from them to given points, being in each case deduced and stated, proved of great advantage to the gunboats in ranging their guns.

It is proper to remark that during the stay of the Coast Survey party at Stono the buoy vessel was in service as the tender of the steamer Bibb, and, in charge of members of the party of Mr. Boutelle, she piloted in from time to time from the outer bar buoy the gunboats and transports as they were assigned to service in the river. Mr. Boutelle was for the most part personally engaged, under Commander Drayton, senior naval officer at Stono, in reconnaissance, for which his intimate local knowledge fitted him. He accompanied and piloted the expedition up Folly island river, as also the reconnaissance of Fort Pemberton, made with the gunboat Ellen, and another, made with the steamer Bibb, up the Kiawah river.

The Coast Survey party left Stono inlet on the 23d of June, the Bibb being then much out of repair, and the time of most of her crew having expired. She had been in service with the party afloat during six consecutive months. On the 1st of July she left Charleston bar, having passed the intervening week at Port Royal, and, after touching on her way north at Fortress Monroe, returned to New York. The Caswell reached New York on the 12th of that month, and the Arago on the day following.

Among the incidents while the party was at work in the vicinity of Stono inlet was the capture of six out of a company of outlying rebel pickets belonging to the twenty-fifth South Carolina regiment, one of whom was about to fire on Mr. Boyd when he was taken. This was effected by Messrs. Boyd and Bradford, who had landed from their boats with four men opposite to Legaréville, to examine the western side of James's island. The prisoners were brought in by the party and delivered to Captain Godon, who was at that time (May 21) the senior naval officer at Stono.

North Edisto entrance, S. C.—A partial examination of this harbor was made in December, 1861, with the steamer Vixen, when Assistant Boutelle piloted into the river the naval expedition under Captain Percival Drayton, U. S. N. No attempt was then made to buoy the channel, nor until the 11th of the following February, after General Sherman had decided to occupy Edisto and the adjacent islands. At that date, and under the orders of Commodore DuPont, Mr. Boutelle, with the steamer Bibb, convoyed the army transport Ben Deford, with the forty-seventh regiment New York volunteers, and, in company with the gunboat Crusader, protected the troops for some time after their landing on Edisto island from night attack, the enemy being then in force only a few miles from Rockville. Daylight was employed by the party in sounding the bar, and the boats of the Bibb returned each night to the vicinity of "Point of Pines House" to guard the approaches to the military station. The hydrographic work was made very difficult by stormy weather, but the labors of the party were successful. A new channel was found to the southward of the old one, and with more water. The bar was thoroughly sounded, and temporary buoys were laid, from the boats.

Commodore DuPont requiring the services of the party in Port Royal sound, the steamer Bibb left North Edisto on the 23d of February, and did not return until near the end of April. In the last week of that month both channels were permanently buoyed, and a first-class buoy was placed at the point where the channels meet; the sailing lines were plotted; and the sailing directions were drawn out and communicated to the flag-officer.

The triangulation work done at North Edisto was auxiliary to the hydrography, and was executed by Mr. Boyd. Some of the old points were restored, and those, as well as the hydrographic signals and the new buoys, were determined in position. The survey was completed by the end of April, and on the 1st of May the vessel returned to Port Royal. During both of her visits to North Edisto the Bibb had been constantly employed in the protection of the shores, and in service incidental to the objects of the military and naval expedition.

St. Helena sound, S. C.—Assistant Boutelle's party went with the naval expedition which visited St. Helena sound on the 24th of November, and at that time made a preliminary examination of the bar and placed some temporary buoys. As the different vessels of the squadron passed to the bar, they were piloted by members of the Coast Survey party. Drawings and plans of the rebel works were also furnished, the intrenchments there being strong and elaborate. Mr. Boutelle's local knowledge was again made effective, and under his direction the sloop-of-war Dale was piloted through Parrot creek to her anchorage off Otter island. Soundings were made through the tortuous channels of Morgan river and the creek just mentioned, a service rendered hazardous by the narrowness of the streams, as the pilotage was made difficult by the fact that the Dale drew fourteen feet of water. After closing this preliminary service the party left for another station, and did not return to St. Helena until the 5th of April, for the survey of the bar and entrance. Commodore DuPont having special duty for the steamer Bibb, Mr. Boutelle, with one of her officers, went to work with the buoy tender, partially sounded the channels, placed large iron buoys in one, determined their position, and took measures for restoring the triangulation points. On the 19th the Bibb, having been relieved, returned with the party, and by the 23d the bar and channels were thoroughly sounded and buoyed.

Port Royal sound, Beaufort and Broad rivers, Skull creek, &c., S. C.—As already stated in the beginning of this chapter, the party of Mr. Boutelle was employed in local surveys in the vicinity of Port Royal between the 7th and the 24th of November, 1861, and had in use the steamer Vixen and the schooner Arago. During that interval obstructions in Port Royal harbor were buoyed; a hydrographic survey of Skull creek was commenced; and some of the party were occupied in restoring the triangulation points, in setting up signals, and in observing with the theodolite, so as to give data for extending the shore-line survey beyond the limits of the published charts.

Sub-Assistant W. H. Dennis and Mr. Cleveland Rockwell arrived on the 1st of December in the steamer Bienville, and at once reported for duty. Mr. Rockwell was directed to take up for military purposes the topography of the inside shore of Port Royal island, and that of the adjacent inside islands. This service he steadily prosecuted, under the orders of Brigadier General I. I. Stevens, to the extent required inland, and his zeal and activity were warmly commended in a communication addressed to me by that commander. Mr. C. L. Bixby aided in this plane-table work.

To Sub-Assistant Dennis was at the same time assigned the topographical survey of the shores of Broad and Beaufort rivers and that of Archer's creek, and the outside shore-line of Port Royal island. The work was commenced immediately, and will be again referred to in the course of this notice.

Sub-Assistant W. S. Edwards reported for duty on the 21st of December, and with him returned Mr. Bradford, of the party in the Vixen, who had been sent from Port Royal with official despatches after the naval attack of the preceding month. Mr. Edwards at once took charge of the schooner Arago, and began the sounding of Skull creek. He was aided by Mr. W. W. Harding. Mr. Bradford returned to his former position on board of the Vixen.

The party in the steamer proceeded on the 22d to the important labor of surveying and permanently buoying the south and southeast channels into Port Royal sound, and by the end of December ten first-class iron buoys had been fixed in position in both passages. A change in the direction of the channels was observed, and an increased depth. In the south channel was found nineteen and a half feet of water, and in the southeast channel twenty-one feet.

The hydrography of Skull creek was finished by Mr. Edwards on the 3d of January, and that of Broad river at once taken up. About a week afterwards the light-vessel for Port Royal which had been sent out by the Light-House Board was taken to her station and safely moored in the position indicated by Mr. Boutelle. Sailing directions for Port Royal sound were then made out, and, after being approved by the flag-officer, were published for the use of the navy and of the army transports.

The arrival of the steamer Bibb on the 12th of January relieved the Vixen, which had become unfit for service. By an arrangement with the chief quartermaster, Captain Rufus Saxton, U. S. A., the disabled vessel was shortly after taken in tow by the steamer Baltic as far north as Cape Henry, and thence made her way unaided to New York.

During the month of January the field-work and hydrography were vigorously carried on. The Bibb was elsewhere employed. Messrs. Dennis and Rockwell were surveying the shores of Broad river and Port Royal island. By the end of February the hydrography of Broad river was extended up as far as Hogg's Neck, but it was found impracticable to continue soundings through Whale Branch to Port Royal ferry, as had been intended when the work was taken up.

As already mentioned, the Bibb had been some time on service at North Edisto. She was detained after her return to Port Royal to act as an armed vessel in concert with the Varuna, the greater part of the fleet having gone southward to repossess certain points on the coast of Florida. Mr. Boutelle was also directed to sound and buoy an anchorage proper for the United States ship-of-the-line Vermont, then daily expected at Port Royal. His party executed that duty early in March.

On the 2d of March the steam transport Mississippi, having on board Major General Butler and fourteen hundred soldiers, destined for the coast of Louisiana, reached Port Royal in distress, the vessel having struck on the Frying Pan shoals. She was then leaking badly. Commander Boggs, senior naval officer at Port Royal, assigned the charge of the repairs to the party in the Bibb, and, by the unremitting labors of Sailing-master Platt and Chief Engineer French, the transport in the course of a week was declared seaworthy. At the request of General Butler Mr. Boutelle detached Sailing-master A. C. Mitchell from the Arago, with direction to proceed with the expedition to the Gulf of Mexico, his local knowledge of its northern coast being extensive and accurate.

Commodore DuPont detailed the steamer Bibb on the 5th of April to make special visits at the naval stations between Port Royal and Mosquito inlet. Assistant Boutelle being then engaged at St. Helena sound, the vessel went in charge of Mr. Platt, and returned on the 11th. The flag-officer came on board, visited Fort Pulaski, which had just surrendered, and then proceeded in her to Port Royal, where she was returned to the charge of Mr. Boutelle on the 18th.

The United States frigate Savannah having in the absence of the party struck on a shoal point near the southeast channel, a spar buoy was set to mark the position. This was done after the return of the party from the survey of North Edisto. Mr. H. W. Longfellow, one of the aids in the party of Mr. Boutelle, was detached on the 10th of May and returned to the north, in consequence of illness.

The hydrography of Beaufort river, Archer's creek, Jericho creek, and Cowan creek was reported by Sub-Assistant Edwards complete on the 23d of May. Mr. Rockwell at the same date had completed the topography between the shores of the Beaufort and Coosaw rivers, and was then under orders to report at Stono inlet. Mr. Dennis finished the shore-line survey of Beaufort river and of Archer's and Cowan creeks near the end of May. He returned to the north soon after and engaged in other plane-table duty, as I have stated under the head of Section I.

Tybee roads, Calibogue sound, and Savannah river, S. C. and Ga.—In accordance with orders from Flag-Officer DuPont, the surveying party proceeded about the middle of January to examine and buoy the channels into Tybee roads and Calibogue sound, and notwithstanding the extremely stormy weather at that period, the entrance of the Savannah (Tybee bar) was marked with iron buoys, and the sound with spar buoys, by the end of the same month. Other duty, which has been mentioned under several preceding heads, was performed in the succeeding three months.

On the 1st of May, Mr. Boutelle made a careful examination of the lower part of the Savannah river between Fort Pulaski and Square Beacon. Three large hulks had been sunk there by the enemy, and it was found that they had deepened the channel by as much as nearly six feet. It was, moreover, found that the obstructions could be easily removed.

Sub-Assistant Edwards had taken up the hydrography of Calibogue sound on the 8th of March. He completed that work by the 23d, and then returned to Beaufort river.

One of the buoys set at the entrance of Calibogue sound having been carried away by the collision of a vessel, the working party placed larger buoys in May, and slightly changed the sailing lines, so as to give the best water across the bulkhead.

The facts ascertained in regard to the channel into Savannah river were promptly communicated to the flag-officer. Sailing directions to accord with the changes observed were reported without delay.

Wassaw sound, Ga.—Immediately after closing his first examination of Tybee entrance and Calibogue sound, Assistant Boutelle sounded and buoyed the Wassaw bar, and the channel leading into Wassaw sound. This work he finished on the 8th of February, and on the next day furnished sailing directions for the sound in a report to the flag-officer. He also forwarded a preliminary chart of Wassaw sound to the office in Washington, copies of which were at once made by lithograph, and distributed from the Naval Observatory for the South Atlantic squadron.

The survey of Wassaw entrance, as mentioned in my report of last year, was provided for by instructions issued for the surveying season of 1860–'61. The instructions were not then carried out, for reasons given in the same report.

St. Simon's bar and sound, Ga.—The surveying party reached St. Simon's entrance on the 23d of March, and at once proceeded to set buoys in place. The examination made then showed that the bar had decreased in depth since the survey of 1857, the chart of that year showing seventeen feet. Mr. Boutelle found only fifteen feet on the bar at low water.

The light-house at St. Simon's having been destroyed by the rebels, the party set a large signal on the ruins, and marked it as a conspicuous object for the use of vessels of the squadron, as a range, when they might have need to run into the sound.

This survey was finished on the 27th of March. Sailing lines proper for entering were at once reported to the flag-officer.

Fernandina bar and Cumberland sound, Fla.—On the 13th of March the surveying steamer Bibb arrived at Fernandina, and at once commenced the examination of the bar. The fact was soon established that the depth of water had changed for the worse, and also that the bar had shifted to the southward. Only twelve feet depth was found on it at low water. The channel was buoyed by the party with the old buoys, which had been removed and hidden by the enemy.

Mr. Boutelle, on the occasion of a visit of General Sherman, whom he accompanied to Jacksonville, found thirteen buoys and a lot of mooring chain which had been provided by the Light-house Board. The property was brought away and put to its proper use on other parts of the coast of this section.

In all of the nine harbors examined this year by Assistant Boutelle, the triangulation done was merely auxiliary to the plane-table surveys and hydrography, and was effected by restoring the station points which had been used in the regular progress of the Coast Survey. Without such data the buoys set in position, fifty-four in all, could not have been properly marked on the charts.

I give, in conclusion, a summary of statistics from the field-books of the topographical parties, and from the journals of the hydrographic parties:

TOPOGRAPHY.

Shore-line surveyed	100½ miles.
Outline of marsh	76 "
Roads and causeways	102 "
Fortifications	14

HYDROGRAPHY.

Miles run in sounding	803
Angles measured	9, 038
Number of soundings	62, 247

It has been stated already, in the notice of work done at Stono inlet, that the steamer Bibb and schooners Arago and Caswell returned to New York in July. The party in these three vessels had been nine months uninterruptedly employed in their several spheres of duty.

SECTION VI.

FROM ST. MARY'S RIVER TO ST. JOSEPH'S BAY, (SOUTH,) INCLUDING THE EASTERN AND PART OF THE WESTERN COAST OF FLORIDA, WITH THE REEFS AND KEYS.—(SKETCH F, No. 32.

The only party available for continuing the survey of this section was prepared to co-operate by reconnaissances, or hydrographic duty, in any military or naval service which might be deemed expedient by the commanders of the department of Florida. None of the harbors of the peninsula below St. Augustine and Cedar Keys having been occupied by the forces of the government during the working season, the party took up and continued the hydrography of the Florida reef This important work will be completed by a party which is now preparing to return to the section.

The magnetic observations have been continued at Key West.

OFFICE-WORK.—The drawing and engraving of the chart of St. Augustine harbor, and the engraving of St. Mary's river and Fernandina harbor, have been completed. Progress has been made in the drawing and engraving of general coast chart No. X, Florida reef, from Key Biscayne to Marquesas keys, and coast chart No. 71, Newfound-harbor key to Boca Grande; the engraving of coast chart No. 70, Garden Key to Lower Matacumbe, has been commenced; and the annual additions to the progress sketches of the section have been made. A preliminary chart of the vicinity of the Tortugas, Fla., has been lithographed.

Hydrography of the Florida Reef.—Being advised by General Brannan that in the spring of the present year such arrangements would be in progress in his department as might render it desirable that Coast Survey parties should be detailed for work on the coast of Florida, instructions were issued in April, in accordance with which Assistant George Davidson organized a party in the surveying steamer Vixen and schooner James Hall. As in other cases, on the coast below Cape Henlopen, he was directed to co-operate, as far as possible, with any military operations that might be devised. To that end the Vixen was furnished with two Parrott guns, and was well provided with other means for making or resisting attack. Some delay occurred in fitting out the Vixen, the call, at that time, for iron-clad gunboats having pre-engaged all the suitable mechanics. The vessel did not reach Key West until the 14th of May, having touched at Port Royal to deliver despatches from the blockading squadron off Charleston and to take in coal. Admiral DuPont, at Port Royal, promptly ordered such facilities as furthered the wishes of Assistant Davidson to be at his destination.

Upon consulting with General Brannan, at Key West, it was found that operations by the land forces were not contemplated. The bays on the western coast of Florida, moreover, were all in possession of the enemy, so that the unfinished work could not be profitably taken up.

In accordance with the discretionary instructions which had been given, Assistant Davidson transferred his party to the Florida reef, on which a stretch of twenty-five miles remained to be sounded in order to complete the chart. The parties of Assistant G. A. Fairfield and Sub-Assistant C. T. Iardella being under his general direction were likewise moved to that locality in the schooner James Hall, and signals were erected for the prosecution of the outside hydrography. The weather proved unfavorable, being marked by excessive rains and heavy squalls. Attempts were made to work by the boats, but these being frustrated the sounding-lines were mostly run by the steamer. The area sounded out embraces Alligator, Crocker, Conch, and Pickle reefs, (See Sketch No. 32,) and leaves a gap of but a few miles in the outside hydrography of the reef. Soundings were carried seaward to the depth of forty fathoms. While the work was going on the positions of the steamer and most of those of the boats were determined by two theodolites from long bases.

The statistics of this work are as follows:

Hydrographic signals erected	10
Miles run in sounding	422
Angles measured	1,119
Number of soundings	15,965
Area sounded out, (square miles)	70

A tidal station was occupied on Indian Key, at which nearly a thousand observations were recorded in the space of twenty-six days. The zero of the tide-staff was referred to the bench-mark previously used, and which was more distinctly marked by Mr. Davidson. He also reported on the condition of the lettered beacons on the Florida reef, some of which had been displaced. In the interest of navigation, the following remark occurs in his report: "As seen from seaward, Indian Key is so well and so peculiarly marked by the houses and cocoa trees that a sketch of it was taken from the edge of the Gulf Stream, on the line of best water for crossing the reef to the anchorage in soft bottom about six hundred yards off the key, and also to give Alligator reef on the starboard hand a good berth." This sketch will be engraved for the finished chart of the Florida reef.

Sub-Assistant C. Fendall was attached to the party of Assistant Davidson. Messrs. A. T. Mosman, L. L. Nicholson, and A. R. Fauntleroy served as aids. Assistant Fairfield and Sub-Assistant Iardella heartily co-operated in prosecuting the hydrography.

During a heavy blow on the 4th of June the schooner Hall dragged her anchors and was driven on the coral rocks of Indian Key. After three days of severe labor she was hauled off by the steamer Vixen. Assistant Davidson acknowledges the valuable assistance of Acting Master Wm. Richardson, U. S. N., in his efforts to get the vessel off.

Late in June the two vessels repaired to Key West, where the needful facilities for coaling and watering had been on different occasions supplied by General Brannan. The season for active operations in this section being past, both parties returned to New York. Assistant Davidson reported to me personally at Washington, and then took up the reduction of the season's work. The other members of the parties have, since the middle of July, been employed at various localities in Sections I and II.

The steamer Vixen, with her armament, was transferred to the Navy Department on the 12th of July. At the end of October she was returned to the Coast Survey, and is now fitting out for the completion of the hydrography outside of the Florida reef.

Magnetic Observations.—Sub-Assistant J. G. Oltmanns remained in charge of the magnetic instruments at Key West until near the end of March of the present year, when he was detailed for duty near the mouths of the Mississippi, of which notice will be taken in a succeeding chapter. The regular photographic and differential observations were continued by Sub-Assistant F. F. Nes, aided by Mr. G. F. Ferguson, until May, when Mr. Samuel Walker was left in charge, and Sub-Assistant Nes assigned to duty in Section II.

In May of the present year magnetometer No. 6 was sent to replace the instrument which was stolen from the temporary observatory at Key West in the midst of the public troubles, and which has not yet been traced.

The records from Key West have been regularly received from Mr. Walker since April.

Tidal Observations.—The series of observations which had been conducted at Fort Clinch was stopped soon after the breaking out of the present war, as stated in my last annual report.

After the port of Fernandina had been regained to the authority of the government, steps were taken for the recovery of the self-registering tide-gauge, but so far without success. According to the most direct information yet obtained the instruments were destroyed at an early date in the war.

SECTION VII.

FROM ST. JOSEPH'S BAY (NEAR TAMPA) TO MOBILE BAY, INCLUDING PART OF THE WESTERN COAST OF FLORIDA, AND THE COAST OF ALABAMA.

Of the most important harbor in this section (Pensacola) the survey is nearly complete, and the chart published several years ago is sufficient to meet all the present requirements of the naval and transport service. The work yet needed is chiefly in the upper part of the dependencies of the bay, in localities now held by the enemy.

My regret that no party was available for continuing the survey of the western side of the Florida peninsula is lessened by the consideration that none of the unsurveyed parts have been occupied by the government forces. For the ports visited by our blockading vessels, the preliminary charts have sufficed. Those already published give the soundings in Waccasassa bay, in Cedar Keys harbor, Ocilla river entrance, St. Mark's harbor, the passes of St. George's sound, Apalachicola bay and harbor, and St. Andrew's bay. The hydrography most pressing, and for which preparation has been made by preliminary work, is that of St. Joseph's bay at the lower end of the section, (near Tampa,) and the coast soundings northward from it in the approaches to Bayport, Chassahowitzka bay, Homosassa bay, Crystal bay, and We-thlocco-chee bay. These include St. Martin's reef. The party last employed in St. George's sound, and which, but for the outbreak of the rebellion, would have completed hydrography for the full chart by soundings from Royal Bluff westward to Apalachicola entrance, has been constantly on duty afloat near the seat of war in Virginia and North Carolina. Of other hydrographic work which might be taken up, if means and the requisite parties were available, may be mentioned that to the eastward of, and between St. George's sound and St. Mark's harbor, and that of St. Joseph's bay near Cape San Blas. The triangulation which was commenced in the working season of 1860–'61 for the survey of the latter, and the completed topography of the first named locality, furnish ample preliminaries for the soundings

The double party which has usually divided its field-work between this section and Section VIII, passed the entire season in active service at the delta of the Mississippi, of which further mention will be made in the next chapter. Besides this and the single hydrographic party alluded to, the only assistant heretofore connected with the section, and who has usually worked on the western coast of Florida in winter and spring, has been employed in Section I.

Though all due interest has been shown by the blockading officers to whom the inventories were referred, none of the property of the survey which was forcibly taken by rebel citizens from the custody of the topographical party while working last year near Bayport, as stated in my report for 1861, has yet been recovered.

It is supposed that the tide-gauge which had been in use at several stations near Pensacola, and finally stored at Warrington, was destroyed by the burning of the navy yard.

OFFICE-WORK.—A sheet showing the entrance to Santa Rosa bay, and a general chart of the northeastern part of the Gulf of Mexico, in two sheets, have been drawn and lithographed for the use of the blockading squadron. Copies of these and of the charts referred to in the notice of the field-work of the section have been largely supplied for the Gulf squadron and for the transport service. The engraving of the chart of Escambia and Santa Maria de Galvez bays, Fla., has been completed.

SECTION VIII.

FROM MOBILE BAY TO VERMILION BAY, INCLUDING THE COAST OF MISSISSIPPI AND PART OF THE COAST OF LOUISIANA.—(SKETCH H, No. 35.)

The issue of the labors of the party sent to this section shows in a strong light the soundness of the policy which provided means for their supply. The steamer which had been used for the hydrographic work was lost at sea in 1860, and had not been replaced when the war broke out, though I have requested an appropriation for the purpose. Neither of the few vessels left to us by the emergency of the spring of 1861, capable of standing a long sea voyage, was available for the accommodation of the party. The difficulty thus presented was overcome by the liberality of the Hon. Secretary of the Navy, to which further allusion will be made in the detailed notice of the work done.

OFFICE-WORK.—The engraving of coast chart No. 93, Lakes Borgne and Pontchartrain, has been commenced. Additions have been made on coast chart No. 92, western part of Mississippi sound, and to the progress sketch of the section; and a hydrographic sketch of the southwest pass of the Mississippi has been lithographed. Drawings and photographs have also been made of the approaches to Forts St. Philip and Jackson, below New Orleans, and of a survey of Fort Jackson after the bombardment.

Coast Survey operations between Mobile bar and New Orleans.—Upon the application of Commodore (now Rear Admiral) D. G. Farragut, U. S. N., Sub-Assistsnt R. E. Halter was detailed as topographical assistant to accompany him in the flag-ship Hartford. Subsequently a complete topographical and hydrographical party was organized to accompany the western gulf blockading squadron of Admiral Farragut, and to be especially attached to the mortar fleet of Commodore (now Rear Admiral) David D. Porter, U. S. N. Assistant F. H. Gerdes was placed in charge of this party, his personal knowledge of the Gulf coast, its harbors, inlets, and anchorages being extensive and precise, from a service of many years in this quarter. Sub-Assistant J. G. Oltmanns and Mr. T. C. Bowie were attached to this party, and some time after Sub-Assistant Halter also joined it. Mr. Oltmanns and Mr. Halter had both served for several years with Mr. Gerdes on the Gulf coast.

In a ready spirit of co-operation in the government service, the Commissioner of the Northwestern Boundary Survey, Archibald Campbell, esq., placed at my disposal for the same duty, the services of Mr. Joseph S. Harris, who had previously been attached to a Coast Survey party in this section, and who was also well acquainted with the localities in which the squadron was to operate. His intelligence and characteristic energy fully met the expectations which I had formed in organizing the party.

Sub-Assistant Halter preceded the other members assigned to this section, having in accordance with my instructions reported to Commodore Farragut on the 17th of January at Philadelphia. He reached Ship island in the flag-ship Hartford, and, under the orders of the commodore, a few days after took up the sounding and buoying of the channel of the southwest pass of the Mississippi. For this service, which was completed on the 11th of March, the schooner Wilder was detailed for his use, by the flag-officer, with a working crew. On the 14th Mr. Halter piloted the sloop-of-war Brooklyn over the bar, and on the 16th took in the flag-ship. Other vessels of the squadron intended for the reduction of New Orleans were furnished with sailing directions for entering the Mississippi by the Southwest Pass.

At the end of March the party in the Wilder, which was then provided with a twelve-pound gun and a well-armed crew, made a reconnaissance to the rear of Fort St. Philip, the object of the commodore being to ascertain the depth that could be carried towards Raccoon Point. It was found that the water approach to the fort afforded only seven feet in depth at a distance of rather more than three miles.

Sub-Assistant Halter returned to the head of the passes on the 5th of April, and retransferred the Wilder to the naval authorities. When not employed in surveying or reconnaissance, the schooner had served as a tender to the larger vessels of the fleet, and in that way had rendered much general service while in charge of Mr. Halter. On the 10th he reported to Assistant Gerdes, who had arrived in the Mississippi a short time before, by way of Ship Island, in one of the naval transports. Sub-Assistant Oltmanns reached the Section in the same vessel, from Key West, where he had been employed on other duty, to which I have referred under the head of Section VI. Both had rendered assistance in passing vessels of the squadron over the bar of the Southwest Pass, as Mr. Halter had done in the case of the flag-ship and others.

For the use of the Coast Survey party, when it was organized in February, the honorable Secretary of the Navy temporarily transferred to the Treasury Department the steamer Uncas, with a suitable armament. That vessel left New York on the 27th of February, in charge of Mr. Harris, but stormy weather on the run to Hampton Roads showed clearly that she could not make the passage to the Delta without extensive repairs. With as little delay as possible, the steamer Sachem, of the same class, was there substituted by the Navy Department, and, in charge of Mr. Harris, after a tedious passage, reached the mouth of the Mississippi on the 10th of April, where she was joined by Assistant Gerdes and the other members of his party. By previous arrangement with the flag-officer their services were placed at the disposal of Commander D. D. Porter, who was then about moving with the bomb flotilla of the squadron to attack Fort Jackson

In the season previous to the breaking out of the rebellion, the triangulation of the Mississippi delta had been extended up to the vicinity of the lower defences of the river. The points then determined, and the computed distances between them, gave the means for assigning exact distances from either of the forts, by the aid of some additional observations. Mr. Gerdes took up this work on the 12th. Next day all the members of the party were employed in it, and by the morning of the 18th, when the mortar vessels, twenty-one in number, were in position, the exact distance of each of them from Fort Jackson, and the precise direction, had been made known to the officers in charge. This hazardous and difficult service, the river being at that time over its banks, was mainly performed by Mr. Harris and Sub-Assistant Oltmanns, aided by Mr. Bowie. While measuring with the theodolite, Mr. Oltmanns was, in one instance, fired on by riflemen from the bushes on the river bank, but, though at short range, only the oars of his boat were struck. In nearing the forts, on the last day employed in making observations, the party of Mr. Harris came under the fire of the enemy's gunboats, but no casualty occurred, though the distance was inconsiderable.

The bombardment of Fort Jackson opened immediately after the completion of the measurement of distances to the several positions occupied by the mortar vessels. For the next three days Messrs. Harris and Oltmanns remained with the flotilla, and when, from various causes, any of the vessels had to shift their berth, the distances to other positions were computed for them anew. The rest of the party were meanwhile engaged in furnishing manuscript charts of the Mississippi in the neighborhood of the defences, for the use of the fleet, the regular hydrography of the river not having extended, previously, above the passes.

At the request of Commodore Porter, the Sachem dropped down the river on the 22d, to await the return of a detachment which he had sent to reconnoitre in the rear of Fort Jackson. Mr. Oltmanns, having charge of the vessel, then completed an examination which had been commenced the day before by Mr. Harris, Mr. Halter, and himself, of the channels which start near Fort Jackson and connect the Mississippi with the Gulf. Next day the Sachem took the wounded men of Commodore Farragut's fleet to the hospital at Pilot Town.

On the 24th of April Assistant Gerdes accompanied Major General Butler into the waters north of Fort St. Philip, and piloted his boats to the quarantine ground on the east bank of the Mississippi, the intention of the general being to turn the forts, which had not, at that date, surrendered. Sub-Assistant Halter piloted the army transports to the anchorage nearest to the intended landing place, and marked the way for boats to pass up into the quarantine bayou. In performing this duty his party necessarily came within range of the guns of Fort St. Philip, but received no injury. Several days after, when the Sachem reached the anchorage of the army transports, soundings to the northward of the fort were begun, to ascertain whether the light-draught vessels could approach near enough to attack from that side, but the surrender of all the defences of the Mississippi, on the afternoon of the 28th, made it unnecessary to continue the operations. The party therefore rejoined the flotilla of Commodore Porter in the vicinity of Fort Jackson. As a matter of interest a map was made, at his request, by Mr. Harris, to show the condition of the fort at the time of surrender, with marks corresponding in position to the places in which solid shot and shells had struck during the bombardment; the parts burnt, and the portion of the site overflowed by the effect of shot on the levee, that, until so damaged, had always kept out the water of the river at its highest level. A reduction of the drawing here referred to appeared in a printed report from the Navy Department to Congress in June last.

Sub-Assistant Halter was detached from the party on the 30th of April, and soon after reporting at the office in Washington was assigned to field duty in my party in Section I.

On the 6th of May the party in the Sachem accompanied the bomb flotilla to Mobile entrance, and on the following morning buoyed the bar, so that vessels might pass Sand Island light. The purpose being merely a reconnaissance of the defences at the entrance of Mobile bay, the steamer returned with the fleet, on the 9th, to the anchorage at Ship Island.

The assistants on board of the Sachem being well acquainted with all the waters in the vicinity of New Orleans, that vessel was taken to pilot the steamers Westfield, Clifton, and Jackson on an expedition intended for Lakes Borgne and Pontchartrain on the 13th; but finding at Madisonville that Lieutenant Commander Read, with the gunboat New London, had been looking after the vessels of the enemy in that quarter, Lieutenant Commander Renshaw, senior naval officer of the expedition, decided to return and make an examination of the same kind in Pearl river. This was done on the 15th. At a point about fifteen miles above the mouth, the river being there so narrow and crooked that the larger vessels could not pass the bends, Lieutenant Commanders Renshaw and Baldwin came on board the Sachem, and that vessel proceeded alone towards Gainesville, where it was supposed that a small armed vessel of the enemy was lying. With great labor the Sachem was warped around the sharp turns of the stream and taken up as far as the town site of Napoleon. The breadth there and at some places below was barely equal to the length of the vessel. Suddenly a volley of musketry was fired on her from the wooded shore, and that, though instantly returned, was followed by a second volley. Sub-Assistant Oltmanns, executive officer of the Sachem, being at that moment in an exposed position, was severely wounded by a bullet which pierced his right breast. With this exception, all the officers on board, and the crew, were uninjured, though nearly twenty shots had struck the vessel. To disperse the enemy the Sachem fired round shot and grape into the woods, and was not further molested. Where this occurred the river was not over fifty yards wide, and the bushes were so thick on both banks that the enemy could not be seen. Lieutenant Commander Renshaw deeming it unadvisable to proceed further up, the steamer was swung around with difficulty and passed down the stream. After receiving surgical treatment, Mr. Oltmanns was sent to New York. He recovered in part from his hurt, and has since been engaged in field duty in Section III, but is still suffering from the effect of the wound.

Mr. Gerdes had meanwhile collected the buoys belonging to the Delta, all of which had been taken up and secreted by the insurgents, and had towed them to the Southwest Pass. After making the requisite soundings, six buoys were set in place in the channel. A thorough hydrographic reconnaissance of the bar was made, and materials collected for the issue of a chart of the pass. This work occupied the party in the Sachem until the 7th of June, when the vessel was ordered to accompany the flotilla to Vicksburg. The health of Mr. Gerdes having declined, he was obliged to give up the charge of the party after it had reached New Orleans. Mr. Harris again took command of the steamer, but at his request Commander Porter detailed Acting Master E. C. Merriman as executive officer, the sailing-master and the first mate of the Sachem being both sick. Mr. Harris started up the Mississippi on the 13th of June, but near Baton Rouge the machinery of the propeller was disabled by a snag, and the party returned to New Orleans. The Sachem was there transferred to Commodore Farragut, to be put in order for naval service, which he then had in view west of the Mississippi.

The work for which he had been assigned to the western gulf blockading squadron having been completed, Assistant Gerdes left New Orleans on the 18th of June and reported at the office in Washington.

Mr. Harris sailed for the north on the 10th of July, and after discharging his party resumed his duties in the office of the Northwestern Boundary Survey.

Mr. Gerdes has, since his return from this section, completed a hydrographic survey, to which reference has been made under the head of Section I. He is now making arrangements to resume work on the Mississippi in connexion with Admiral Porter. Mr. J. W. Donn, who has performed much duty in plane-table and ordinary reconnaissance in aid of the military operations in Section III, has been assigned to service with the same expedition.

Military surveys in the vicinity of St. Louis, Mo.—This service was performed at the request of Colonel R. D. Cutts, of the staff of Major General Halleck, whose headquarters during the winter of 1861–'62 were at St. Louis.

Sub-Assistant John Mechan commenced work on the 15th of January, taking the northwest quarter of the city suburbs, and surveyed the ground to a range of rather more than three miles in front of the five forts which had been erected there. The forts are included on the plane-table sheets, and also the auxiliary lines of defence. The contour of the ground is represented in his survey by curves of twenty feet elevation, showing, amongst others, one height of a hundred and sixty-five feet. These curves were run carefully with the military water level. Colonel Thorn, of the topographical engineers, supplied the initial altitudes, which facilitated the execution of the detailed topography.

Mr. Mechan closed work on the 5th of April, and after inking his plane-table sheet and turning it in at the office, was assigned to field duty in Section II, of which mention has already been made. His sheet of the military defences of St. Louis shows an area of about fifteen square miles.

Assistant R. M. Bache commenced work in the southern suburbs on the 12th of March, and continued the survey to Carondelet, joining at Chouteau avenue with the work of Sub-Assistant Mechan. He is still engaged in the contouring of the ground, which will probably occupy his party until the end of December, Four miles of the river shore are shown on the sheet, as well as the details of ground three miles back from the shore. These include the sites and surroundings of five forts, and all the particulars of surface that could be needed in the arrangement of military operations.

The map of Assistant Bache represents ninety-nine miles of road and twenty-eight miles of the courses of creeks and other water-line within an area of fourteen square miles.

Tidal Observations.—The self-registering tide-gauge left by Mr. P. H. Donegan at the office of the British consul, in New Orleans, after the observer's release from captivity, the particulars of which were stated in my previous report, was recovered after the capture of that city, and together with the other instruments used by Mr. Donegan has been returned to the Coast Survey Office.

The observations taken at Isle Dernière (Last island,) in April and May, 1861, were received from New Orleans through the post office in June of this year, but without explanation. Since the breaking out of the present war nothing has been ascertained either in reference to the observer or the instruments which he had in charge.

SECTION IX.

FROM VERMILION BAY TO THE RIO GRANDE BOUNDARY, INCLUDING PART OF THE COAST OF LOUISIANA AND THE COAST OF TEXAS.

The death of Sub-Assistant Wyllys S. Gilbert, in January of the present year, of which notice has been taken, under the head of Obituaries, in the introductory part of this report, has left the charge vacant of the only party that worked in this section during the season of 1860–'61, under a civilian. The only other party available during that year was in charge of Captain George Bell, U. S. A., who was detached from the survey in April, 1861. Mr. Charles Hosmer, who assisted Mr. Gilbert on the coast of Texas, has been constantly employed during the present year in Section III, as was stated under that head. He is now preparing for duty under the orders of Major General Banks, and is specially qualified for rendering assistance in reconnaissances or special surveys by his local knowledge of the most important parts of the southwestern coast, over which he has passed in prosecuting the shore topography in previous years.

In addition to the active assistance, the expedition has been furnished with copies of the coast memoir relating to Texas, and copies of all the charts which have been issued for the western part of the Gulf of Mexico.

Several efforts have been made, but thus far without avail, for the recovery of the schooner Twilight, which, together with the property on board, in April, 1861, was seized by the insurgents at Aransas, and for the property supposed to have been detained at Corpus Christi. The particulars of these seizures were stated in my last annual report. Inventories of the lost articles have been furnished to officers of the blockading squadron, whose convictions of the usefulness of the survey, and interest for its success, were well known. Copies of them have also been made for such contingent use in regaining the articles as the events of the coming winter may render practicable.

OFFICE-WORK.—The drawing of coast chart No. 108, Matagorda and Lavacca bays, Texas, and of general chart No. XVI, Gulf coast, from Galveston bay to the Rio Grande, has been continued. Progress has been made in the engraving of chart No. 106, Gulf coast, from Galveston bay to Oyster bay, Texas, and the annual additions to the progress sketch of the section have been made. A general chart of the northwestern part of the Gulf of Mexico, on two sheets, has been drawn and lithographed for the use of the blockading squadron.

SECTION X.

FROM SAN DIEGO, OR THE SOUTHERN BOUNDARY ON THE PACIFIC, TO THE FORTY-SECOND PARALLEL, INCLUDING THE COAST OF CALIFORNIA.—(SKETCHES J, NOS. 37 AND 38.)

The surveys made during the year in this section have developed the coast-line and hydrography in the following named localities:

1. From Point Duma eastward, triangulation has been extended to meet the work going northward and

westward from San Pedro. The stations occupied this year give the shore-line of Bahia Ona, (part of the Santa Barbara channel,) and provide for the topography of San Clemente island.

2. Topographical survey of Bodega bay, and, in connexion with it, that of the coast above and below the entrance. The plane-table work is now continuous from the Golden Gate northward to Bodega bay, inclusive.

3. A hydrographic resurvey made in the lower part of Karquines strait, and continued into Mare Island strait, developing important changes since the previous survey, (1856-'57.) Changes were also noticed in the hydrography of the eastern part of San Pablo bay, Cal.

4. Bodega bay and roadstead sounded out, in connexion with the coast hydrography between it and Tomales entrance, Cal.

5. Tidal observations at San Diego and San Francisco.

OFFICE-WORK.—The drawing of Napa creek and Petaluma creek, as finished charts, and the engraving of the same in preliminary form, have been completed, and a preliminary chart of Tomales bay has been drawn and engraved. The engraving of the chart of San Pablo bay is nearly completed, and progress has been made in the drawing and engraving of that of Drake's bay. The drawing of the lower part of San Francisco bay, and of a chart of the Pacific coast from Point Pinos north to Bodega Head, has been commenced. Additions have been made to the progress sketches of the section, and to plates of charts previously engraved.

Triangulation of the Santa Barbara channel and of San Clemente island, Cal.—This work was in active progress at the end of the last surveying year, the party of Assistant W. E. Greenwell not having then returned to San Francisco. Before closing for the season he erected thirteen signals on San Clemente island, intending to go on then with the triangulation; but his vessel, the surveying schooner Humboldt, was driven away by a southeast gale of unusual severity. Mr. Greenwell states that no season since the autumn and winter of 1849 has been so unfavorable as the last for field operations on the lower part of the Western coast.

Previous to disbanding his party for the winter, Mr. Greenwell set up a tripod signal on the west end and another on the eastern end of Santa Cruz island, (Sketch No. 37.) A similar one was erected on Anacapa island, and a fourth at Station San Buenaventura, on the main shore of the channel.

With the opening of spring the triangulation of San Clemente island was resumed, and completed by the 1st of June. Twenty-five signals were used in that work, additional to the ones prepared in the preceding autumn. The only two anchorages being at the extreme ends of the island, the field operations proceeded from them, and met at stations near the middle. Mr. Greenwell found that San Clemente island is twenty-four miles in length. Its entire surface is broken into gulches or valleys, without a vestige of wood or running water. The signals required were got into their places only by great labor and with much difficulty, there being no inhabitant on the island, nor any animals, with the exception of about one hundred and fifty head of wild sheep. Mr. Greenwell states that the highest point on the surface of the island has an elevation of about fifteen hundred feet.

During the summer the coast triangulation was taken up at Point Duma, (Sketch No. 37,) and stations were occupied for defining seventeen miles of the shore-line eastward, which constitute the bight known as Bahia Ona. This work was joined with the secondary triangulation, which had been pushed upwards from San Pedro in a previous season. To provide for field operations during the winter, Mr. Greenwell readjusted the main signals, intended for connecting the islands with the coast, and took his camp fixtures to Santa Barbara, the next station which will be occupied on the shore of the channel. The schooner Humboldt returned to San Francisco in September, field-work for the autumn having been discontinued on the 14th of that month.

Assistant Greenwell was aided by Mr. Julius Kincheloe, and makes special mention of his readiness and efficiency in the performance of duty.

Four volumes, containing the records of the work of the season, with computations and sketches, and descriptions of signals, have been received and deposited in the office. The following statistics, reported by Mr. Greenwell, include also the work of last season, the returns of which were not received in time for my last annual report:

Primary signals erected	5
Secondary signals erected	58
Stations occupied	42
Signals observed on	56
Number of observations	3, 268

The angular measurements were made with the eight-inch Gambey theodolite, No. 44.

Mr. Greenwell, in the course of the present season, again examined the lagoon at the mouth of the Santa Anna river, the general character of which was described in my previous annual report. His attempts to pass in were in all cases attended with risk, and he states that the entrance, for any general purposes, may be regarded as impracticable.

Topography of Half Moon bay, Cal.—No report of the season's work has yet been received from Sub-Assistant W. M. Johnson, who has been engaged in the survey of the shores of Half Moon bay, though it is known that good progress has been made.

One of his plane-table sheets of the survey of Santa Cruz island has been forwarded to the office by Mr. Johnson, and three others of different localities are reported to be nearly complete in their office details.

Topography of Bodega bay, Cal.—This survey, made by Assistant A. F. Rodgers, completes the land work on the shores of Bodega bay. It includes the topography of the coast to the southward and westward, and connects with the plane-table survey of Tomales bay, which was made last year by the same party. Above the entrance to Tomales bay, (Sketch No. 38,) the work was taken up early in December and carried on during the winter and spring. In the latter part of April the party commenced the topography of the shores of Bodega bay, and furnished shore-line for the hydrographic sheet of this season, the particulars of which will be mentioned presently. The plane-table survey was extended to a point about four miles north of the mouth of Bodega bay, and from that point southward the topography is continuous to the Golden Gate. It has throughout a breadth of about a mile and a half.

Assistant Rodgers was aided by Mr. David Kerr.

The following are statistics of the work, which was closed early in October:

Shore-line surveyed	35 miles.
Area of topography, (square miles)	25

The finished topographical sheet of Bodega bay is now at the office.

Assistant Rodgers is at present with his party on the shores of Suisun bay. He will, also, for the time being, take the oversight of the labors of the hydrographic party now on board of the schooner Marcy.

Mr. A. W. Chase has been assigned to duty under the direction of Mr. Rodgers.

Hydrographic resurveys in Karquines strait, Mare Island Strait, and off Point Wilson, San Pablo bay, Cal.—These localities were examined by Commander B. F. Sands, U. S. N., assistant in the Coast Survey, soon after the great flood of February, 1862, and the results have been reported on after comparison with the soundings made in 1856–'57.

In reference to Karquines strait, between Benicia and Martinez, Commander Sands remarks:

"The water on the three fathom bank, off the ferry wharf at Benicia, has deepened to four fathoms, and we now find four fathoms on the lump off the Pacific Company's wharf, which in 1856–'57 had only three fathoms on it, but around the wharf itself the water has shoaled in some places five and in others as much as fifteen feet. On the south side of the strait the six and twelve feet curves have made out considerably from the shore."

"At the confluence of Karquines and Mare Island straits an important change has taken place. The spit of the shoal which stretches out from the north shore, at the meeting of the straits, has been cut off and shifted to the southward and westward since the survey of 1856. This encroachment has materially narrowed at its entrance the channel which passes up to the navy yard."

Commander Sands promptly communicated to the light-house inspector of the district the fact concerning the lessened width of the channel into Mare Island strait, and recommended the marking of the spit by a buoy. He thus continues, in allusion to the "bar" or shoal water in San Pablo bay off Point Wilson:

"At the bar, or shoalest water through San Pablo bay, in passing towards the navy yard abreast of Point Penole and Point Wilson, the depth seems to have changed somewhat. The four fathom curve of the resurvey is different from that shown by the survey of 1856, and the bar has shoaled about a foot. The six feet curve also has made out from a quarter to a half a mile from the eastern shore of the bay, in the bights between the several points which are represented on the chart."

The finished chart of San Pablo bay, the engraving of which is now nearly completed, will contain the results given in the three hydrographic sheets forwarded by Commander Sands. The following are the general statistics of the work:

Miles run in sounding	150
Angles measured	1,034
Casts of the lead	8,295

The labors of Commander Sands in this part of the section are associated with a sad event—the loss of his son, Acting Master William F. Sands, who was drowned in consequence of an accident near the Mare Island navy yard, on the night of the 2d of April.

The steamer Active was sold, in accordance with my instructions, on the 12th of June, the extent of repairs required to make her seaworthy being too great to be made by our limited appropriation. The hydrography will be done with the schooner Marcy, transferred from the revenue service, until another steamer can be had and maintained.

Hydrography of Bodega bay and roadstead, Cal.—This survey was made in August by Commander Sands, with the schooner Marcy. Shore-line for the chart (Sketch No. 41) was furnished by Assistant Rodgers. The location of the bay is shown by the general chart (No. 40.) Besides the bay and roadstead, the soundings made develop the coast hydrography between the roadstead and the bar of Tomales bay, which was sounded out last year. From Tomales entrance a line of soundings was continued to Point Reyes in the track of vessels that make that headland from the northward. The following is a synopsis of the statistics:

Miles run in sounding	135
Angles observed	437
Casts of the lead	4,277

This work was concluded on the 2d of September. Of the character of the bay, Commander Sands says: "Bodega bay will admit vessels of less draught than eight feet. The roadstead is a good harbor of refuge during the summer months from the northwest winds and sea that prevail at that season."

Commander Sands was detached from service on the Coast Survey by an order from the Navy Department dated October 11th. Since his departure from the section, the nautical duty in the hydrographic party has been conducted by Acting Master A. S. Hussey, under the general direction of Assistant Aug. F. Rodgers.

Tidal observations.—Under the general supervision of Lieutenant G. H. Elliot, of the corps of engineers, the self-registering tide-gauges at San Diego and San Francisco have been kept in successful operation in charge of Messrs. A. Cassidy and H E. Uhrlandt.

Mr. Uhrlandt has also, as heretofore, read off the results of the observations for the two stations named above, and for the third permanent station, (Astoria,) previous to forwarding the rolls to the Coast Survey office.

SECTION XI.

FROM THE FORTY-SECOND PARALLEL TO THE NORTHWESTERN BOUNDARY OF THE UNITED STATES, INCLUDING THE COAST OF THE STATE OF OREGON AND THE COAST OF WASHINGTON TERRITORY.—(SKETCH K, No. 42.)

The work of the only party which was available for duty in this section comprises the following surveys:

1. Supplementary triangulation and topography continued at Koos bay, Oregon. A chart of the entrance to the bay has been published.
2. A hydrographic reconnaissance in Koos bay, supplementary to work done in the vicinity of the bar.
3. Hydrography of the bar and entrance of Gray's harbor, W. T.
4. Tidal observations at Astoria.

OFFICE-WORK.—A preliminary chart of Koos bay, Oregon, has been drawn and engraved; and the drawing and engraving of a new edition of the chart of Washington sound, W. T., and the engraving of that of Coquille river entrance, Oregon, have been completed. Additions have been made to the progress sketch and other plates of the section.

Topography of Koos bay, Oregon.—This work was referred to in my last annual report as being in progress at the latter part of the surveying year. Before returning to San Francisco for the winter, Sub-Assistant J. S. Lawson reoccupied two of the stations used in his triangulation, and at them and two others intended for topographical purposes measured twelve angles by over five hundred repetitions, with the ten inch Gambey theodolite, No. 20. The concluding work for the season was the tracing of shore-line and topographical details along the south side of the entrance from Koos Head to Cape Gregory, (Sketch No. 42.) and further plane-table work in the South Slough. This duty proved difficult by reason of the dense fogs that prevailed. Six miles of shore-line were added to the plane-table sheet, and, as last year intimated, measures were taken for sounding out the entrance of the bay.

Mr. Lawson was aided by Messrs. A. T. Mosman and H. Anderson.

The party in the brig Fauntleroy sailed for San Francisco on the 22d of October, and returned to Koos bay about the middle of April. During the winter the computations of the season's work were made, the topographical sheets were inked, and these, with duplicates of the records of observations, were forwarded to the office. The preliminary chart of the entrance of Koos bay which accompanied my previous annual report contains the shore-line traced during the working season.

Hydrographic reconnaissance of Koos bay.—The soundings in the channel and approaches and on the bar of Koos bay, as shown by the preliminary chart referred to in the preceding notice of work, were made in October, 1861. Sub-Assistant Lawson used for this service the steam-tug Fearless, the sailing vessel employed generally by his party not being suitable for the purpose. The work inside of the entrance was done with one of the boats of the brig Fauntleroy. Tidal observations were made while the party was engaged in sounding. The following are statistics of the reconnaissance:

Miles run in sounding	65
Angles measured	377
Number of soundings	3,167
Area sounded, (square miles)	10

This work was plotted soon after the return of the party to San Francisco. The sheet containing the soundings is now at the office, with duplicates of the journals of observations.

Mr. Mosman, one of the aids of the party, was detached on the 1st of November, and has been on duty in the Atlantic sections. Mr. Horace Anderson also aided Mr. Lawson at Koos bay and in the execution of his office-work during the winter.

In April the party in the Fauntleroy again proceeded to Koos bay, and made a reconnaissance of its upper shores, with a view of completing the entire hydrography of the bay, if practicable, in the early part of the season. Some of the requisite signals were erected, but it was found, as the party advanced, that natural difficulties there would make it impracticable to take up work in another locality which was also included in my instructions for the season. The inside soundings have been for that reason deferred, but will be resumed and completed at an early date.

Hydrography of Gray's harbor, W. T.—In July the party with the surveying brig Fauntleroy proceeded northward, the intention being to take up and prosecute to completion the soundings necessary for a chart of Gray's harbor, provision having been made for that work by the triangulation, and by the topography which was concluded last year. Sub-Assistant Lawson, after providing what was necessary for the service, took passage from San Francisco and rejoined his vessel at Port William, in Shoal Water bay. Three days had been spent by the crew of the brig in attempting to pass into Gray's harbor. No one belonging to the vicinity would consent to take the vessel in, the belief being general that no definite channel existed to lead across the bar.

Before Mr. Lawson's arrival, his aid, Mr. Anderson, had taken up stores and had commenced work with a boat and crew. A tide-gauge was set up, and a register kept of each high and low water. The signals required had been erected. Soundings were commenced immediately, but frequent interruptions occurred, in consequence of bad weather. Mr. Lawson met hindrances also in the currents, which are naturally very strong in that vicinity. Close watch was kept for opportunity to work on the bar, but during his stay of nearly two months he reports that only three days offered in which a boat could be risked for sounding, and that during one of them there was a break until the flood tide had run a considerable time. Arrangements had been made for determining the positions of the boat while on the bar by simultaneous angular measurements at three stations on the shores, which were to be occupied, respectively, by Mr. Lawson, Mr. Anderson, and Captain Charles F. Winsor, of the quartermaster's department, who had kindly offered his assistance, and who seconded all the efforts of Sub-Assistant Lawson during the entire working season. At this juncture the sailing-master refused to do duty, and Mr. Lawson was constrained to take charge of the boat, leaving his shore station unoccupied.

The hydrography was continued until the middle of September, when it had embraced about four miles of the inside of the harbor, the anchorage in South bay, and part of the north channel, as will be seen by reference to the resulting chart (Sketch No. 44,) which accompanies this report. The following is a summary of the hydrographic statistics:

Miles run in sounding	128
Angles measured	1,036
Number of soundings	15,230
Area sounded, (square miles)	24

Two hundred and eighty-five observations were made with theodolites in determining the positions of the boat when sounding on the bar.

The party of Mr. Lawson returned to their vessel at Shoal Water bay, and went to sea on the 28th of September, his purpose being to stop at Koos bay. A very heavy and long-continued gale made it impracticable to do so. The Fauntleroy reached San Francisco on the 8th of October, and was there laid up for the winter. After discharging his crew Mr. Lawson and his aid took up their office-work.

The embarrassment before referred to in connexion with the charge of the boat was relieved by the continued kindness of Captain Winsor. Under the terms of a leave of absence from the quartermaster at Gray's harbor, he acted as sailing-master of the Fauntleroy and conducted the vessel to San Francisco. His unremitting disposition to oblige is specially mentioned by Sub-Assistant Lawson as having furthered the work of the party.

Mr. Lawson's report contains the following remarks in allusion to the character of Gray's harbor:

"The results of the work confirm my previous estimation of the nature of the entrance. There seems to be no well-defined channel across the bar, and the bar is very uneven and lumpy. In one place I found nine feet of water on it. Nor is the channel as straight as I supposed; it takes a curve to the northward." "According to my experience on the bar the coast current *always* sets to the northward. The flood tide sets in across the South sands, and not in the channel across the bar. The strong ebb tide strikes this off-shore current and is deflected to the north, thus, probably, causing the curve in the channel. I estimate the off-shore current that runs across the bar to have an average rate of about three knots per hour."

Mr. Anderson was detached from the party of Sub-Assistant Lawson on the 21st of October, and has since reported in person at the office in Washington. He had served in this section from May, 1860.

Tidal observations.—Mr. L. Wilson has continued, under the general supervision of Lieutenant G. H. Elliot, U. S. Engineers, to keep in operation the self-registering tide-gauge at Astoria, in Oregon. He has also furnished a very complete series of meteorological observations.

COAST SURVEY OFFICE.

Major W. R. Palmer, U. S. Topographical Engineers, Assistant Coast Survey, retained the charge of the office until the 11th of April, taking occasional supervision of the division details, while at the same time attached to the staff of Major General McClellan, and at intervals performing active military duty in the army of the Potomac. Since that date the office operations have been directed by *Assistant J. E. Hilgard,* the permanent charge having devolved upon him by the death of Brevet Lieutenant Colonel Palmer in June.

The duties of general assistant were performed until June by *Assistant Edward Goodfellow;* since that time in turn by *Mr. W. L. Nicholson* and *Mr. J. S. Bradford,* of whom the last-named had passed the first half of the working year in field service in Section V, which he is now about to resume. He has been replaced by *Mr. C. H. Boyd,* who was also of the field party which worked until June on the coast of South Carolina.

The report of Assistant Hilgard, (Appendix No. 11,) and the sub-reports accompanying it from the chiefs of the several divisions, give a general view of the occupation in each. Though the force of the office has been materially reduced since the outbreak of the war, it will be seen by the statistics given in the sub-reports that the average of work heretofore done has not been remitted. No change in the charge of either branch has occurred within the year excepting in the Drawing division, the charge of which was resigned by *Captain T. J. Lee* on the 8th of April, his services having been requested by the Bureau of Topographical Engineers.

I proceed to review here briefly the report of the assistant in charge, referring for further details to the Appendix. The office divisions will be mentioned in their usual order.

Hydrographic division.—The details of office-work, arrangements in regard to vessels for the parties assigned to duty afloat, and an emergency requiring his personal services for the hydrography of the Potomac river, have fully tried the energy of *Captain C. P. Patterson,* the able chief of this branch of the office. At certain junctures during the year the requisites for service in connexion with the blockading squadrons, to which reference has been made under the heads of sections, have called for more than usual address and promptitude in action. As the instances occurred, the difficulties have been met and overcome with the sound judgment that has also directed the ordinary details of his division. These have been executed, as heretofore, chiefly by two draughtsmen.

Mr. Arthur Balbach, principal hydrographic draughtsman, has verified the reductions prepared for engraving, and also the soundings on the engraved proofs of charts and on lithographed sheets, adding the sailing lines and the positions of buoys, beacons, &c., plotted for the purpose in the division, from data furnished by the Light-house Board or by assistants of the Coast Survey. He also verifies the work shown by the original hydrographic sheets, and tests the ranges of sailing directions sent in by the working parties, as a preliminary to the engraving of notes on charts. In addition to the routine duties of the year, he has revised and made additions to the table of depths at port entrances of the United States, which is given in Appendix No. 5, and, as heretofore, has furnished information to the hydrographic aids as they were assigned to duty in connexion with parties afloat.

Mr. Louis Karcher has made the projections required for the work of the hydrographic parties, and, generally, the reductions for the engraver and lithographer from the original hydrographic sheets. He has assisted in the verification of soundings marked on the sheets turned in, and has plotted two sheets of soundings from the hydrographic journals, in addition to those now in hand of the survey of the Potomac river between Georgetown and Alexandria, in which he assisted Captain Patterson during June and part of July. The miscellaneous duties performed have been, among others, the tracing of curves of equal depth for the engraver, and the addition of soundings to tracings from topographical sheets on the full scale.

Tidal Division.—This has remained under the charge of *Assistant L. F. Pourtales.* The force of the division has been kept nearly at a minimum, owing to the lessened number of observations received since the breaking out of the rebellion. In Appendix No. 10 the field return is given of the observations recorded within the year, and in Appendix No. 11 a report on the office-work and computations.

Mr. R. S. Avery has continued the reduction of tidal observations, tabulated the daily inequality for several stations, and has completed the graphical decomposition of those made in the Gulf of Mexico. He is now employed in examining the record of diurnal tides. *Mr. John Downes* has read off the sheets from the self-registering tide-gauges and reduced the results. *Mr. P. H. Donegan,* though still suffering from the ill-treatment received at Calcasieu and New Orleans, the particulars of which were stated in my last annual report, has continued on duty and has made various reductions from the tidal registers, besides completing a catalogue of the tidal records now in the archives. In July and August he served as recorder to Assistant Schott in field duty in Section II. Some of the ordinary reductions, and the copying required in the work of the division, have been performed by M. Thomas and S. D. Pendleton.

Computing Division.—The charge of work in the computing division has remained with Assistant Charles A. Schott, of whose qualification for its important duties I have made repeated mention. When engaged in field service in Section II during parts of July and August, the assistant in charge of the office, Mr. Hilgard, directed the details of the division. The current office-work has been kept up, though no change has been made in the number of computers, which was diminished last year. In the Appendix, Nos. 18 and 21 are given the reports of Assistant Schott on observations additional to the duties of the office. In Appendix No. 11 will be found a detailed statement of the labors of each computer. They have been in general as follows: *Mr. T. W. Werner* has been chiefly employed in computing triangulations. *Mr. E. Nulty* in reducing magnetic observations and in making computations for time, azimuth, latitude and longitude. *Mr. James Main* has been engaged, generally, in revising astronomical computations, and also in calculations for the magnetic elements at certain stations. *Mr. G. Rumpf* has been employed in geodetic computations; in extending the geographical registers, and in the office adjustment of triangulations. *Mr. J. Wiessner* has made reductions from the records of angles in primary and other triangulations.

During the year the clerical duties of the division have been discharged in turn by *Mr. J. E. Dow* and *Mr. G. J. Pinckard.*

Drawing Division.—Until the 8th of April, this branch of the office continued under the charge of Captain T. J. Lee, and since under the supervision of Assistant Hilgard, who, a few days after, as already stated, took the general direction of this and of the other divisions of the office. In the matter of details pertaining to the oversight of the division he was assisted by *Mr. W. T. Bright.* The distribution of work amongst the draughtsmen has been as follows: *Assistant M. J. McClery* has added topographical details to the photographs taken from original plane-table sheets, and prepared the photographs for engraving. *Mr. E. Hergesheimer* has been engaged in compiling military maps from the sheets of this and of last year, and in making projections for others. He has also generalized the details of original sheets intended to be photographed, and executed the lettering for first class maps and charts. *Mr. A Lindenkohl* has worked on topographical and hydrographic reductions, and made projections for the field parties. He has also continued the compilation of geographical sketches of the coast, and the addition of details for the progress sketches. *Mr. L. D. Williams* has been engaged on fine reductions of topography and hydrography for copper-plate engraving, and on projections and verification of details. *Mr. H. Lindenkohl* has continued the construction of lithographic maps and sketches by compilation and engraving on stone, and has also worked on reductions from original plane-table and hydrographic sheets. *Mr. F. Fairfax* has made reductions of various kinds, projections, and tracings. *Mr. J. W. Maedel* has executed lithographic tracings, and others to be used in photography for engraving, besides ordinary tracings and miscellaneous work. *Mr. T. Petingale* has worked upon miscellaneous maps and tracings, and also assisted in another branch of the office in the distribution of charts and compilation of statistics. *Messrs. B. Hooe* and *W. Fairfax* have been employed in making tracings. *Mr. T. R. Smith* has been engaged since February on tracings and in miscellaneous work. *Mr. W. B. McMurtrie* was transferred to this division in August, and has been employed in plotting hydrographic work and in inking plane-table sheets.

Engraving Division.—The distribution of the details of work in this part of the office has remained during the year in charge of *Mr. Edward Wharton*. The engravers have been employed as follows: *Messrs. G. McCoy, A. Rollè*, and *J. Enthoffer*, upon topographical details from photographic reductions; *Mr. John Knight*, upon lettering for first-class charts; *Messrs. A. Sengteller, H. C. Evans, A. Blondeau*, and *A. Maedel*, upon topography; *Mr. W. Phillips*, upon topography and sanding; *Mr. G. B. Metzeroth*, upon topography, sanding, and views for charts; *Messrs. H. S. Barnard* and *W. Ogilvie*, upon sanding generally; *Mr. J. C. Kondrup*, upon topography and outline engraving for first-class charts; *Messrs. E. A. Maedel* and *W. Langran*, upon lettering and figures; *Mr. A. Petersen*, upon topography and lettering; *Messrs. R. F. Bartle, W. A. Thompson*, and *F. W. Benner*, upon topography, sanding, and miscellaneous engraving; *Messrs. C. T. Klakring, J. G. Thompson*, and *E. H. Sipe*, upon lettering and diagrams; and *Mr. A. Buckle* in further practice with punches as substitutes for cut figures to represent soundings on charts. Three plates have been prepared by this process for publication.

Photograph and Electrotype Division.—The details of work done in this division will be found in the report of *Mr. George Mathiot*, (Appendix No. 11,) who has continued in charge. Further improvement has been made in the photographic process, and an important advance in the reversion of the collodion plate in the camera, instead of the tracing which is to be reproduced as a glass "positive." The results of experiments which Mr. Mathiot has made in photo-lithography are also given in the appendix.

The newer applications of the photographic process have much facilitated the miscellaneous work required in the office, and extensive use has been made of them during the past year in producing copies of maps for military purposes. This has been done in addition to the routine work of electrotyping plates and photographing for the use of the engraving division.

Mr. David Hinkle, the intelligent and efficient assistant of Mr. Mathiot, has been constantly employed in the division.

Lithographing Division.—This division, which was organized and added to the office establishment during the month of May, 1861, to meet the increased calls for charts arising out of the exigencies of the war, has been continued in active operation under the charge of *Mr. W. L. Nicholson*.

Besides the printing of a number of charts from transfers, in order to assist the issue from the copper-plate presses, many impressions have been taken from original drawings, some engraved or drawn upon stone, and others transferred by the ordinary lithographic process. The requirements of the War and Navy Departments have been promptly met. On the two lithographic presses nearly thirty-one thousand copies of charts and sketches have been printed during the year ending with October, and assistance has been rendered in special cases for the use of the War Department by the rapid duplication of the details of military maps and sketches.

The preparation and distribution of lithographed descriptions of the coast have been continued. Of the edition now on record, three hundred and eighty-five copies with accompanying charts have been furnished to officers of the army and navy, in command of expeditions, since the commencement of their issue in August, 1861. Appendix No. 11 shows in full detail the operations in this branch of the office.

Miscellaneous Division.—The duties connected with the oversight of the copper-plate and lithographic printing, and distribution of maps, charts, and sketches, and the distribution of the annual reports, have also been discharged by Mr. Nicholson since the 1st of June, when Assistant Edward Goodfellow, who had the charge up to that date, was assigned to field service.

The demand for maps and charts for the use of the army and navy having increased more than seven-fold within the past two years, has called for great activity with the limited means at our disposal for keeping up the supply of printed sheets. The detailed report of Mr. Nicholson (Appendix No. 11) shows that over fifty-one thousand copies of maps, charts, and sketches have been printed within the year, and that more than forty-four thousand of them have been distributed, the greater part (about twenty-six thousand) through the naval observatory, and the others to officers of the army and navy, the government departments, to captains and pilots in the transport service, and, with the discrimination alluded to in my report of last year, to loyal citizens.

Of special topographical sheets of the vicinity of Washington, which for obvious reasons have not been either engraved or lithographed, about a hundred photographic copies have been furnished from the office for the use of the corps of engineers and principal commanders of the army.

The supervision of hydrographic details in the office, and the arrangements in regard to the vessels of the survey, have been, as last year, under the able charge of *Captain C. P. Patterson*, hydrographic inspector, whose unremitting exertions in the public service are worthy of all praise.

The services of the general disbursing agent, *Samuel Hein, esq.*, have been continued with his usual zeal and fidelity.

The clerical services in the office of the superintendent have been acceptably discharged, as heretofore, under the direction of *W. W. Cooper, esq.*, and the clerical duties with the superintendent in the field, which have been unusually intricate and onerous this year, have been most thoroughly and zealously performed by *Mr. J. T. Hoover*.

Respectfully submitted by

A. D. BACHE,
Superintendent United States Coast Survey.

Hon. S. P. CHASE,
Secretary of the Treasury.

APPENDIX.

APPENDIX No. 1.

Distribution of the parties of the Coast Survey upon the coasts of the United States during the surveying season of 1861–'62.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION I. From Passamaquoddy bay to Point Judith, including the coast of Maine, New Hampshire, Massachusetts, and Rhode Island.	No. 1	Triangulation	F. P. Webber, sub-assistant.	Secondary triangulation of the coast of Maine, from Machias bay, southward and westward, to Pigeon Hill, including Englishman's bay, Chandler's River bay, Indian river, and Pleasant river. (See also Section III.)
	2	Triangulation	G. A. Fairfield, assistant	Secondary triangulation embracing Isle au Haut bay, Eggemoggin Reach, and the adjacent islands between Mt. Desert and Penobscot bay. (See also Section VI.)
	3	Triangulation	S. C. McCorkle, sub-assistant.	Triangulation above Belfast and Castine, nearly completing the preliminary work in Penobscot bay, and including the shores of Belfast bay and the mouth of the Penobscot river.
	4	Topography	W. H. Dennis, sub-assistant.	Shore-line survey of Eastport harbor completed, including Eastport or Moose island, in Passamaquoddy bay; shore of Johnson's bay and of the St. Croix river traced from its mouth up to Pleasant Point; that of the western side of Campo Bello island traced; and that of Lubec Neck surveyed southward to embrace West Quoddy Head. (See also Section V.)
	5	Topography	Cleveland Rockwell	Eastern shore of Frenchman's bay embracing the coast of Maine from Jones's Cove to Winter Harbor, and most of the islands between the coast and Mt. Desert island. (See also Section V.)
	6	Topography	Charles Ferguson, sub-assistant.	Plane-table survey of the shores of Tennant's harbor, Wheeler's bay, and Long cove, including Crescent, Clark's, and other islands; and embracing the western shore of Penobscot bay from Fig Hill, southward, to Hack's Neck. (See also Section III.)
	7	Topography	C. T. Iardella, sub-assistant.	Topography nearly completed between the Sheepscot and Kennebec rivers, by shore-line and detailed survey of the lower part of Back river, Robin Hood's cove, Hall's bay, and Little Sheepscot river. (See also Section VI.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION I—Continued.	No. 8	Topography	A. W. Longfellow, assistant	Detailed survey of the shores of Yarmouth and Freeport rivers, and of Wolf's Neck, in the upper part of Casco bay, Me. (See also Section III.)
	9	Plane-table reconnaissance.	F. W. Dorr, sub-assistant; H. W. Longfellow, aid.	Reconnaissance for defensive purposes, and mapping of the environs and southern approaches of the city of Portland, Me. (See also Section III.)
	10	Topography	H. L. Whiting, assistant	Special plane-table survey of Coaster's Harbor island and of the adjacent shore of Narragansett bay from the environs of Newport, northward, to include Coddington cove, and eastward to Miantonomy Hill, and other details. (See also Sections II and III.)
	11	Topography	A. M. Harrison, assistant; H. W. Bache, aid; F. A. Lueber, aid.	Plane-table survey continued on the islands of Narragansett bay, including parts of Connanicut and Dutch islands, with Taylor's cove and Dutch Island harbor; and shore-line survey of Prudence, Patience, Dyer's, Gould, and other islands. (See also Section III.)
	12	Hydrography	F. H. Gerdes, assistant; C. Fendall, sub-assistant; T. C. Bowie, aid; F. H. Gerdes, jr., aid.	Soundings completed between the Sheepscot and Kennebec rivers, including Wiscasset bay, Montseag bay, Great and Little Hurl Gate, Little river, and Robin Hood's cove. (See also Section VIII.)
	13	Hydrography	Edward Cordell, L. L. Nicholson, L. A. Sengteller, J. A. Sample, aids.	Hydrography of Casco bay extended by soundings east of Crotch and Jewel islands to Mark Island ledge; and from Harpswell Neck to the main shore, westward, above Cousin's and Whale Boat islands, and as far as the mouth of Freeport river; Yarmouth and Freeport rivers sounded; supplementary soundings made in the vicinity of Peak's and Bangs's islands, and between Trundy's reef and Portland Head.
	14	Hydrography	Henry Mitchell, assistant; C. L. Bixby, C. P. Dillaway, P. Frazer, jr., aids.	Soundings continued in Narragansett bay, R. I., from Half Way rock, southward, to a point below Goat Island light, including the approaches to Newport harbor, and hydrography of the western passage in the vicinity of Dutch island. (See also Section IV.)
		Magnetic observations.	Samuel Walker, (part of season,) R. H. Talcott, (part of season.)	Determination of magnetic constants continued monthly at Eastport, Me. (See also Section VI.)
		Tidal observations.	R. H. Talcott, T. E. Ready	Series of tidal observations continued at Eastport, Me., with self-registering and staff gauges; and at Charlestown navy yard, Mass., with box gauge and self-registering gauge.
SECTION II. From Point Judith to Cape Henlopen, including the coast of Connecticut, N. York, New Jersey, Pennsylvania, and part of Delaware.	1	Geodetic, astronomical, and magnetic observations.	A. D. Bache, superintendent; G. W. Dean, assistant; Edward Goodfellow, assistant; R. E. Halter, sub-assistant; S. H. Lyman and H. M. De Wees, aids.	Mount Tom, Hampshire county, Mass., and Sandford Station, in New Haven county, Conn., occupied for connecting the primary base on Epping Plains (Section I) with that on Fire island. Observations made at both stations for latitude, azimuth, and the magnetic elements.

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION II—Continued.	No. 2	Triangulation	W. S. Edwards, sub-assistant; F. H. Dietz, aid.	Triangulation of Connecticut river extended upwards from Goodspeed's landing to Higganam. (See also Section V.)
	3	Triangulation	Edmund Blunt, assistant; A. T. Mosman and A. R. Fauntleroy, aids.	Triangulation on the east side of Hudson river, in the vicinity of Rhinebeck and Poughkeepsie.
	4	Triangulation	John Farley, assistant	Revision of triangulation on the coast of New Jersey from Shark river, southward, to Green island.
	5	Topography.......	H. L. Whiting, assistant; J. W. Donn, aid.	Supplementary topography between Flushing and Jamaica, L. I., and details extended westward to the environs of Brooklyn, for completing the new edition of the chart of New York harbor. Plane-table survey of the Hudson river extended on the eastern side from Tarrytown, northward, to Croton river, including Sing Sing and other villages. (See also Sections I and III.)
	6	Topography and hydrography.	John Mechan, sub-assistant; W. W. Harding and C. S. Hein, aids.	Shore-line survey extended to Coxsackie, and soundings continued in Hudson river, upwards, from Tivoli to Four-Mile Point, below Coxsackie. (See also Section VIII.)
	7	Hydrography	George Davidson, assistant..	Special hydrographic examination made in the vicinity of Pea Patch island, Delaware river, and development of changes by comparison with previous surveys. Lines of level run on League island, and at Red Bank, N. J. (See also Section VI.)
	8	Magnetic observations.	C. A. Schott, assistant; P. H. Donegan, aid.	Magnetic elements determined at Philadelphia, at Harrisburg, near Brownsville, at Erie, and at Williamsport, Penn'a.; and at Bath, N. Y. (See also Section III.)
		Tidal observations.	R. T. Bassett..............	Observations continued at the station on Governor's island, New York harbor, with self registering tide gauge.
SECTION III. From Cape Henlopen to Cape Henry, including the coast of part of Delaware and the coast of Maryland and part of Virginia.	1	Triangulation and topography.	Fairman Rogers, acting assistant; H. L. Whiting and A. W. Longfellow, assistants; F. P. Webber, Chas Ferguson, John Mechan, and R. E. Halter, sub-assistants; Chas. Hosmer, aid.	Triangulation and plane-table survey of the banks of the Potomac completed from Blakistone island to Washington, and joined with the topographical survey of the District of Columbia. (See also Sections 1 and II.)
	2	Topography.......	John Mechan, sub-assistant; Charles Hosmer, W. W. Harding, and F. A. Lueber, aids.	Detailed survey of the environs of Williamsport, Md., for military purposes. (See also Sections II and VIII.)
	3	Topography.......	Charles M. Bache, sub-assistant.	Topography for military use of the ground north and west of Bladensburg, Md., along the line of the District of Columbia.

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION III—Continued.	No 4	Topography	J. G. Oltmanns, sub-assistant.	Plane-table survey commenced of the site and approaches of Fort Lincoln, and other defensive works, near Washington city. (See also Section VIII.)
	5	Topography	T. W. Robbins	Extension of the topographical survey in Fairfax county, Va., from Falls Church towards Fort Marcy and Lewinsville.
	6	Topography	H. L. Whiting, assistant; C. M. Bache, sub-assistant.	Topography of Manassas Junction, Va., and its vicinity, including, with other surface details, the intrenchments erected in 1861. (See also Sections I and II.)
	7	Topography	C. M. Bache, sub-assistant; T. W. Robbins, aid.	Plane-table survey on the north side of the Rappahannock river, opposite Fredericksburg, including Falmouth and its environs, and the roads leading to Belle Plain and the upper part of Potomac creek.
	8	Topography	F. W. Dorr, sub-assistant; J. W Donn, aid.	Special topographical service in the army of the Potomac, on the peninsula, between York and James rivers, including local surveys and general reconnaissance. (See also Sections I and II.)
	9	Verification of topography.	A. M. Harrison, assistant; H. W. Bache, aid.	Line run with the plane-table from the upper sea-coast of Virginia to the head of Pocomoke sound, connecting the survey of Chincoteague bay with that of the Chesapeake. (See also Section I.)
	10	Topography	Charles Hosmer; F. A. Lueber, aid.	Topographical survey of Drummondtown and its vicinity, for military purposes, embracing also the surface details of Accomac county, Va., eastward and westward, to junctions with former plane-table surveys of the Atlantic coast and shore of Chesapeake bay.
	11	Topography	A. M. Harrison, assistant; H. W. Bache and F. A. Lueber, aids.	Special plane-table surveys of redoubts, forts, and intrenched camps on the banks of Elizabeth river, Va., and in the neighborhood of Norforlk; showing also the condition of the navy yard in June, 1862. (See also Section I.)
	12	Hydrography	Lieut Comg. T. S. Phelps, U. S. N., assistant.	Hydrography of the Potomac river extended upwards from Blakistone island to the vicinity of Indian Head, including the development of the Kettlebottom shoals. (See also Section IV.)
	13	Hydrography	C. P. Patterson, hydrographic inspector.	Hydrographic survey of the Potomac from Alexandria to Georgetown, including the Eastern Branch to the vicinity of the navy yard.
	14	Special service	Lieut. Comg. T. S. Phelps, U. S. N., assistant.	With North Atlantic blockading squadron before Yorktown, Va.; in York river and its branches; extended reconnaissance up the Mattaponi river; and guard duty at West Point. (See also Section IV.)

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION III—Continued.	No. 15	Hydrography	A. M. Harrison, assistant; H. W. Bache, aid.	Hydrographic resurvey of Metomkin inlet, Va., including also Metomkin bay, and development of changes in the shore-line of the entrance for military purposes. Buoys set to mark the channel into the inlet. (See also Section I.)
		Magnetic observations.	C. A. Schott, assistant; P. H. Donegan, aid.	Magnetic declination, dip, and intensity, and instrumental constants determined at the station in Washington, D. C. (See also Section II.)
		Tidal observations.	M. C. King	Self-registering tide gauge continued in operation at Old Point Comfort, Va.
SECTION IV.				
From Cape Henry to Cape Fear, including part of the coast of Virginia and of North Carolina.	1	Hydrography	Lieut. Comg. T. S. Phelps, U. S. N., assistant.	Complete hydrographic resurvey of Hatteras inlet, including its approaches from seaward and the channels leading into Pamplico sound.* (See also Section III.)
	2	Physical survey	Henry Mitchell, assistant	Observations on the tides and currents at Hatteras inlet, N. C., with reference to their effect in changing the shore-lines outside and inside of Pamplico sound. (See also Section I.)
	3	Special service and hydrography.	A. S. Wadsworth, assistant; H. Mitchell, assistant; Edw'd Cordell, C. P. Dillaway, and L. A. Sengteller, aids.	Special service at Hatteras inlet with North Atlantic blockading squadron. Hydrography of Oregon inlet, and hydrographic reconnaissance in Neuse river, N. C. Stakes set to mark the channel and buoys placed on the Middle Ground. (See also Section I.)
	4	Topography and hydrography.	Albert Boschke, acting assistant; E. H. Courtenay, aid.	Shore-line survey to determine changes, and hydrographic resurvey of the entrance, approaches, and harbor of Beaufort, N. C.
SECTION V.				
From Cape Fear to St. Mary's river, including part of the coast of North Carolina, and the coast of S. Carolina and Georgia.	1	Triangulation, topography, and hydrography.	C. O. Boutelle, assistant; C. H. Boyd, J. S. Bradford, H. W. Longfellow, C. L. Bixby, aids.	Special and general service on the coast of South Carolina and Georgia, with the South Atlantic blockading squadron. Soundings made and buoys set on Rattlesnake shoal. Reconnaissance and direction of surveying parties in sounding Stono inlet and its branches; in North Edisto river; St. Helena sound; Port Royal sound, including Broad and Beaufort rivers and their tributaries; Skull creek and Calibogue sound, S. C.; Tybee roads; Wassaw sound; and St. Simon's sound, Ga.; and Fernandina harbor, Florida. Buoys set and determined in position at these entrances. Hydrographic changes ascertained and sailing directions furnished for new editions of the harbor charts.
	2	Topography	Cleveland Rockwell	Shore-line survey for military purposes of Stono, Folly, and Kiawah rivers, and of John's, James's, Cole's, Kiawah, and Folly islands, including the intrenchments found on their banks. Topographical survey of the inside shore of Port Royal island, and of part of Broad river, S. C. (See also Section I.)

* Superintendent's Report for 1861, page 44.

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION V—Continued.	No. 3	Topography	W. H. Dennis, sub-assistant.	Shore-line survey for military purposes of Beaufort river, S. C., and of the upper part of Broad river, including Archer's creek and Cowan creek. (See also Section I.)
	4	Hydrography	W. S. Edwards, sub-assistant.	Hydrography of Stono, Folly, and Kiawah rivers, and supplementary soundings in Broad and Beaufort rivers, S. C., including the channels of Archer's and Cowan creeks for military purposes. Complete hydrographic survey of Skull creek and of Calibogue sound. (See also Section II.)
SECTION VI. From Saint Mary's river to Saint Joseph's bay, including the eastern and part of the western coast of the Florida peninsula, and the Florida reefs and keys	--------	Hydrography	George Davidson, assistant; G. A. Fairfield, assistant; C. T. Iardella and C. Fendall, sub assistants; A. T. Mosman, L. L. Nicholson, and A. R. Fauntleroy, aids.	Hydrography outside of Florida reef abreast of Upper Matacumba Key, and extending southward and westward to a junction with former work abreast of Lower Matacumba Key. (See also Sections I and II.)
		Magnetic observations.	J. G. Oltmanns, sub-assistant, (part of season;) F. F. Nes, sub-assistant, (part of season;) Samuel Walker.	Differential observations for the three magnetic elements continued by photography, and absolute determinations made monthly. (See also Sections I and VIII.)
SECTION VIII. From Mobile bay to Vermilion bay, including the coast of Alabama and Mississippi, and part of the coast of Louisiana.	1	Hydrography and special service.	F. H. Gerdes, assistant; J. S. Harris, acting assistant; J. G. Oltmanns, sub-assistant; T. C. Bowie, aid.	Special service and determination of positions by triangulation near Forts Jackson and St. Philip, Mississippi Delta. Southwest Pass of the Mississippi sounded out and buoys set to mark its channel. Sailing directions furnished and general service with the Western Gulf blockading squadron. (See also Section I.)
	2	Topography	John Mechan, sub-assistant; R. M. Bache, assistant.	Plane-table surveys for military purposes of the ground commanded by the defensive works erected at St. Louis, Mo., in 1861. (See also Section II.)
SECTION X. Western coast of the United States from the San Diego boundary to the forty-second parallel, including the coast of California.	1	Triangulation	W. E. Greenwell, assistant; Julius Kincheloe, aid.	Triangulation of San Clemente island (Santa Barbara channel) completed, and that of the coast of California between San Pedro and Point Duma.
	2	Topography	W. M. Johnson, sub-assistant.	Plane-table survey continued of the shores of Half Moon bay, Cal.
	3	Topography	A. F. Rodgers, assistant; David Kerr, aid.	Topography completed of the shore of Tomales bay, Cal., and complete plane-table survey made of the shores of Bodega bay.

APPENDIX No. 1—Continued.

Limits of sections.	Parties.	Operations.	Persons conducting operations.	Localities of operations.
SECTION X—Continued.	No. 4	Hydrography -----	Commander B. F. Sands, U. S. N., assistant.	Hydrographic survey of Bodega bay and roadstead, and of the coast of California between it and the bar of Tomales bay. Soundings made in Karquines strait, between Benicia and Martinez, and at the junction with Mare Island strait; and development of the bar and shoal water off Point Wilson in San Pablo bay.
		Tidal observations.	A. Cassidy, H. E. Uhrlandt..	Regular series continued with self-registering tide-gauges at San Diego and San Francisco.
SECTION XI.				
From the 42d parallel to the northwestern boundary of the United States, including the coast of Oregon and that of Washington Territory.	--------	Hydrography -----	James S. Lawson, sub-assistant; A. T. Mosman, aid, (part of season;) H. Anderson, aid.	Soundings further extended in Koos bay, Oregon, and hydrographic survey commenced of the bar and entrance of Gray's harbor, W. T.
		Tidal observations.	L. Wilson ----------------	Observations continued at Astoria, with self-registering tide-gauge.

APPENDIX No. 2.

Information furnished from the Coast Survey office by tracings from original sheets in reply to special calls during the year 1861–'62

Date.		Names.	Data furnished
1861.			
Nov.	6	Navy Departmunt	Tracing of the topography of the coast of North Carolina from Cape Hatteras to Ocracoke inlet.
Dec.	3	Captain R. F. Loper, U. S. A.	Tracing from the hydrographic resurvey of Hatteras inlet, N. C., (1861.)
	3	Brig. Gen. John G. Foster, U. S. A.	Tracings from the hydrographic and topographical sheets of Roanoke island and vicinity, N. C.
1862.			
Jan.	4	do	Tracing of the shore-line of the coast of North Carolina 1–200,000.
	4	do	Tracings from the hydrographic and topographical sheets of Roanoke island and vicinity, N. C.
	24	do	Tracings from topographical sheets, coast of North Carolina.
Feb.	12	Brig. Gen. Seth Williams, U. S. A.	Tracings from reconnaissance sheets of White House Point, Lower Cedar Point, and Mathias Point, Potomac river.
March	21	Brig. Gen. Joseph G. Totten, chief engineer, U. S. A.	Tracing from hydrographic sheet of Casco bay, Me.
	17	Com G. J. Pendergrast, U. S. N.	Hydrography of the Delaware river, above Fort Mifflin.
	17	do	Hydrography of the Delaware river, below Fort Mifflin.
	18	Hon. Henry Ingalls, Maine	Hydrography and topography of the Sheepscot river, Me.
	18	Brig. Gen. W. B. Franklin, U. S. A.	Tracing of the topography of the Pocosin river, Chesapeake bay.
	18	Lieut. Col. J. N. Macomb, corps of topographical engineers.	Tracing from topographical sheet of the city of Richmond, Va.
	20	do	Tracing from hydrographic and topographical sheets of the Appomattox river to Petersburg, Va.
April	14	Hon. P. H. Watson, Assistant Secretary of War.	Tracing of the topography and hydrography of Sewell's Point, Hampton roads, and vicinity, Va.
	15	John A. Clarke, esq , Philadelphia.	Topography of Lockwood's Folly inlet and vicinity, N C.
	16	Col. Andrew A. Humphreys, corps of topographical engineers.	Topography of Yorktown and vicinity, Va.
	26	Lieut. Col. J. N. Macomb, corps of topographical engineers.	Tracing of the topography of Fredericksburg and vicinity, Va.
	29	Col. Richard Delafield, corps of engineers	Hydrography and topography of the vicinity of Fort Schuyler, N. Y.
May	7	War Department	Tracing of the plane-table survey of Richmond, Va.
	12	Bowdoin, Larocques & Barlow, N. Y	Shore-line of the Rio Grande river, Texas, with six, twelve, and eighteen feet curves.
	12	do	Geographical positions mouth of the Rio Grande river, Texas.
	20	Hon. Benj. Stark, Washington, D. C.	Shore-line of the Rio Grande river, Texas, with six, twelve, and eighteen feet curves.
June	14	United States district attorney for the southern district of New York.	Tracing showing shore-line, soundings, and currents in the East river, near the Brooklyn navy yard.
	14	Charles Hastings, consulting engineer, Brooklyn navy yard.	Tracing showing shore-line, soundings, and currents in the East river, near the Brooklyn navy yard.
	14	Navy Department	Topography and hydrography of League island and vicinity, Delaware river.
	18	do	Hydrography of the upper waters of Stono river, S C., and of the inland passage between Charleston and Savannah.
	21	do	Tracing of the hydrography and topography of the Delaware river from the Philadelphia navy yard to Fort Mifflin.
July	8	Maj. Gen. George B. McClellan, U. S A.	Tracing of the plane-table survey of James river from Harrison's Point to Curl's Neck, Va.

APPENDIX No. 2—Continued.

Date.		Names.	Data furnished.
1862.			
July	9	Maj. Gen. George B. McClellan, U. S. A.	Tracing of the plane-table survey of James river from Curl's Neck to Falling creek, Va.
	11	Brig. Gen. Andrew A. Humphreys, U. S. A.	Tracing of the James river survey from Kingland's creek to Falling creek, including site of Fort Darling, Va.
	17	Hon. Henry May, Maryland	Topography of St. Michael's river, with part of Thirdhaven creek, Md.
	17	Brig. Gen. Andrew A. Humphreys, U. S. A.	Topography and hydrography of James river from Sandy Point to Harrison's bar, Va.
	22	do	Topography of James river from Curl's Neck to Wilton, Va
	22	do	Topography of James river from Curl's Neck to Cogain's Point, Va.
August	2	Hon. G. V. Fox, Assistant Secretary of the Navy	T acing of part of Narragansett bay, R I.
	8	do	Hydrography of Potomac river from the entrance up to Indian Head.
	8	Col. Richard Delafield, corps of engineers	Topography and hydrography of the vicinity of Castle Richmond, N. Y.
	8	Navy Yard Commission	Hydrography and topography of League island and vicinity, Delaware river.
	14	do	Hydrography and topography of New London harbor and Thames river, Conn.
	14	Brig. Gen. H. H. Lockwood, U. S. A.	Topography of part of Accomac county, with hydrography of Metomkin inlet and Onancock creek, Va.
	16	Brig. Gen. Andrew A. Humphreys, U. S. A.	Topography of Appomattox river from City Point to Petersburg, Va.
	20	Col. Richard Delafield, corps of engineers	Topography and hydrography of Willet s Point and vicinity, L. I sound.
Sept.	1	Lieut. Col. J. N. Macomb, corps of topographical engineers.	Topography of the left bank of the Rappahannock river, Va.
	1	do	Tracing of a reconnaissance of the roads near Fredericksburg, Va.
	22	Navy Department	Hydrography of the resurvey made in 1862 of Beaufort harbor, N. C.
	25	Gouverneur Morris, esq., N. Y.	Hydrography of Throg's Neck reach, Long Island sound.
Oct.	2	Prof. Warren Holden, Philadelphia	Results of azimuth computations for Girard College, Philadelphia.
	31	Navy Department	Topography and hydrography of James river from Harrison's Point to Richmond, Va., manuscript map in three sheets on full scale of survey.

APPENDIX No. 3.

Statistics of field and office work of the United States Coast Survey during the years—

	Previous to 1844.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	Total.
Reconnaissance—																				
Area, in square miles	9,642	1,140	3,739	1,830	2,950	3,940	10,159	3,280	3,510	1,706	1,708	795	1,487	4,072	2,855	709	1,782	6,050	585	61,939
Parties, number of, in each year	4	2	4	5	5	7	6	4	6	6	5	13	7	5	8	4	3	1	1	....
Base lines—																				
Primary, number of	1	2	....	....	1	1	....	1	....	....	1	....	2	....	1	....	....	....	....	10
Secondary, number of	2	....	....	....	2	1	4	3	3	4	5	2	8	8	1	4	5	2	1	55
Length of, in miles	19½	16	....	....	9¼	13	6¼	17½	2	4½	18½	3¾	24½	9½	9	3½	6¼	1½	½	164¾
Triangulation—																				
Area, in square miles	9,076	795	2,166	1,185	1,903	2,592	4,091	2,097	2,465	1,703	3,089	2,701	2,729	2,793	1,640	3,033	3,724	4,773	1,632	54,187
Extent of general coast, in miles	570	179	162	123	159	115	285	216	243	220	94	246	188	320	357	278	358	232	173	4,518
Extent of shore-line, in miles, including bays, sounds, islands, and rivers	1,588	589	554	1,018	541	796	1,328	730	1,097	1,104	884	1,269	1,401	1,895	1,481	1,715	2,092	1,617	1,200	22,899
Horizontal angle stations occupied	750	120	80	197	120	98	204	157	184	223	224	204	410	544	385	384	344	322	159	5,109
Geographical positions determined	1,183	147	148	372	194	227	319	294	307	446	346	388	584	1,210	777	603	794	681	402	9,452
Vertical angle stations occupied	15	2	5	7	3	1	18	13	22	14	7	89	6	1	4	11	17	17	10	262
Elevations determined, number of	44	12	7	46	44	1	59	22	53	66	9	127	6	12	15	14	31	44	11	623
Parties, number of, in each year	4	5	8	7	8	10	13	14	14	13	18	17	17	20	20	19	21	21	14	....
Astronomical operations—																				
Stations occupied for azimuth	9	8	2	2	3	3	4	4	6	6	9	5	4	2	1	2	7	5	2	84
Stations occupied for latitude	9	8	5	3	8	2	4	6	8	17	20	6	4	6	3	5	5	6	2	127
Stations occupied for longitude	1	1	....	2	3	3	7	3	7	18	21	4	1	1	2	2	....	7	2	85
Permanent longitude stations	....	1	1	2	1	1	2	3	5	5	5	4	3	1	1	1	1	1	1	....
Special longitude stations for occultations, &c	....	....	....	....	....	....	....	....	....	....	....	....	....	....	23	30	24	24	....	....
Parties, number of, in each year	1	3	2	2	3	3	5	5	6	4	7	7	6	4	3	4	5	6	2	....
Magnetic stations occupied temporarily	8	14	21	28	19	4	11	9	10	8	13	9	8	23	4	5	18	17	4	233
Permanent magnetic stations	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	2	2	....
Parties, number of, in each year	1	2	3	3	3	3	5	4	3	2	3	6	3	4	3	3	4	7	4	....
Topography—																				
Area surveyed, square miles	6,131	195	503	750	595	471	532	652	681	653	554	513	656	536	1,003	798	657	592	478	16,950
Length of general coast, in miles	414	110	168	119	117	185	95	133	260	236	251	174	176	165	309	292	224	320	190	3,938
Length of shore-line, in miles, including rivers, creeks, and ponds	7,667	424	879	1,120	1,460	1,703	1,709	1,557	1,760	1,737	2,100	1,796	2,138	2,398	3,913	3,583	2,669	2,052	1,595	42,260
Length of road, in miles	11,734	395	997	1,402	1,351	640	504	511	500	732	502	618	733	750	1,404	885	482	260	669	25,072
Parties, number of, in each year	6	5	6	8	9	9	11	11	13	13	17	12	17	17	23	23	22	23	17	....
Hydrography—																				
Parties, number of, in each year	2	5	5	6	6	8	11	11	12	9	9	10	11	12	12	10	9	9	9	....

APPENDIX No. 3—Continued.

	Previous to 1844	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	Total.
Hydrography—																				
Number of miles run while sounding	29,214	1,857	3,493	3,559	3,138	8,047	4,299	5,995	10,590	9,531	9,050	9,141	13,115	15,305	12,377	8,884	9,426	9,438	2,434	168,896
Area sounded out, square miles...	9,601	663	677	574	979	2,185	1,335	2,012	3,200	2,823	2,061	1,937	3,433	3,743	2,705	1,799	4,310	1,651	225	45,913
Miles run additional of outside or deep-sea soundings	1,800	1,020	....	....	210	2,240	....	1,198	2,037	360	1,902	2,793	5,219	1,202	3,218	2.092	2,353	2,375	....	30,019
Soundings, number of	808,147	120,827	125,173	220,402	228,403	255,003	265,824	264,718	371,660	288,375	305,377	162,454	526,875	439,614	506,034	513,607	398,053	373,251	221,978	6,398,774
Soundings in Gulf Stream for temperature	....	....	118	581	207	425	....	....	....	....	1,053	257	310	....	478	172	235	236	....	4,072
Tidal stations, permanent	....	2	2	2	3	3	3	3	4	4	7	7	7	8	8	10	10	11	7	....
Tidal stations occupied temporarily.	127	14	33	39	33	29	35	41	51	76	78	89	80	77	74	53	32	50	23	1,034
Tidal parties, number of, in each year	2	5	5	5	5	8	11	11	12	9	11	12	13	14	14	13	10	12	7	....
Current stations occupied	....	27	42	41	59	54	28	44	41	24	89	10	84	84	156	47	38	84	26	978
Current parties, number of, in each year	....	3	5	3	3	4	6	4	7	7	5	3	5	6	6	2	2	[illegible]	2	....
Specimens of bottom, number of...	1,029	2,776	89	129	371	769	287	381	278	215	141	135	255	146	422	668	164	188	11	8,454
Records—																				
Triangulation, originals, number of volumes	97	12	17	23	17	32	38	40	33	33	64	46	79	96	76	96	94	120	82	1,095
Astronomical observations, originals, number of volumes	17	10	11	10	16	22	72	30	41	48	29	88	35	12	35	63	27	35	13	614
Magnetical observations, originals, number of volumes.............	4	2	1	6	7	4	3	5	5	7	6	4	33	13	4	10	9	13	17	153
Duplicates of the above, number of volumes	27	26	32	32	44	49	19	23	45	73	76	84	139	101	140	168	77	111	103	1,369
Computations, number of volumes	78	25	17	21	26	23	57	24	40	72	101	91	109	99	83	101	88	115	66	1,236
Hydrographic soundings and angles, originals, volumes	188	22	26	152	54	154	134	170	213	206	183	66	332	197	319	322	306	194	129	3,367
Hydrographic soundings and angles, duplicates, volumes.............	28	2	5	4	11	11	12	12	16	27	15	7	26	27	21	20	19	10	4	277
Tidal and current observations, originals, volumes...............	127	23	47	51	44	40	67	88	114	139	123	70	196	110	213	104	75	64	37	1,732
Tidal and current observations, duplicates, volumes	....	23	47	51	44	41	63	79	385	132	114	79	87	100	67	74	57	53	14	1,510
Sheets from self-registering tide-gauges, number of	......	....	....	....	....	....	....	....	....	26	72	106	80	103	119	141	149	189	116	1,092
Tidal reductions, number of vols...	....	46	94	102	88	80	16	58	22	26	17	99	79	73	63	64	52	60	46	1,085
Total number of volumes of records.	566	191	297	452	351	456	481	529	914	763	728	634	1,115	828	1,021	1,022	804	775	511	12,458
Maps and charts—																				
Topographical maps, originals	168	14	16	25	29	29	22	30	41	47	54	45	55	51	76	46	45	47	33	864
Hydrographic charts, originals	142	9	8	18	18	21	16	20	47	56	56	52	65	62	51	33	41	37	16	768

APPENDIX No. 3—Continued.

	Previous to 1844.	1844.	1845.	1846.	1847.	1848.	1849.	1850.	1851.	1852.	1853.	1854.	1855.	1856.	1857.	1858.	1859.	1860.	1861.	Total.
Maps and charts—																				
Reductions from original sheets, number of	15	9	15	16	17	13	18	22	26	48	35	27	36	39	40	35	92	23	21	547
Total number of manuscript maps and charts	325	32	39	59	64	54	56	72	114	151	145	124	156	152	167	114	178	107	70	2,179
Number of sketches made in field and office	311	24	33	32	29	48	82	85	126	137	103	101	132	125	132	127	353	108	62	2,150
Engraving and printing—																				
Engraved plates of finished charts, number of	5	2	3	5	3	6	3	5	6	5	4	2	7	3	7	6	8	8	9	97
Engraved plates of preliminary charts, sketches, and diagrams for the Coast Survey reports, number of	......	......	......	4	5	7	6	10	38	20	39	42	46	51	51	25	21	17	14	396
Electrotype plates made in each year	......	......	......	......	1	7	6	25	16	23	47	77	50	69	79	95	87	58	43	683
Finished charts published in each year	......	4	3	4	3	10	3	4	6	6	3	2	8	3	5	6	6	7	7	90
Preliminary charts and hydrographic sketches published	......	......	......	2	4	2	4	10	36	19	34	34	34	38	41	22	15	15	31	341
Printed sheets of maps and charts distributed	......	169	416	1,708	1,104	2,923	1,848	326	5,619	5,799	8,042	5,195	5,392	8,858	19,147	4,209	10,486	4,092	13,094	98,457
Printed sheets of ditto deposited with sale agents	......	......	880	1,686	4,981	5,016	1,506	3,115	5,168	6,866	4,375	3,232	2,577	2,898	648	1,717	3,584	2,145	733	51,127
Library—																				
Number of volumes	......	......	......	......	......	655	95	590	333	171	273	155	250	389	106	116	174	159	163	3,629
Instruments—																				
Cost of	......	......	......	......	......	......	$8,326	$4,652	$4,603	$3,635	$5,296	$5,402	$3,958	$5,369	$3,185	$1,224	$1,852	$1,729	$2,522	......

GENERAL NOTE.

Parties.—An average number is given for the years previous to 1844. A party operating in more than one section during the year is counted but once.

Triangulation.—The extent of general coast is measured in general outline, including Delaware and Chesapeake, as well as all open bays, but omitting the minor indentations of the sea-coast. The extent of shore-line is also measured in general outline, and includes such rivers only as have been triangulated.

Topography.—The length of general coast is measured similarly to that under triangulation; but shore-line under topography represents the whole water-line surveyed, including all the minor indentations, as represented on the plane-table sheets.

Records.—The total number of volumes of records given in the table is greater than the number now on hand, owing to the binding up of separate volumes.

Engraved plates.—Progress sketches (averaging fourteen yearly) are not counted.

Preliminary charts and sketches published.—Including a large number of maps of the scene of operations of the war.

Library.—The number of volumes purchased and donated up to 1849 was 655.

It is to be remarked that the numbers appearing in the column of this table for the year immediately preceding that of its compilation are, in some cases, subject to be changed, more or less, in the succeeding report, owing to data not being, at the time of compilation, fully turned into the office from the distant parties in the field.

APPENDIX No. 4.

GENERAL LIST OF COAST SURVEY DISCOVERIES AND DEVELOPMENTS TO 1861, INCLUSIVE.

1. A ledge with four fathoms of water on it, discovered S.SW. ¼ W. (true) and a mile and a quarter from Pemaquid light-house, coast of Maine, 1860.

2. Numerous dangerous reefs and ledges developed at the entrance and in the approaches of Damariscotta river, Maine, 1860.

3. Two rocks, one with three and a quarter fathoms, the other with only ten feet of water, and a ledge with three and a half fathoms, found in the channel of Booth bay, Maine, 1860.

4. Jeffrey's bank and Jeffrey's ledge, off the coast of Maine, thoroughly sounded out, 1860.

5. Only eighteen feet at mean low water found on the rock one mile to the southward of Seguin island, coast of Maine, 1859.

6. Temple's ledge, near Cape Small Point, Maine, 1857.

7. True position of the Hussey rock, in Casco bay, determined, correcting the erroneous one assigned on previous charts, 1859.

8. Determination of the position of a sunken rock on which the steamer Daniel Webster struck, in Casco bay, on the evening of the 13th of October, 1856.

9. Determination of the dimensions of Alden's rock, near Cape Elizabeth, Maine, 1854.

10. Determination of the position of the "Hue and Cry," the "Old Proprietor," and other dangers off Cape Elizabeth, Maine, 1859.

11. Huzzy's rock, south of Fletcher's Neck, Maine, determined in position, 1859.

12. Development of a four-fathom bank off Cape Porpoise, Maine, 1859.

13. Fishing ledge, off Kennebunk, Maine, thoroughly sounded, 1859.

14. A rock one mile to the southward and westward of Boon island, with seventeen feet water. The sea breaks on it in heavy weather, 1858.

15. Development of a rock off Ogunquit, bare at low tides, and very little known, 1859.

16. Development of Boon Island ledge, coast of Maine, 1858.

17. A rock off Cape Neddick, Maine, determined in position, 1858.

18. A detached rock, two thirds of a mile northward and eastward of York ledge, Me., 1858.

19. Determination of the position of a rock more than a mile off the mouth of York river, Maine, bare at low tides and dangerous to coasters, 1858.

20. Development of Duck Island ledge, 1858.

21. A fishing bank sounded out off Wood island, coast of Maine, 1859.

22. A very dangerous rock, with only six and a half feet water, off the entrance to Portsmouth harbor, New Hampshire, about four nautical miles eastward from the Whale's Back light, 1858.

23. A rock with twelve feet at mean low water about four miles and a third eastward of the Whale's Back, 1858.

24. Determination of the positions of four points of rock in Sandy bay, (Cape Ann,) Mass., 1861.

25. A rock (not on any chart) in the inner harbor of Gloucester, Massachusetts, discovered in 1853.

26. Determination of rocks off Marblehead and Nahant, 1855.

27. Determination of the position of White Rock ledge, at the entrance of Saugus river, Massachusetts, 1860.

28. A bank ninety miles eastward of Boston, with about thirty-six fathoms of water, probably a knoll connected with Cashe's ledge, but with deep water between it and the ledge, 1853.

29. Boston harbor; Broad Sound channel thoroughly surveyed and marks recommended, 1848.

30. Several rocks in the fair channel-way in Boston harbor entrance, 1854.

31. An extension of the sand-pit to the southward of Sunken ledge, Boston harbor, since the survey of 1847, 1858.

32. Discovery of a rock with only seventeen feet of water at mean low tide in the Narrows of Boston harbor, 1860.

33. Special investigation of the currents of Boston harbor, 1860 and 1861.

34. A bank (Stellwagen's bank) with ten and a half to fourteen and a half fathoms of water on it, at

the entrance to Massachusetts bay, and serving as an important mark for approaching Boston and other harbors, 1854.

35. Extension of Stellwagen's bank to the southward and eastward some sixteen or seventeen square miles, enclosed by the twenty-fathom curve, 1855.

36. Changes in the vicinity of East harbor, (Cape Cod,) 1857.

37. Special tidal and current observations at the mouth of Scusset river, (Cape Cod bay,) 1860.

38. A dangerous sunken ledge (Davis's ledge) to the eastward and in the neighborhood of Minot's ledge, 1854.

39. Development of a reef extending between Minot's and Scituate light, 1856.

40. A sunken rock, with only six feet on it at low water, off Webster's Flag-staff, Massachusetts bay, 1856.

41. A dangerous rock near Saquish Head, entrance to Plymouth harbor, 1856.

42. Three rocks determined in position, partly bare at low water, off Manomet Point, Massachusetts bay, 1856.

43. Determination of a very dangerous rock off Indian Hill, and four miles southward of Manomet Point, Massachusetts bay, with as little as six feet water on it, 1856.

44. The currents of Cape Cod bay observed with reference to their physical effects on the shores, 1861.

45. Determination of the position of a small rock with less than four feet at mean low water, near the channel and in the vicinity of Great Rock, Hyannis harbor, Massachusetts, 1859.

46. Probable connexion of George's bank and the deep sea banks north and east of Nantucket, 1855.

47. The decrease of depth, with general permanence of form of George's bank, off the coast of Massachusetts, 1857.

48. A shoal spot near Little George's bank, 1857.

49. Non-existence determined of "Clark's bank" and "Crab ledge," laid down on certain charts as distinct from an immense shoal ground off Cape Cod peninsula, 1856.

50. Nantucket shoals; Davis's New South shoals, six miles south of the old Nantucket south shoals, in the track of all vessels going between New York and Europe, or running along the coast from the eastern to the southern States, or to South America; discovered in 1846.

51. Two new shoals north and east of Nantucket; discovered in 1847.

52. Six new shoals near Nantucket, the outermost fourteen and a half miles from land, and with only ten feet water; discovered in 1848.

53. McBlair's shoals off Nantucket; discovered in 1849.

54. The tidal currents of Nantucket shoals and the approaches, 1854.

55. Davis's bank, Nantucket shoals; discovered in 1848, and survey finished in 1851.

56. Fishing Rip, a large shoal extending north and south, about ten miles to the eastward of Davis's bank, and thirty miles from Nantucket, with four and a half fathoms; surveyed in 1852.

57. A ridge connecting Davis's New South shoal and Davis's bank; found in 1853.

58. A small bank or knoll with but five fathoms on it, about five miles east of Great Rip, with twelve fathoms between it and Davis's bank and Fishing Rip, the water gradually deepening outside of it to the northward and eastward beyond the limits of the series of shoals, 1853.

59. Discovery of a shoal lying N.NE., over six miles long, and twenty-four miles southeast of Davis's south shoal, with ten to ten and a half fathoms of water, 1860.

60. Discovery of three small banks off the Nantucket shoals in the vicinity of Phelps's bank, and further development of the extent of that shoal ground, 1861.

61. Discovery of Edwards's shoal, one mile and seven-eighths southward of Nantucket light-boat, 1855.

62. Examination of the interference tides of Nantucket and Martha's Vineyard sounds, 1855.

63. The study of the tidal currents of the Vineyard and Nantucket sounds, 1857.

64. Contraction of the inlet at the north end of Monomoy island, and opening of a new entrance to Chatham harbor, 1853.

65. Muskeget channel, surveyed by Lieutenant C. H. Davis, in 1848, and Lieutenant C. H. McBlair, in 1850.

66. Discovery of two shoal spots, with twelve and thirteen feet water, eastward from Great and Little Round shoals, Nantucket sound, 1856.

67. Determination of two shoal spots near the northern extremity of Davis's bank, with fourteen and eighteen feet water, 1856.

68. Further development of Edward's shoal, three-fourths of a mile from the southern Cross Rip; Nantucket sound, 1856.

69. Shoal sand ridges discovered northward of Great Point light, Nantucket sound, 1856.

70. Important changes in geographical feature at the southeastern end of Martha's Vineyard, Muskeget channel, 1856.

71. Numerous rocks in Martha's Vineyard sound, Long Island sound, and the various bays and harbors connected with them.

72. Luddington rocks determined in position, about ten yards apart, a mile and a half (nautical) southwest by compass from New Haven light, 1858.

73. The tidal currents of Long Island sound, 1854.

74. The tidal currents of Hell Gate, 1857.

75. Least water on the Hell Gate rocks determined by dragging, 1857.

76. Tidal currents in East river, New York, and surface and sub-currents investigated in New York harbor, the lower bay, and on the bar, 1858.

77. The currents of the great bay between Massachusetts, Rhode Island, Connecticut, New York, and New Jersey, 1855.

78. Gedney's channel in New York bay, having two feet more water than the old channels. Had the true depth of this channel been known in 1778, (then probably existing, as seen by comparing old and new charts,) the French fleet under Count D'Estaing would have passed into the bay and taken the assembled British vessels, 1845.

79. The changes in New York harbor, near New York city, between 1845 and 1858.

80. Increase of depth in Buttermilk channel, ascertained and made known in 1848 by survey of Lieutenant D. D. Porter, United States navy.

81. The existence of a seventeen-foot spot on the shoal off the battery, New York harbor, the extension of the shoal towards the channel, and the shoaling of the water generally between the shoal and shore, 1859.

82. Shoal in the main ship channel of New York harbor, 1855.

83. The existence and character of sub-currents ascertained as bearing on the physical conditions of New York harbor, 1859.

84. The tides of Hudson river, 1856.

85. Sandy Hook; its remarkable increase traced from the surveys of the topographical engineers and others, and by several successive special surveys made between 1844 and 1857.

86. Development, by soundings, of a ridge lying sixteen miles off Barnegat, N. J., with eleven to thirteen fathoms of water, and sixteen fathoms between it and the coast, 1861.

87. Special examination made and changes noted in the vicinity of the Five-fathom bank, off Cape May, 1861.

88. Delaware bay; Blake's channel at the entrance discovered in 1844; open when the eastern channel is closed by ice. This discovery has served to develop strikingly the resources of that portion of Delaware.

89. Blunt's channel in Delaware bay.

90. Changes in the Delaware, near the Pea Patch, 1847.

91. Hydrographic changes developed in the Delaware river, at the Bulk Head shoal, near Fort Delaware, at the bar off Fort Mifflin, and opposite to Philadelphia, 1861.

92. The true extent and position of the dangerous shoals near Chincoteague inlet, Virginia, 1852.

93. Metomkin inlet, Virginia, shoaling from eleven to eight feet in the channel during 1852.

94. Two channels into Wachapreague inlet, Virginia—one from the northward and the other from the eastward; both with seven feet water at low tide, 1852.

95. A shoal half a mile in extent, not put down on any chart, five and a half miles east from the north end of Paramore's island, Virginia. It has but four fathoms water on it, and nine fathoms around it, 1852.

96. Great Machipongo inlet, Virginia. Found to have a fine wide channel, with eleven feet water on the bar at low ebb and fourteen at high tide. Good anchorage inside, from two to eight fathoms. The best harbor between the Chesapeake and Delaware entrances, 1852.

97. Two shoals near the entrance to the Chesapeake—one four and three-quarters nautical miles SE. by E. from Smith's Island light-house, with seventeen feet water upon it; the other, E. by S., nearly seven and three-quarters miles from the same light, with nineteen and a half feet upon it, 1853.

98. Only three feet water upon the "inner middle," the shoal part of the middle ground, west of the "north channel" at the Chesapeake entrance, 1852.

99. A twenty-five fathom hole two and a half miles W.SW. from Tazewell triangulation point, eastern shore of the Chesapeake. All other charts give not more than sixteen fathoms in this vicinity.

100. A shoal at the mouth of the Great and Little Choptank, in Chesapeake bay, 1848.

101. The sounding and measurement of the bars in Rappahannock river, 1855.

102. The general permanence of the Bodkin channel and shoals in its vicinity, at the entrance of the Patapsco river, between 1844 and 1854.

103. Changes developed in the shore-lines at the entrance of Little Annemessex river, Chesapeake bay, 1859.

104. A shoal (New Point shoal) in Chesapeake bay, with sixteen feet water on it, southeast from New Point Comfort light-house, off Mobjack bay, 1854.

105. Re-examination of York spit, Chesapeake bay, and least water determined, (nine feet,) 1855.

106. York river, Va., as a harbor, 1857.

107. A reconnaissance of the Wimble shoals, near Nag's Head, coast of North Carolina, 1854.

108. Submarine range of hills beyond the Gulf Stream tracked from Cape Florida to Cape Lookout, 1855.

109. Deep water found on Diamond shoal, and a dangerous nine-feet shoal off Cape Hatteras, 1850.

110. A new channel, with fourteen feet water, into Hatteras inlet, formed during the year 1852, which is better and straighter than the old channel.

111. Changes at Hatteras and Ocracoke inlets, 1857.

112. Extent of the sea encroachment at Cape Hatteras, and changes found near Hatteras inlet, N. C., 1860 and 1861.

113. The general permanence in depth on the bar of Beaufort, N. C., with the changes of position of the channel, 1854.

114. Changes on the bar of Beaufort, N. C., 1857.

115. The well-ascertained influence of prevailing winds in the movement of the bars at Cape Fear and New Inlet entrances, and the gradual shoaling of the main bar; the latter fact being of great importance to the extensive commerce seeking that harbor, 1853.

116. Changes in the main Western and New Inlet channels in Cape Fear, 1855.

117. Frying Pan shoals, off Cape Fear, N. C.; a channel of two and a half fathoms upwards of a mile wide, distant eleven nautical miles from Bald Head light-house across the Frying Pan shoals. A channel extending from three to four miles from the point of Cape Fear to eight or eight and a half miles from it, with sufficient water at low tide to allow vessels drawing from nine to ten feet to cross safely. A channel at the distance of fourteen nautical miles from Bald Head light-house, one mile wide, with three and a half to seven fathoms water on it. The Frying Pan shoals extend twenty nautical miles from Bald Head light-house, and sixteen, seventeen, and eighteen feet water is found seventeen and eighteen nautical miles out from the light, 1851.

118. Shoaling of Cape Fear River bar thoroughly examined for purposes of improvement, 1852.

119. Changes of shore-line and hydrography determined at the Cape Fear entrances, N. C., 1858.

120. Changes of the Cape Fear bars and channels, 1857.

121. Changes at the entrance of Winyah bay and Georgetown harbor, and the washing away of Light-house Point at the same entrance, 1853.

122. Less water found off Cape Romain, by preliminary examination, than has been heretofore assigned, 1859.

123. Maffitt's new channel, Charleston harbor, with the same depth of water as the ship channel, 1850.

124. The changes in Maffitt's channel, Charleston harbor, S. C., from 1852 to 1857.

125. Increase of depth developed in Maffitt's channel, Charleston harbor, S. C., 1858.

126. Changes in the main ship channel, Charleston harbor, 1851.

127. Changes in the channels at the entrance of Charleston harbor, 1852.

128. The remarkable discovery of continuous deep-sea soundings off Charleston, and of soundings in the depth of between four and five hundred fathoms beyond the Gulf Stream, 1853.

129. Development of the changes affecting the entrance to North Edisto river, S. C., 1856.

130. Greater depth found through the channel of Coosaw river, S. C., (inland passage,) than has been hitherto supposed to exist, 1860.

131. Discovery of a new channel between Martin's Industry (shoal) and the southeast breakers, Port Royal entrance, S. C., 1856.

132. Discovery of cold water at the bottom of the ocean below the Gulf Stream, along the coast of North and South Carolina, Georgia, and Florida, 1853.

133. The discovery of the cold wall, alternate warm and cold bands, and various other features of the Gulf Stream, especially such as concern its surface and deep-sea temperatures, and its distribution relative to the shore and bottom of the ocean.

134. Various facts relative to the distribution of minute shells on the ocean bottom, of probable use to navigators for recognizing their positions.

135. Changes in shore-line and in depth observed in Ossabaw sound, Ga., 1860.

136. A new channel developed leading into Sapelo sound, Ga., three-quarters of a mile southward, and better than the one in use, 1860.

137. Examination of Doboy, St. Simon's, and Cumberland entrances, 1855.

138. A shoal inside of the entrance to Amelia river, Fla., 1857.

139. Hetzel shoal, off Cape Cañaveral, Fla., 1850.

140. A shoal spot found off the coast of Florida, ten miles from land and fifteen miles NE. of Indian River inlet, 1860.

141. Temperature of 34° beneath the Gulf Stream, thirty-five miles east of Cape Florida, at a depth of three hundred and seventy fathoms, 1855.

142. Further explorations and investigations in developing the character of the Gulf Stream in the Florida channel, 1859 and 1860.

143. A harbor of refuge (Turtle harbor) to the northward and westward of Carysfort light-house, Florida reef, with a depth of water of twenty-six feet at the entrance, 1854.

144. A new passage, with three fathoms water, across the Florida reef, to Legaré harbor, under Triumph reef, (latitude 25° 30′ N., longitude 80° 03′ W.,) which, if properly buoyed, will be valuable as a harbor of refuge, 1852.

145. A safe rule for crossing the Florida reef near Indian key, 1854.

146. Tennessee shoal, Florida reef, developed, giving only twelve feet of water on its outer patch, 1860.

147. The position of a sunken wreck determined and marked, lying off Grassy key, Florida reef, and near the track of vessels, 1860.

148. A new channel into Key West harbor, 1850.

149. Co-tidal lines for the Atlantic coast of the United States, 1854.

150. Rules for navigators in regard to the tidal currents of the coast, 1857.

151. Isaac shoal, near Rebecca shoal, Florida reef; not laid down on any chart, 1852.

152. Channel No. 4, a northeast entrance into Cedar Keys bay, 1852.

153. Directions for entering the harbor from Crystal River offing, west coast of Florida peninsula, 1856.

154. A new channel discovered, leading into St. George's sound, (Apalachicola, Fla.,) at the east end of Dog island, and anchorage connected with it, 1858.

155. Shoals near the east and west passes of St. George's sound, (Apalachicola, Fla.,) and a new channel found between St. George's and St. Vincent's islands, 1858.

156. Indications noticed of a deeper and better channel forming to lead to the East Pass anchorage, St. George's sound, Fla., 1860.

157. Changes in the depth of water observed by comparison of soundings at Perdido entrance, 1860.

158. Mobile Bay Entrance bar; in 1832 only seventeen feet at low water could be carried over it; in 1841 it had nineteen, and in 1847 it had twenty feet and three quarters, as shown by successive surveys, 1847.

159. The diminution, almost closing, of the passage between Dauphine and Pelican islands, at the entrance of Mobile bay, 1853.

160. The currents of Mobile bay specially investigated, 1860.

161. Horn Island channel, Mississippi sound, 1852.

162. The removal of the east spit of Petit Bois island in the hurricane of 1852, opening a new communication between the Gulf and Mississippi sound, and the rendering of Horn Island Pass more easy of access by the removal of knolls, 1853.

163. The accurate determination of Ship shoal, off the coast of Louisiana, in connexion with the site for a light-house, 1853.

164. An increase of depth of water on the bar of Pass Fourchon, La., 1854.

165. Deep-sea soundings in the Gulf of Mexico, 1855–'56.

166. Tidal phenomena of the Gulf, 1855.

167. The changes at Aransas Pass, Texas, as bearing on the question of a light-house site, 1853.

168. Co-tidal lines of the Gulf of Mexico, 1856.

169. On the effect of wind in disturbing the tides of the Gulf of Mexico, 1856.

170. Development of a bar at the entrance of San Diego bay, Cal., 1856.

171. A shoal inside of Ballast Point, San Diego bay, with only twelve and a half feet of water, not laid down on any chart, 1852.

172. The determination of the position and soundings on Cortez bank, off the coast of California, 1853.

173. Complete hydrographic survey and determination of a point of rock on Cortez shoal, 1856.

174. Tides of San Diego, San Francisco, and Astoria, 1854.

175. The non-existence of San Juan island, usually laid among the Santa Barbara group, 1852.

176. Co-tidal lines of the Pacific coast, 1855.

177. Determination of Uncle Sam rock, 1855.

178. Investigation of the currents of Santa Barbara channel, 1856.

179. Red sand marking the entrance to the Golden Gate, 1855.

180. Channel sounded out between Yerba Buena and the Contra Costa, San Francisco bay, 1855.

181. A reef developed off the Contra Costa flats, San Francisco bay, Cal., 1858.

182. Whiting's rock determined in position, near the "Brothers," at the entrance of San Pablo bay, Cal., 1858.

183. Further development of the extent of Commission rock, San Pablo bay, 1856.

184. Changes in the channel entrance of Humboldt bay or harbor, Cal., 1852 and 1853.

185. South channel, Columbia river, surveyed and made available to commerce, 1851. Changes of channels, their southward tendency, and a new three-fathom channel from Cape Disappointment due west to open water, Columbia entrance, 1852. Further changes, 1853.

186. The depth of water on the bars at the entrance of Rogue river and Umpquah river, Oregon, 1853.

187. A shoal at the northern entrance to the strait of Rosario, W. T., giving good holding ground in thirty-three feet, 1854.

188. Boulder reef, northwest of Sinclair island, Rosario strait, partly bare at unusually low tides, and surrounded by kelp, 1854.

189. A bank of three and a half fathoms, about a mile off the southwest point of Sucia island, at the northern entrance of Washington sound, W. T., 1858.

190. Belle rock, in the middle of Rosario strait, visible only at extreme low tides, 1854.

191. Entrance rock, at the entrance of Rosario strait, 1854.

192. Unit rock, in the Canal de Haro, W. T., visible only at extreme low tides, 1854.

193. A three-fathom shoal in the strait of Juan de Fuca, off the southeast part of Bellevue, or San Juan island, 1854.

194. Allen's bank, Admiralty inlet, W. T., 1857.

195. A five-fathom shoal in the strait of Juan de Fuca, between Canal de Haro and Rosario strait, 1854.

196. A bank in eleven fathoms off the southern entrance to Canal de Haro, 1854.

197. The non-existence of two islands at the northern entrance of Canal de Haro, laid down on charts, 1853.

198. Various surveys and charts of small harbors on the Pacific coast of the United States, and a continuous reconnaissance of the entire Western Coast and islands adjacent, a great part of which was imperfectly known.

199. Winds of the Western Coast of the United States, 1857.

ADDITIONAL LIST FOR 1862.

1. Two rocks discovered in the approaches to Newport harbor, R. I. One of these has fourteen and a quarter feet of water on it at mean low tide; the other has seventeen feet at low water. Ten other rocks, before known, were determined in position.

2. The shifting of the bar of Metomkin inlet, Va., and changes of shore-line, but without alteration of depth on the bar.

3. Development of the best line of water for crossing the Kettlebottom shoals, Potomac river, there being no well defined channel.

4. Changes in depth and outline at Oregon inlet, N. C.

5. Special examination of the tides and currents, with reference to the hydrographic and shore-line changes at Hatteras inlet, N. C.

6. Development of the alteration in outline and depth, at the entrance of Beaufort harbor, N. C.

7. Re-examination, by soundings, of the Rattlesnake shoal, S. C.

8. Stono entrance, S. C., sounded, and channel found half a mile to westward of its former position, with slight increase of depth.

9. The shoaling of North Edisto entrance from its former depth, to nine feet of water.

10. St. Helena entrance, S. C., examined, and a new channel from the eastward found, giving sixteen feet at mean low water.

11. The south channel of Port Royal sound developed, and nineteen and a half feet found to be the least depth of water.

12. The channel of the inland passage thoroughly sounded, leading from Port Royal sound to Tybee roads, through Skull creek and Calibogue sound.

13. The bar and entrance of St. Simon's sound, Ga., examined, showing no material change of depth within the past two years.

14. The shifting to southward and shoaling by several feet of the channel into Fernandina harbor, Fla., having now only eleven feet at mean low water.

15. The further encroachment of the sand spit at the confluence of Karquines and Mare Island straits upon the channels which lead to the navy yard and to Benicia.

APPENDIX No. 5.

Table showing the least water in the channels of certain harbors, rivers, and anchorages on the coasts of the United States; reprinted from the list of 1859 and revised with additions and tidal data.

Places.	Limits between which depths are given.	Least water in channel way. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	Feet.	Feet.	Feet.	
Kennebec river	On sailing line up to Hanniwell's Point	25.5	33.6	25.1	34.4	C. S., 1858.
Portland, Maine	From Cape Elizabeth to Portland light	45	53.9	44.5	54.4	
	*From Portland light to breakwater	36	44.9	35.5	45.4	
	From breakwater to end of Munjoy Point	30	38.9	29.5	39.4	C. S., 1850, 1853, and 1854.
	From breakwater to anchorage	16	24.9	15.5	25.4	
	Channel-way off town and wharves	27	35.9	26.5	36.4	
	From Munjoy to railroad bridge	19.5	28.4	19	28.9	
Portsmouth, N. H.	From Whale's Back to Fort Constitution	42	50.6	41.4	51.3	
	From Fort Constitution to the Narrows	51	59.6	50.4	60.3	C. S., 1851.
	From the Narrows to the city	45	53.6	44.4	54.3	
	Off the wharves	63	71.6	62.4	72.3	
Newburyport	Over bar	7	14.8	6.6	15.7	
Ipswich	Over bar	7.5	16.1	6.6	16.8	C. S., 1857.
Annisquam	Over bar	6.5	15.5	5.6	15.4	
Gloucester	Channel into southeast harbor	30	38.9	29.1	39.8	
	Inner harbor channel to abreast Ten Pound Island light	31	39.9	30.1	40.8	C. S., 1854.
	Up into inner harbor	24	32.9	23.1	33.8	
Salem, Mass.	Northern ship channel, between Baker's and Misery islands	52	61.2	51.3	61.9	
	Southern ship channel, passing Half-way Rock, Gooseberry and Eagle islands to the northward, and Cat island and Coney island to the southward	28	37.2	27.3	37.9	C. S., 1850 and 1851.
	Inside of Salem Neck	19	28.2	18.3	28.9	
Boston, Mass.	Main ship channel, between Lovell's and Gallop's islands	28.5	38.5	27.8	39.1	
	Broad sound, south channel	19.5	29.5	18.8	30.1	
	President's roads, anchorage	31.5	41.5	30.8	42.1	C. S., 1846, 1847, 1848, and 1853.
	Main ship channel, between Governor's island and Castle island	18	28	17.3	28.6	
Plymouth	Entrance off Gurnet lights	21	31.2	20.3	31.7	
	South of Duxbury pier, in mid channel	48	58.2	47.3	58.7	
	Up to anchorage inside the pier head on Long Beach	14	24.2	13.3	24.7	C. S., 1857.
	At anchorage inside the pier head	24	34.2	23.3	34.7	
	Anchorage in the Cow Yard	24	34.2	23.3	34.7	
Barnstable harbor	Over bar	7.7	17.0	6.7	17.5	C. S., 1862.
Narragansett bay to Prudence island.	Entering with Boston Neck on port hand, Beavertail and Dutch island lights on starboard hand, passing between Canonicut Point and Hope island	25	28.9	24.6	29.2	Com. Wadsworth, 1832.
	Entering with Beavertail light on the port and Castle Hill on the starboard hand, up to Goat island	60	63.9	59.6	64.2	
	Anchorage southward and westward of Goat island	33	36.9	32.6	37.2	
	Abreast of wharves inside of Goat island	21	24.9	20.6	25.2	
	From Newport harbor, inside of Gull Rocks to Prudence island	31	34.9	30.6	35.2	C. S., 1848.
	To Mount Hope bay	42	45.9	41.6	46.2	
	To Mount Hope bay, with Cormorant Rock, Sachuest Point on port, and Saughkonnet Point on starboard hand	20	23.9	19.6	24.2	
New York	Gedney's channel	23	27.8	22.6	28.1	
	Swash channel	17	21.8	16.6	22.1	C. S., 1855 and 1856.
	Old South channel	21	25.8	20.6	26.1	
	Main ship channel, passing Sandy Hook to SW. spit buoy	31	35.8	30.6	36.1	
	Main ship channel, after passing SW. spit buoy on NE. course, one mile up the bay for New York	23	27.8	22.6	28.1	C. S., 1855.

* The depth in channel way varies between 6 and 8½ fathoms.

APPENDIX No. 5—Continued.

Places.	Limits between which depths are given.	LEAST WATER IN CHANNEL WAY. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Arthur's Kill	Anchorage at Perth Amboy	22	26.9	21.5	27.5	
	From anchorage to Woodbridge wharf	22	26.9	21.5	27.5	
	*From Woodbridge wharf to Rossville	13.5	18.6	13.0	19.2	
	†From Rossville to Chelsea	14	19.1	13.5	19.7	C. S., 1855.
	‡From Chelsea, in the western channel, to Elizabethport	13	18.1	12.5	18.7	
	§From Elizabethport to Shooter's island	6.5	10.9	6.0	11.5	
Kill van Kull	From Shooter's island to Bergen Point light-house	10	14.3	9.5	14.9	
	From Bergen Point light-house to New Brighton	27	31.3	26.5	31.9	
Newark bay	‖From Bergen Point light-house to the mouth of Hackensack river	7	11.6	6.5	12.2	C. S., 1855.
Hudson river	From Castle Garden to Manhattanville	32	36.0	31.6	36.8	Do.
	From Manhattanville to Yonkers	27	30.8	26.7	31.3	Do.
	¶From Yonkers to Piermont Ferry	39	42.6	38.7	43.0	C. S., 1853.
	**From Piermont Ferry to Sing Sing	24.5	28.0	24.3	28.3	Do.
	From Sing Sing to Haverstraw	26	29.1	25.8	29.8	Do.
	From Haverstraw to Peekskill	27	30.1	26.8	30.8	C. S. 1854.
Delaware bay	††Main ship channel, passing Delaware breakwater	61	64.5	60.4	64.9	
	Off Brandywine light-house	43	46.5	42.4	46.9	
	Main ship channel, passing False Liston's tree to abreast of Bombay Hook light	27.5	33.4	27.3	34.2	C. S., from 1840 to 1844, inclusive.
	Blake's channel, along Flogger shoal	13.5	19.4	13.3	20.2	
	Blake's channel, passing Mahon river light	13.5	19.4	13.3	20.2	
	Main ship channel approaching Liston's Point	20	25.9	19.8	26.7	
Delaware river	Main ship channel up to Reedy island	20	26	19.6	26.3	
	Main ship channel, opposite Reedy island light-house	24.5	30.5	24.1	30.8	
	Opposite Delaware City	30	36	29.6	36.3	
	Up to Christiana Creek light	20.5	27	20.3	27.2	
	Up to Marcus Hook	20.5	27	20.3	27.2	C. S., from 1840 to 1844, inclusive.
	Opposite Chester	24.5	30.7	24.4	31.2	
	Bar off Hog island	18.5	24.7	18.4	25.2	
	Between Greenwich Point and Gloucester Point	31.5	37.5	31.4	38.2	
	From Greenwich Point up to Philadelphia	21.5	27.5	21.4	28.2	
Chesapeake bay	From capes at entrance to Hampton Roads	30	32.5	29.8	32.8	
	Anchorage in Hampton Roads	59	61.5	58.8	61.8	
	From Hampton Roads to Sewall's Point	25	27.5	24.8	27.8	
	South of Sewall's Point, (one mile and a half)	21	23.5	20.8	23.8	
	Up to Norfolk	23	25.5	22.8	25.8	1852, 1853, and 1854.
	From Hampton Roads to James river, entering to the northward of Newport News middle ground	22	24.5	21.7	24.8	
	From Hampton Roads to James river, entering to the southward of Newport News middle ground	27	29.5	26.7	29.8	
Potomac river	......	......	......	......	......	
	......	......	......	......	......	
	......	......	......	......	......	
	......	......	......	......	......	
	......	......	......	......	......	
	......	......	......	......	......	
York river, Va	From abreast the tail of York spit up to Yorktown	33	35.5	32.7	35.8	1852, 1853, and 1854.

* Two bars, each a quarter of a mile, have a less depth than 18 feet.

† A small shoal, with 12 feet, lies in the middle of the kill, opposite the wharf at Blazing Star; and another, with 10 feet, a quarter of a mile to th northward; but deeper water is found on east side of both.

‡ A shoal, with 4 feet, obstructs the eastern channel, half way between Chelsea and its junction with the main channel.

§ Channel very narrow in the vicinity of Black beacon.

‖ From Bergen Point light, half way to Newark Bay light-house, 17 feet may be carried.

¶ In a straight line.

** A shoal of 21.5 feet occurs about a mile below Sing Sing.

†† Soundings varying between 10 and 15 fathoms.

APPENDIX No. 5—Continued.

Places.	Limits between which depths are given.	LEAST WATER IN CHANNEL WAY. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
James river, Va.	Over White Shoal bar	16	18.5	15 5	18 9	C. S., 1852–'59.
	On sailing line up to Jamestown Island bar	19	21.5	18.5	21.9	
	Through channel to the northward, and northward and westward of White shoals to a point one mile above Deep Water light-house	23	25.5	22 5	25.9	
	Over Jamestown Island bar	15	17.5	14.5	17.9	
	Harrison's bar	13.5	16.3	13.4	16.5	
	*Trent's reach	8.5	11.7	8.5	11.9	
	*Warwick bar	12.5	15.7	12.5	15.9	
	*Richmond bar	7	9.9	7.0	10.1	
Elizabeth river, Va.	Between Norfolk and navy yard	25.5	28	25.3	28.3	1852, 1853, and 1854.
Hatteras inlet, N. C.	Over bar	14	17.6	13.6	18.2	C. S., 1862.
	†Over bulkhead into Pamplico sound	7	9	6 9	9.1	
Ocracoke inlet	Over bar	10	12 4	9.8	12.6	1857.
	Anchorage in Wallico's channel	19	21.4	18 8	21.6	
Albemarle sound	‡From light-boat off Caroon's Point to a line joining Powell's Point and shell bank, near the mouth of Currituck sound	7	....	....	....	1851.
	‡Thence up the sound to Martin's Point	5.5	....	....	....	
	‡From Martin's Point to Trout Hole, south of Rattlesnake island	5	....	....	....	
North river, N. C.	‡At entrance, and seven miles up from Albemarle sound	6.7	....	....	....	1850.
Beaufort, N. C.	Main ship channel	15	17.8	14.8	18.1	C. S., 1862.
	Through the slue	7	9.8	6.8	10.1	Do.
Cape Fear	New Inlet bar	8	12.5	7.5	13	1857.
	Western bar	8	12.5	7.5	13	
Georgetown, S. C.	Entrance to Winyah bay, East and Southeast Pass	7	10.8	6.7	11.3	1851, 1852, and 1853.
	Anchorage inside of North island	27	30.8	26.7	31.3	
	Up to Georgetown	9	12.6	8.7	13.1	
Bull's bay	Over bar	13	17.8	12.6	18.3	1857.
	At anchorage	21	25 8	20.6	26.3	
Charleston, S. C.	Main bar	11	16.1	10.6	16.5	1857.
	North channel	10	15.1	9.6	15.5	
	Maffit's channel	11	16.1	10.6	16.5	1858.
Stono inlet	Over bar	6.5	12.5	5.9	13 0	Do.
North Edisto	South or main channel	12	17.8	11.5	18.4	Do.
	East channel	9	14.8	8.5	15.4	Do.
St Helena Sound	South channel	17	22.9	16.3	23.7	Do.
	East channel	16	21.9	15.3	22.7	Do.
	South Edisto	14	19.9	13.3	20.7	1856–'57.
Port Royal entrance	SE. channel	19.5	25.9	19.2	26.5	1862.
	South channel	19.5	25.9	19.2	26.5	Do.
Tybee entrance	Bar near Tybee island	19	26	18.4	26.5	1851 and 1852.
	Tybee roads	31	38	30.4	38.5	
Savannah	Channel up to city, (Wrecks and Garden Bank)	11	17.5	10.6	18.2	Captain Gilmer, U. S. Engineers.—1856.
Ossabaw sound	North channel to Vernon river	8	14.6	7.1	15.1	1860.
	South channel to Vernon river	12	18.6	11.1	19.1	Do.
	South channel to Ogeechee river	13	19.6	12.1	20.1	Do.
Sapelo sound	Over bar	18	25 0	17.4	15.7	Do.
Doboy bar, (inlet)	Entrance over bar	15.5	22.1	14.7	22.5	1855.
	Anchorage in sound	24	30.6	23.2	31	
St. Simon's sound	Over bar	15	21.8	14.3	22.5	1862.
	Entrance to sound	38	44.8	37.3	45.5	1855–'56.
	Turtle river up to Blythe island	21	27.8	20.3	28.5	
	To Brunswick over bar off south end of Buzzard's Roost island	9	15.8	8.3	16.5	
	To Brunswick through channel north of Buzzard's Roost island	13	19.8	12.3	20.5	

* The effect of spring and neap tides is very small. The depth is affected much more sensibly by the stage of the river above.

† The tide diminishes rapidly after entering the inlet.

‡ There are no lunar tides in Albemarle, Currituck, and Pamplico sounds.

APPENDIX No. 5—Continued.

Places.	Limits between which depths are given.	LEAST WATER IN CHANNEL-WAY. Mean. Low water.	Mean. High water.	Spring tides. Low water.	Spring tides. High water.	Authorities.
		Feet.	*Feet.*	*Feet.*	*Feet.*	
St. Mary's	Over bar	11	16.5	10.5	17.1	C. S., 1862.
St. John's river, Fla	Over bar at entrance	7	11.5	6.4	11.9	1855.
	Channel passing up to Jacksonville	23	25.1	22.5	25.5	
St. Augustine	Over bar	7	11.2	6.8	11.7	1860.
Florida reef	Approaches to the inside of the reef:					
	Cape Florida light-house bearing W.SW. ¾ W.	20	21.5	19.9	21.7	
	Entrance to the northward of Fowey Rocks; Soldier key bearing SW. ½ W.	19	20.5	18.9	20.7	1862.
	Entrance to Legaré anchorage	20	21.5	19.9	21.7	
	Turtle Harbor entrance	26	27.5	25.9	27.7	
	Channel inside the reefs (Hawk channel) from entrance off Cape Florida light-house to Rodrigues key	11	12.5	10.9	12.7	1854.
	Anchorage one mile from Indian key	21	22.8	20.7	23.1	
	Bahia Honda channel, west point of Bahia Honda bearing N.NW.	18	19.3	17.7	19.5	
	Key Sambo channel, between Middle and Western Sambo	34	35.3	33.7	35.5	
	Inside the reef and steering W. by N. for buoy	14	15.3	13.7	15.5	
Key West	Main ship channel to middle buoy on shoals	27	28.3	26.9	28.5	
	From shoals to anchorage	30	31.3	29.9	31.5	
	East channel, entering	30	31.3	29.9	31.5	
	On course N.NW. ¼ W. (light on O'Hara's observatory) and passing between shoals	28	29.3	27.9	29.5	
	From 14-feet shoals to anchorage	30	31.3	29.9	31.5	
	At anchorage	27	28.3	26.9	28.5	
	Rock Key channel	20	21.3	19.9	21.5	1850 and 1851.
	Sand Key channel	27	28.3	26.9	28.5	
	West channel	30	31.3	29.9	31.5	
	Northwest channel up to abreast Northwest light	15	16.3	14.9	16.5	
	Over Northwest channel bar	12	13.3	11.9	13.5	
Tortugas	Northwest channel	45	46.2	44.8	46.4	
	Southwest channel	54	55.2	53.8	55.4	
Tampa bay	Over bar	19	20.4	18.8	20.4	1855.
	Channel between Egmont and Passage keys	17	18.4	16.8	18.4	
Waccasassa bay	Channel up to anchorage	8	10.6	7.7	10.9	1857.
Cedar keys	Main channel	9	......	......	......	
	Main channel over bar	9	11.5	8.7	11.8	1860.
	North Key channel	5.5	8.0	5.2	8.3	Do.
	Through Northwest channel up to Depot key	7.5	10.0	7.2	10.3	Do.
St. Mark's	Over bar	9	11.5	8.7	11.8	
	Channel at Middle buoy	12	14.5	11.7	14.8	1855.
	In mid-channel, off light-house	15	17.5	14.7	17.8	
	Up to Fort St. Mark's	7	9.5	6.7	9.8	1852.
St. George's sound	East entrance over bar	15.5	17.1	15.2	17.4	
	Main ship channel	14	15.6	13.7	15.9	
	Swash channel	13	14.6	12.7	14.9	
	At anchorage	19	20.6	18.7	20.9	1858.
Apalachicola	*Over bar	13	14.1	12.6	14.4	
	In mid-channel, off beacon on St. Vincent's island	39	40.1	38.6	40.4	
	Up to anchorage	10	11.1	9.6	11.4	
St. Andrew's bay	*Main ship channel, over bar	13	14	12.8	14.3	
	Swash channel, over bar	7	8	6.8	8.3	1855.
	West Pass, over bar	7	8	6.8	8.3	
Pensacola	*Over bar	22.5	23.5	22.3	23.8	
	From bar to navy yard	27	28	26.8	28.3	1856.
	Off wharf at Pensacola	21	22	20.8	22.3	

* The highest tides occur at the moon's greatest declination, and are applied in the column headed "spring tides."

APPENDIX No. 5—Continued.

Places.	Limits between which depths are given.	LEAST WATER IN CHANNEL WAY.				Authorities.
		Mean.		Spring tides.		
		Low water.	High water.	Low water.	High water.	
		Feet.	*Feet.*	*Feet.*	*Feet.*	
Mobile bay and river	*Over outer bar	21	22	20.7	22.2	1847 to 1852, inclusive.
	Main ship channel to Fort Morgan	36	37	35.7	37.2	
	To the upper fleet	12	13	11.7	13.2	
	*Grant's Pass	6.5	7.5	6.3	7.8	1847.
Mississippi sound	*From Grant's Pass to Pascagoula mail wharf	7.5	8.7	7.2	9	1851.
	Horn Island Pass, over bar	15	16.2	14.7	16.5	1853.
	Anchorage inside Horn island	19	20.2	18.7	20.5	1852 and 1853.
	Up to Pascagoula mail wharf	8	9.2	7.7	9.5	
Ship Island harbor	*Channel	19	20.3	18.7	20.6	1848.
	Northwest channel	19.5	20.8	19.2	21.1	
	Anchorage, Man-of-war harbor	18	19.3	17.7	19.6	
Cat Island harbor	*Ship channel	16	17.3	15.7	17.6	1848.
	South Pass	14	15.3	13.7	15.6	
	Shell Bank channel	15.2	16.5	14.9	16.8	
Mississippi delta	*Pass à l'Outre, North channel	9.5	10.6	9.3	10.7	1851.
	South channel	12	13.1	11.8	13.2	
Northeast Pass	*Over bar, north entrance	9.5	10.6	9.3	10.7	
	Over bar, south entrance	9	10.1	8.8	10.2	
Southeast Pass	*Entering	10	11.1	9.8	11.2	
South Pass	*Channel	8	9.1	7.8	9.2	
Southwest Pass	Channel	15.5	16.6	15.2	16.7	1862.
Barrataria bay	*Over bar outside of Grand Pass	7.5	8.7	7.2	8.9	1852.
	Grand passage to Independence island	15	16.2	14.7	16.4	
Dernière or Last island	*Channel inside, and North of Ship Island Shoal light-ship	27	28.4	26.7	28.8	1853.
	Channel north of Ship Island shoal, one mile from beach of Dernière island	14	15.4	13.7	15.8	1853.
Atchafalaya bay	*From entrance to Cut-off Channel buoy	8	9.6	7.6	10.0	1858.
	On the Narrows	6.5	8.1	6.1	8.5	
	On Bulkhead	6.5	8.1	6.1	8.5	
	Mouth of Atchafalaya river in mid-channel	48	49.6	47.6	50.0	
Vermilion bay	In mid-channel off light-house	42	43.6	41.6	44	1855.
Calcasieu river	*Entrance over bar	5.5	7.4	5.3	7.6	1855.
Sabine Pass	*Across the bar	7.5	9	7.2	9.3	1853.
Galveston bay	*Entrance over bar	12	13.1	11.7	13.3	1853.
San Luis Pass	*Over bar	8	9.1	7.8	9.3	1853.
Brazos river	*Over bar	8	9.1	7.8	9.3	1858.
Matagorda bay	*Entrance over bar	9	10.1	8.8	10.3	1857.
Aransas Pass	*Aransas Pass	9	10.1	8.7	10.5	1853.
Rio Grande	*Channel	4	4.9	3.8	5	1853.

* The highest tides occur at the moon's greatest declination, and are applied in the column headed "spring tides."

APPENDIX No. 5—Continued.

Places.	Limits between which depths are given.	LEAST WATER IN CHANNEL-WAY. Mean lowest of day. Low water.	Mean lowest of day. High water.	Spring tides. Mean. Lowest low water.	Spring tides. Mean. Highest high water.	Spring tides. Moon's greatest declination. Lowest low water.	Spring tides. Moon's greatest declination. Highest high water.	Date.
		Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	
San Diego bay	Entrance	27.4	31.3	25.8	33.5	26.3	33.8	1851.
San Diego	Midway between south end of Zuniga shoal and Point Loma light-house, bearing N. 61½ W. by compass, distant nearly a statute mile	20	23.9	19.4	26.1	18.9	26.4	1856.
	Middle Ground light-house, bearing N. 67½ W. by compass, distant three-fourths of a statute mile	18	21.9	17.4	24.1	16.9	24.4	1856.
	Midway and nearly in range between Ballast Point and point opposite	22	25.9	21.4	28.1	20.9	28.4	1856.
	Abreast of La Plaza, 160 yards from shore	18	21.9	17.4	24.1	16.9	24.4	1856.
	At the end of wharf, (Newtown)	23	26.9	22.4	29.1	21.9	29.4	1856.
San Clemente island, (SE. end.)	About midway between NE. and SW. points at anchorage in deepest bight, 450 yards from shore	40	43.9	39.4	46.1	38.9	46.4	1856.
San Clemente island, (NW. end.)	About 200 yards from shore at anchorage	36	39.9	35.4	42.1	34.9	42.4	1852.
Mission San Juan Capistrano.	At anchorage	42	45.9	41.5	48.1	41.0	48.5	1853.
Santa Catalina island, (SW. side.)	Anchorage in Catalina harbor	21	24.9	20.5	27.1	20.0	27.5	1852.
San Pedro	In range between Point Pedro and half a mile from Dead Man's island	18	21.9	17.5	24.1	17.0	24.5	1852.
Point Duma	Anchorage	54	58.0	53.5	60.2	53.0	60.7	1853.
San Buenaventura	Anchorage half a mile from shore	36	40.0	35.5	42.3	35.0	42.8	1855.
Santa Cruz island	Anchorage, Prisoner's harbor	75	79.0	74.5	81.3	74.0	81.8	1852.
Santa Barbara	Anchorage inside of kelp, 450 yards from shore	18	22.0	17.5	24.4	17.0	24.9	1852.
San Miguel island	Anchorage, Cuyler's harbor	37	41.1	36.5	43.5	36.0	44.0	1852.
Coxo harbor	Anchorage	30	34.0	29.5	36.3	28.9	36.8	1852.
San Luis Obispo	Anchorage in harbor	33	36.8	32.4	39.0	31.8	39.3	1852.
San Simeon	Harbor anchorage	24	27.8	23.4	29.9	22.8	30.2	1852.
Monterey harbor	Anchorage	42	45.9	41.5	47.8	40.8	48.0	1852.
	Near shore	30	33.9	29.5	35.6	28.8	36.0	1852.
Santa Cruz harbor	Anchorage	27	31.6	26.5	33.3	25.9	33.7	1852.
San Francisco bay	From 4-fathom bank around to southern shore	28	32.1	27.6	33.6	26.9	33.8	1851.
	Anchorage off Rincon Point, 450 yards from shore	66	70.1	65.6	71.6	64.9	71.8	1851.
	Anchorage off Market Street wharf, San Francisco	54	58.1	53.6	59.6	52.9	59.8	1851.
	Off Cunningham's wharf	36	40.1	35.6	41.6	34.9	41.8	1851.
	Off Clark's Point, 450 yards from shore	42	46.1	41.6	47.6	40.9	47.8	1851.
San Francisco harbor	On the bar	33	37.1	32.6	38.6	31.9	38.8	1855.
	At best wharves	20	24.1	19.6	25.6	18.9	25.8	1855.
Mare Island straits	In mid-channel, between Commission Rock and western shore	25	30.5	24.8	32.0	24.2	32.1	1856.
	In mid-channel, between navy yard and Vallejo	25	30.5	24.8	32.0	21.2	32.1	1856.
Ballenas bay	Inside of breakers on Duxbury reef, about a mile from shore	24	28.1	23.6	29.6	22.9	29.8	1853.
Sir Francis Drake's bay	Half a mile inside the point, and 400 yards from shore	17	21.1	16.6	22.6	15.9	22.8	1855.
Tomales bay	Over bar	10	14.1	9.6	15.6	8.9	15.8	1861.
Bodega bay	Half a mile inside of reef, at anchorage off point, 900 yards from shore	36	40.1	35.6	41.6	34.9	41.8	1853.
Coast	At Haven's anchorage	48	52.3	47.6	54.0	46.9	54.2	1853.
Albion river	Anchorage at entrance	48	52.4	47.6	54.1	46.9	54.4	1853.
Mendocino city	Anchorage inside of point	30	34.4	29.6	36.1	28.9	36.4	1853.
Shelter cove	Anchorage 500 yards inside of point	22	26.6	21.5	28.5	20.8	28.7	1853.
Humboldt bay	On bar, half a mile from shore	21	25.7	20.5	27.7	19.8	28.0	1853.
	Main channel	20	24.7	19.5	26.7	18.8	27.0	1851.
Crescent City harbor	Anchorage half a mile off Crescent city	21	25.2	20.5	28.1	19.8	28.5	1853.
Port Orford, or Ewing harbor.	Anchorage three fourths of a mile from Tichenor's Rock, and half a mile from Battle Rock	46	51.7	45.6	53.6	44.9	51.0	1853.
Koos bay	Over bar	11	16.7	10.6	18.6	9.9	19.0	1862.
Umpqua river	On bar, opposite mid-channel	13	19.0	12.5	20.9	11.8	21.3	1853.

APPENDIX No. 5—Continued.

Places.	Limits between which depths are given.	LEAST WATER IN CHANNEL-WAY.						Date.
		Mean lowest of day.		Spring tides. Mean.		Spring tides. Moon's greatest declination.		
		Low water.	High water.	Lowest low water.	Highest high water.	Lowest low water.	Highest high water.	
		Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	
Columbia river	North channel to Baker's bay	24	30.5	23.3	32.4	22 6	32.7	1852.
	*Entrance into south channel	19	25.5	18.3	27.4	17.6	27.7	1852.
	On bar of south channel	16	22.5	15.3	24.4	14.6	24.7	1853.
Shoalwater bay	On bar	18	24.5	17.3	26.4	16.6	26.7	1851.
	North channel	22.5	29.0	21 8	30.9	21.1	31 2	....
	South channel	25	31.5	24.3	33.4	23.6	33.7	1853.
Grenville harbor	Anchorage three-quarters of a mile inside of Point Grenville, and same distance from shore	22	28.5	21.2	30.5	20.5	31.0	1854.
Neé-ah harbor	Anchorage a mile inside of Waddah island, and 450 yards from shore	36	42.5	35.0	44.7	34.3	45.3	1851.
False Dungeness	Harbor anchorage	54	60.4	53.2	62.3	52.2	62.5	1853.
New Dungeness	......do	45	51.4	44.3	52.9	43.1	53.3	1855.
Smith's island, (north side)	Anchorage near kelp, 450 yards from shore	25	31.4	24 4	32.7	23.1	33.0	1854.
Bellingham bay	†	60	66.4	59.4	67.7	58.1	67.9	1855.
	Anchorage 400 yards southwest of Fitzhugh's wharf	18	24.4	17.4	25.7	16.1	25.9	1855.
Port Townshend	†Anchorage 400 yards east of custom-house	48	54.4	47.4	55.7	46.1	55.9	1854.
Port Ludlow	†Anchorage	36	42.4	35.4	43.7	34.1	43.9	1855.
Port Gamble	†.....do	18	24 4	17.4	25.7	16.1	25.9	1855.
Seattle	†.....do	20	28.0	19.3	29 5	17.9	30.0	1854.
Blakely harbor	†Anchorage 450 yards inside of entrance	46	54.0	45.3	55.5	43.9	56.0	1856.
Steilacoom harbor	†Anchorage off Steilacoom creek, 400 yards	18	29.5	17.0	32.0	15.3	32.2	1855.
Olympia harbor	†Mid-channel, town 1¼ mile distant, mission bearing E NE	11	22.5	10.0	25.0	8.3	25.2	......

* Twenty-one feet may be carried in at mean low water by keeping a little northward and westward, nearer the breakers of the middle sands, and, at the turn, hauling up for Cape Disappointment.

† The last column at these stations gives the height of highest water of spring tides at the time of the moon's declination being *zero*, the highest high waters of the month occurring at that time.

APPENDIX No. 6.

NOTICE TO MARINERS.

In the approaches to Newport harbor, Rhode Island, two rocks have been discovered by Henry Mitchell, Assistant United States Coast Survey.

1. Lies about 700 yards west from the poor-house on Coaster's Harbor island, and 375 yards north by east from Red Buoy No. 6. This rock is about one acre in extent, with 17 feet at mean low water on its shoalest spot, which is not over 6 feet square. At the lowest spring tides there will probably not be less than 15½ feet on this spot.

This rock lies in nearly mid-channel of the northern passage. To clear it, hug closely the bold shore of Coaster's Harbor island.

2. Lies nearly on the line between the Rose Island spindle and Goat Island light-house, and about 325 yards from the Rose Island spindle. This rock has two sharp peaks lying NW. and SE., with 14½ feet on the outer one at mean low water. To the westward of this rock the depth is 5; to the northward, 7; to the eastward, 8; and to the southward, 7 fathoms water. This rock lies outside of the line between the Rose Island spindle and Buoy No. 3. To clear it, keep on the Goat island side of the channel.

A. D. BACHE,
Superintendent United States Coast Survey.

COAST SURVEY OFFICE,
November 4, 1862.

APPENDIX No. 7.

NOTICE TO MARINERS.

Notice is hereby given to mariners that the Baltic, Captain J. J. Comstock, is reported to have run aground, drawing 18½ feet, on a shoal spot situated about 2½ miles due east from Winter Quarter shoal, on the coast of Maryland, and about 11 miles from the shore. This shoal is not laid down on the charts, and a survey of the ground will be made at the earliest practicable moment.

A. D. BACHE,
Superintendent United States Coast Survey.

COAST SURVEY OFFICE,
November 5, 1862.

APPENDIX No. 8.

TIDE TABLES FOR MARINERS, PREPARED FROM THE COAST SURVEY OBSERVATIONS, BY A. D. BACHE, SUPERINTENDENT.

[Furnished by authority of the Treasury Department to E. and G. W. Blunt, New York, and revised October, 1862.]

The following tables will enable navigators to ascertain the time and height of high and low water in some of the principal ports of the United States. The results are approximate, the observations being still in progress, but they may safely be used for practical purposes. The number of places of observation, and the time during which many of them have been made, are steadily on the increase as the Coast Survey advances.

The tides on the coast of the United States, on the Atlantic, Gulf of Mexico, and Pacific, are of three different classes. Those of the Atlantic are of the most ordinary type, ebbing and flowing twice in twenty-four hours, and having but moderate differences in height between the two successive high waters or low waters, one occurring before noon, the other after noon.

Those of the Pacific coast also ebb and flow twice during twenty-four hours, but the morning and afternoon tides differ very considerably in height, so much so that at certain periods a rock which has three feet and a half water upon it at low tide may be awash on the next succeeding low water. The intervals, too, between successive high and successive low waters may be very unequal.

The tides of ports in the Gulf of Mexico, west of Cape St. George, ebb and flow, as a rule, but once in twenty-four hours, or are single-day tides. At particular parts of the month there are two small tides in the twenty-four hours. The rise and fall in all these ports is small. East of Cape St. George the rise and fall increases; there are two tides, as a rule, during the twenty-four hours, and the daily inequality referred to in the Pacific tides is large.

These peculiarities require a different way of treating the cases, and in some of them separate tables.

I propose to enable the navigator to find, from the Nautical Almanac and the following tables, the time and height of high and low water at any date within the ordinary range of difference produced by winds and other variable circumstances. I will endeavor to divest the matter of unfamiliar technical expressions as far as practicable, though for shortness-sake some such terms may be employed after defining them. The discussion of the Gulf tides has not been carried so far as to enable me to present the results in as definite a form as the others.

As is well known, the interval between the time of the moon's crossing the meridian (moon's transit) and the time of high water at a given place is nearly constant; that is, this interval varies between moderate limits, which can be assigned. The interval at full and change of the moon is known as the establishment of the port, and is ordinarily marked on the charts. As it is not generally the average of the interval during a month's tides, it is a less convenient and less accurate quantity for the use of the navigation than the average interval which is used on the Coast Survey charts, and is sometimes called the "mean" or "corrected establishment."* The following table gives the principal tidal quantities for the different ports named in the first column, where they are arranged under specific heads. The third column of the table gives the mean interval, in hours and minutes, between the moon's transit and the time of high water next after the transit; the fourth, the difference between the greatest and the least interval occurring in different parts of the month, (lunar.) A simple inspection of this column will show how important it is to determine these changes in many of the ports where they amount to more than half an hour, or to more than fifteen minutes from the average interval. The fifth, sixth, and seventh columns refer to the height of the tide. The fifth gives, in feet, the average rise and fall, or average difference between high and low water. The sixth gives the greatest difference commonly known as the rise and fall of spring tides, and the seventh the least difference known as the rise and fall of the neap tides.

The average duration of the flood or rising tide is given in the eighth column; of the ebb or falling tide in the ninth; and of the period during which the tide neither rises nor falls, or the "stand," in the tenth. The duration of the flood is measured from the middle of the stand at low water to the middle of the stand at high water, so that the whole duration from one high water to the next, or from one low water to the next, should be given by the sum of the numbers in the eighth and ninth columns. At most of these places given in the list a mark of reference has been established for the height of the tide. I have omitted the description of these marks, (except in the following localities,) as of no particular interest in this connexion.

BENCH-MARKS.

Boston.—The top of the wall or quay at the entrance of the dry dock in the Charlestown navy yard is fourteen feet $\frac{69}{100}$ (or 14.69 feet) above mean low water.†

New York.—The lower edge of a straight line cut in a stone wall, at the head of a wooden wharf on Governor's island, is thirteen feet $\frac{97}{100}$ (or 13.97 feet) above mean low water. The letters U. S. C. S. are cut in the same stone.

Old Point Comfort, Va.—A line cut in the wall of the light-house, one foot from the ground, on the southwest side, is eleven feet (11 feet) above mean low water.

Charleston, S. C.—The outer and lower edge of embrasure of gun No. 3, at Castle Pinckney, is ten feet $\frac{13}{100}$ (10.13 feet) above mean low water.

* This term was introduced by the Rev. Dr. Whewell, who has done so much for the investigation of the laws of the tides

† In consequence of alterations made to the wall during the year 1860, the coping is seven hundredths of a foot lower than formerly.

TABLE I.

Tide table for the coast of the United States.

PORT.	STATE.	Interval between time of moon's transit and time of high water: Mean interval.	Interval between time of moon's transit and time of high water: Diff. between greatest and least interval.	Rise and fall: Mean.	Rise and fall: Spring tides.	Rise and fall: Neap tides.	Mean duration of—: Flood tide.	Mean duration of—: Ebb tide.	Mean duration of—: Stand.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
COAST FROM PORTLAND TO NEW YORK.		h. m.	h. m.	Feet.	Feet.	Feet.	h. m.	h. m.	h. m.
Hanniwell's Point, Kennebec river	Maine	11 15	1 14	8.1	9.3	7.0	6 16	6 11	0 22
Portland	...do	11 25	0 44	8.9	9.9	7.6	6 14	6 12	20
Portsmouth	New Hampshire	11 23	53	8.6	9.9	7.2	6 22	6 7	21
Newburyport	Massachusetts	11 22	50	7.8	9.1	6.6	5 16	7 9	24
Rockport	...do	10 57	42	8.6	10.2	7.1	6 17	6 9	30
Salem	...do	11 13	50	9.2	10.6	7.6	6 19	6 6	6
Boston Light	...do	11 12	35	9.3	10.9	8.1	6 20	6 6	15
Boston	...do	11 27	43	10.0	11.3	8.5	6 13	6 13	9
Plymouth	...do	11 19	51	10.2	11.4	9.0	6 13	6 17	29
Wellfleet	...do	11 5	1 13	11.2	13.2	9.2	6 6	6 17	15
Provincetown*	...do	11 22	40	9.2	10.8	7.7	6 16	6 10	21
Monomoy	...do	11 58	37	3.8	5.3	2.6	6 25	5 59	36
Nantucket	...do	12 24	37	3.1	3.6	2.6	6 23	5 44	9
Hyannis	...do	12 22	30	3.2	3.9	1.8	6 44	5 41	9
Edgartown	...do	12 16	34	2.0	2.5	1.6	6 51	5 29	24
Holmes's Hole	...do	11 43	31	1.7	1.8	1.3	6 41	5 21	12
Tarpaulin Cove	...do	8 4	49	2.3	2.8	1.8	6 9	6 17	34
Wood's Hole, north side	...do	7 59	53	4.0	4.7	3.1	6 51	5 31	38
Wood's Hole, south side	...do	8 34	45	1.6	2.0	1.2	5 17	7 10	59
Menemsha Bight	...do	7 45	1 0	2.7	3.9	1.8	6 14	6 14	4
Quick's Hole, north side	...do	7 31	1 15	3.7	4.3	2.9	6 31	5 54	39
Quick's Hole, south side	...do	7 36	1 10	3.1	3.8	2.3	6 29	5 55	40
Cuttyhunk	...do	7 40	49	3.5	4.2	2.9	6 31	5 54	39
Kettle Cove	...do	7 48	1 0	4.3	5.0	3.7	6 17	6 4	29
Bird Island Light	...do	7 59	45	4.4	5.3	3.5	6 51	5 58	....
New Bedford entrance, (Dumpling Rock)	...do	7 57	41	3.8	4.6	2.8	6 50	5 33	42
Newport	Rhode Island	7 45	24	3.9	4.6	3.1	6 21	6 3	23
Point Judith	...do	7 32	46	3.1	3.7	2.6	6 12	6 10	1 0
Block Island	...do	7 36	41	2.8	3.5	2.0	6 23	6 2	5
Montauk Point, L. I.	New York	8 20	1 11	1.9	2.4	1.8	6 17	6 7	31
Sandy Hook	...do	7 29	47	4.8	5.6	4.0	6 10	6 15	21
New York	...do	8 13	43	4.3	5.4	3.4	6 0	6 25	28
HUDSON RIVER.									
Dobb's Ferry	New York	9 19	44	3.6	4.4	2.7	6 5	6 18	17
Tarrytown	...do	9 57	58	3.5	4.0	2.7	6 6	6 20	43
Verplanck's Point	...do	10 8	34	3.1	3.8	2.5	5 25	7 12	16
West Point	...do	11 2	37	2.7	3.2	2.0	5 28	7 10	20
Poughkeepsie	...do	12 34	54	3.2	3.9	2.4	5 41	6 41	22
Tivoli	...do	1 24	51	4.0	4.6	3.2	5 40	6 54	25
Stuyvesant	...do	3 23	48	3.8	4.4	3.0	5 18	7 2	31
Castleton	...do	4 29	55	2.7	3.0	2.3	5 1	7 23	20
Greenbush	...do	5 22	40	2.3	2.5	1.9	4 26	7 59	....
LONG ISLAND SOUND.									
Watch Hill	Rhode Island	9 0	23	2.7	3.1	2.4	6 35	5 56	14
Stonington	Connecticut	9 7	30	2.7	3.2	2.2	6 15	6 10	25
Little Gull island	New York	9 38	1 7	2.5	2.9	2.3	6 1	6 21	37
New London	Connecticut	9 28	52	2.6	3.1	2.1	5 56	6 26	22
New Haven	...do	11 16	1 8	5.9	6.2	5.2	6 24	6 5	33
Bridgeport	...do	11 11	1 3	6.5	8.0	4.7	6 1	6 7	30

* From Major J. D. Graham's observations.

TABLE I—Continued.

PORT.	STATE.	Interval between time of moon's transit and time of high water. Mean interval.	Diff. between greatest and least interval.	Rise and fall. Mean.	Spring tides.	Neap tides.	Mean duration of— Flood tide.	Ebb tide.	Stand.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
LONG ISLAND SOUND—Continued.		*h. m.*	*h. m.*	*Feet.*	*Feet.*	*Feet.*	*h. m.*	*h. m.*	*h. m.*
Oyster Bay, L. I.	New York	11 7	0 51	7.3	9.2	5.4	6 8	6 24	0 25
Sand's Point, L. I.	...do	11 13	31	7.7	8.9	6.4	5 55	6 30	14
New Rochelle	...do	11 22	32	7.6	8.6	6.6	5 51	6 35	12
Throg's Neck	...do	11 20	39	7.3	9.2	6.1	5 50	6 33	43
COAST OF NEW JERSEY.									
Cold Spring inlet	New Jersey	7 32	51	4.4	5.4	3.6	6 8	6 18	19
Cape May Landing	...do	8 19	47	4.8	6.0	4.3	6 11	6 15	20
DELAWARE BAY AND RIVER.									
Delaware breakwater	Delaware	8 0	50	3.5	4.5	3.0	6 15	6 6	26
Higbee's, Cape May	New Jersey	8 33	43	4.9	6.2	3.9	6 26	6 0	19
Egg Island light	...do	9 4	51	6.0	7.0	5.1	5 52	6 27	36
Mahon's river	Delaware	9 52	48	5.9	6.9	5.0	6 11	6 11	26
Newcastle	...do	11 53	24	6.5	6.9	6.0	5 6	6 43	47
Philadelphia	Pennsylvania	13 41	44	6.0	6.8	5.1	4 52	7 6	15
CHESAPEAKE BAY AND RIVERS.									
Old Point Comfort	Virginia	8 17	60	2.5	3.0	2.0	6 1	6 25	14
Point Lookout	Maryland	12 58	45	1.4	1.9	0.7	5 59	6 19	35
Annapolis	...do	17 4	40	0.9	1.0	0.8	6 11	6 15	32
Bodkin light	...do	18 8	48	1.0	1.3	0.8	5 23	7 8	15
Baltimore	...do	18 59	44	1.3	1.5	0.9	5 54	6 33	44
Washington	Dist. of Columbia	20 10	52	3 0	3.4	2.6	5 37	6 49	....
James river, (City Point)	Virginia	14 37	1 0	2.8	3.0	2.5	5 14	6 58	32
Richmond	...do	16 54	1 6	2.9	3.4	2.3	4 53	7 31	35
Tappahannock	...do	13 8	46	1.6	1.9	1.3	5 21	7 6	....
COAST OF NORTH AND SOUTH CAROLINA, GEORGIA, AND FLORIDA.									
Hatteras inlet	North Carolina	7 4	57	2.0	2.2	1.8	6 7	6 7	50
Beaufort	...do	7 26	50	2.8	3.3	2.2	6 11	6 10	42
Bald Head	...do	7 26	34	4.3	5.0	3.4	6 18	6 17	31
Smithville	...do	7 19	38	4.5	5 5	3.8	6 1	6 26	26
Wilmington	...do	9 6	1 0	2.7	3.1	2.2	4 45	7 40	30
Georgetown entrance	South Carolina	7 56	42	3.8	4.7	2.7	6 4	6 19	35
Bull's Island bay	...do	7 16	57	4.8	5.7	3.7	6 20	6 6	30
Charleston, (custom house wharf)	...do	7 26	48	5.1	6.0	4.1	6 19	6 7	33
St. Helena sound	...do	7 8	1 0	5.9	7.4	4.4	6 13	6 12	23
Fort Pulaski, (Savannah entrance)	Georgia	7 20	40	7.0	8 0	5.9	5 49	6 35	26
Savannah, (dry-dock wharf)	...do	8 13	51	6.5	7.6	5.5	5 4	7 22	14
Doboy Light-house	...do	7 33	55	6.6	7.8	5.4	6 2	6 20	....
St. Simons	...do	7 43	46	6.8	8.2	5.4	6 10	6 16	20
Fort Clinch	Florida	7 53	1 6	5.9	6.7	5.3	6 9	6 17	....
St. John's river	...do	7 28	48	4.5	5.5	3.7	5 58	6 28	16
St. Augustine	...do	8 21	43	4.2	4.9	3.6	6 5	6 11	32
Cape Florida	...do	8 34	51	1.5	1.8	1.2	6 0	6 26	45
Indian key	...do	8 23	49	1 8	2.2	1.3	6 25	5 59	19
Sand key	...do	8 40	....	1.2	2.0	0.6	6 31	5 55	13
Key West	...do	9 30	1 15	1.3	1.5	0.9	6 55	5 29	12
Tortugas	...do	9 56	1 32	1.2	1.5	0.6	6 43	5 40	....
Charlotte Harbor	...do	13 9	1 38	1.1	1.3	0.8	6 51	5 35	....
Tampa Bay, (Egmont key)	...do	11 21	1 33	1.4	1.8	1.0	6 36	6 11	43
Cedar Keys, (Depot key)	...do	13 15	1 55	2.6	3.2	1.6	6 12	6 13	....
St. Mark's	...do	13 38	00	2.2	2.9	1.4	6 12	6 11	....

TABLE I—Continued.

PORT.	STATE.	INTERVAL BETWEEN TIME OF MOON'S TRANSIT AND TIME OF HIGH WATER.		RISE AND FALL.			MEAN DURATION OF—		
		Mean interval.	Diff. between greatest and least interval.	Mean.	Spring tides.	Neap tides.	Flood tide.	Ebb tide.	Stand.
1.	2.	3.	4.	5.	6	7.	8.	9.	10.
WESTERN COAST.		h. m.	h. m.	Feet.	Feet.	Feet.	h. m.	h. m.	h. m.
San Diego	California	9 38	1 35	3.7	5.0	2.3	6 22	6 0	0 30
San Pedro	do.	9 39	1 48	3.7	4 7	2.2	6 18	6 5	30
Cuyler's harbor	do	9 25	1 2	3.7	5.1	2.8	6 13	6 5	....
San Luis Obispo	do	10 8	1 52	3.6	4.8	2.4	6 25	5 58	....
Monterey	do	10 22	49	3.4	4.3	2.5	6 31	6 2	35
South Farallone	do	10 37	1 16	3.6	4.4	2 8	6 18	6 9	....
San Francisco, (north beach)	do	12 6	1 4	3.6	4.3	2.8	6 39	5 51	34
Mare Island, (San Francisco bay)	do	13 40	1 15	4.8	5.2	4.1	6 13	6 7	....
Benicia .... do	do	14 10	1 0	4.5	5.1	3.7	6 26	5 59	....
Ravenswood .... do	do	12 36	57	6.3	7.3	4.9	6 15	6 11	....
Bodega	do	11 17	1 54	3.6	4.7	2.7	6 19	5 59	....
Humboldt bay	do	12 2	1 11	4.4	5.5	3.5	6 19	6 0	....
Port Orford	Oregon	11 26	1 6	5.1	6.8	3.7	6 19	6 7	39
Astoria	do	12 42	1 13	6.1	7.4	4.6	6 3	6 28	33
Nee-ah harbor	Washington Terr'y.	12 33	1 28	5.6	7.4	4.8	6 20	6 6	....
Port Townshend*	do	3 49	1 3	4.6	5.5	4 0	6 34	5 52	....
Steilacoom*	do	4 46	1 6	[illegible].2	11.1	7.2	6 3	6 25	28
Semiahmoo bay	do	4 50	1 2	5.7	6.6	4.8	6 11	6 19	26

* See remarks on page 102 and following.

Note.—The mean interval in column 3 has been increased by 12*h.* 26*m.* (half a mean lunar day) for some of the ports in Delaware river and Chesapeake bay, so as to show the succession of times from the mouth. Therefore 12*h.* 26*m.* ought to be subtracted from the establishments which are greater than that quantity before using them.

The foregoing Table I gives the means of determining, roughly, the time and height of high water at the several ports named. The hour of transit of the moon preceding the time of high water is to be taken from the Almanac, and the mean establishment being added, the time of high water results. Thus:

Example I.—It is required to find the time of high water at New York on November 5, 1854. The American Almanac gives 0*h.* 0*m.* as the time of transit of the moon on that day. The mean interval for New York, from Table I, column 3, is 8*h.* 13*m.*, which, as the transit was at 0*h.*, is, roughly, the time of high water. The moon being full, the height is that of spring tides of column 6, viz: 5.4 feet. If the soundings on the chart are reduced to low water spring tides, 5.4 feet are to be added to them to give the depth at high water. If the soundings are reduced to mean low water, the rise and fall of mean tides being 1.1 foot less than for springs, the rise or increase of depth will be half of this, or 0.6 of a foot less than 5.4 feet, which is 4.8 feet, or nearly four feet ten inches.

Example II.—Required the time of high water at Boston on January 23, 1851. From the American Almanac we find the time of the moon's southing or transit on that day 5*h.* 18*m.* a. m., and from Table I the mean interval at Boston dry dock is 11*h.* 27*m.*

We have then 5*h.* 18*m.* time of transit.

To which add 11 27 mean interval from Table I.

16 45 time of high water, or 4*h.* 45*m.* p. m.

If the Greenwich Nautical Almanac is used, add 2*m.* to the time of transit of Greenwich for every hour of west longitude, and its proportional part for less than an hour. It will suffice to take the half hour which may be over any number of hours, as the correction for less than this would be less than one minute, and need not be taken into account. Thus, Boston is *4h. 44m.* west of Greenwich. The correction to be applied to the time of transit of the moon is, for the four hours, eight minutes, and for the forty-four minutes, one minute. The time of transit on the date assumed in the preceding example is *17h. 9m.* of the 22d, or *5h. 9m.* a. m. of the 23d, to which add nine minutes; the correction just found gives *5h. 18m.*, as before ascertained from the American Almanac.

In using the United States Nautical Almanac, in the astronomical part of which the transits of the moon are given for the meridian of Washington, the corrections required may, in this first approximation for the Atlantic coast, be neglected. To find the time of the next following low water, add, from Table I, the duration of ebb tide.

This gives *4h. 45m.* p. m. time of high water.
6 13 duration of ebb tide from Table I.

10 58 p. m.

By subtracting the duration of flood tide we obtain the time of the preceding low water, *10h. 32m.* a. m., recollecting that *4h. 45m.* p. m. is the same as *16h. 45m.* reckoned from midnight.

The height of this tide, corresponding to the transit of *5h.*, will bring it nearly to a neap tide, and the rise and fall obtained from column 7, Table I, is 8.5 feet. The next following high water may be had by adding to the time of low water the duration of flood from Table I, thus:

10h. 58m. p. m. time of low water January 23.
6 13 duration of flood from Table I.

Sum 17 11 or *5h. 11m.* on January 24.

Or, having found the time of high water, the time of the next following high water may be found by adding the duration of flood and ebb together, and their sum to the time of high water found, thus:

6h. 13m. duration of ebb tide from Table I.
6 13 duration of flood.

Sum 12 26 duration of whole tide.
4 45 p. m., January 23, time of high water.

Sum 17 11 or *5h. 11m.* a. m., January 24, time of the next succeeding high water.

Subtracting the same quantity will give the time of the preceding high water, thus:

4h. 45m. p. m., or *16h. 45m.* from midnight, is the time of high water.
12 26 duration of flood and ebb tide.

4 19 a. m. of the 23d for the preceding high water.

The duration of the flood and the ebb being reckoned from the middle of one stand or slack water to the middle of the next, the time of beginning of stand of ebb or flood will be found by subtracting half the duration of stand or slack water given by column 10, Table I, from the time of high or low water, and the time of the end of the stand of ebb or flood by adding the same. A nearer approximation to the times and heights of high water may be obtained by the use of Tables II and III.

TABLE II.

Interval between the time of moon's transit and the time of high water for different hours of transit, and for several different ports.

Time of moon's transit.	Boston, Mass.	New York, N. Y.	Philadelphia, Pa.	Old Pt. Comfort, Va.	Baltimore, Md.	Smithville, N. C.	Charleston, S. C.	Ft. Pulaski, Savannah, Ga.	Key West, Fla.	San Francisco, Cal.
h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
0 0	11 38	8 20	1 31	8 33	6 47	7 26	7 38	7 30	9 33	12 5
0 30	11 33	8 18	1 28	8 27	6 42	7 21	7 33	7 25	9 26	11 59
1 0	11 [illegible]8	8 15	1 25	8 21	6 37	7 16	7 27	7 19	9 19	11 53
1 30	11 24	8 10	1 21	8 15	6 31	7 13	7 21	7 15	9 13	11 47
2 0	11 20	8 6	1 18	8 9	6 26	7 9	7 16	7 11	9 6	11 41
2 30	11 16	8 0	1 14	8 4	6 21	7 6	7 12	7 8	9 1	11 36
3 0	11 13	7 55	1 11	8 0	6 17	7 4	7 8	7 6	8 57	11 33
3 30	11 10	7 52	1 8	7 56	6 13	7 3	7 5	7 5	8 53	11 33
4 0	11 7	7 52	1 6	7 52	6 11	7 2	7 2	7 4	8 53	11 38
4 30	11 6	7 52	1 3	7 49	6 10	7 3	7 2	7 3	8 56	11 46
5 0	11 6	7 53	1 0	7 48	6 10	7 4	7 3	7 4	9 2	11 55
5 30	11 9	7 56	0 59	7 50	6 13	7 6	7 7	7 6	9 10	12 3
6 0	11 13	7 59	0 59	7 53	6 19	7 9	7 12	7 8	9 22	12 11
6 30	11 19	8 5	1 1	8 0	6 25	7 13	7 19	7 12	9 33	12 16
7 0	11 25	8 11	1 7	8 7	6 32	7 17	7 24	7 16	9 49	12 23
7 30	11 32	8 17	1 15	8 15	6 39	7 23	7 32	7 22	10 0	12 29
8 0	11 38	8 23	1 23	8 24	6 44	7 28	7 38	7 28	10 6	12 34
8 30	11 43	8 27	1 29	8 33	6 49	7 33	7 45	7 34	10 7	12 37
9 0	11 47	8 32	1 34	8 40	6 52	7 37	7 48	7 39	10 6	12 36
9 30	11 48	8 34	1 39	8 45	6 54	7 39	7 50	7 42	10 3	12 34
10 0	11 49	8 35	1 42	8 48	6 53	7 40	7 50	7 43	9 59	12 30
10 30	11 48	8 34	1 43	8 48	6 52	7 40	7 47	7 41	9 56	12 24
11 0	11 47	8 31	1 41	8 46	6 50	7 36	7 44	7 37	9 48	12 17
11 30	11 43	8 25	1 37	8 40	6 48	7 30	7 41	7 34	9 40	12 9

TABLE III.

Showing the rise and fall of tides, and corrections to be applied to determine the depth at high water of soundings on charts referred to mean low water, and to low water spring tides.

Time of moon's transit.	Boston, Mass.			New York, N. Y.			Philadelphia, Pa.			Old Point Comfort.			Baltimore, Md.			Time of moon's transit.
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Hour.*
0	11.2	10.6	11.3	4.9	4.5	4.9	6.3	6.2	6.3	2.9	2.6	2.9	1.5	1.4	1.6	0
1	11.3	10.6	11.3	4.9	4.5	4.9	6.4	6.4	6.5	3.0	2.7	3.0	1.5	1.4	1.6	1
2	11.2	10.5	11.2	4.7	4.4	4.8	6.6	6.5	6.6	2.9	2.7	2.9	1.5	1.3	1.5	2
3	10.6	10.3	10.0	4.3	4.2	4.6	6.6	6.5	6.6	2.6	2.6	2.8	1.4	1.3	1.5	3
4	10.0	10.0	10.7	3.8	4.0	4.4	6.4	6.4	6.5	2.3	2.4	2.7	1.3	1.2	1.4	4
5	9.2	9.7	10.4	3.5	3.8	4.2	6.1	6.2	6.3	2.1	2.3	2.6	1.1	1.1	1.3	5
6	8.8	9.4	10.1	3.3	3.7	4.1	5.7	5.9	6.0	2.0	2.2	2.5	0.9	1.1	1.3	6
7	8.6	9.3	10.0	3.3	3.7	4.1	5.4	5.6	5.7	2.0	2.3	2.5	0.9	1.1	1.3	7
8	8.9	9.5	10.2	3.6	3.8	4.2	5.2	5.3	5.4	2.2	2.4	2.6	1.0	1.2	1.4	8
9	9.4	9.7	10.4	4.0	4.0	4.4	5.4	5.4	5.5	2.5	2.5	2.8	1.1	1.3	1.5	9
10	10.1	10.0	10.7	4.5	4.3	4.7	5.7	5.7	5.8	2.8	2.7	2.9	1.3	1.4	1.6	10
11	10.7	10.3	11.0	4.8	4.5	4.9	6.0	6.0	6.1	3.0	2.8	3.0	1.4	1.4	1.6	11

TABLE III—Continued.

Time of moon's transit.	Smithville, N. C.			Charleston, S. C.			Fort Pulaski, Savannah entrance.			Key West, Fla.			San Francisco, Cal.			Time of moon's transit.
	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	A.	B.	C.	
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Hour.*
0	5.2	4.8	5.1	6.0	5.5	6.0	7.8	7.4	7.8	1.5	1.4	1.5	4.5	4.0	4.4	0
1	5.1	4.8	5.1	5.9	5.5	5.9	7.9	7.4	7.9	1.5	1.4	1.5	3.9	3.7	4.1	1
2	5.0	4.7	5.0	5.7	5.4	5.8	7.6	7.3	7.7	1.5	1.4	1.5	3.7	3.6	4.1	2
3	4.6	4.5	4.8	5.3	5.2	5.6	7.1	7.0	7.5	1.4	1.3	1.4	3.5	3.5	4.0	3
4	4.3	4.4	4.7	4.7	4.9	5.4	6.5	6.7	7.2	1.2	1.2	1.3	3.1	3.3	3.8	4
5	4.0	4.3	4.6	4.4	4.8	5.2	6.1	6.5	7.0	1.0	1.1	1.2	2.8	3.1	3.6	5
6	3.8	4.2	4.5	4.2	4.6	5.1	5.8	6.4	6.8	0.9	1.0	1.1	2.7	3.1	3.6	6
7	3.8	4.1	4.4	4.3	4.7	5.1	6.0	6.5	6.9	0.9	1.1	1.2	3.0	3.3	3.7	7
8	4.0	4.2	4.5	4.5	4.8	5.3	6.4	6.7	7.1	1.0	1.2	1.3	3.4	3.5	3.9	8
9	4.3	4.3	4.6	5.0	5.0	5.5	6.9	6.9	7.4	1.2	1.3	1.4	3.8	3.6	4.1	9
10	4.7	4.6	4.9	5.5	5.3	5.8	7.4	7.0	7.6	1.4	1.4	1.5	4.0	3.8	4.2	10
11	5.0	4.7	5.0	5.9	5.5	5.9	7.8	7.2	7.8	1.5	1.4	1.5	4.2	3.8	4.3	11

In these the variations in the interval between the moon's transit and high water are shown for some of the principal ports contained in Table I. These variations of intervals depend upon the age of the moon, and, as they go through their values in half a lunar month, are known as the half-monthly inequality of interval. The table extends from the *0h.* of transit, midnight of the calendar day, or full of the moon, to 11½ hours. The numbers for change of the moon correspond to those of *0h.*, and for 13 hours (or *1h* p. m. of the calendar day) to 1 hour, and so on up to 23 hours. The ports for which the numbers are given are designated by the heading of the columns.

The mean interval, it will be seen, does not occur at full and change, but nearly two days afterwards, on the Atlantic coast. At Key West it occurs more nearly at full and change, and at San Francisco still more nearly.

The same remark applies to the heights. Spring tides occur about two days after the full and change of the moon, and neaps two days after the first and last quarters. The use of this table of nearer approximation is quite as simple as that of Table I.

Rule to find the time of high water.—Look in the Almanac for the time of moon's transit (or southing) for the date required. In the table corresponding to that time will be found the number to be added to the time of transit.

Example III.—Required the time of high water at New York October 1, 1856. Using the United States Nautical Almanac, we find the time of moon's transit *1h. 24m.* astronomical reckoning, or *1h. 24m.* p. m. calendar time. From Table II we have, under the heading of New York, for *1h. 30m.* (the nearest number to *1h. 24m.* in the table) *8h. 10m.*

Thus, to *1h. 24m.*, time of moon's transit,
Add 8 10 interval found in Table III.

The sum 9 34 p. m. is the time of high water on the 1st of October, 1856.

If the sum of these numbers had exceeded twelve, the tide would have belonged to October 2, and we must have gone back to the transit of the day before and computed with it to obtain the tide of October 1.

Rule to find the height of high water.—Enter Table III, column 1, with the time of moon's transit. In the column headed with the name of the place, and marked A, will be found the rise and fall corresponding to the time of transit; in column B, the number to be added to soundings on the chart, where the soundings are given for mean low water; in column C, the number to be added to charts of which the soundings are given for low water spring tides.

In the foregoing example, (III,) the time of transit being 1 and 2 hours, we find from Table III the rise and fall of tides on the 1st of October, 1856, between 4.9 and 4.7; the number to be added to soundings given for mean low water 4.5 feet, (column B,) and for low water spring tides (column C) 4.9 feet.

Having found the time of high water, that of low water may be obtained, nearly, by adding the duration of ebb from column 9, Table I. The time of the next preceding low water may be found by subtracting the duration of flood from column 8, Table I. The time of the next following high water may be found by adding the duration of both flood and ebb, and of the next preceding high water by subtracting the same duration of the whole tide.

Example IV.—To find the next high water following that of Example III.

The duration of flood, column 8, Table I, for New York, is 6*h.* 0*m.*; and of ebb, from column 9, is 6*h.* 25*m.*; the sum is 12*h.* 25*m.*

To	9*h.*	34*m.*	p. m., October 1, time of high water found,
Add	12	25	duration of flood and ebb.
Sum	21	59	or 9*h.* 59*m.* a. m. of October 2, the time of the next high water.

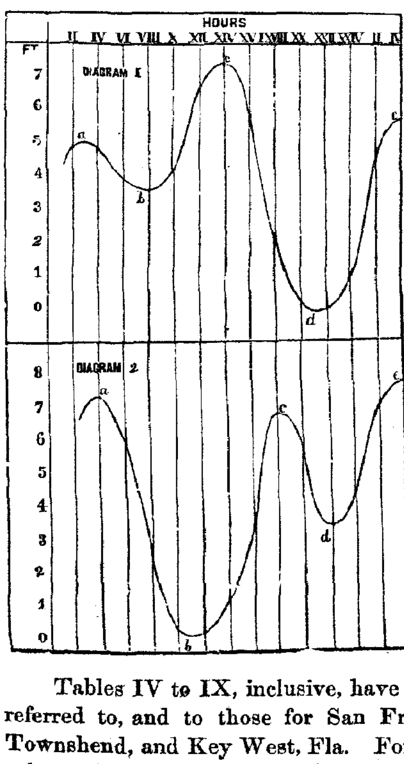
TIDES OF THE PACIFIC COAST AND OF PART OF THE COAST OF FLORIDA.

On the Pacific coast there are, as a general rule, one large and one small tide during the day, the height of the two successive high waters occurring one a. m. the other p. m. of the same twenty-four hours, and the intervals from the next preceding transit of the moon are very different. The inequalities depend upon the moon's declination; they disappear near the time of the moon's declination being nothing, and are greatest about the time of its being greatest. The inequalities for low water are not the same as for high, though they disappear and have the greatest value at nearly the same times. The tides of the southern part of Florida and of the western coast of that peninsula, as far as St. Mark's, are of the same character.

In Puget's sound the inequalities for the interval of high water and for the height of low water follow this rule; but those for the interval of low water and height of high water disappear about one day before the moon's declination is greatest, and are greatest about four or five days before the greatest declination.

When the moon's declination is north, the highest of the two tides of the twenty-four hours occurs at San Francisco about eleven and a half hours after the moon's southing, (transit;) and when the declination is south, the lowest of the two high tides occurs about that interval.

The lowest of the two low waters of the day is one which follows next the highest high water. The nature of these tides will probably appear more plainly from the annexed diagrams. In them the height of the tide is set off at the side on a scale of feet, and the hours of the day are at the top. At 12 noon, for example, the tide-gauge marked 6.7 feet. Joining all the heights observed in the twenty-four hours, we have a curve like that marked in the figure. The two high waters are *a* and *c;* the two low waters *b* and *d*. If *a* is the high water which occurs about twelve hours after the transit of the moon, when the declination is south, the ebb *a b* is quite small, and the high water, *a*, is much lower than the next high water, *c*. If the moon's declination is north, it is the large high water, *a*, of the second diagram which occurs next after the transit, and about twelve hours from it. At Key West the contrary obtains, diagram 1 applying when the moon's declination is north, and diagram 2 when south. Tables IV and V give the number to be added to the time of moon's transit to find the time of high water almost as readily as in the former case. They are of double entry, the time of transit being, as before, placed in the first column. The number of days from the day at which the moon had the greatest declination is arranged at the top of the table. Entering the first column with the time of transit, and following the line horizontally until we come under the column containing the days from the greatest declination, we find the number to be added to the time of the transit to give the time of high water. If the moon's declination is south, Table IV is to be used; if north, Table V.



Tables IV to IX, inclusive, have been recomputed, using more complete data for the inequalities above referred to, and to those for San Francisco similar tables have been added for San Diego, Astoria, Port Townshend, and Key West, Fla. For the other places on the Western Coast given in Table I the following rules will give sufficiently close approximations.

To obtain the times of high or low water for San Pedro, Cuyler's harbor, and San Luis Obispo, compute first the time for San Diego by Tables IV, V, or VIII; then add to the time thus obtained 30 minutes to obtain the time for San Luis Obispo, and subtract 13 minutes for Cuyler's harbor. At San Pedro the time of high or low water is sensibly the same as at San Diego.

For Monterey, South Farrallone, Mare island, Benicia, Ravenswood, and Bodega, compute first the time for San Francisco; then subtract from the time thus obtained *1h. 44m.* for Monterey, *1h. 29m.* for the South Farallone, and *49m.* for Bodega; and add *34m.* for Mare island, *1h. 4m.* for Benicia, and *30m.* for Ravenswood. For Humboldt bay, Port Orford, and Neeah harbor, compute first the time for Astoria; then subtract from it *40m.* for Humboldt bay, *1h. 16m.* for Port Orford, and *9m.* for Neeah harbor.

For Steilacoom and Semiahmoo bay, compute first the time for Port Townshend, and add to it *57m.* for Steilacoom and *1h.* for Semiahmoo. The approximation will be only a rough one for Steilacoom.

For the heights, Tables VI, VII, and IX for San Diego can be used without change for San Pedro, Cuyler's harbor, and San Luis Obispo. These tables for San Francisco are also applicable to Monterey, South Farrallone, and Bodega. For Mare island add 1.2 foot, for Benicia 0.9 foot, and for Ravenswood 2.7 feet, to the quantities for San Francisco.

For Humboldt bay, Port Orford, and Neeah harbor, the tables for Astoria may be used, subtracting 1.7 foot for Humboldt bay, and 1.0 foot for Port Orford. For Neeah harbor the tables will give approximate results without change.

For Semiahmoo bay, add one foot to the quantities in the tables for Port Townshend. For Steilacoom, a rough approximation may be obtained by adding 4.6 feet to them.

For the coast of Florida, compute the times of high or low water for Key West, and subtract *1h. 7m.* for Indian key, and add *26m.* for Tortugas and *1h. 51m.* for Egmont key, *3h. 45m.* for Cedar keys, and *4h. 8m.* for St. Mark's. For the heights, add half a foot for Indian key, and use the tables without change for Tortugas and Egmont key. For Cedar keys and St. Mark's, the results could not be obtained with much accuracy in this way; special tables will be prepared for those places.

TABLE IV.—KEY WEST.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 00	9 40	9 30	9 18	9 07	9 01	8 49	8 44	8 40	8 40	8 46	8 54	9 06	9 16	9 27	9 37
0 30	9 33	9 23	9 11	9 00	8 54	8 42	8 37	8 33	8 33	8 39	8 47	8 59	9 09	9 20	9 30
1 00	9 26	9 16	9 04	8 53	8 47	8 35	8 30	8 26	8 26	8 32	8 40	8 52	9 02	8 13	9 23
1 30	9 20	9 10	8 58	8 47	8 41	8 29	8 24	8 20	8 20	8 26	8 34	8 46	8 56	9 07	9 17
2 00	9 13	9 03	8 51	8 40	8 34	8 22	8 17	8 13	8 13	8 19	8 27	8 39	8 49	9 00	9 10
2 30	9 08	8 58	8 46	8 35	8 29	8 17	8 12	8 08	8 08	8 14	8 22	8 34	8 44	8 55	9 05
3 00	9 04	8 54	8 42	8 31	8 25	8 13	8 08	8 04	8 04	8 10	8 18	8 30	8 40	8 51	9 01
3 30	9 00	8 50	8 38	8 27	8 21	8 09	8 04	8 00	8 00	8 06	8 14	8 26	8 36	8 47	8 57
4 00	9 00	8 50	8 38	8 27	8 21	8 09	8 04	8 00	8 00	8 06	8 14	8 26	8 35	8 47	8 57
4 30	9 03	8 53	8 41	8 30	8 24	8 12	8 07	8 03	8 03	8 09	8 17	8 29	8 39	8 50	9 00
5 00	9 09	8 59	8 47	8 36	8 30	8 18	8 13	8 09	8 09	9 15	8 23	8 35	8 45	8 56	9 06
5 30	9 17	9 07	8 55	8 44	8 38	8 26	8 21	8 17	8 17	8 23	8 31	8 43	8 53	9 04	9 14
6 00	9 29	9 19	9 07	8 56	8 50	8 38	8 33	8 29	8 29	8 35	8 43	8 55	9 05	9 16	9 26
6 30	9 40	9 30	9 18	9 07	9 01	8 49	8 44	8 40	8 40	8 46	8 54	9 06	9 16	9 27	9 37
7 00	9 56	9 46	9 34	9 23	9 17	9 05	9 00	8 56	8 56	9 02	9 10	9 22	9 32	9 43	9 53
7 30	10 07	9 57	9 45	9 34	9 28	9 16	9 11	9 07	9 07	9 13	9 21	9 33	9 43	9 54	10 04
8 00	10 13	10 03	9 51	9 40	9 34	9 22	9 17	9 13	9 13	9 19	9 27	9 39	9 49	10 00	10 00
8 30	10 14	10 04	9 52	9 41	9 35	9 23	9 18	9 14	9 14	9 20	9 28	9 40	9 50	10 01	10 11
9 00	10 13	10 03	9 51	9 40	9 34	9 22	9 17	9 13	9 13	9 19	9 27	9 39	9 49	10 00	10 10
9 30	10 10	10 00	9 48	9 37	9 31	9 19	9 14	9 10	9 10	9 16	9 24	9 36	9 46	9 57	10 07
10 00	10 06	9 56	9 44	9 33	9 27	9 15	9 10	9 06	9 06	9 12	9 20	9 32	9 42	9 53	10 03
10 30	10 03	9 53	9 41	9 30	9 24	9 12	9 07	9 03	9 03	9 09	9 17	9 29	9 39	9 50	10 00
11 00	9 55	9 45	9 33	9 22	9 16	9 04	8 59	8 55	8 55	9 01	9 09	9 21	9 31	9 42	9 52
11 30	9 47	9 37	9 25	9 14	9 08	8 56	8 51	8 47	8 47	8 53	9 01	9 13	9 23	9 34	9 44

TABLE V.—KEY WEST.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	9 29	9 36	9 43	9 53	10 06	10 16	10 22	10 22	10 22	10 18	10 06	9 56	9 43	9 34	9 27
0 30	9 22	9 29	9 36	9 46	9 59	10 09	10 15	10 15	10 15	10 11	9 59	9 49	9 36	9 27	9 20
1 0	9 15	9 22	9 29	9 39	9 52	10 02	10 08	10 08	10 08	10 04	9 52	9 42	9 29	9 20	9 13
1 30	9 09	9 16	9 23	9 33	9 46	9 56	10 02	10 02	10 02	9 58	9 46	9 36	9 23	9 14	9 07
2 0	9 02	9 09	9 16	9 26	9 39	9 49	9 55	9 55	9 55	9 51	9 39	9 29	9 16	9 07	9 00
2 30	8 57	9 04	9 11	9 21	9 34	9 44	9 50	9 50	9 50	9 46	9 34	9 24	9 11	9 02	8 55
3 0	8 53	9 00	9 07	9 17	9 30	9 40	9 46	9 46	9 46	9 42	9 30	9 20	9 07	8 58	8 51
3 30	8 49	8 56	9 03	9 13	9 26	9 36	9 42	9 42	9 52	9 38	9 26	9 16	9 03	8 54	8 47
4 0	8 49	8 56	9 03	9 13	9 26	9 36	9 42	9 42	9 42	9 38	9 26	9 16	9 03	8 54	8 47
4 30	8 52	8 59	9 06	9 16	9 29	9 39	9 45	9 45	9 45	9 41	9 39	9 29	9 06	8 57	8 50
5 0	8 58	9 05	9 12	9 22	9 25	9 45	9 51	9 51	9 51	9 47	9 35	9 25	9 12	9 03	8 56
5 30	9 06	9 13	9 20	9 30	9 43	9 53	9 59	9 59	9 59	9 55	9 43	9 33	9 20	9 11	9 04
6 0	9 18	9 25	9 32	9 42	9 55	10 05	10 11	10 11	10 11	10 07	9 55	9 45	9 32	9 23	9 16
6 30	9 29	9 36	9 43	9 53	10 06	10 16	10 22	10 22	10 22	10 18	10 06	9 56	9 43	9 34	9 27
7 0	9 45	9 52	9 59	10 09	10 22	10 32	10 38	10 38	10 38	10 34	10 22	10 12	9 59	9 50	9 43
7 30	9 56	10 03	10 10	10 20	10 33	10 43	10 49	10 49	10 49	10 45	10 33	10 23	10 10	10 01	9 54
8 0	10 02	10 09	10 16	10 26	10 39	10 49	10 55	10 55	10 55	10 51	10 39	10 29	10 16	10 07	10 00
8 30	10 03	11 10	10 17	10 27	10 40	10 50	10 56	10 56	10 56	10 52	10 40	10 30	10 17	10 08	10 01
9 0	10 02	10 09	10 16	10 26	10 39	10 49	10 55	10 55	10 55	10 51	10 39	10 29	10 16	10 07	10 00
9 30	9 59	10 06	10 13	10 23	10 36	10 46	10 52	10 52	10 52	10 48	10 36	10 26	10 13	10 04	9 57
10 0	9 55	10 02	10 09	10 19	10 32	10 42	10 48	10 48	10 48	10 44	10 32	10 22	10 09	10 00	9 53
10 30	9 52	9 59	10 06	10 16	10 29	10 39	10 45	10 45	10 45	10 41	10 29	10 19	10 06	9 57	9 50
11 0	9 44	9 51	9 58	10 08	10 21	10 31	10 37	10 37	10 37	10 33	10 21	10 11	9 58	9 49	9 42
11 30	9 36	9 43	9 50	10 00	10 13	10 23	10 29	10 29	10 29	10 25	10 13	10 03	9 50	9 41	9 34

TABLE IV.—SAN DIEGO.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	9 25	9 40	9 52	10 3	10 12	10 20	10 25	10 29	10 29	10 25	10 19	10 10	10 0	9 47	9 30
0 30	9 15	9 30	9 42	9 53	10 2	10 10	10 15	10 19	10 19	10 15	10 9	10 0	9 50	9 27	9 20
1 0	9 8	9 23	9 35	9 46	9 55	10 3	10 8	10 12	10 12	10 8	10 2	9 53	9 43	9 30	9 13
1 30	9 1	9 16	9 28	9 39	9 48	9 56	10 1	10 5	10 5	10 1	9 55	9 46	9 36	9 23	9 6
2 0	8 54	9 9	9 21	9 32	9 41	9 49	9 54	9 58	9 58	9 54	9 48	9 39	9 29	9 16	8 59
2 30	8 49	9 4	9 16	9 27	9 36	9 44	9 49	9 53	9 53	9 49	9 43	9 34	9 24	9 11	8 54
3 0	8 48	9 3	9 15	9 26	9 35	9 43	9 48	9 52	9 52	9 48	9 42	9 33	9 23	9 10	8 53
3 30	8 48	9 3	9 15	9 26	9 35	9 43	9 48	9 52	9 52	9 48	9 42	9 33	9 23	9 10	8 53
4 0	8 52	9 7	9 19	9 30	9 39	9 47	9 52	9 56	9 56	9 52	9 46	9 37	9 27	9 14	8 57
4 30	8 56	9 11	9 23	9 34	9 43	9 51	9 56	10 0	10 0	9 56	9 50	9 41	9 31	9 18	9 1
5 0	9 15	9 30	9 42	9 53	10 2	10 10	10 15	10 19	10 19	10 15	10 9	10 0	9 50	9 37	9 20
5 30	9 37	9 52	10 4	10 15	10 24	10 32	10 37	10 41	10 41	10 37	10 31	10 22	10 12	9 59	9 42
6 0	9 55	10 10	10 22	10 33	10 42	10 50	10 55	10 59	10 59	10 55	10 49	10 40	10 30	10 17	10 0
6 30	10 12	10 27	10 39	10 50	10 59	11 7	11 12	10 16	10 16	11 12	11 6	10 57	10 47	10 34	10 17
7 0	10 18	10 33	10 45	10 56	11 5	11 13	11 18	11 22	11 22	11 18	11 12	11 3	10 53	10 40	10 23
7 30	10 20	10 35	10 47	10 58	11 7	11 15	11 20	11 24	11 24	11 20	11 14	11 5	10 55	10 42	10 25
8 0	10 22	10 37	10 49	11 0	10 9	11 17	11 22	11 26	11 26	11 22	11 16	11 7	10 57	10 44	10 27
8 30	10 24	10 39	10 51	11 2	11 11	11 19	11 24	11 28	11 28	11 24	11 18	11 9	10 59	10 46	10 29
9 0	10 18	10 33	10 45	10 56	11 5	11 13	11 18	11 22	11 22	11 18	11 12	11 3	10 53	10 40	10 23
9 30	10 10	10 25	10 37	10 48	10 57	11 5	11 10	11 14	11 14	11 10	11 4	10 55	10 45	10 32	10 15
10 0	10 0	10 15	10 27	10 38	10 47	10 55	11 0	11 4	11 4	11 0	10 54	10 45	10 35	10 22	10 5
10 30	9 53	10 8	10 20	10 31	10 40	10 48	10 53	10 57	10 57	10 53	10 47	10 38	10 28	10 15	9 58
11 0	9 45	10 0	10 12	10 23	10 32	10 40	10 45	10 49	10 49	10 45	10 39	10 30	10 20	10 7	9 50
11 30	9 36	9 51	10 3	10 14	10 23	10 31	10 36	10 40	10 40	10 36	10 30	10 21	10 11	9 58	9 41

TABLE V.—SAN DIEGO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	9 30	9 16	9 4	8 53	8 44	8 36	8 31	8 27	8 27	8 31	8 37	8 46	8 56	9 9	9 26
0 30	9 21	9 6	8 54	8 43	8 34	8 26	8 21	8 17	8 17	8 21	8 27	8 36	8 46	8 59	9 16
1 0	9 14	8 59	8 47	8 36	8 27	8 19	8 14	8 10	8 10	8 14	8 20	8 29	8 39	8 52	9 9
1 30	9 7	8 52	8 40	8 29	8 20	8 12	8 7	8 3	8 3	8 7	8 13	8 22	8 32	8 45	9 2
2 0	9 0	8 45	8 33	8 22	8 13	8 5	8 0	7 56	7 56	8 0	8 6	8 15	8 25	8 38	8 55
2 30	8 55	8 40	8 28	8 17	8 8	8 0	7 55	7 51	7 51	7 55	8 1	8 10	8 20	8 33	8 50
3 0	8 54	8 39	8 27	8 16	8 7	7 59	7 54	7 50	7 50	7 54	8 0	8 9	8 19	8 32	8 49
3 30	8 54	8 39	8 27	8 16	8 7	7 59	7 54	7 50	7 50	7 54	8 0	8 9	8 19	8 32	8 49
4 0	8 58	8 43	8 31	8 20	8 11	8 3	7 58	7 54	7 54	7 58	8 4	8 13	8 23	8 36	8 53
4 30	9 2	8 47	8 35	8 24	8 15	8 7	8 2	7 58	7 58	8 2	8 8	8 17	8 27	8 40	8 57
5 0	9 21	9 6	8 54	8 43	8 34	8 26	8 21	8 17	8 17	8 21	8 27	8 36	8 46	8 59	9 16
5 30	9 43	9 28	9 16	9 5	8 56	8 48	8 43	8 39	8 39	8 43	8 49	8 58	9 8	9 21	9 38
6 0	10 1	9 46	9 34	9 23	9 14	9 6	9 1	8 57	8 57	9 1	9 7	9 16	9 26	9 39	9 56
6 30	10 18	10 3	9 51	9 40	9 31	9 23	9 18	9 14	9 14	9 18	9 24	9 33	9 43	9 56	10 13
7 0	10 24	10 9	9 57	9 46	9 37	9 29	9 24	9 20	9 20	9 24	9 30	9 39	9 49	10 2	10 19
7 30	10 26	10 11	9 59	9 48	9 39	9 31	9 26	9 22	9 22	9 26	9 32	9 41	9 51	10 4	10 21
8 0	10 28	10 13	10 1	9 50	9 41	9 33	9 28	9 24	9 24	9 28	9 34	9 43	9 53	10 6	10 23
8 30	10 30	10 15	10 3	9 52	9 43	9 35	9 30	9 26	9 26	9 30	9 36	9 45	9 55	10 8	10 25
9 0	10 24	10 9	9 57	9 46	9 37	9 29	9 24	9 20	9 20	9 21	9 30	9 39	9 49	10 2	10 19
9 30	10 16	10 1	9 49	9 38	9 29	9 21	9 16	9 12	9 12	9 16	9 22	9 31	9 41	9 54	10 11
10 0	10 6	9 51	9 39	9 28	9 19	9 11	9 6	9 2	9 2	9 6	9 12	9 21	9 31	9 44	10 1
10 30	9 59	9 44	9 32	9 21	9 12	9 4	8 59	8 55	8 55	8 59	9 5	9 14	9 24	9 37	9 54
11 0	9 51	9 36	9 24	9 13	9 4	8 56	8 51	8 47	8 47	8 51	8 57	9 6	9 16	9 29	9 46
11 30	9 42	9 27	9 15	9 4	8 55	8 47	8 42	8 38	8 38	8 42	8 48	8 57	9 7	9 20	9 37

TABLE IV.—SAN FRANCISCO.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
0 0	11 43	11 59	12 15	12 33	12 50	13 03	13 17	13 20	13 19	13 14	13 07	12 57	12 45	12 32	12 18
0 30	11 37	11 53	12 09	12 27	12 44	12 57	13 11	13 14	13 13	13 08	13 01	12 51	12 39	12 26	12 12
1 0	11 31	11 47	12 03	12 21	12 38	12 51	13 05	13 08	13 07	13 02	12 55	12 45	12 33	12 20	12 06
1 30	11 25	11 41	11 57	12 15	12 32	12 45	12 59	13 02	13 01	12 56	12 49	12 39	12 27	12 14	12 00
2 0	11 19	11 35	11 51	12 09	12 26	12 39	12 53	12 56	12 55	12 50	12 43	12 33	12 21	12 08	11 54
2 30	11 14	11 30	11 46	12 04	12 21	12 34	12 48	12 51	12 50	12 45	12 38	12 28	12 16	12 03	11 49
3 0	11 11	11 27	11 43	12 01	12 18	12 31	12 45	12 48	12 47	12 42	12 35	12 25	12 13	12 00	11 46
3 30	11 11	11 27	11 43	12 01	12 18	12 31	12 45	12 48	12 47	12 42	12 35	12 25	12 13	12 00	11 46
4 0	11 16	11 32	11 48	12 06	12 23	12 36	12 50	12 53	12 52	12 47	12 40	12 30	12 18	12 05	11 51
4 30	11 24	11 40	11 56	12 14	12 31	12 44	12 58	13 01	13 00	12 55	12 48	12 38	12 26	12 13	11 59
5 0	11 33	11 49	12 05	12 23	12 40	12 53	13 07	13 10	13 09	13 04	12 57	12 47	12 35	12 22	12 08
5 30	11 41	11 57	12 13	12 31	12 48	13 01	13 15	13 18	13 17	13 12	13 05	12 55	12 43	12 30	12 16
6 0	11 49	12 05	12 21	12 39	12 56	13 09	13 23	13 25	13 25	13 20	13 13	13 03	12 51	12 38	12 24
6 30	11 54	12 10	12 26	12 44	13 01	13 14	13 28	13 31	13 30	13 25	13 18	13 08	12 56	12 43	12 29
7 0	12 01	12 17	12 33	12 51	13 08	13 21	13 35	13 38	13 37	13 32	13 25	13 15	13 03	12 50	12 36
7 30	12 07	12 23	12 39	12 57	13 14	13 27	13 41	13 44	13 43	13 38	13 31	13 21	13 09	12 56	12 42
8 0	12 12	12 28	12 44	13 02	13 19	13 32	13 46	13 49	13 48	13 43	13 36	13 26	13 14	13 01	12 47
8 30	12 15	12 31	12 47	13 05	13 22	13 35	13 49	13 52	13 51	13 46	13 39	13 29	13 17	13 04	12 50
9 0	12 14	12 30	12 46	13 04	13 21	13 34	13 48	13 57	13 50	13 45	13 38	13 28	13 16	13 03	12 49
9 30	12 12	12 28	12 44	13 02	13 19	13 32	13 46	13 49	13 48	13 43	13 36	13 26	13 14	13 01	12 47
10 0	12 08	12 24	12 40	12 58	13 15	13 28	13 42	13 45	13 44	13 39	13 32	13 22	13 10	12 57	12 43
10 30	12 02	12 18	12 34	12 52	13 09	13 22	13 36	13 39	13 38	13 33	13 26	13 16	13 04	12 51	12 37
11 0	11 55	12 11	12 27	12 45	13 02	13 15	13 29	13 32	13 31	13 26	13 19	13 09	12 57	12 44	12 30
11 30	11 47	12 03	12 19	12 37	12 54	13 07	13 21	13 24	13 23	13 18	13 11	13 01	12 49	12 36	12 22

TABLE V.—SAN FRANCISCO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
0 0	12 27	12 11	11 55	11 37	11 20	11 07	10 53	10 50	10 51	10 56	11 03	11 13	11 25	11 38	11 52
0 30	12 21	12 05	11 49	11 31	11 14	11 01	10 47	10 44	10 45	10 50	10 57	11 07	11 19	11 32	11 46
1 0	12 15	11 59	11 43	11 25	11 08	10 55	10 41	10 38	10 39	10 44	10 51	11 01	11 13	11 26	11 40
1 30	12 09	11 53	11 37	11 19	11 02	10 49	10 35	10 32	10 33	10 38	10 45	10 55	11 07	11 20	11 34
2 0	12 03	11 47	11 31	11 13	10 56	10 43	10 29	10 26	10 27	10 32	10 39	10 49	11 01	11 14	11 28
2 30	11 58	11 42	11 26	11 08	10 51	10 38	10 24	10 21	10 22	10 27	10 34	10 44	10 56	11 09	11 23
3 0	11 55	11 39	11 23	11 05	10 48	10 35	10 21	10 18	10 19	10 24	10 31	10 41	10 53	11 06	11 20
3 30	11 55	11 39	11 23	11 05	10 48	10 35	10 21	10 18	10 19	10 24	10 31	10 41	10 53	11 06	11 20
4 0	12 00	11 44	11 28	11 10	10 53	10 40	10 26	10 23	10 24	10 29	10 36	10 46	10 58	11 11	11 25
4 30	12 08	11 52	11 36	11 18	11 01	10 48	10 34	10 31	10 32	10 37	10 44	10 54	11 06	11 19	11 33
5 0	12 17	12 01	11 45	11 27	11 10	10 57	10 43	10 40	10 41	10 46	10 53	11 03	11 15	11 28	11 42
5 30	12 25	12 09	11 53	11 35	11 18	11 05	10 51	10 48	10 49	10 54	11 01	11 11	11 23	11 36	11 50
6 0	12 33	12 17	12 01	11 43	11 26	11 13	10 59	10 56	10 57	11 02	11 09	11 19	11 31	11 44	11 58
6 30	12 38	12 22	12 06	11 48	11 31	11 18	11 04	11 01	11 02	11 07	11 14	11 24	11 36	11 49	12 03
7 0	12 45	12 29	12 13	11 55	11 38	11 25	11 11	11 08	11 09	11 14	11 21	11 31	11 43	11 56	12 10
7 30	12 51	12 35	12 19	12 01	11 44	11 31	11 17	11 14	11 15	11 20	11 27	11 37	11 49	12 02	12 16
8 0	12 56	12 40	12 24	12 06	11 49	11 36	11 22	11 19	11 20	11 25	11 32	11 42	11 54	12 07	12 21
8 30	12 59	12 43	12 27	12 09	11 52	11 39	11 25	11 22	11 23	11 28	11 35	11 45	11 57	12 10	12 24
9 0	12 58	12 42	12 26	12 08	11 51	11 38	11 24	11 21	11 22	11 27	11 34	11 44	11 56	12 09	12 23
9 30	12 56	12 40	12 24	12 06	11 49	11 36	11 22	11 19	11 20	11 25	11 32	11 42	11 54	12 07	12 21
10 0	12 52	12 36	12 20	12 02	11 45	11 32	11 18	11 15	11 16	11 21	11 28	11 38	11 50	12 03	12 17
10 50	12 46	12 30	12 14	11 56	11 39	11 26	11 12	11 09	11 10	11 15	11 22	11 32	11 44	11 57	12 11
11 0	12 39	12 23	12 07	11 49	11 32	11 19	11 05	11 02	11 03	11 08	11 15	11 25	11 37	11 50	12 04
11 30	12 31	12 15	11 59	11 41	11 24	11 11	10 57	10 54	10 55	11 00	11 07	11 17	11 29	11 42	11 56

TABLE IV.—ASTORIA.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	12 42	12 55	13 5	13 18	13 28	13 38	13 41	13 45	13 46	13 44	13 40	13 34	13 24	13 14	13 2
0 30	12 36	12 49	12 59	13 12	13 22	13 22	13 35	13 39	13 40	13 38	13 34	13 28	13 18	13 8	12 56
1 0	12 29	12 42	12 52	13 5	13 15	13 25	13 28	13 32	13 33	13 31	13 27	13 21	13 11	13 1	12 49
1 30	12 23	12 36	12 46	12 59	13 9	13 19	13 22	13 26	13 27	13 25	13 21	13 15	13 5	12 55	12 43
2 0	12 15	12 28	12 38	12 51	13 1	13 11	13 14	13 18	13 19	13 17	13 13	13 7	12 57	12 47	12 35
2 30	12 9	12 22	12 32	12 45	12 55	13 5	13 8	13 12	13 13	13 11	13 7	13 1	12 51	12 41	12 29
3 0	12 3	12 16	12 26	13 39	12 49	12 59	13 2	13 6	13 7	13 5	13 1	12 55	12 45	12 35	12 23
3 30	11 58	12 11	12 21	12 34	12 44	12 54	12 57	13 1	13 2	13 0	12 56	12 50	12 40	12 30	12 18
4 0	11 57	12 10	12 20	12 33	12 43	12 53	12 56	13 0	13 1	12 59	12 55	12 49	12 39	12 29	12 17
4 30	12 0	12 13	12 23	12 36	12 46	12 56	12 59	13 3	13 4	13 2	12 58	12 52	12 42	12 32	12 20
5 0	12 8	12 21	12 31	12 44	12 54	13 4	13 7	13 11	12 12	13 10	13 6	13 0	12 50	12 40	12 28
5 30	12 15	12 28	12 38	12 51	13 1	13 11	13 14	13 18	13 19	13 17	13 13	13 7	12 57	12 47	12 35
6 0	12 25	12 38	12 48	13 1	13 11	13 21	13 24	13 28	13 29	13 27	13 23	13 17	13 7	12 57	12 45
6 30	12 36	12 49	12 59	13 12	13 22	13 32	13 35	13 39	13 40	13 38	13 34	13 28	13 18	13 8	12 56
7 0	12 45	12 58	13 8	13 21	13 31	13 41	13 44	13 48	13 49	13 47	13 43	13 37	13 27	13 17	13 5
7 30	12 55	13 8	13 18	13 31	13 41	13 51	13 54	13 58	13 59	13 57	13 53	13 47	13 37	13 27	13 15
8 0	13 3	13 16	13 26	13 39	13 49	13 59	14 2	14 6	14 7	14 5	14 1	13 55	13 45	13 35	13 23
8 30	13 8	13 21	13 31	13 44	13 54	14 4	14 7	14 11	14 12	14 10	14 6	14 0	13 50	13 40	13 28
9 0	13 16	13 23	13 33	13 46	13 56	14 6	14 9	14 13	14 14	14 12	14 8	14 2	13 52	13 42	13 30
9 30	13 9	13 22	13 32	13 45	13 55	14 5	14 8	14 12	14 13	14 11	14 7	14 1	13 51	13 41	13 29
10 0	13 5	13 18	12 28	13 41	13 51	14 1	14 4	14 8	14 9	14 7	14 3	13 57	13 47	13 37	13 25
10 30	12 59	13 12	13 22	13 35	13 45	13 55	13 58	14 2	14 3	14 1	13 57	13 51	13 41	13 31	13 19
11 0	12 53	13 6	13 16	13 29	13 39	13 49	13 52	13 56	13 57	13 55	13 51	13 45	13 35	13 25	13 13
11 30	12 46	12 59	13 9	13 22	13 32	13 42	13 45	13 49	13 50	13 48	13 44	13 38	13 28	13 18	13 6

TABLE V.—ASTORIA.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m	h. m.	h. m.	h m	h. m.	h. m.	h m.	h. m.	h. m.	h. m.	h. m	h. m.	h. m.	h. m.	h. m.
0 0	13 10	12 57	12 47	12 34	12 24	12 14	12 11	12 7	12 6	12 8	12 12	12 18	12 28	12 38	12 50
0 30	13 4	12 51	12 41	12 28	12 18	12 8	12 5	12 1	12 0	12 2	12 6	12 12	12 22	12 32	12 44
1 0	12 57	12 34	12 34	12 21	12 11	12 1	11 58	11 54	11 53	11 55	11 59	12 5	12 15	12 25	12 37
1 30	12 51	12 28	12 28	12 15	12 5	11 55	11 52	11 48	11 47	11 49	11 53	11 59	12 9	12 19	12 31
2 0	12 43	12 30	12 20	12 7	11 57	11 47	11 44	11 40	11 39	11 41	11 45	11 51	12 1	12 11	12 23
2 30	12 37	12 24	12 14	12 1	11 51	11 41	11 38	11 34	11 33	11 35	11 39	11 45	11 55	12 5	12 17
3 0	12 31	12 18	12 8	11 55	11 45	11 35	11 32	11 28	11 27	11 29	11 33	11 39	11 49	11 59	12 11
3 30	12 26	12 13	12 3	11 59	11 40	11 30	11 27	11 23	11 22	11 24	11 28	11 34	11 44	11 54	12 6
4 0	12 25	12 12	12 2	11 49	11 39	11 29	11 26	11 22	11 21	11 23	11 27	11 33	11 43	11 53	12 5
4 30	12 28	12 15	12 5	11 52	11 42	11 32	11 29	11 25	11 24	11 26	11 30	11 36	11 46	11 56	12 8
5 0	12 36	12 23	12 13	12 0	11 50	11 40	11 37	11 33	11 32	11 34	11 38	11 44	11 54	12 4	12 16
5 30	12 43	12 30	12 20	12 7	11 57	11 47	11 44	11 40	11 39	11 41	11 45	11 51	12 1	12 11	12 23
6 0	12 53	12 40	12 30	12 17	12 7	11 57	11 54	10 50	11 49	11 51	11 55	12 1	12 11	12 21	12 33
6 30	13 4	12 51	12 41	12 28	12 18	12 8	12 5	12 1	12 0	12 2	12 6	12 12	12 22	12 32	12 44
7 0	13 13	13 0	12 50	12 37	12 27	12 17	12 14	12 10	12 9	12 11	12 15	12 21	12 31	12 41	12 53
7 30	13 23	13 10	13 0	12 47	12 37	12 27	12 24	12 20	12 19	12 21	12 25	12 31	12 41	12 51	13 3
8 0	13 31	13 18	13 8	12 55	12 45	12 35	12 32	12 28	12 27	12 29	12 33	12 39	12 49	12 59	13 11
8 30	13 36	13 23	13 13	13 0	12 50	12 40	12 37	12 33	12 32	12 34	12 38	12 44	12 54	13 4	13 16
9 0	13 38	13 25	13 15	13 2	12 52	12 42	12 39	12 35	12 34	12 36	12 40	12 46	12 56	13 6	13 18
9 30	13 37	13 24	13 14	13 1	12 51	12 41	12 38	12 34	12 33	12 35	12 39	12 45	12 55	13 5	13 17
10 0	13 33	13 20	13 10	12 57	12 47	12 37	12 34	12 30	12 29	12 31	12 35	12 41	12 51	13 1	13 13
10 30	13 27	13 14	13 4	12 51	12 41	12 31	12 28	12 24	12 23	12 25	12 29	12 35	12 45	12 55	13 7
11 0	13 21	13 8	12 58	12 45	12 35	12 25	12 22	12 18	12 17	12 19	12 23	12 29	12 39	12 49	13 1
11 30	13 14	13 1	12 51	12 38	12 28	12 18	12 15	12 11	12 10	12 12	12 16	12 22	12 32	12 42	12 54

TABLE IV.—PORT TOWNSHEND.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
0 0	3 45	3 21	2 51	2 2	1 32	1 13	1 26	1 44	2 2	2 21	2 42	2 57	3 15	3 33	3 45
0 30	3 38	3 14	2 41	1 55	1 25	1 6	1 19	1 37	1 55	2 14	2 35	2 50	3 8	3 26	3 38
1 0	3 32	3 8	2 38	1 49	1 19	1 0	1 13	1 31	1 49	2 8	2 29	2 44	3 2	3 20	3 32
1 30	3 26	3 2	2 32	1 43	1 13	0 54	1 7	1 25	1 43	2 2	2 23	2 38	2 56	3 14	3 26
2 0	3 21	2 57	2 27	1 38	1 8	0 49	1 2	1 20	1 38	1 57	2 18	2 33	2 51	3 9	3 21
2 30	3 18	2 54	2 24	1 35	1 5	0 46	0 59	1 17	1 35	1 54	2 15	2 20	2 48	3 6	3 18
3 0	3 16	2 52	2 22	1 33	1 3	0 41	0 57	1 15	1 33	1 52	2 13	2 28	2 46	3 4	3 16
3 30	3 17	2 53	2 23	1 34	1 4	0 45	0 58	1 16	1 34	1 53	2 14	2 29	2 47	3 5	3 17
4 0	3 21	2 57	2 27	1 38	1 8	0 49	1 2	1 20	1 38	1 57	2 18	2 33	2 51	3 9	3 21
4 30	3 26	3 2	2 32	1 43	1 13	0 54	1 7	1 25	1 43	2 2	2 23	2 38	2 56	3 14	3 26
5 0	3 32	3 8	2 38	1 49	1 19	1 0	1 13	1 31	1 49	2 8	2 29	2 44	3 2	3 20	3 32
5 30	3 41	3 17	2 47	1 58	1 28	1 9	1 22	1 40	1 58	2 17	2 38	2 53	3 11	3 29	3 41
6 0	3 52	3 28	2 58	2 9	1 39	1 20	1 33	1 51	2 9	2 28	2 49	3 4	3 22	3 40	3 52
6 30	4 1	3 37	3 7	2 18	1 48	1 29	1 42	2 0	2 18	2 37	2 58	3 13	3 31	3 49	4 1
7 0	4 8	3 44	3 14	2 25	1 55	1 36	1 49	2 7	2 25	2 41	3 5	3 20	3 38	3 56	4 8
7 30	4 15	3 51	3 21	2 32	2 2	1 43	1 56	2 14	2 32	2 51	3 12	3 27	3 45	4 3	4 15
8 0	4 18	3 54	3 24	2 35	2 5	1 46	1 59	2 17	2 35	2 54	3 15	3 30	3 48	4 6	4 18
8 30	4 19	3 55	3 25	2 36	2 6	1 47	2 0	2 18	2 36	2 55	3 16	3 31	3 49	4 7	4 19
9 0	4 18	3 54	3 24	2 35	2 5	1 46	1 59	2 17	2 35	2 54	3 15	3 30	3 48	4 6	4 18
9 30	4 15	3 51	3 21	2 32	2 2	1 43	1 56	2 14	2 32	2 51	3 12	3 27	3 45	4 3	4 15
10 0	4 10	3 46	3 16	2 27	1 57	1 38	1 51	2 9	2 27	2 46	3 7	3 22	3 40	3 58	4 10
10 30	4 6	3 42	3 12	3 23	1 53	1 34	1 47	2 5	2 23	2 42	3 3	3 18	3 36	3 54	4 6
11 0	4 0	3 36	3 6	2 17	1 47	1 28	1 41	1 59	2 17	2 36	2 57	3 12	3 30	3 48	4 0
11 30	3 54	3 30	3 0	2 11	1 41	1 22	•1 35	1 53	2 11	2 30	2 51	3 6	3 24	3 42	3 54

TABLE V.—PORT TOWNSHEND.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
0 0	3 45	4 9	4 39	5 28	5 58	6 17	6 4	5 46	5 28	5 9	4 48	4 33	4 15	3 57	3 45
0 30	3 38	4 2	4 32	5 21	5 51	6 10	5 57	5 39	5 21	5 2	4 41	4 26	4 8	3 50	3 38
1 0	3 32	3 56	4 26	5 15	5 45	6 4	5 51	5 33	5 15	4 56	4 35	4 20	4 2	3 44	3 32
1 30	3 26	3 50	4 20	5 9	5 39	5 58	5 45	5 27	5 9	4 50	4 29	4 14	3 56	3 38	3 26
2 0	3 21	3 45	4 15	5 4	5 34	5 53	5 40	5 22	5 4	4 45	4 24	4 9	3 51	3 33	3 21
2 30	3 18	3 42	4 12	5 1	5 31	5 50	5 37	5 19	5 1	4 42	4 21	4 6	3 48	3 30	3 18
3 0	3 16	3 40	4 10	4 59	5 29	5 48	5 35	5 17	4 59	4 40	4 19	4 4	3 46	3 28	3 16
3 30	3 17	3 41	4 11	5 0	5 30	5 49	5 36	5 18	5 0	4 41	4 20	4 5	3 47	3 29	3 17
4 0	3 21	3 45	4 15	5 4	5 34	5 53	5 40	5 22	5 4	4 45	4 24	4 9	3 51	3 33	3 21
4 30	3 26	3 50	4 20	5 9	5 39	5 58	5 45	5 27	5 9	4 50	4 29	4 14	3 56	3 38	3 26
5 0	3 32	3 56	4 26	5 15	5 45	6 4	5 51	5 33	5 15	4 56	4 35	4 20	4 2	3 44	3 32
5 30	3 41	4 5	4 35	5 24	5 54	6 13	6 0	5 42	5 24	5 5	4 44	4 29	4 11	3 53	3 41
6 0	3 52	4 16	4 46	5 35	6 5	6 24	6 11	5 53	5 35	5 16	4 55	4 40	4 22	4 4	3 52
6 30	4 1	4 25	4 55	5 44	6 14	6 33	6 20	6 2	5 44	5 25	5 4	4 49	4 31	4 13	4 1
7 0	4 8	4 32	5 2	5 51	6 21	6 40	6 27	6 9	5 51	5 32	5 11	4 56	4 38	4 20	4 8
7 30	4 15	4 39	5 9	5 58	6 28	6 47	6 34	6 16	5 58	5 30	5 18	5 3	4 45	4 27	4 15
8 0	4 18	4 42	5 12	6 1	6 31	6 50	6 37	6 19	6 1	5 42	5 21	5 6	4 48	4 30	4 18
8 30	4 19	4 43	5 13	6 2	6 32	6 51	6 38	6 20	6 2	5 43	5 22	5 7	4 49	4 31	4 19
9 0	4 18	4 42	5 12	6 1	6 31	6 50	6 37	6 19	6 1	5 42	5 21	5 6	4 48	4 30	4 18
9 30	4 15	4 39	5 9	5 58	6 28	6 47	6 34	6 16	5 58	5 39	5 18	5 3	4 45	4 27	4 15
10 0	4 10	4 34	5 4	5 53	6 23	6 42	6 29	6 11	5 53	5 34	5 13	4 58	4 40	4 22	4 10
10 30	4 6	4 30	5 0	5 49	6 19	6 38	6 25	6 7	5 49	5 30	5 9	4 51	4 35	4 18	4 6
11 0	4 0	4 24	4 54	5 43	6 13	6 32	6 19	6 1	5 43	5 24	5 3	4 48	4 30	4 12	4 0
11 30	3 54	4 18	4 48	5 37	6 7	6 26	6 13	5 55	5 37	5 18	4 57	4 42	4 24	4 6	3 54

If we disregard the daily inequality, the column headed San Francisco in Table II would give us, as in the examples on the Atlantic coast, the means of determining the time of high water.

Example V.—Required the time of high water at North Beach, San Francisco, Cal., on the 7th of February, 1853.

1st. The time of the moon's transit at Greenwich, from the Nautical Almanac, is 11*h.* 41*m.*; the longitude of San Francisco 8*h.* 10*m.*, requiring a correction of 16*m.* to the time of transit for San Francisco, which is thus found to be 11*h.* 57*m.*

2d. The moon's declination is south, and at the time of transit about two days after the greatest. Entering Table IV, we find 12*h.* (or 0*h.*) of transit, the nearest number to 11*h.* 57*m.* which the table gives; and following the line horizontally, until we come to two days after the greatest declination, we find 13*h.* 14*m.*

To 11*h.* 57*m.*, time of transit of the moon, February 7, San Francisco, add 13*h.* 14*m.*, from column 0*h.*, transit, and two days after greatest declination; the sum, 25*h.* 11*m.*, or 1*h.* 11*m.*, February 8, is the time of high water, corresponding to the transit which we took of February 7. If we desire the tide of February 7 we must go back to the moon's transit of the 6th. The example was purposely assumed to show this case.

	11*h.*	01*m.*	time of transit February 6, 1853.
	13	31	number for 11*h.* transit, and one day from greatest declination.
Sum	24	32	time of high water 0*h.* 32*m.* a. m. February 7.

The height of high water.—The height of high water is obtained in a similar manner by the use of Table VI and Table VII, entering these in the same way with the time of transit and days from the greatest declination. Table VI is for south declination, and Table VII for north.

TABLE VI.—KEY WEST.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.5	1.6	1.8	1.9	2.0	2.0	2 0	2 0	2.0	2.0	2.0	1.9	1.8	1.7	1.5
1	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5
2	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5
3	1.4	1.5	1.7	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.7	1.6	1.4
4	1.3	1.4	1.6	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.6	1.5	1.3
5	1.2	1.3	1.5	1.6	1.7	1.7	1.7	1.7	1 7	1.7	1.7	1.6	1.5	1.4	1.2
6	1.1	1.2	1.4	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.4	1.3	1.1
7	1.1	1.2	1.4	1.5	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.5	1.4	1.3	1.1
8	1.2	1.3	1.5	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.6	1.5	1.4	1.2
9	1.3	1.4	1.6	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.7	1.6	1.5	1.3
10	1.4	1.5	1.7	1.8	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.8	1.7	1.6	1.4
11	1.5	1.6	1.8	1.9	2.0	2.0	2.0	2.0	2.0	2.0	2.0	1.9	1.8	1.7	1.5

TABLE VII.—KEY WEST.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8
1	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8
2	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8
3	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.9	1.0	1.0	1.1	1.2	1.3	1.5	1.7
4	1.5	1.4	1.2	1.1	1.0	0.9	0.8	0.8	0.9	0.9	1.0	1.1	1.2	1.4	1.6
5	1.4	1.3	1.1	1.0	0.9	0.8	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.3	1.5
6	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.2	1.4
7	1.3	1.2	1.0	0.9	0.8	0.7	0.6	0.6	0.7	0.7	0.8	0.9	1.0	1.2	1.4
8	1.4	1.3	1.1	1.0	0.9	0.8	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.3	1.5
9	1.5	1.4	1.2	1.1	1.0	0.9	0.9	0.8	0.9	0.9	1.0	1.1	1.2	1.4	1.6
10	1.6	1.5	1.3	1.2	1.1	1.0	0.9	0.9	1.0	1.0	1.1	1.2	1.3	1.5	1.7
11	1.7	1.6	1.4	1.3	1.2	1.1	1.0	1.0	1.1	1.1	1.2	1.3	1.4	1.6	1.8

TABLE VI.—SAN DIEGO.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
0	4.7	4.5	4.3	4.2	4.1	4.1	4.1	4.1	4.2	4.3	4.5	4.8	5.1	5.5	5.8
1	4.6	4.4	4.2	4.1	4.0	4.0	4.0	4.0	4.1	4.2	4.4	4.7	5.0	5.4	5.7
2	4.4	4.2	4.0	3.9	3.8	3.8	3.8	3.8	3.9	4.0	4.2	4.5	4.8	5.2	5.5
3	4.1	3.9	3.7	3.6	3.5	3.5	3.5	3.5	3.6	3.7	3.9	4.2	4.5	4.9	5.2
4	3.8	3.6	3.4	3.3	3.2	3.2	3.2	3.2	3.3	3.4	3.6	3.9	4.2	4.6	4.9
5	3.6	3.4	3.2	3.1	3.0	3.0	3.0	3.0	3.1	3.2	3.4	3.7	4.0	4.4	4.7
6	3.6	3.4	3.2	3.1	3.0	3.0	3.0	3.0	3.1	3.2	4.4	3.7	4.0	4.4	4.7
7	3.7	3.5	3.3	3.2	3.1	3.1	3.1	3.1	3.2	3.3	3.5	3.8	4.1	4.5	4.8
8	3.8	3.6	3.4	3.3	3.2	3.2	3.2	3.2	3.3	3.4	3.6	3.9	4.2	4.6	4.9
9	4.4	4.2	4.0	3.9	3.8	3.8	3.8	3.8	3.9	4.0	4.2	4.5	4.8	5.2	5.5
10	4.7	4.5	4.3	4.2	4.1	4.1	4.1	4.1	4.2	4.3	4.5	4.8	5.1	5.5	5.8
11	4.8	4.6	4.4	4.3	4.2	4.2	4.2	4.2	4.3	4.4	4.6	4.9	5.2	5.6	5.9

TABLE VII.—SAN DIEGO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
0	5.7	5.9	6.1	6.2	6.3	6.3	6.3	6.3	6.2	6.1	5.9	5.6	5.3	4.9	4.6
1	5.6	5.8	6.0	6.1	6.2	6.2	6.2	6.2	6.1	6.0	5.8	5.5	5.2	4.8	4.5
2	5.4	5.6	5.8	5.9	6.0	6.0	6.0	6.0	5.9	5.8	5.6	5.3	5.0	4.6	4.3
3	5.1	5.3	5.5	5.6	5.7	5.7	5.7	5.7	5.6	5.5	5.3	5.0	4.7	4.3	4.0
4	4.8	5.0	5.2	5.3	5.4	5.4	5.4	5.4	5.3	5.2	5.0	4.7	4.4	4.0	3.7
5	4.6	4.8	5.0	5.1	5.2	5.2	5.2	5.2	5.1	5.0	4.8	4.5	4.2	3.8	3.5
6	4.6	4.8	5.0	5.1	5.2	5.2	5.2	5.2	5.1	5.0	4.8	4.5	4.2	3.8	3.5
7	4.7	4.9	5.1	5.2	5.3	5.3	5.3	5.3	5.2	5.1	4.9	4.6	4.3	3.9	3.6
8	4.8	5.0	5.2	5.3	5.4	5.4	5.4	5.4	5.3	5.2	5.0	4.7	4.4	4.0	3.7
9	5.4	5.6	5.8	5.9	6.0	6.0	6.0	6.0	5.9	5.8	5.6	5.3	5.0	4.6	4.3
10	5.7	5.9	6.1	6.2	6.3	6.3	6.3	6.3	6.2	6.1	5.9	5.6	5.3	4.9	4.6
11	5.8	6.0	6.2	6.3	6.4	6.4	6.4	6.4	6.3	6.2	6.0	5.7	5.4	5.0	4.7

TABLE VI.—SAN FRANCISCO.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	4.8	4.7	4.5	4.3	4.3	4.2	4.3	4.3	4.4	4.5	4.7	4.8	5.0	5.3	5.5
1	4.7	4.6	4.4	4.2	4.2	4.1	4.2	4.2	4.3	4.4	4.6	4.7	4.9	5.2	5.4
2	4.6	4.5	4.3	4.1	4.1	4.0	4.1	4.1	4.2	4.3	4.5	4.6	4.8	5.1	5.3
3	4.5	4.4	4.2	4.0	4.0	3.9	4.0	4.0	4.1	4.2	4.4	4.5	4.7	5.0	5.2
4	4.3	4.2	4.0	3.8	3.8	3.7	3.8	3.8	3.9	4.0	4.2	4.3	4.5	4.8	5.0
5	4.1	4.0	3.8	3.6	3.6	3.5	3.6	3.6	3.7	3.8	4.0	4.1	4.3	4.6	4.8
6	4.1	4.0	3.8	3.6	3.6	3.5	3.6	3.6	3.7	3.8	4.0	4.1	4.3	4.6	4.8
7	4.2	4.1	3.9	3.7	3.7	3.6	3.7	3.7	3.8	3.9	4.1	4.2	4.4	4.7	4.9
8	4.4	4.3	4.1	3.9	3.9	3.8	3.9	3.9	4.0	4.1	4.3	4.4	4.6	4.9	5.1
9	4.5	4.4	4.2	4.0	4.0	3.9	4.0	4.0	4.1	4.2	4.4	4.5	4.7	5.0	5.2
10	4.7	4.6	4.4	4.2	4.2	4.1	4.2	4.2	4.3	4.4	4.6	4.7	4.9	5.2	5.4
11	4.8	4.7	4.5	4.3	4.3	4.2	4.3	4.3	4.4	4.5	4.7	4.8	5.0	5.3	5.5

TABLE VII.—SAN FRANCISCO.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	5.4	5.5	5.7	5.9	5.9	6.0	5.9	5.9	5.8	5.7	5.5	5.4	5.2	4.9	4.7
1	5.3	5.4	5.6	5.8	5.8	5.9	5.8	5.8	5.7	5.6	5.4	5.3	5.1	4.8	4.6
2	5.2	5.3	5.5	5.7	5.7	5.8	5.7	5.7	5.6	5.5	5.3	5.2	5.0	4.7	4.5
3	5.1	5.2	5.4	5.6	5.6	5.7	5.6	5.6	5.5	5.4	5.2	5.1	4.9	4.6	4.4
4	4.9	5.0	5.2	5.4	5.4	5.5	5.4	5.4	5.3	5.2	5.0	4.9	4.7	4.4	4.2
5	4.7	4.8	5.0	5.2	5.2	5.3	5.2	5.2	5.1	5.0	4.8	4.7	4.5	4.2	4.0
6	4.7	4.8	5.0	5.2	5.2	5.3	5.2	5.2	5.1	5.0	4.8	4.7	4.5	4.2	4.0
7	4.8	4.9	5.1	5.3	5.3	5.4	5.3	5.3	5.2	5.1	4.9	4.8	4.6	4.3	4.1
8	5.0	5.1	5.3	5.5	5.5	5.6	5.5	5.5	5.4	5.3	5.1	5.0	4.8	4.5	4.3
9	5.1	5.2	5.4	5.6	5.6	5.7	5.6	5.6	5.5	5.4	5.2	5.1	4.9	4.6	4.4
10	5.3	5.4	5.6	5.8	5.8	5.9	5.8	5.8	5.7	5.6	5.4	5.3	5.1	4.8	4.6
11	5.4	5.5	5.7	5.9	5.9	6.0	5.9	5.9	5.8	5.7	5.5	5.4	5.2	4.9	4.7

TABLE VI.—ASTORIA.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	8.0	8.3	8.4	8.5	8.6	8.6	8.6	8.6	8.5	8.4	8.3	8.1	7.7	7.4	7.0
1	8.0	8.2	8.4	8.5	8.6	8.6	8.6	8.6	8.5	8.4	8.2	8.1	7.7	7.4	7.0
2	7.8	8.1	8.2	8.4	8.4	8.4	8.4	8.4	8.3	8.2	8.1	7.9	7.5	7.2	6.8
3	7.5	7.8	7.9	8.1	8.1	8.1	8.1	8.1	8.0	7.9	7.8	7.6	7.2	6.9	6.5
4	7.1	7.4	7.5	7.7	7.7	7.7	7.7	7.7	7.6	7.5	7.4	7.2	6.8	6.5	6.1
5	6.7	7.0	7.2	7.3	7.3	7.3	7.3	7.3	7.2	7.1	7.0	6.8	6.5	6.1	5.7
6	6.5	6.8	7.0	7.1	7.1	7.1	7.1	7.1	7.0	6.9	6.8	6.6	6.3	5.9	5.5
7	6.7	7.0	7.1	7.2	7.3	7.3	7.3	7.3	7.2	7.1	7.0	6.8	6.4	6.1	5.7
8	7.0	7.3	7.5	7.6	7.6	7.9	7.6	7.6	7.5	7.4	7.3	7.1	6.8	6.4	6.0
9	7.5	7.8	8.0	8.1	8.1	8.1	8.1	8.1	8.0	7.9	7.8	7.8	7.3	6.9	6.5
10	7.9	8.2	8.4	8.5	8.5	8.5	8.5	8.5	8.4	8.3	8.2	8.0	7.7	7.3	6.9
11	8.1	8.4	8.6	8.7	8.7	8.7	8.7	8.7	8.6	8.5	8.4	8.2	7.9	7.5	7.1

TABLE VII.—ASTORIA.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	4	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	7.4	7.1	6.8	6.8	6.6	6.8	6.8	6.8	6.9	7.0	7.1	7.3	7.6	8.0	8.4
1	7.4	7.1	6.9	6.8	6.8	6.8	6.8	6.8	6.9	7.0	7.1	7.3	7.6	8.0	8.4
2	7.2	6.9	6.8	6.6	6.6	6.6	6.6	6.6	6.7	6.8	6.9	7.1	7.5	7.8	8.2
3	6.9	6.6	6.5	6.3	6.3	6.3	6.3	6.3	6.4	6.5	6.6	6.8	7.2	7.5	7.9
4	6.5	6.2	6.1	5.9	5.9	5.9	5.9	5.9	6.0	6.1	6.2	6.4	6.7	7.1	7.5
5	6.1	5.9	5.7	5.6	5.5	5.5	5.6	5.6	5.7	5.7	5.9	6.0	6.4	6.7	7.1
6	5.9	5.7	5.5	5.4	5.3	5.3	5.3	5.4	5.5	5.5	5.7	5.9	6.2	6.5	6.9
7	6.1	5.8	5.6	5.5	5.5	5.5	5.5	5.5	5.6	5.7	5.8	6.0	6.3	6.7	7.1
8	6.4	6.2	6.0	5.9	5.8	5.8	5.8	5.8	5.9	6.0	6.2	6.3	6.7	7.0	7.4
9	6.9	6.7	6.5	6.4	6.3	6.3	6.3	6.4	6.4	6.5	6.7	6.8	7.2	7.5	7.9
10	7.3	7.1	6.9	6.8	6.7	6.7	6.7	6.8	6.9	6.9	7.0	7.2	7.6	7.9	8.3
11	7.5	7.2	7.1	7.0	6.9	6.9	6.9	6.9	7.0	7.1	7.2	7.4	7.8	8.1	8.5

TABLE VI.—PORT TOWNSHEND.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
0	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9
1	6.7	6.4	6.0	6.2	6.5	7.0	7.3	7.5	7.6	7.6	7.6	7.6	7.7	7.8	8.0
2	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9
3	6.3	6.0	5.6	5.8	6.1	6.6	6.9	7.1	7.2	7.2	7.2	7.2	7.3	7.4	7.6
4	6.0	5.7	5.3	5.5	5.8	6.3	6.6	6.8	6.9	6.9	6.9	6.9	7.0	7.1	7.3
5	5.9	5.6	5.2	5.4	5.7	6.2	6.5	6.7	6.8	6.8	6.8	6.8	6.9	7.0	7.2
6	6.1	5.8	5.4	5.6	5.9	6.4	6.7	6.9	7.0	7.0	7.0	7.0	7.1	7.2	7.4
7	6.4	6.1	5.7	5.9	6.2	6.7	7.0	7.2	7.3	7.3	7.3	7.3	7.4	7.5	7.7
8	6.5	6.2	5.8	6.0	6.3	6.8	7.1	7.3	7.4	7.4	7.4	7.4	7.5	7.6	7.8
9	6.5	6.2	5.8	6.0	6.3	6.8	7.1	7.3	7.4	7.4	7.4	7.4	7.5	7.6	7.8
10	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9
11	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9

TABLE VII.—PORT TOWNSHEND.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
0	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
1	7.7	8.0	8.4	8.2	7.9	7.4	7.1	6.9	6.8	6.8	6.8	6.8	6.7	6.6	6.4
2	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
3	7.3	7.6	8.0	7.8	7.5	7.0	6.7	6.5	6.4	6.4	6.4	6.4	6.3	6.2	6.0
4	7.0	7.3	7.7	7.5	7.2	6.7	6.4	6.2	6.1	6.1	6.1	6.1	6.0	5.9	5.7
5	6.9	7.2	7.6	7.4	7.1	6.6	6.3	6.1	6.0	6.0	6.0	6.0	5.9	5.8	5.6
6	7.1	7.4	7.8	7.6	7.3	6.8	6.5	6.3	6.2	6.2	6.2	6.2	6.1	6.0	5.8
7	7.4	7.7	8.1	7.9	7.6	7.1	6.8	6.6	6.5	6.5	6.5	6.5	6.4	6.3	6.1
8	7.5	7.8	8.2	8.0	7.7	7.2	6.9	6.7	6.6	6.6	6.6	6.6	6.5	6.4	6.2
9	7.5	7.8	8.2	8.0	7.7	7.2	6.9	6.7	6.6	6.6	6.6	6.6	6.5	6.4	6.2
10	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
11	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3

NOTE.—To use these tables with a chart on which the soundings ar referred to mean low water, subtract 1.2 foot from the numbers in the tables from San Diego for Astoria, 1.7 foot for Neeah harbor, 2.3 for Port Townshend, and 2.7 for Semiahmoo and Steilacoom.

Example VI.—In Example V, to obtain the height of tide on February 7, the declination being south, we enter Table VI for San Francisco, with 0*h.* of transit, and two days after greatest declination, and find that the tide will be 4.5 feet above the mean of the lowest low waters, or that 4.5 feet are to be added to the soundings of a chart reduced to the mean of the lowest low waters of each day. If the soundings of the chart are given for mean low water, then 1.2 foot ought to be subtracted from the Tables VI and VII. Thus, in this example, it would be 3.3 feet.

The approximate time of the successive low and high waters of the day will be found by adding the numbers in Table VIII to the time of the first high water already determined. The table gives the numbers for the different days from the greatest declination.

Tables containing numbers to be added to the time of high water found from Tables IV and V, to obtain the successive high and low waters.

TABLE VIII.—KEY WEST.

Days from moon's greatest declination.	South declination. Low water. (Large.)	South declination. High water. (Small.)	South declination. Low water. (Small.)	North declination. Low water. (Small.)	North declination. High water. (Large.)	North declination. Low water. (Large.)	Days from moon's greatest declination.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	
Before. 7	5 22	12 10	17 38	5 36	12 33	17 45	7 Before.
6	5 42	12 31	17 40	5 18	12 18	17 50	6
5	6 05	12 55	17 41	4 58	12 03	17 56	5
4	6 24	13 17	17 44	4 35	11 44	17 59	4
3	6 39	13 28	17 39	4 11	11 18	17 58	3
2	7 02	13 52	17 40	3 50	10 58	17 58	2
1	7 13	14 01	17 39	3 39	10 46	17 56	1
0	7 18	14 10	17 42	3 37	10 45	17 59	0
After. 1	7 12	14 10	17 48	3 44	10 46	17 52	1 After.
2	6 57	13 58	17 51	3 57	10 54	17 47	2
3	6 39	13 41	17 53	4 21	11 19	17 48	3
4	6 15	13 18	17 53	4 43	11 38	17 45	4
5	5 57	12 59	17 53	5 09	12 03	17 44	5
6	5 32	12 36	17 54	5 26	12 22	17 46	6
7	5 13	12 16	17 53	5 40	12 36	17 46	7

TABLE VIII.—SAN DIEGO.

Days from moon's greatest declination.	South declination. Low water. (Small.)	South declination. High water. (Large.)	South declination. Low water. (Large.)	North declination. Low water. (Large.)	North declination. High water. (Small.)	North declination. Low water. (Small.)	Days from moon's greatest declination.
	h. m.	*h. m.*	*h m.*	*h. m.*	*h. m.*	*h. m.*	
Before. 7	5 44	12 28	18 44	6 16	12 16	18 00	7 Before.
6	5 18	11 58	18 40	6 42	12 46	18 04	6
5	5 00	11 34	18 34	7 00	13 10	18 10	5
4	4 47	11 12	18 25	7 13	13 32	18 19	4
3	4 34	10 54	18 20	7 26	13 50	18 24	3
2	4 24	10 38	18 14	7 36	14 05	18 30	2
1	4 17	10 28	18 11	7 43	14 16	18 33	1
0	4 12	10 20	18 08	7 48	14 24	18 56	0
After. 1	4 14	10 20	18 06	7 46	14 24	18 38	1 After.
2	4 24	10 28	18 04	7 36	14 16	18 40	2
3	4 38	10 40	18 02	7 22	14 04	18 42	3
4	5 01	10 58	17 57	6 59	13 46	18 47	4
5	5 25	11 18	17 53	6 35	13 26	18 51	5
6	5 49	11 44	17 55	6 11	13 00	18 49	6
7	6 18	12 18	18 00	5 42	12 26	18 44	7

TABLE VIII.—SAN FRANCISCO.

	Days from moon's greatest declination.	SOUTH DECLINATION. Low water. (Small.)	SOUTH DECLINATION. High water. (Large.)	SOUTH DECLINATION. Low water. (Large.)	NORTH DECLINATION. Low water. (Large.)	NORTH DECLINATION. High water. (Small.)	NORTH DECLINATION. Low water. (Small.)	Days from moon's greatest declination.	
		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.		
Before.	7	5 58	13 14	18 58	5 41	11 46	17 41	7	Before.
	6	5 36	12 42	18 48	6 06	12 18	17 54	6	
	5	5 14	12 10	18 38	6 28	12 50	18 04	5	
	4	4 55	11 34	18 21	6 47	13 26	18 21	4	
	3	4 37	11 00	18 05	7 05	14 00	18 37	3	
	2	4 24	10 34	17 52	7 18	14 26	18 50	2	
	1	4 12	10 06	17 36	7 30	14 54	19 06	1	
	0	4 13	10 00	17 30	7 30	15 00	19 12	0	
After.	1	4 17	10 02	17 27	7 25	14 58	19 15	1	After.
	2	4 27	10 12	17 27	7 15	14 48	19 15	2	
	3	4 41	10 26	17 27	7 01	14 34	19 15	3	
	4	4 56	10 46	17 32	6 46	14 14	19 10	4	
	5	5 14	11 10	17 36	6 28	13 50	19 04	5	
	6	5 36	11 36	17 42	6 06	13 24	19 00	6	
	7	5 57	12 04	17 49	5 45	12 56	18 53	7	

TABLE VIII.—ASTORIA.

	Days from moon's greatest declination.	SOUTH DECLINATION. Low water. (Small.)	SOUTH DECLINATION. High water. (Large.)	SOUTH DECLINATION. Low water. (Large.)	NORTH DECLINATION. Low water. (Large.)	NORTH DECLINATION. High water. (Small.)	NORTH DECLINATION. Low water. (Small.)	Days from moon's greatest declination.	
		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.		
Before.	7	6 38	12 59	19 17	6 18	12 03	18 41	7	Before.
	6	6 14	12 33	19 15	6 42	12 29	18 43	6	
	5	5 55	12 13	19 14	7 01	12 49	18 44	5	
	4	5 34	11 47	19 09	7 22	13 15	18 49	4	
	3	5 20	11 27	19 03	7 36	13 35	18 55	3	
	2	5 09	11 07	18 54	7 47	13 55	19 04	2	
	1	5 05	11 01	18 52	7 51	14 01	19 06	1	
	0	5 03	10 53	18 46	7 53	14 09	19 12	0	
After.	1	5 05	10 51	18 42	7 51	14 11	19 16	1	After.
	2	5 11	10 55	18 40	7 45	14 07	19 18	2	
	3	5 18	11 03	18 41	7 38	13 59	19 17	3	
	4	5 32	11 15	18 39	7 24	13 47	19 19	4	
	5	5 50	11 35	18 41	7 06	13 27	19 17	5	
	6	6 11	11 55	18 40	6 45	13 07	19 18	6	
	7	6 35	12 19	18 40	6 21	12 43	19 18	7	

TABLE VIII.—PORT TOWNSHEND.

Days from moon's greatest declination.		South declination. Low water.	South declination. High water.	South declination. Low water.	North declination. Low water.	North declination. High water.	North declination. Low water.	Days from moon's greatest declination.	
		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.		
Before.	7	6 05	12 26	18 05	5 39	12 26	18 31	7	Before.
	6	6 38	13 14	18 20	5 06	11 38	18 16	6	
	5	7 18	14 14	18 40	4 26	10 38	17 56	5	
	4	8 13	15 52	19 23	3 31	9 00	17 13	4	
	3	8 36	16 52	20 00	3 08	8 00	16 36	3	
	2	8 43	17 30	20 31	3 01	7 22	16 05	2	
	1	8 12	17 04	20 36	3 32	7 48	16 00	1	
	0	7 40	16 28	20 32	4 04	8 24	16 04	0	
After.	1	7 18	15 52	20 18	4 26	9 00	16 18	1	After.
	2	6 59	15 14	19 59	4 45	9 38	16 37	2	
	3	6 38	14 32	19 38	5 06	10 20	16 58	3	
	4	6 24	14 02	19 22	5 20	10 50	17 14	4	
	5	6 10	13 26	19 00	5 34	11 26	17 36	5	
	6	5 59	12 50	18 35	5 45	12 02	18 01	6	
	7	5 42	12 26	18 28	6 02	12 26	18 08	7	

The days from the greatest declination are written in the first and last columns of the table. :cond, third, and fourth columns refer to south declination, and fifth, sixth, and seventh to north, an :verse for Key West. The second column gives the number which is to be added, according to the de on, to the time of high water, obtained by means of Tables IV and V, to give the next low water, wl ıe small low water, *b*, of diagram I. The third contains the numbers to be added to the same to gi :cond or large high water, *c*, of diagram I. The fourth, the numbers to be added to the same to gi :cond or large low water, *d*, of diagram I. The succeeding columns give the numbers to be used ıme way for north declination to obtain the low water, *b*, (large,) of diagram II; the high water, *c*, (s ıd the low water, *d*, (small,) of the same diagram. The rise and fall of the same successive tides m ɔtained by inspection from Table IX, in which the first column at the side contains the time of transi .e successive columns the numbers corresponding to that time and to the number of days from gr :clination. The arrangement of this table is like that already given.

The numbers for the small ebb tide, *a b*, of diagram I, or *c d*, of diagram II, are first given; then r small low and large high waters, *b c*, of diagram I, and *d c*, of diagram II; next, the large ebb tid ' diagram I, or *a b*, of diagram II; and lastly, from the large low water to the small high water, *c* agram I, or *b c*, of diagram II.

TABLE IX.—KEY WEST.

Time of moon's transit.	SMALL EBB TIDE. Days from moon's greatest declination. Before—								After—							SMALL LOW TO LARGE HIGH WATER. Days from moon's greatest declination. Before—								After—							Time of moon's transit.
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	0
1	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	1
2	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	2
3	1.5	1.3	1.0	0.9	0.7	0.6	0.6	0.6	0.6	0.7	0.8	1.0	1.1	1.4	1.7	1.3	1.3	1.4	1.5	1.5	1.6	1.6	1.6	1.6	1.5	1.6	1.6	1.5	1.4	1.3	3
4	1.3	1.1	0.8	0.7	0.5	0.4	0.4	0.4	0.4	0.5	0.6	0.8	0.9	1.2	1.5	1.1	1.1	1.2	1.3	1.3	1.4	1.4	1.4	1.4	1.3	1.4	1.4	1.3	1.2	1.1	4
5	1.1	0.9	0.6	0.5	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.6	0.7	1.0	1.3	0.9	0.9	1.0	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.2	1.2	1.1	1.0	1.9	5
6	1.0	0.8	0.5	0.4	0.2	0.1	0.1	0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.2	0.8	0.8	0.9	1.0	1.0	1.1	1.1	1.1	1.1	1.0	1.1	1.1	1.0	0.9	0.8	6
7	1.0	0.8	0.5	0.4	0.2	0.1	0.1	0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.2	0.8	0.8	0.9	1.0	1.0	1.1	1.1	1.1	1.1	1.0	1.1	1.1	1.0	0.9	0.8	7
8	1.1	0.9	0.6	0.5	0.3	0.2	0.2	0.2	0.2	0.3	0.4	0.6	0.7	1.0	1.3	0.9	0.9	1.0	1.1	1.1	1.2	1.2	1.2	1.2	1.1	1.2	1.2	1.1	1.0	0.9	8
9	1.3	1.1	0.8	0.7	0.5	0.4	0.4	0.4	0.4	0.5	0.6	0.8	0.9	1.2	1.5	1.1	1.1	1.2	1.3	1.3	1.4	1.4	1.4	1.4	1.3	1.4	1.4	1.3	1.2	1.1	9
10	1.5	1.3	1.0	0.9	0.7	0.6	0.6	0.6	0.6	0.7	0.8	1.0	1.1	1.4	1.7	1.3	1.3	1.4	1.5	1.5	1.6	1.6	1.6	1.6	1.5	1.6	1.6	1.5	1.4	1.3	10
11	1.6	1.4	1.1	1.0	0.8	0.7	0.7	0.7	0.7	0.8	0.9	1.1	1.2	1.5	1.8	1.4	1.4	1.5	1.6	1.6	1.7	1.7	1.7	1.7	1.6	1.7	1.7	1.6	1.5	1.4	11

TABLE IX.—KEY WEST—Continued.

Time of moon's transit.	LARGE EBB TIDE. Days from moon's greatest declination. Before—								After—							LARGE LOW TO SMALL HIGH WATER. Days from moon's greatest declination. Before—								After—							Time of moon's transit.
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	0
1	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	1
2	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	2
3	1.3	1.5	1.8	1.9	2.1	2.2	2.2	2.2	2.2	2.1	2.0	1.8	1.7	1.4	1.1	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.3	1.2	1.2	1.3	1.4	1.5	3
4	1.1	1.3	1.6	1.7	1.9	2.0	2.0	2.0	2.0	1.9	1.8	1.6	1.5	1.2	0.9	1.3	1.2	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.1	1.2	1.3	4
5	0.9	1.1	1.4	1.5	1.7	1.8	1.8	1.8	1.8	1.7	1.6	1.4	1.3	1.0	0.7	1.1	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.8	0.9	1.0	1.1	5
6	0.8	1.0	1.3	1.4	1.6	1.7	1.7	1.7	1.7	1.6	1.5	1.3	1.2	0.9	0.6	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.8	0.7	0.7	0.8	0.9	1.0	6
7	0.8	1.0	1.3	1.4	1.6	1.7	1.7	1.7	1.7	1.6	1.5	1.3	1.2	0.9	0.6	1.0	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.8	0.7	0.7	0.8	0.9	1.0	7
8	0.9	1.1	1.4	1.5	1.7	1.8	1.8	1.8	1.8	1.7	1.6	1.4	1.3	1.0	0.7	1.1	1.0	1.0	0.9	0.9	0.8	0.8	0.8	0.8	0.9	0.8	0.8	0.9	1.0	1.1	8
9	1.1	1.3	1.6	1.7	1.9	2.0	2.0	2.0	2.0	1.9	1.8	1.6	1.5	1.2	0.9	1.3	1.2	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.1	1.0	1.0	1.1	1.2	1.3	9
10	1.3	1.5	1.8	1.9	2.1	2.2	2.2	2.2	2.2	2.1	2.0	1.8	1.7	1.4	1.1	1.5	1.4	1.4	1.3	1.3	1.2	1.2	1.2	1.2	1.3	1.2	1.2	1.3	1.4	1.5	10
11	1.4	1.6	1.9	2.0	2.2	2.3	2.3	2.3	2.3	2.2	2.1	1.9	1.8	1.5	1.2	1.6	1.5	1.5	1.4	1.4	1.3	1.3	1.3	1.3	1.4	1.3	1.3	1.4	1.5	1.6	11

TABLE IX.—SAN DIEGO.

Time of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER.															FROM SMALL LOW WATER TO LARGE HIGH WATER.															Time of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.															
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.
0	4.0	3.4	3.0	2.6	2.3	2.1	2.0	2.0	2.1	2.3	2.7	3.2	3.8	4.6	5.2	5.1	4.9	4.7	4.5	4.4	4.3	4.2	4.2	4.1	4.1	4.0	4.0	3.9	3.9	4.0	0
1	3.8	3.2	2.8	2.4	2.1	1.9	1.8	1.8	1.9	2.1	2.5	3.0	3.6	4.4	5.0	4.9	4.7	4.5	4.3	4.2	4.1	4.0	4.0	3.9	3.9	3.8	3.8	3.7	3.7	3.8	1
2	3.5	2.9	2.5	2.1	1.8	1.6	1.5	1.5	1.6	1.8	2.2	2.7	3.3	4.1	4.7	4.6	4.4	4.2	4.0	3.9	3.8	3.7	3.7	3.6	3.6	3.5	3.5	3.4	3.4	3.5	2
3	3.0	2.4	2.0	1.6	1.3	1.1	1.0	1.0	1.1	1.3	1.7	2.2	2.8	3.6	4.2	4.1	3.9	3.7	3.5	3.4	3.3	3.2	3.2	3.1	3.1	3.0	3.0	2.9	2.9	3.0	3
4	2.2	1.6	1.2	0.8	0.5	0.3	0.2	0.2	0.3	0.5	0.9	1.4	2.0	2.8	3.4	3.3	3.1	2.9	2.7	2.6	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.1	2.1	2.2	4
5	1.7	1.1	0.7	0.3	0.0	–.2	–.3	–.3	–.2	0.0	0.4	0.9	[illegible]	2.3	2.9	2.8	2.6	2.4	2.2	2.1	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.6	1.6	1.7	5
6	1.8	1.2	0.8	0.4	0.1	–.1	–.2	–.2	–.1	0.1	0.5	1.0	1.6	2.4	3.0	2.9	2.7	2.5	2.3	2.2	2.1	2.0	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.8	6
7	2.3	1.7	1.3	0.9	0.6	0.4	0.3	0.3	0.4	0.6	1.0	1.5	2.1	2.9	3.5	3.4	3.2	3.0	2.8	2.7	2.6	2.5	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.3	7
8	2.9	2.3	1.9	1.5	1.2	1.0	0.9	0.9	1.0	1.2	1.6	2.1	2.7	3.5	4.1	4.0	3.8	3.6	3.4	3.3	3.2	3.1	3.1	3.0	3.0	2.9	2.9	2.8	2.8	2.9	8
9	3.7	3.1	2.7	2.3	2.0	1.8	1.7	1.7	1.8	2.0	2.4	2.9	3.5	4.3	4.9	4.8	4.6	4.4	4.2	4.1	4.0	3.9	3.9	3.8	3.8	3.7	3.7	3.6	3.6	3.7	9
10	4.2	3.6	3.2	2.8	2.5	2.3	2.2	2.2	2.3	2.5	2.9	3.4	4.0	4.8	5.4	5.3	5.1	4.9	4.7	4.6	4.5	4.4	4.4	4.3	4.3	4.2	4.2	4.1	4.1	4.2	10
11	4.3	3.7	3.3	2.9	2.6	2.4	2.3	2.3	2.4	2.6	3.0	3.5	4.1	4.9	5.5	5.4	5.5	5.0	4.8	4.7	4.6	4.5	4.5	4.4	4.4	4.3	4.3	4.2	4.2	4.3	11

From *a* to *b* .... Diagram I.
From *c* to *d* .... Diagram II.

From *b* to *c* .... Diagram I.
From *d* to *e* .... Diagram II.

TABLE IX.—SAN DIEGO—Continued.

Time of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER.															FROM LARGE LOW WATER TO SMALL HIGH WATER.															Time of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.															
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.
0	5.2	5.8	6.2	6.6	6.9	7.1	7.1	7.2	7.2	6.9	6.5	6.0	5.4	4.6	4.0	4.1	4.3	4.5	4.7	4.8	4.9	5.0	5.0	5.1	5.1	5.2	5.2	5.3	5.3	5.2	0
1	5.0	5.6	6.0	6.4	6.7	6.9	7.0	7.0	6.9	6.7	6.3	5.8	5.2	4.4	3.8	3.9	4.1	4.3	4.5	4.6	4.7	4.8	4.8	4.9	4.9	5.0	5.0	5.1	5.1	5.0	1
2	4.7	5.3	5.7	6.1	6.4	6.6	6.7	6.7	6.6	6.4	6.0	5.5	4.9	4.1	3.5	3.6	3.8	4.0	4.2	4.3	4.4	4.5	4.5	4.6	4.6	4.7	4.7	4.8	4.8	4.7	2
3	4.2	4.8	5.2	5.6	5.9	6.1	6.2	6.2	6.1	5.9	5.5	5.0	4.4	3.6	3.0	3.1	3.3	3.5	3.7	3.8	3.9	4.0	4.0	4.1	4.1	4.2	4.2	4.3	4.3	4.2	3
4	3.4	4.0	4.4	4.8	5.1	5.3	5.4	5.4	5.3	5.1	4.7	4.2	3.6	2.8	2.2	2.3	2.5	2.7	2.9	3.0	3.1	3.2	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.4	4
5	2.9	3.5	3.9	4.3	4.6	4.8	4.9	4.9	4.8	4.6	4.2	3.7	3.1	2.3	1.7	1.8	2.0	2.2	2.4	2.5	2.6	2.7	2.7	2.8	2.8	2.9	2.9	3.0	3.0	2.9	5
6	3.0	3.6	4.0	4.4	4.7	4.9	5.0	5.0	4.9	4.7	4.3	3.8	3.2	2.4	1.8	1.9	2.1	2.3	2.5	2.6	2.7	2.8	2.8	2.9	2.9	3.0	3.0	3.1	3.1	3.0	6
7	3.5	4.1	4.5	4.9	5.2	5.4	5.5	5.5	5.4	5.2	4.8	4.3	3.7	2.9	2.3	2.4	2.6	2.8	3.0	3.1	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.6	3.6	3.5	7
8	4.1	4.7	5.1	5.5	5.8	6.0	6.1	6.1	6.0	5.8	5.4	4.9	4.3	3.5	2.9	3.0	3.2	3.4	3.6	3.7	3.8	3.9	3.9	4.0	4.0	4.1	4.1	4.2	4.2	4.1	8
9	4.9	5.5	5.9	6.3	6.6	6.8	6.9	6.9	6.8	6.6	6.2	5.7	5.1	4.3	3.7	3.8	4.0	4.2	4.4	4.5	4.6	4.7	4.7	4.8	4.8	4.9	4.9	5.0	5.0	4.9	9
10	5.4	6.0	6.4	6.8	7.1	7.3	7.4	7.4	7.3	7.1	6.7	6.2	5.6	4.8	4.2	4.3	4.5	4.7	4.9	5.0	5.1	5.2	5.2	5.3	5.3	5.4	5.4	5.5	5.5	5.4	10
11	5.5	6.1	6.5	6.9	7.2	7.4	7.5	7.5	7.4	7.2	6.8	6.3	5.7	4.9	4.3	4.4	4.6	4.8	5.0	5.1	5.2	5.3	5.3	5.4	5.4	5.5	5.5	5.6	5.6	5.5	11

From *c* to *d* .... Diagram I.
From *a* to *b* .... Diagram II.

From *d* to *e* .... Diagram I.
From *b* to *e* .... Diagram II.

TABLE IX.—SAN FRANCISCO.

Hours of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER.															FROM SMALL LOW WATER TO LARGE HIGH WATER.															Hours of moon's transit.
	Days from moon's greatest declination															Days from moon's greatest declination.															
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H	Ft	Ft.	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	[illegible]	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft	Ft.	H.
0	4.7	4.0	3.4	2.9	2.4	2.0	1.8	1.7	1.7	1.9	2.2	2.6	3.1	3.7	4.4	5.2	4.9	4.6	4.5	4.0	3.7	3.4	3.2	3.1	3.0	3.1	3.1	3.3	3.4	3.5	0
1	4.5	3.8	3.2	2.7	2.2	1.8	1.6	1.5	1.5	1.7	2.0	2.4	2.9	3.5	4.2	5.0	4.7	4.4	4.3	3.8	3.5	3.2	3.0	2.9	2.8	2.9	2.9	3.1	3.2	3.3	1
2	4.3	3.6	3.0	2.5	2.0	1.6	1.4	1.3	1.3	1.5	1.8	2.2	2.7	3.3	4.0	4.8	4.5	4.2	4.1	3.6	3.3	3.0	2.8	2.7	2.6	2.7	2.7	2.9	3.0	3.1	2
3	4.0	3.3	2.7	2.2	1.7	1.3	1.1	1.0	1.0	1.2	1.5	1.9	2.4	3.0	3.7	4.5	4.2	3.9	3.8	3.3	3.0	2.7	2.5	2.4	2.3	2.4	2.4	2.6	2.7	2.8	3
4	3.6	2.9	2.3	1.8	1.3	0.9	0.7	0.6	0.6	0.8	1.1	1.5	2.0	2.6	3.3	4.1	3.8	3.5	3.4	2.9	2.6	2.3	2.1	2.0	1.9	2.0	2.0	2.2	2.3	2.4	4
5	3.2	2.5	1.9	1.4	0.9	0.5	0.3	0.2	0.2	0.4	0.7	1.1	1.6	2.2	2.9	3.7	3.4	3.1	3.0	2.5	2.2	1.9	1.7	1.6	1.5	1.6	1.6	1.8	1.9	2.0	5
6	3.2	2.5	1.9	1.4	0.9	0.5	0.3	0.2	0.2	0.4	0.7	1.1	1.6	2.2	2.9	3.7	3.4	3.1	3.0	2.5	2.2	1.9	1.7	1.6	1.5	1.6	1.6	1.8	1.9	2.0	6
7	3.4	2.7	2.1	1.6	1.1	0.7	0.5	0.4	0.4	0.6	0.9	1.3	1.8	2.4	3.1	3.9	3.6	3.3	3.2	2.7	2.4	2.1	1.9	1.8	1.7	1.8	1.8	2.0	2.1	2.2	7
8	3.8	3.1	2.5	2.0	1.5	1.1	0.9	0.8	0.8	1.0	1.3	1.7	2.2	2.8	3.5	4.3	4.0	3.7	3.6	3.1	2.8	2.5	2.3	2.2	2.1	2.2	2.2	2.4	2.5	2.6	8
9	4.1	3.4	2.8	2.3	1.8	1.4	1.2	1.1	1.1	1.3	1.6	2.0	2.5	3.1	3.8	4.6	4.3	4.0	3.9	3.4	3.1	2.8	2.6	2.5	2.4	2.5	2.5	2.7	2.8	2.9	9
10	4.5	3.8	3.2	2.7	2.2	1.8	1.6	1.5	1.5	1.7	2.0	2.4	2.9	3.5	4.2	5.0	4.7	4.4	4.3	3.8	3.5	3.2	3.0	2.9	2.8	2.9	2.9	3.1	3.2	3.3	10
11	4.7	4.0	3.4	2.9	2.4	2.0	1.8	1.7	1.7	1.9	2.2	2.6	3.1	3.7	4.4	5.2	4.9	4.6	4.5	4.0	3.7	3.4	3.2	3.1	3.0	3.1	3.1	3.3	3.4	3.5	11

From *a* to *b*.................................... Diagram I.
From *c* to *d*.................................... Diagram II.

From *b* to *c*.................................... Diagram I.
From *d* to *e*.................................... Diagram II.

TABLE IX.—SAN FRANCISCO—Continued.

Hours of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER.															FROM LARGE LOW WATER TO SMALL HIGH WATER.															Hours of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.															
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.
0	3.9	4.6	5.2	5.7	6.2	6.6	6.8	6.9	6.9	6.7	6.4	6.0	5.5	4.9	4.2	3.4	3.7	4.0	4.1	4.6	4.9	5.2	5.4	5.5	5.6	5.6	5.5	5.3	5.2	5.2	0
1	3.7	4.4	5.0	5.5	6.0	6.4	6.6	6.7	6.7	6.5	6.2	5.8	5.3	4.7	4.0	3.2	3.5	3.8	3.9	4.4	4.7	5.0	5.2	3.3	5.4	5.3	5.3	5.1	5.0	5.0	1
2	3.5	4.2	4.8	5.3	5.8	6.2	6.4	6.5	6.5	6.3	6.0	5.6	5.1	4.5	3.8	3.0	3.3	3.6	3.7	4.2	4.5	4.8	5.0	5.1	5.2	5.1	5.1	4.9	4.8	4.8	2
3	3.2	3.9	4.5	5.0	5.5	5.9	6.1	6.2	6.2	6.0	5.7	5.3	4.8	4.2	3.5	2.7	3.0	3.3	3.4	3.9	4.2	4.5	4.7	4.8	4.9	4.8	4.8	4.6	4.5	4.5	3
4	2.8	3.5	4.1	4.6	5.1	5.5	5.7	5.8	5.8	5.6	5.3	4.9	4.4	3.8	3.1	2.3	2.6	2.9	3.0	3.5	3.8	4.1	4.3	4.4	4.5	4.4	4.4	4.2	4.1	4.1	4
5	2.4	3.1	3.7	4.2	4.7	5.1	5.3	5.4	5.4	5.2	4.9	4.5	4.0	3.4	2.7	1.9	2.2	2.5	2.6	3.1	3.4	3.7	3.9	4.0	4.1	4.0	4.0	3.8	3.7	3.7	5
6	2.4	3.1	3.7	4.2	4.7	5.1	5.3	5.4	5.4	5.2	4.9	4.5	4.0	3.4	2.7	1.9	2.2	2.5	2.6	3.1	3.4	3.7	3.9	4.0	4.1	4.0	4.0	3.8	3.7	3.7	6
7	2.6	3.3	3.9	4.4	4.9	5.3	5.5	5.6	5.6	5.4	5.1	4.7	4.2	3.6	2.9	2.1	2.4	2.7	2.8	3.3	3.6	3.9	4.1	4.2	4.3	4.2	4.2	4.0	3.9	3.9	7
8	3.0	3.7	4.3	4.8	5.3	5.7	5.9	6.0	6.0	5.8	5.5	5.1	4.6	4.0	3.3	2.5	2.8	3.1	3.2	3.7	4.0	4.3	4.5	4.6	4.7	4.6	4.6	4.4	4.3	4.3	8
9	3.3	4.0	4.6	5.1	5.6	6.0	6.2	6.3	6.3	6.1	5.8	5.4	4.9	4.3	3.6	2.8	3.1	3.4	3.5	4.0	4.3	4.6	4.8	4.9	5.0	4.9	4.9	4.7	4.6	4.6	9
10	3.7	4.4	5.0	5.5	6.0	6.4	6.6	6.7	6.7	6.5	6.2	5.8	5.3	4.7	4.0	3.2	3.5	3.8	3.9	4.4	4.7	5.0	5.2	5.3	5.4	5.3	5.3	5.1	5.0	5.0	10
11	3.9	4.6	5.2	5.7	6.2	6.6	6.8	6.9	6.9	6.7	6.4	6.0	5.5	4.9	4.2	3.4	3.7	4.0	4.1	4.6	4.9	5.2	5.4	5.5	5.6	5.5	5.5	5.3	5.2	5.2	11

From *c* to *d*.................................... Diagram I.
From *a* to *b*.................................... Diagram II.

From *d* to *e*.................................... Diagram I.
From *b* to *c*.................................... Diagram II.

TABLE IX.—ASTORIA.

Hours of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER.															FROM SMALL LOW WATER TO LARGE HIGH WATER.															Hours of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.															
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	7.4	6.7	6.0	5.4	5.0	4.6	4.5	4.5	4.6	4.7	5.1	5.5	6.2	6.9	7.8	8.0	7.8	7.5	7.2	6.8	6.4	6.3	6.2	6.1	6.2	6.2	6.3	6.3	6.3	6.4	0
1	7.5	6.8	6.1	5.5	5.1	4.7	4.6	4.6	4.7	4.8	5.2	5.6	6.3	7.0	7.9	8.1	7.9	7.6	7.3	6.9	6.5	6.4	6.3	6.2	6.3	6.3	6.4	6.4	6.4	6.5	1
2	7.2	6.5	5.8	5.2	4.8	4.4	4.3	4.3	4.4	4.5	4.9	5.3	6.0	6.7	7.6	7.8	7.6	7.3	7.0	6.6	6.2	6.1	6.0	5.9	6.0	6.0	6.1	6.1	6.1	6.2	2
3	6.6	5.9	5.2	4.6	4.2	3.8	3.7	3.7	3.8	3.9	4.3	4.7	5.4	6.1	7.0	7.2	7.0	6.7	6.4	6.0	5.6	5.5	5.4	5.3	5.4	5.4	5.5	5.5	5.5	5.6	3
4	5.9	5.2	4.5	3.9	3.5	3.1	3.0	3.0	3.1	3.2	3.6	4.0	4.7	5.4	6.3	6.5	6.3	6.0	5.7	5.3	4.9	4.8	4.7	4.6	4.7	4.7	4.8	4.8	4.8	4.9	4
5	5.2	4.5	3.8	3.2	2.8	2.4	2.3	2.3	2.4	2.5	2.9	3.3	4.0	4.7	5.6	5.8	5.6	5.3	5.0	4.6	4.2	4.1	4.0	3.9	4.0	4.0	4.1	4.1	4.1	4.2	5
6	4.8	4.1	3.4	2.8	2.4	2.0	1.9	1.9	2.0	2.1	2.5	2.9	3.6	4.3	5.2	5.4	5.2	4.9	4.6	4.2	3.8	3.7	3.6	3.5	3.6	3.6	3.7	3.7	3.7	3.8	6
7	5.0	4.3	3.6	3.0	2.6	2.2	2.1	2.1	2.2	2.3	2.7	2.1	3.8	4.5	5.4	5.6	5.4	5.1	4.8	4.4	4.0	3.9	3.8	3.7	3.8	3.8	3.9	3.9	3.9	4.0	7
8	5.5	4.8	4.1	3.5	3.1	2.7	2.6	2.6	2.7	2.8	3.2	3.6	4.3	5.0	5.9	6.1	5.9	5.6	5.3	4.9	4.5	4.4	4.3	4.2	4.3	4.3	4.4	4.4	4.4	4.5	8
9	6.3	5.6	4.9	4.3	3.9	3.5	3.4	3.4	3.5	3.6	4.0	4.4	5.1	5.8	6.7	6.9	6.7	6.4	6.1	5.7	5.3	5.2	5.1	5.0	5.1	5.1	5.2	5.2	5.2	5.3	9
10	7.0	6.3	5.6	5.0	4.6	4.2	4.1	4.1	4.2	4.3	4.7	5.1	5.8	6.5	7.4	7.6	7.4	7.1	6.8	6.4	6.0	5.9	5.8	5.7	5.8	5.8	5.9	5.9	5.9	6.0	10
11	7.3	6.6	6.9	5.3	4.9	4.5	4.4	4.4	4.5	4.6	5.0	5.4	6.1	6.8	7.7	7.9	7.7	7.4	7.1	6.7	6.3	6.2	6.1	6.0	6.1	6.1	6.2	6.2	6.2	6.3	11

From *a* to *b* .... Diagram I.
From *c* to *d* .... Diagram II.

From *b* to *c* .... Diagram I.
From *d* to *e* .... Diagram II.

TABLE IX.—ASTORIA—Continued.

Hours of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER.															FROM LARGE LOW WATER TO SMALL HIGH WATER.															Hours of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.															
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	7.0	7.7	8.4	9.0	9.4	9.8	9.9	9.9	9.8	9.7	9.3	8.9	8.2	7.5	6.6	6.4	6.6	6.9	7.2	7.6	8.0	8.1	8.2	8.3	8.2	8.2	8.1	8.1	8.1	8.0	0
1	7.1	7.8	8.5	9.1	9.5	9.9	10.0	10.0	9.9	9.8	9.4	9.0	8.3	7.6	6.7	6.5	6.7	7.0	7.3	7.7	8.1	8.2	8.3	8.4	8.3	8.3	8.2	8.2	8.2	8.1	1
2	6.8	7.5	8.2	8.8	9.2	9.6	9.7	9.7	9.6	9.5	9.1	8.7	8.0	7.3	6.4	6.2	6.4	6.7	7.0	7.4	7.8	7.9	8.0	8.1	8.0	8.0	7.9	7.9	7.9	7.8	2
3	6.2	6.9	7.6	8.2	8.6	9.0	9.1	9.1	9.0	8.9	8.5	8.1	7.4	6.7	5.8	5.6	5.8	6.1	6.4	6.8	7.2	7.3	7.4	7.5	7.4	7.4	7.3	7.3	7.3	7.2	3
4	5.5	6.2	6.9	7.5	7.9	8.3	8.4	8.4	8.3	8.2	7.8	7.4	6.7	6.0	5.1	4.9	5.1	5.4	5.7	6.1	6.5	6.6	6.7	6.8	6.7	6.7	6.6	6.6	6.6	6.5	4
5	4.8	5.5	6.2	6.8	7.2	7.6	7.7	7.7	7.6	7.5	7.1	6.7	6.0	5.3	4.4	4.2	4.4	4.7	5.0	5.4	5.8	5.9	6.0	6.1	6.0	6.0	5.9	5.9	5.9	5.8	5
6	4.4	5.1	5.8	6.4	6.8	7.2	7.3	7.3	7.2	7.1	6.7	6.3	5.6	4.9	4.0	3.8	4.0	4.3	4.6	5.0	5.4	5.5	5.6	5.7	5.6	5.6	5.5	5.5	5.5	5.4	6
7	4.6	5.3	6.0	6.6	7.0	7.4	7.5	7.5	7.4	7.3	6.9	6.5	5.8	5.1	4.2	4.0	4.2	4.5	4.8	5.2	5.6	5.7	5.8	5.9	5.8	5.8	5.7	5.7	5.7	5.6	7
8	5.1	5.8	6.5	7.1	7.5	7.9	8.0	8.0	7.9	7.8	7.4	7.0	6.3	5.6	4.7	4.5	4.7	5.0	5.3	5.7	6.1	6.2	6.3	6.4	6.3	6.3	6.2	6.2	6.2	6.1	8
9	5.9	6.6	7.3	7.9	8.3	8.7	8.8	8.8	8.7	8.6	8.2	7.8	7.1	6.4	5.5	5.3	5.5	5.8	6.1	6.5	6.9	7.0	7.1	7.2	7.1	7.1	7.0	7.0	7.0	6.9	9
10	6.6	7.3	8.0	8.6	9.0	9.4	9.5	9.5	9.4	9.3	8.9	8.5	7.8	7.1	6.2	6.0	6.2	6.5	6.8	7.2	7.6	7.7	7.8	7.9	7.8	7.8	7.7	7.7	7.7	7.6	10
11	6.9	7.6	8.3	8.9	9.3	9.7	9.8	9.8	9.7	9.6	9.2	8.8	8.1	7.4	7.5	6.3	6.5	6.8	7.1	7.5	7.9	8.0	8.1	8.2	8.1	8.1	8.0	8.0	8.0	7.9	11

From *c* to *d* .... Diagram I.
From *a* to *b* .... Diagram II.

From *d* to *e* .... Diagram I.
From *b* to *c* .... Diagram II.

TABLE IX.—PORT TOWNSHEND.

Hours of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER.															FROM SMALL LOW WATER TO LARGE HIGH WATER.															Hours of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.															
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	4.5	5.6	6.9	8.0	8.6	8.9	8.8	8.8	8.7	8.7	8.5	8.0	7.3	6.6	5.5	3.5	3.9	4.6	6.0	7.2	8.4	9.0	9.5	9.6	9.4	9.2	8.7	8.2	7.9	7.1	0
1	4.5	5.6	6.9	8.0	8.6	8.9	8.8	8.8	8.7	8.7	8.5	8.0	7.3	6.6	5.5	3.5	3.9	4.6	6.0	7.2	8.4	9.0	9.5	9.6	9.4	9.2	8.7	8.2	7.9	7.1	1
2	4.4	5.5	6.8	7.9	8.5	8.8	8.7	8.7	8.6	8.6	8.4	7.9	7.2	6.5	5.4	3.4	3.8	4.5	5.9	7.1	8.5	8.9	9.4	9.5	9.3	9.1	8.6	8.1	7.8	7.0	2
3	4.1	5.2	6.5	7.6	8.2	8.5	8.4	8.4	8.3	8.3	8.1	7.6	6.9	6.2	5.1	3.1	3.5	4.2	5.6	6.8	8.0	8.6	9.1	9.2	9.0	8.8	8.3	7.8	7.5	6.7	3
4	3.5	4.6	5.9	7.0	7.6	7.9	7.8	7.8	7.7	7.7	7.5	7.0	6.3	5.6	4.5	2.5	2.9	3.6	5.0	6.2	7.4	8.0	8.5	8.6	8.4	8.2	7.7	7.2	6.9	6.1	4
5	3.1	4.2	5.5	6.6	7.2	7.5	7.4	7.4	7.3	7.3	7.1	6.6	5.9	5.2	4.1	2.1	2.5	3.2	4.6	5.8	7.0	7.6	8.1	8.2	8.0	7.8	7.3	6.8	6.5	5.7	5
6	3.1	4.2	5.5	6.6	7.2	7.5	7.4	7.4	7.3	7.3	7.1	6.6	5.9	5.2	4.1	2.1	2.5	3.2	4.6	5.8	7.0	7.6	8.1	8.2	8.0	7.8	7.3	6.8	6.5	5.7	6
7	3.3	4.4	5.7	6.8	7.4	7.7	7.6	7.6	7.5	7.5	7.3	6.8	6.1	5.4	4.3	2.3	2.7	3.4	4.8	6.0	7.2	7.8	8.3	8.4	8.2	8.0	7.5	7.0	6.7	5.9	7
8	3.5	4.6	5.9	7.0	7.6	7.9	7.8	7.8	7.7	7.7	7.5	7.0	6.3	5.6	4.5	2.5	2.9	3.6	5.0	6.2	7.4	8.0	8.5	8.6	8.4	8.2	7.7	7.2	6.9	6.1	8
9	3.7	4.8	6.1	7.2	7.8	8.1	8.0	8.0	7.9	7.9	7.7	7.2	6.5	5.8	4.7	2.7	3.1	3.8	5.2	6.4	7.6	8.2	8.7	8.8	8.6	8.4	7.9	7.4	7.1	6.3	9
10	4.1	5.2	6.5	7.6	8.2	8.5	8.4	8.4	8.3	8.3	8.1	7.6	6.9	6.2	5.1	3.1	3.5	4.2	5.6	6.8	8.0	8.6	9.1	9.2	9.0	8.8	8.3	7.8	7.5	6.7	10
11	4.4	5.5	6.8	7.9	8.5	8.8	8.7	8.7	8.6	8.6	8.4	7.9	7.2	6.5	5.4	3.4	3.8	4.5	5.9	7.1	8.2	8.9	9.4	9.5	9.3	9.1	8.6	8.1	7.8	7.0	11

TABLE IX.—PORT TOWNSHEND—Continued.

Hours of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER.															FROM SMALL LOW WATER TO LARGE HIGH WATER.															Hours of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.															
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	6.5	5.4	4.1	3.0	2.4	2.1	2.2	2.2	2.3	2.3	2.5	3.0	3.7	4.4	5.5	7.5	7.1	6.4	5.0	3.8	2.6	2.0	1.5	1.4	1.6	1.8	2.3	2.8	3.1	3.9	0
1	6.5	5.4	4.1	3.0	2.4	2.1	2.2	2.2	2.3	2.3	2.5	3.0	3.7	4.4	5.5	7.5	7.1	6.4	5.0	3.8	2.6	2.0	1.5	1.4	1.6	1.8	2.3	2.8	3.1	3.9	1
2	6.4	5.3	4.0	2.9	2.3	2.0	2.1	2.1	2.2	2.2	2.4	2.9	3.6	4.3	5.4	7.4	7.0	6.3	4.9	3.7	2.5	1.9	1.4	1.3	1.5	1.7	2.2	2.7	3.0	3.8	2
3	6.1	5.0	3.7	2.6	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.6	3.3	4.0	5.1	7.1	6.7	6.0	4.6	3.4	2.2	1.6	1.1	1.0	1.2	1.4	1.9	2.4	2.7	3.5	3
4	5.5	4.4	3.1	2.0	1.4	1.1	1.2	1.2	1.3	1.3	1.5	2.0	2.7	3.4	4.5	6.5	6.1	5.4	4.0	2.8	1.6	1.0	0.5	0.4	0.6	0.8	1.3	1.8	2.1	2.9	4
5	5.1	4.0	2.7	1.6	1.0	0.7	0.8	0.8	0.9	0.9	1.1	1.6	2.3	3.0	4.1	6.1	5.7	5.0	3.6	2.4	1.2	0.6	0.1	0.4	0.2	0.4	0.9	1.4	1.7	2.5	5
6	5.1	4.0	2.7	1.6	1.0	0.7	0.8	0.8	0.9	0.9	1.1	1.6	2.3	3.0	4.1	6.1	5.7	5.0	3.6	2.4	1.2	0.6	0.1	0.0	0.2	0.4	0.9	1.4	1.7	2.5	6
7	5.3	4.2	2.9	1.8	1.2	0.9	1.0	1.0	1.1	1.1	1.3	1.8	2.5	3.2	4.3	6.3	5.9	5.2	3.8	2.6	1.4	0.8	0.3	0.2	0.4	0.6	1.1	1.6	1.9	2.7	7
8	5.5	4.4	3.1	2.0	1.4	1.1	1.2	1.2	1.3	1.3	1.5	2.0	2.7	3.4	4.5	6.5	6.1	5.4	4.0	2.8	1.6	1.0	0.5	0.4	0.6	0.8	1.3	1.8	2.1	2.9	8
9	5.7	4.6	3.3	2.2	1.6	1.3	1.4	1.4	1.5	1.5	1.7	2.2	2.9	3.6	4.7	6.7	6.3	5.6	4.2	3.0	1.8	1.2	0.7	0.6	0.8	1.0	1.5	2.0	2.3	3.1	9
10	6.1	5.0	3.7	2.6	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.6	3.3	4.0	5.1	7.1	6.7	6.0	4.6	3.4	2.2	1.6	1.1	1.0	1.2	1.4	1.9	2.4	2.7	3.5	10
11	6.4	5.3	4.0	2.9	2.3	2.0	2.1	2.1	2.2	2.2	2.4	2.9	3.6	4.3	5.4	7.4	7.0	6.3	4.9	3.7	2.5	1.9	1.4	1.3	1.5	1.7	2.2	2.7	3.0	3.8	11

Example VII.—Thus, in Example VI, the high water of February 7th was found to be 3.3 feet above mean low water. The declination being south, Diagram I applies, and this high water is the small one. To obtain the fall of the next low water or small low water, we enter Table IX, for San Francisco, with *0h.* of moon's transit, and two days after the greatest declination in the first part of the table, and find 1.9 foot, which will be the difference in the height of this high and low water. Entering with the same transit and day in the second part, we find 3.0 feet, which is the rise of the large high above the small low water; the difference between 1.9 and 3.0, or 1.1 foot, is the difference of height of the two successive high waters.

It is easy to see how, in this way, the soundings of a chart can be reduced to what they would be approximately at all the successive high and low waters.

TIDES OF THE GULF OF MEXICO.

On the coast of Florida, from Cape Florida around the peninsula to St. Mark's, the tides are of the ordinary kind, but with a daily inequality which, small at Cape Florida, goes on increasing as we proceed westward to Tortugas. From the Tortugas to St. Mark's the daily inequality is large and sensibly the same, giving the tides a great resemblance to those of the Pacific coast, though the rise and fall is much smaller. Between St. Mark's and St. George's island, Apalachicola entrance, the tides change to the single day class, ebbing and flowing but once in the twenty-four (lunar) hours.

At St. George's island there are two tides a day, for three or four days, about the time of the moon's declination being zero. At other times there is but one tide a day, with a long stand at high water of from six to nine hours. From Cape St. Blas to and including the mouth of the Mississippi, the single day tides are very regular, and the small and irregular double tides appear only for two or three days, (and frequently even not at all,) about the time of zero declination of the moon. The stand at high and low water is comparatively short, seldom exceeding an hour.

To the west of the mouth of the Mississippi the double tides reappear. At Isle Dernière they are distinct, though a little irregular for three or four days near the time of the moon's zero declination. At all other times the single day type prevails, the double tides modifying it, however, in the shape of a long stand of from six to ten hours at high water. This stand is shortest at the time of the moon's greatest declination, sometimes being reduced to but one hour. At Calcasieu the tides are distinctly double, but with a large daily inequality. The rise and fall being small, they would often present to the ordinary observer the same appearance as at Isle Dernière. At Galveston the double tides are plainly perceptible, though small, for five or six days at the time of the moon's zero declination. At other times they present the single day type, with the peculiarity that, after standing at high water for a short time, the water falls a small distance, and stands again at that height for several hours, then continues to fall to low water. Sometimes it falls very slowly for nine or ten hours following high water, and then acquires a more rapid rate to low water. At Aransas Pass and Brazos Santiago the single day tides prevail. Small, irregular, double tides are only perceived for two or three days at the moon's zero declination. At all other times there is but one high water in the day, with a long stand of from six to nine hours, during which there are often small, irregular fluctuations or a very slow fall. In the following table the mean rise and fall of tides at the above stations are given.

The highest high and the lowest low waters occur when the greatest declination of the moon happens at full or change; the least tide when the moon's declination is nothing at the first or last quarter. The rise and fall being so small, the times and heights are both much influenced by the winds, and are thus rendered quite irregular.

TABLE X.

Rise and fall at several stations on the Gulf of Mexico.

Stations.	Mean rise and fall of tides		
	Mean.	At moon's greatest declination.	At moon's least declination.
	Feet.	*Feet.*	*Feet.*
St. George's island, Florida	1.1	1.8	0.6
Pensacola, Florida	1.0	1.5	0.4
Fort Morgan, Mobile bay, Alabama	1.0	1.5	0.4
Cat island, Mississippi	1.3	1.9	0.6
Southwest Pass, Louisiana	1.1	1.4	0.5
Isle Dernière, Louisiana	1.4	2.2	0.7
Entrance to Lake Calcasieu, Louisiana	1.9	2.4	1.7
Galveston, Texas	1.1	1.6	0.8
Aransas Pass, Texas	1.1	1.8	0.6
Brazos Santiago, Texas	0.9	1.2	0.5

TO DETERMINE THE RISE AND FALL OF THE TIDES FOR ANY GIVEN TIME FROM HIGH OR LOW WATER.

It is sometimes desirable to know how far the tide will rise in a given time from low water, or fall in a given time from high water, or to approximate to the time which has elapsed from low or high water, by knowing the rise and fall of the tide in the interval. If the proportion of the rise and fall in a given time were the same in the different ports, this would easily be shown in a single table, giving the proportional rise and fall, which, by referring to Table I, showing the rise and fall of the tide at the port, would give the rise and fall, in feet and decimals. The proportion, however, is not the same in different ports, nor in the same ports for tides of different heights. The following table XI shows the relation between the heights above low water for each half hour for New York and Old Point Comfort, and for spring and neap tides at each place. Units express the total rise of high water above low water, and the figures opposite to each half hour denote the proportional fall of the tide from high water onward to low water. For example, at New York, three hours after high water, a spring tide has fallen six-tenths (sixty-hundredths) of the whole fall. Suppose the whole rise and fall of that day to be 5.4 feet, (Table I;) then, three hours after high water, the tide will have fallen 3.24 feet, or three feet three inches, nearly. Conversely, if we have observed that a spring tide has fallen three feet three inches, we may know that high water has passed about three hours.

TABLE XI.

Giving the height of the tide above low water for every half hour before or after high water, the total range being taken as equal to 1.

Time before or after high water.	New York.		Old Point Comfort.	
	Spring tide.	Neap tide.	Spring tide.	Neap tide.
h. m.				
0 0	1.00	1.00	1.00	1.00
0 30	0.98	0.98	0.98	0.98
1 0	0.94	0.93	0.95	0.94
1 30	0.89	0.86	0.88	0.87
2 0	0.80	0.72	0.80	0.78
2 30	0.72	0.59	0.70	0.68
3 0	0.60	0.45	0.59	0.57
3 30	0.49	0.31	0.49	0.44
4 0	0.39	0.19	0.37	0.34
4 30	0.28	0.10	0.26	0.22
5 0	0.18	0.02	0.17	0.13
5 30	0.09	0.00	0.08	0.05
6 0	0.05	....	0.03	0.01
6 30	0.00	....	0.00	0.00

TIDES IN COASTING.

By observing the time of high water and low water along the coast we find the places at which they are the same. The map of co-tidal lines (Sketch No. 65, C. S. Rep., 1857) shows that it is high water nearly at the same hour all along the coast from Sandy Hook to Cape Cañaveral; of course not in bays and harbors and up the rivers, but on the outer coast.

It is high water exactly at the same hour all along the line marked XII, seen on the chart, near Sandy Hook, and north and south of Hatteras, and, with small interruptions at Cape Lookout and Cape Fear, all the way to near Cape Cañaveral. This same line extends eastward to near Block island, and south of Nantucket, and then passes away from our coast. At full and change of the moon, along this line, (approximately,) it is high water at twelve o'clock, Greenwich time, the local time of high water depending upon the longitude of the place; or, to speak more correctly, in the average of a lunar month it is high water so many hours after the time of the moon's passing the meridian of Greenwich. By these lines, called co-tidal lines, we can determine what tidal currents the navigators must expect to meet in coasting; and for this purpose we divide the ports of the coast into two sets, those south and those north of New York.

The sailing lines of coasters bound to southern ports this side of the straits of Florida are marked upon the map, and also of those bound through the sounds to eastern ports, and outside to Halifax and European ports.

VESSELS TO AND FROM PORTS SOUTH OF NEW YORK.

South of Sandy Hook, New Jersey, the line of XII hours is nowhere more than 18 miles from the coast; that of XI$\frac{3}{4}$ nowhere more than 35 miles; that of XI$\frac{1}{2}$ nowhere more than 48; and XI nowhere more than 110. The distance of these lines of XII to XI hours, (corresponding within four minutes to VII and VI of New York time,) for different parts of the coast, is shown from table A, where the first column gives the name of the place, and the second, third, fourth, fifth, respectively, the distances of the co-tidal lines of XII, XI$\frac{3}{4}$, XI$\frac{1}{2}$, and XI hours. The distances are measured from the ports on perpendiculars to the co-tidal lines. They may be taken as if measured on the parallel of latitude at all the points for the line of XII hours, and at all between Sandy Hook and Cape Hatteras for the lines of XI$\frac{3}{4}$ and XI$\frac{1}{2}$ hours.

A.

Names of locations.	Distance from coast, measured on perpendicular to co-tidal lines.			
	At XII hours.	At XI$\frac{3}{4}$ hours.	At XI$\frac{1}{2}$ hours.	At XI hours.
	Nautical miles.	*Nautical miles.*	*Nautical miles.*	*Nautical miles.*
Sandy Hook	12	32	53	100
Barnegat	2	29	39	78
Cape May	15	30	46	92
Cape Henlopen	18	33	47	92
Assateague	7	22	36	82
Cape Henry	12	28	43	100
Cape Hatteras	----------	8	20	63
Ocracoke inlet	----------	11	26	71
Cape Lookout	----------	7	18	56
Beaufort entrance, North Carolina	6	15	24	63
Cape Fear	----------	6	16	55
Cape Roman	----------	10	21	67
Charleston light	3	15	27	70
Port Royal entrance	5	17	29	78
Tybee entrance	6	17	31	82
St. Mary's entrance	12	25	40	110
St. John's entrance	17	35	48	----------
Cape Cañaveral	16	----------	----------	----------
Cape Florida	----------	----------	----------	----------

The co-tidal lines are in such directions that at 10, 20, and 30 miles from the coast, between Sandy Hook and the St. John's, there is but a variation of seven minutes, and even to Cape Cañaveral only of eight minutes.

Keeping ten miles from the shore, the coaster would pass from 12 hours at Sandy Hook to 11 hours 45 minutes at Hatteras, and increase again irregularly to 12 hours 7 minutes at the St. John's, as shown more explicitly in table B. These three tracks of 10, 20, and 30 miles are inside of the cold wall of the Gulf Stream, and generally in the cold current, except at Cape Cañaveral.

B.

Names of stations.	Co-tidal hour at 10, 20, and 30 nautical miles from the coast, perpendicular to the coast.		
	Ten miles off.	Twenty miles off.	Thirty miles off.
	h. m.	*h. m.*	*h. m.*
Sandy Hook	12 0	11 52	11 45
Barnegat	11 52	11 44	11 35
Cape May	12 5	11 53	11 45
Cape Henlopen	12 7	11 57	11 48
Assateague	12 0	11 48	11 37
Cape Henry	12 5	11 48	11 42
Cape Hatteras	11 45	11 30	11 22
Ocracoke inlet	11 47	11 36	11 25
Cape Lookout	11 45	11 30	11 20
Beaufort entrance, N. C	11 55	11 38	11 25
Cape Fear	11 38	11 25	11 18
Cape Roman	11 45	11 33	11 24
Charleston light	11 52	11 38	11 25
Port Royal entrance	11 57	11 45	11 32
Tybee entrance	11 55	11 43	11 30
St. Mary's entrance	12 8	11 57	11 47
St. John's entrance	12 7	11 57	11 50
Cape Cañaveral	12 8		
Cape Florida	13 10		

It follows, then, as a general thing, from these two tables, that the coaster, in passing from Sandy Hook to the St. John's, would have the tides the same, within some fifteen minutes, as if he remained at Sandy Hook; so that leaving, for example, at high water, he would, according to the elapsed time, have the ebb and flood alternating every six hours and a quarter, nearly, as if he had remained near Sandy Hook. As the flood tide sets in generally to the northward and on shore, and the ebb to the southward and off shore, he would know by the time that elapsed from his departure and the period of the tide at which he started what tidal currents he might expect to meet as he passed along the coast. This, of course, is not peculiar to Sandy Hook as a point of departure, but would be true for any of the entrances given in the table, taking care not to mistake the time of tides within for that at the entrance.

By referring to George W. Blunt, esq., I have obtained the tracks of sailing and steam vessels passing from New York to ports to the south of it, as shown by the lines on the chart accompanying this paper. (See Sketch No. 65, C. S. Rep., 1857.) Tracing these on the map of co-tidal lines, I have determined how the navigator would find the tides as he passes from port to port. The results are shown in the annexed table, (C,) in which the port between which and Sandy Hook the mariner passes is at the head of the table, and, at the side, the place off which the co-tidal hours will be found, as stated in the table.

C.

Off—	Co-tidal hours on sailing lines measured on parallels of latitude of places named in the first column, between New York and—							
	Delaware bay.	Chesapeake bay.	Ocracoke inlet.	Cape Fear.	Charleston.	Savannah.	St. John's.	Cape Florida.
	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
Sandy Hook	12 5	12 5	12 5	12 5	12 5	12 5	12 5	12 5
Barnegat	11 57	11 57	11 57	11 57	11 57	11 57	11 57	11 57
Cape May	12 10	11 52	11 45	11 45	11 45	11 45	11 45	11 45
Cape Henlopen	....	11 51	11 43	11 43	11 43	11 43	11 43	11 43
Assateague	....	11 55	11 33	11 33	11 33	11 53	11 33	11 33
Cape Henry	....	12 13	11 24	11 24	11 24	11 24	11 24	11 24
Cape Hatteras	....	....	11 48	11 48	11 48	11 48	11 48	11 48
Ocracoke inlet	....	....	....	11 42	11 42	11 42	11 42	11 42
Cape Lookout	....	....	....	11 39	11 39	11 39	11 32	11 24
Beaufort entrance	....	....	....	11 39	11 39	11 39	11 32	11 24
Cape Fear	....	....	....	....	11 36	11 36	11 24	11 0
Cape Roman	....	....	....	....	11 46	11 46	11 19	....
Charleston light	....	....	....	....	....	11 52	11 18	....
Port Royal entrance	....	....	....	....	....	12 3	11 18	....
Tybee entrance	....	....	....	....	....	....	11 16	....
St. Mary's entrance	....	....	....	....	....	....	11 55	....
St. John's entrance	....	....	....	....	....	....	12 10	....
Cape Cañaveral	....	....	....	....	....	....	....	....
Cape Florida	....	....	....	....	....	....	....	....

Thus, from Sandy Hook to Delaware bay, starting with 12 hours 5 minutes, off Barnegat there would be, at the same instant, 11 hours 57 minutes, and off Cape May 12 hours 10 minutes, so that the navigator would have the same succession of tides whether he remained at Sandy Hook or passed onward to Delaware bay, or whether he came from Delaware bay to Sandy Hook. So from Sandy Hook to Charleston he will find, at the same instant, 12 hours 5 minutes at Sandy Hook, 11 hours 57 minutes off Barnegat, 11 hours 45 minutes off Cape May, and so onward upon the parallels of latitude for the several points. *For all practical purposes, then, of coasting, the succession of the tides, and, of course, of the tidal currents of flood and ebb will be the same as if the navigator remained stationary.* Leaving at low water he will meet the flood for 6 hours 15 minutes, and then the ebb for another 6 hours 15 minutes, and so on. It is the simplest of all rules that has thus come out of this investigation. That remarkable change of the temperature between the waters of the in-shore cold current and the warm waters of the Gulf Stream occurring in so short a distance that Lieutenant Bache called it the "cold wall," takes place at distances off the coast of from 170 to 29 miles, (see Table D,) between Sandy Hook and Cape Cañaveral, measured, from the several points named in the table, at right angles to the direction of the course, or measured along the parallels of latitude of the points, at distances, from 195 to 28 miles, between Assateague and Cape Cañaveral, (Table D.) The points where the parallels north of Assateague meet this division line have not been accurately determined.

The annexed table shows these distances measured at right angles and on the parallels.

D.

Distance from coast to "cold wall" of Gulf Stream, off—	Measured at right angles to coast.	Measured on parallel of latitude.
	Nautical miles.	*Nautical miles.*
Sandy Hook	170	----------
Barnegat	135	----------
Cape May	137	----------
Cape Henlopen	137	----------
Assateague	95	195
Cape Henry	92	107
Cape Hatteras	30	31
Ocracoke inlet	53	52
Cape Lookout	53	65
Beaufort entrance	62	----------
Cape Fear	54	97
Cape Roman	57	103
Charleston light	61	95
Port Royal entrance	79	97
Tybee entrance	79	95
St. Mary's	90	87
St. John's	85	82
Cape Cañaveral	29	28
Cape Florida	----------	----------

The coasting line of thirty miles keeps inside of the cold wall all the way to Cañaveral, and all the routes traced on the chart from Sandy Hook to southern ports are on the inside of it. The Gulf Stream lines, as drawn on the chart, show how the route to Bermuda and to the Bahamas cuts the alternate bands of warm and cold water of the Gulf Stream.

VESSELS TO AND FROM PORTS EAST OF NEW YORK.

The plate shows the sailing lines of vessels bound from New York to eastern ports and to Halifax, outside. The annexed table (E) gives the Greenwich time of high water off the several points named in the first column on the routes to and from the places named in the heading of the table. The distances are measured at right angles to the co-tidal curves.

E.

Off—	Co-tidal hours on sailing lines between New York and—						
	Newport.	New Bedford.	Nantucket.	Boston.	Portsmouth	Portland.	Halifax.
	h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
Sandy Hook	----------	----------	----------	----------	----------	----------	12 5
Throg's Point	16 16	16 16	16 16	16 16	16 16	16 16	----------
Fisher's island	13 48	13 48	13 48	13 48	13 48	13 48	----------
Block island	12 16	12 16	12 16	12 16	12 16	12 16	11 30
Monomoy	----------	----------	----------	16 10	16 10	16 10	----------
Cape Cod	----------	----------	----------	14 35	14 35	14 35	12 15
Cape Ann	----------	----------	----------	----------	15 00	14 40	----------
Portland	----------	----------	----------	----------	----------	15 30	----------

In passing from New York to an eastern port the first great change in the tides and tidal currents is between the East river and Long Island sound. The difference between Governor's island and Negro Point, on Ward's island, at the eastern entrance to Hell Gate, is two hours and forty-five minutes. Between this point and Throg's Point the change is small. The mariner is now in the full tide of the sound, and between Throg's Point and Fisher's island there is a difference of time of but two hours and twenty minutes, the greatest part of which is at the head of the sound and at its entrance, that is, near Throg's Point and Fisher's island. From off New London to off Sand's Point the difference is but one hour and forty minutes; so that, if the mariner, instead of remaining at Throg's Point, passes onward to Fisher's island he would lose but half a tide in the whole passage. In other words, he would have the same succession of rise and fall, according to the time elapsed, whether stationary or passing onward, within two hours and a half, or less than half a tide.

The tidal current lines show that even a less allowance is to be made for the change of current than for the change of tide, the difference in the change of current between Throg's Point and Fisher's island, along the middle of the sound, being of no practicable importance. Passing out of Long Island sound the tidal hours grow earlier, until off Block island that of Sandy Hook is again reached. The co-tidal line of Sandy Hook and Block island being the same, it is the struggle of the same tide through New York bay and the narrow East river, and obstructed Hell Gate, and through Fisher's island and Long Island sound, and to Throg's Point. The tidal currents meet near Throg's Point.

The lower part of Narragansett bay has the co-tidal hour 12 hours nearly. Buzzard's bay has nearly the same co-tidal hour, the tide wave reaching the shore at nearly the same time all around the bay.

It would be impossible to give in a small compass a minute account of the tides of Martha's Vineyard and Nantucket sound. In general, it may be said that as far as Holmes's Hole and Wood's Hole they resemble those of Block Island sound, and afterwards those of Monomoy, at the eastern entrance; but this generalization is unsatisfactory without more details than there is space here to give. In these sounds takes place the remarkable change of between three and four hours, the greatest change of our coast, dislocating, as it were, the times of high water at places south and west and east and north of Nantucket. The whole of this change takes place between the eastern entrance of Nantucket sound and the western of Martha's Vineyard, giving rise to quite a complex condition of both tides and currents, which it has occupied much time to unravel. The dominant co-tidal line of our coast, from Block island to Cape Cañaveral, is that of 12 hours of Greenwich time; that of our eastern coast, from Nantucket to Passamaquoddy, is, in general, 15 hours. Passing out of Nantucket sound coasters carry nearly the same co-tidal hour to Cape Cod, and thence vary their time about half an hour in passing to Boston, to Portsmouth, to Portland, or to Passamaquoddy. It has long been known that the tidal almanac for Boston might practically be used for eastern ports. Vessels from New York to Halifax, and New York to Europe, which keep outside, and should keep well off the Nantucket shoals, and off St. George's, as shown by the track on the chart, vary their co-tidal hour but little, keeping between the lines of 12 and $11\frac{1}{2}$ until quite well on their course, and beyond Cape Sable. The same rule will apply to their case as has been given for vessels between New York and a southern port.

APPENDIX No. 9

ADDITIONAL RESEARCHES ON THE CO-TIDAL LINES OF THE GULF OF MEXICO, BY A. D. BACHE, SUPERINTENDENT.—(SKETCH No. 46.)

In the Coast Survey Report for 1856 I published a paper on the approximate co-tidal lines of the Gulf of Mexico. This paper was based on observations made at numerous stations during the progress of the survey. But with the exception of four stations where the observations were extended over more than a year, the stations were seldom occupied more than two months. Corrections for the amount of variation derived from the nearest complete station were applied to the means; still, it was thought that better observations carried over longer periods would clear up many of the doubtful points.

Accordingly, a systematic plan of observations was laid out, involving the occupation of four stations simultaneously, with self-registering tide-gauges during one year uninterruptedly. The execution of this plan was begun by establishing the stations of Cape Florida, Indian Key, Key West, and Tortugas. After the completion of the year the gauges from the former three places were transferred to Charlotte Harbor, Tampa Bay, and Cedar Keys; Tortugas remaining as a permanent station of reference, which position it also retained during the observations at a third set of stations comprising St. Mark's and St. Vincent's island, (western entrance to Apalachicola,) and two intermediate stations at Dog island and New inlet. Observations at the two latter stations were not kept up during a whole year, having merely been established to study a rather rapid change in the features of the tides in that region. The gauges were afterwards transferred to the Southwest Pass of the Mississippi and to Last island, on the coast of Louisiana. A self-registering gauge was also kept up for some time at Pensacola by the kindness of S. T. Abert, esq., civil engineer of the navy yard.

After a year's observation at St. Mark's and St. Vincent's island, the gauges were transferred to Calcasieu inlet and Aransas Pass, but at that time the rebellion of the southern States broke out and the vessel employed in their transportation was seized at Aransas, and the observer stationed at Calcasieu was arrested and imprisoned for several months at New Orleans. The scheme having thus been broken before its completion, I am able to give only the results obtained for the eastern part of the Gulf. The observations, which were ably directed by the late G. Wurdemann, and after his death by Mr. A. C. Mitchell, were decomposed by a graphical method after they were received in the office. This laborious work was performed by Messrs. Avery, Downes, Balmain, and J. R. Gillis. To the latter I am particularly indebted for several time and labor saving improvements in the mode of working.

The times and heights of diurnal and semi-diurnal high water were reduced in the usual way. The annual means were reduced to Greenwich time and corrected for transit and for depth in the manner explained in my former paper. The results are given in the following tables:

Semi-diurnal tide.

	Longitude in time.	Mean semi-diurnal interval.	Sum.	Correction for transit.	Correction for depth.	Co-tidal line.
	h. m.	*h. m.*	*h. m.*	*m.*	*m.*	*h. m.*
Cape Florida	5 21	8 37	13 58	— 17	— 20	13 21
Indian Key	5 23	8 15	13 38	16	15	13 7
Key West	5 26	9 18	14 46	19	19	14 8
Tortugas	5 32	9 42	15 14	19	10	14 45
Charlotte Harbor	5 29	12 38	18 7	25	20	17 22
Egmont Key	5 31	11 15	16 46	22	20	16 04
Cedar Keys	5 32	13 9	18 41	26	45	17 31
St. Mark's	5 37	13 52	19 29	28	22	18 39
Dog island	5 39	13 37	19 16	27	15	18 34
New inlet	5 40	14 35	20 15	29	13	19 33
St. Vincent's	5 41	14 59	20 40	30	13	19 57
Pensacola	5 49	11 21	17 10	— 23	— 17	16 30

Diurnal tide.

	Longitude in time.	Mean diurnal interval.	Sum.	Correction for transit.	Correction for depth.	Co-tidal line.
	h. m.	*h. m.*	*h. m.*	*m.*	*m.*	*h. m.*
Cape Florida	5 21	13 59	19 20	— 28	— 20	18 32
Indian Key	5 23	16 51	22 14	34	15	21 25
Key West	5 28	19 8	24 36	38	19	23 39
Tortugas	5 32	18 55	24 27	38	10	23 39
Charlotte Harbor	5 29	21 24	26 53	43	20	25 50
Egmont Key	5 31	20 3	25 34	40	20	24 34
Cedar Keys	5 32	21 26	26 58	43	45	25 30
Saint Mark's	5 37	21 56	27 33	44	22	26 27
Dog island	5 39	21 27	27 6	43	15	26 8
New inlet	5 40	21 33	27 13	43	13	26 17
Saint Vincent's	5 41	21 22	27 3	43	13	26 7
Pensacola	5 49	22 03	27 52	— 44	— 17	26 51

These numbers are set down on the accompanying maps and appropriate co-tidal lines drawn by the eye so as to give the best possible agreement. It will be seen, by comparing these lines with those on the map appended to my paper in the Coast Survey Report for 1856, that the new results have modified the former ines but inconsiderably. Some particulars formerly supposed to be due to errors of observation are con firmed; thus, for instance, the earlier co-tidal hour of the semi-diurnal tide at Indian Key than at Cape Florida.

The question of the interference of the tidal waves coming through the Florida channel and through the Caribbean sea has not made any progress, nor is it likely to do so until the features of the tides at the west end of Cuba and the extremity of Yucatan are better known.

APPENDIX No. 10.

REPORT TO THE SUPERINTENDENT BY ASSISTANT L. F. POURTALES, IN CHARGE OF THE FIELD AND OFFICE WORK RELATING TO TIDAL OBSERVATIONS.

COAST SURVEY OFFICE, *October* 1, 1862.

SIR: I have the honor to submit the following report on the field and office work performed by the tidal party under my charge during the past year.

Field-work.—The tidal observations made under the direction of this division have been confined altogether to the permanent stations at Eastport, Me.; Boston, Mass.; New York; Old Point Comfort, Va.; San Diego and San Francisco, Cal.; and Astoria, Oregon. No temporary stations were occupied except those connected with the hydrographic parties.

The station at Eastport remained in charge of Mr. Samuel Walker until March, when he was ordered to go to Key West, to take charge of the magnetical station. Mr. R. H. Talcott took his place. As in former years, magnetical observations form a part of the observer's duties at this station.

At the other stations nothing has occurred worthy of particular remark.

Of the self-registering tide-gauges seized by the rebels last year, only one has thus far been recovered. It is the one used by Mr. Donegan at Calcasieu entrance, which, when he was imprisoned at New Orleans, he had deposited with the British consul, from whom it was obtained after the capture of the city. Two sheets from the tide-gauge formerly at Last island, La., were received last June with the New Orleans post office mark, but without letter stating by whom they were forwarded. They contain the observations for April and part of May, 1861, ending on the 13th of that last month, when a note on the sheet informs us that the observations were stopped "by order of the governor of Louisiana."

The other gauges are in places not yet brought back under the control of the government, except Fort Clinch. From information obtained at that place by Assistant Boutelle, it appears that the gauge was destroyed by the inhabitants previous to the capture of the town.

The following table gives a recapitulation of the observations received at the office during the year, with the exception of those taken by the hydrographical parties for the reduction of their soundings.

List of observations received during the year ending September 30, 1862.

Section.	Name of station.	Name of observer.	Kind of gauge.	Station, permanent or temporary.	Time of occupation. From—	To—	Total days.	Remarks.
I	Eastport, Me	S. Walker; R. H. Talcott	S. R.	Permanent	Oct. 1, 1861	Sept. 30, 1831	365	
	Boston Dry Dock	T. E. Ready	Box	...do	Oct. 1, 1861	Sept. 30, 1861	365	
II	Governor's Island, N. Y	R. T. Bassett	S. R.	...do	Oct. 1, 1861	Sept. 30, 1861	365	
	Brooklyn, N. Y	...do	Box	...do	Oct. 1, 1861	Sept. 30, 1861	365	Day observations for comparison.
III	Old Point Comfort, Va	M. C. King	S. R.	...do	Oct. 1, 1861	Sept. 30, 1861	365	
VIII	Last Island, La	H. P. Wilson	S. R.	Temporary	April 1, 1861	May 13, 1861	43	
X	San Diego, Cal	A. Cassidy	S. R.	Permanent	Aug. 1, 1861	July 1, 1862	334	
	San Francisco, Cal	H. E. Uhrlandt	S. R.	...do	Aug. 27, 1861	July 14, 1862	321	
XI	Astoria, Oregon	L. Wilson	S. R.	...do	Aug. 1, 1861	July 1, 1862	334	

Office-work.—The persons employed in this division during the year were: R. S. Avery, J. Downes, P. H. Donegan, (since December 23, 1861,) M. Thomas, and S. D. Pendleton.

Mr. Avery was engaged in making out tables of the daily inequality at St. Mark's and Cape San Lucas, n reading off and reducing the tidal observations at Eastport and Vera Cruz, and in completing the decompositions and reducing the diurnal and semi-diurnal tides at the stations in the Gulf of Mexico. The results were used in the preparation by yourself of a paper on the co-tidal lines of the eastern part of the gulf in another part of this volume. After that he was engaged in computations relating to the discussion of the diurnal tides. This has not been brought to a close yet, on account of a severe illness under which he has been suffering for some time.

Mr. Downes has had the duty of reading off and reducing the sheets from the self-registering tide-gauges, and has also made various other reductions.

Mr. Donegan made a catalogue of the tidal reductions in the archives, and also of the sheets of the self-registering tide-gauges, putting the latter in order by stations and years for easier reference. He has also made ordinary reductions and miscellaneous other work.

M. Thomas has been chiefly engaged in copying the readings of the self-registering observations according to a uniform system, besides various other copying.

S. D. Pendleton has made ordinary reductions of the self-registering observations of the western coast.

Very respectfully, your obedient servant,

L. F. POURTALES,
Assistant U. S. Coast Survey, in charge of tidal division.

Prof. A. D. BACHE, LL.D.,
Superintendent U. S. Coast Survey.

APPENDIX No. 11.

REPORT OF ASSISTANT J. E. HILGARD, IN CHARGE OF THE OFFICE, AND SUB-REPORTS OF THE CHIEFS OF OFFICE DIVISIONS.

COAST SURVEY OFFICE, *Washington, November* 1, 1862.

DEAR SIR: The operations of this office, which I took charge of in April last, when Lieutenant Colonel Palmer joined the army of the Potomac, have been continued with uninterrupted activity during the past year. While the regular progress of the work has been steadily kept up, the energies of several branches of the office have been severely taxed to meet the demands arising out of the naval and military operations in which the nation has been engaged. It will be seen from the detailed reports of the chiefs of office divisions, that beside the issue of the extraordinary number of over forty-seven thousand printed maps and charts, the hydrographic, drawing, lithographic, and photographic forces have prepared a great deal of special information for the Navy and War Departments from the archives of the office, which for obvious reasons has not been published. The facilities of this office for multiplying manuscript maps, either by photograph or lithograph, have also been placed at the disposal of the topographical engineer officers of the army engaged in the preparation of military maps, and have proved of much service.

The reports of the several chiefs of divisions of the office are herewith submitted, accompanied by the usual tabular statements of office statistics.

The clerical duties of the office have been performed with great efficiency by Mr. V. E. King, assisted at various times by Mr. S. H. Lyman and Mr. J. E. Dow.

My acknowledgments are due to the chiefs of divisions for the support I have received from them by their ready co-operation at all times; and also to Samuel Hein, esq., our veteran disbursing officer, whose experience and advice have ever been freely available, as well as to Joseph Saxton, esq., the assistant in charge of the office of weights and measures, for general superintendence of mechanical construction.

Yours, very respectfully,

J. E. HILGARD,
Assistant in charge of office.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey

Report of Captain C. P. Patterson, hydrographic inspector, in charge of Hydrographic Division.

COAST SURVEY OFFICE, *Washington, October* 1, 1862.

During the past year the hydrographic duties of this office have consisted of a more miscellaneous and laborious character than usual, in consequence of the new and immense demand for charts of all parts of our southern coast for the use of the greatly increased number of our naval vessels and the vast fleet of transports in the employ both of the army and navy along the whole extent of that coast. These duties consist, in the main, in the examination and verification of original hydrographic sheets, together with the original records of soundings and angle-books belonging to those soundings, duplicating these records in some cases by fair copies; the reduction of some and the examination and verification of all reduced sheets for publication; the plotting of light-houses, light-vessels, beacons, and buoys, as determined by our own parties in the field or from data furnished by the Light-House Board; making, revising, and plotting of sailing directions and sailing lines; the description of dangers; the plotting of tidal and current stations; making projections for the use of hydrographic parties in the field; and comparative tracings of localities of which two or more surveys have been made. In addition to these there has been a very large amount of smaller detail, occupying much time, but impossible to specify.

Mr. Arthur Balbach has had principal charge as draughtsman, and in consequence of his long experience, great accuracy in the minutest detail, and remarkable memory in regard to them, he has been subject to constant calls to supply information required from several divisions of the office, and to correct inaccuracies. His work which can be specified has been as follows:

Original hydrographic sheets compared with the original records and verified	21
Printed maps and charts verified	30
Reduced drawings of hydrographic sheets verified	19
Examined and ruled sailing lines in charts	16
Reduced parts of charts	3
Selected soundings in original sheets for reduction	7
Examined original records in regard to rocks, shoals, and discrepancies	12
Made comparative maps	3
Made projections, single sheets, scale $\frac{1}{10000}$	2
Made tracings of maps and charts	17

To Mr. Balbach I am indebted for much valuable information not otherwise to be obtained. During the past year his services were lost to the office for a number of weeks in consequence of a very severe and painful illness, which for many days threatened his life, and from the effects of which he has not even now recovered. Yet his fidelity has caused him to work many days in the office under great suffering, and at all times to perform his duty in or out of the office hours, with the utmost cheerfulness.

Mr. L. Karcher, draughtsman, has been the only assistant to Mr. Balbach. Mr. Karcher was given a short leave of absence last autumn, to visit his family in Europe, from which he returned and resumed his duties in the office, November 25, 1861.

From May 29 to July 11, 1862, he was employed as assistant in the party under my charge working in the Potomac. With this exception he has been constantly and most diligently employed in the office, and besides a large variety and amount of smaller detail, has done the following work:

Projections made, single sheets, scale $\frac{1}{5000}$	2
Projections made, double sheets, scale $\frac{1}{5000}$	1
Projections made, single sheets, scale $\frac{1}{10000}$	5
Projections made, single sheets, scale $\frac{1}{20000}$	9
Projections made, single sheets, scale $\frac{1}{40000}$	6
Projections made, single sheets, scale $\frac{1}{80000}$	4
Total	27

Angles plotted in various sheets	1,909
Miles of sounding lines	397
Number of soundings	13,642
Examined and verified original sheets with original data	3
Reductions made from scale $\frac{1}{10000}$ to $\frac{1}{20000}$	2
Reductions made from scale $\frac{1}{20000}$ to $\frac{1}{60000}$	2
Reduction made from scale $\frac{1}{20000}$ to $\frac{1}{200000}$	1
Made tracings of maps and charts	8

By Mr. Karcher's assiduity and accuracy he saves much time in the verification of his work, and completes a most satisfactory amount of results.

The draughtsmen attached to the several hydrographic parties have been at work in the office at various times, completing the plotting and copying of the work of their respective parties, under supervision of the chiefs of those parties.

Report of Assistant L. F. Pourtales, in charge of the Tidal Division.

COAST SURVEY OFFICE, *Washington, October* 1, 1862.

The following report of the occupation of the computers in this division during the past year is respectfully submitted:

Mr. R. S. Avery was engaged in making out tables of the daily inequality of St. Mark's and Cape San Lucas, and in reading off and reducing the tides of Eastport and Vera Cruz. He also completed the graphical decompositions and reductions of the diurnal and semi-diurnal tides at the stations in the Gulf of Mexico. He afterwards took up the computations relating to the discussion of the diurnal tides.

Mr. J. Downes has made the readings from the sheets of the self-registering tide-gauges, and has reduced the results, besides making various other reductions.

Mr. P. H. Donegan reported for duty December 23, and was employed in making a catalogue of the tidal reductions in the archives; also one of the sheets from the self-registering tide-gauges, at the same time putting the latter in order by stations and years of observations, for easier reference. He has also made ordinary reductions and other miscellaneous work.

M. Thomas has been chiefly engaged in copying the readings of the self-registering observations according to a uniform system, besides various other copying.

S. D. Pendleton has made ordinary reductions of the self-registering observations of the western coast.

Report of Assistant Charles A. Schott, in charge of the Computing Division.

COAST SURVEY OFFICE, *October* 1, 1862.

The usual annual report on the work done by the several computers for the year ending October 1, 1862, is herewith respectfully submitted.

The force of the computers has remained the same as last year, with the same general distribution of work and organization. Mr. J. E. Dow, clerk to the division, was transferred January 22, 1862, to the assistant in charge of the office, Mr. E. H. Courtenay taking his place. On May 8, Mr. Courtenay was ordered on field duty; he returned to the division August 20; in the interval Mr. G. J. Pinckard temporarily acted as clerk from May 21 to August 10, when he was transferred to the Engraving division. The number of computers was barely sufficient to attend to the current field-work and to all calls from the office for information, which were attended to, and but little time remained to adjust work of preceding seasons. Mr. Main acted in charge of the division during October, 1861, when I was absent on other duty. From July 26 to August 20 I was again engaged on field-work. Up to the month of June the solar spot observations continued regularly; after this date, however, owing to pressure of other official duty and for want of regular assistance, they were nearly discontinued. The duplicate astronomical, geodetic, and magnetic records remain in charge of this division; they are contained in forty-nine boxes, and comprise fourteen hundred and six separate volumes.

During the year eighty-three reports have been submitted on various subjects connected with the duty of the division. The work done by each computer is herewith given in detail.

Assistant Theodore W. Werner supplied L. M. Z. computations to the St. John's river triangulation; computed the triangles of East bay, near Galveston, 1860–'61, and reduced the observations of vertical angles in Section I, 1856–'58–'59; deduced the horizontal angles at primary stations Monadnock, Boxhill, and Baldhill, 1861; computed the triangulations of Koos bay, 1861, and of Penobscot bay, 1861, Assistant G. A. Fairfield and Sub-Assistant S. C. McCorkle's work; computed the additional triangulation near Boston, Assistant C. O. Boutelle, 1860–'61; completed the second computation of the angles at Agamenticus, and made good progress with Assistant E. Blunt's new triangulation in Rhode Island and Connecticut of 1861.

Mr. Eugene Nulty made the second computation of Mr. Vose's magnetic observations at Eastport, Me., in 1860 and 1861; computed the time, azimuth, and latitude of Station Pigeon, Koos bay, 1861; computed the longitude, from observed occultations by Assistant G. Davidson, of Point Restoration, Point Hudson, Point Pinos, Humboldt, Scarborough, and Telegraph hills, all on the western coast.

Mr. James Main revised the longitude computation from observations of the solar eclipse of July, 1851; revised time and latitude computations of Point Henson, 1860; also computed the azimuth at this station; revised the computations for latitude of the following stations: San Diego, Point Pinos, Cape Disappointment, and Western Ridge; also the azimuth at the last station; computed the position of the solar spots for the date of the eclipse in July, 1860; introduced the latest determination of the star places into our azimuth computations, and computed the longitude of Station Pigeon, Section XI, from a chronometer transmission; revised time, azimuth, and latitude computations at this station, and also of Gunstock, Section I; revised time and azimuth computations of Wachusett, Section I; computed the three magnetic components at Stations Troy, Boxhill, and Baldhill; reduced my magnetic observations of 1862; and nearly completed the revision of the time and azimuth computations at Azimuth Point, near Monterey bay. He also performed some miscellaneous astronomical and magnetic computations.

Dr. Gottlieb Rumpf completed the computation of the triangles of Penobscot bay, 1858–'59, and of Chatham bay, Section VI, 1861; adjusted the horizontal angles at Western Ridge; computed L. M. Z. to the triangles of St. Augustine and the work joining Sections V and VI; assisted in preparing the annual statistics for 1860, and computed some additional positions in Sections V and VI; computed the triangulation in the vicinity of Washington by Charles Hosmer, 1861; made a second computation of the horizontal angles at Wachusett; deduced the length of the Koos bay base line; nearly completed Sub-Assistant Webber's triangulation on the coast of Maine, 1860–'61; assisted on the second computation of the horizontal angles in Section I, primary triangulation, (Sebattis and Mount Independence;) computed new primary triangulation, Section II; commenced the second computation of horizontal angles of Station Agamenticus; and computed the triangulation of the Potomac river from Blackistone island to Washington, 1862, by F. Rogers and Charles Hosmer; also that about the District of Columbia of Sub-Assistant Ferguson of 1862.

Mr. John Wiessner completed the computation of the Gray's harbor triangulation, Section XI, 1860; deduced horizontal angles at Station Barkley Point 2, Section VII; reduced horizontal angles at Gunstock, and adjusted computed elevations of points in Section I, 1856–'58–'59; made a second computation of the horizontal angles at Mounts Harris and Unkonoonuc, 1861; of Howard and of Mount Desert; revised the angles at Ragged and Mount Blue, and computed weights to each direction of the lines of the primary triangulation round Epping base; made progress with the least square adjustment of this part of the triangulation; computed L. M. Z. of Mr. Hosmer's triangulation of the Potomac, 1862; also assisted in the preparation of the list of new geographical positions near Boston.

Mr. J. E. Dow attended to the clerical duty of the division, assisted occasionally at the archives, and compared original and duplicate records. On January 22 he was transferred for duty to the assistant in charge of the office.

Mr. E. H. Courtenay was appointed aid in the United States Coast Survey January 22, and performed the clerical duty of the division, and also supplied and revised duplicates. He was ordered on field duty May 8, and returned to the division August 20.

Mr. G. J. Pinckard temporarily filled the position left vacant by Mr. E. H. Courtenay between May 21 and August 10.

R. Freeman attended to the extra copying of the old original records of the Survey.

Report of the operations of the Drawing Division.

COAST SURVEY OFFICE, *November* 1, 1862.

The Drawing division remained under the charge of *Assistant T. J. Lee* until April, since when the work has been carried on under the immediate direction of the assistant in charge of the office, with the efficient aid of *Mr. W. T. Bright.* The numerical force of this division has remained the same as at the date of the last report, the gain in time and labor by the use of the method of reduction by photography being such as to allow, in addition to the regular progress of work, the production of a large number of drawings and tracings of special maps called for by the wants of the public service. The distribution of labor has remained the same as last year, and the detailed statement of the work of each draughtsman is given below.

Assistant M J. McClery has been employed in drawing the hill topography upon photographs on a scale of $\frac{1}{40000}$, to serve, when reduced by photography to one-half that scale, as a guide for the engraving of the following coast maps and charts on a scale of $\frac{1}{80000}$, viz: No. 7, Muscongus bay to Portland, Me.; No. 9, Cape Neddick, Me., to Cape Ann, Mass.; No. 11, Plymouth to Hyannis, Mass.; and No. 21, New York bay and harbor.

Mr. E. Hergesheimer has been engaged upon the generalization and preparation of plane-table sheets for the photographic reduction to the scale of publication of coast maps and charts No. 7, Muscongus bay to Portland, Me.; No. 10, Cape Ann to Plymouth, Mass.; No. 21, New York bay and harbor; No. 108, Matagorda and Lavaca bays, Texas; and of the finished map of Drake's bay, Cal. He has continued the drawing of hill topography for the finished map of the Kennebec and Sheepscot rivers, Me., $\frac{1}{40000}$; and made additions to map of Charleston harbor and approaches, scale $\frac{1}{30000}$, for lithographic transfer. The verification of engraved topography and the arrangement of lettering on the finished charts have been made by him. He has, in addition, had charge of the combination of the surveys in the vicinity of the capital, and of the preparation of photographic copies of the same for the use of the army, and has from them drawn a topographical map of the approaches to Washington City.

Mr. A. Lindenkohl has continued the topography upon general coast charts, scale $\frac{1}{400000}$, No. I, Quoddy Head to Cape Cod, Mass.; No. II, Cape Ann to Gay Head, Mass.; No. VII, Winyah bay, S. C., to St. John's river, Fla.; No. XIII, Waccasassa bay to Choctawhatchee bay, Fla.; No. XVI, Galveston bay to the Rio Grande, Texas; has completed the preliminary chart of Potomac river, sheet No. 1, from entrance to Piney Point, scale $\frac{1}{60000}$, and reduced the topography of Potomac river, sheet No. 3, from Lower Cedar Point to Indian Head, scale $\frac{1}{60000}$; finished the hydrography of Hudson river, sheet No. 2, from Sing Sing to Poughkeepsie, scale $\frac{1}{60000}$; and reduced Wilkes's survey of Tybee bar and Calibogue sound, S. C., scale $\frac{1}{60000}$. He has made additions to coast maps and charts Nos. 12, 13, and 14, from Monomoy and Nantucket shoals to Block Island sound, R. I., scale $\frac{1}{80000}$; and has been engaged upon lithographic maps, coast of South Carolina and Georgia, scale $\frac{1}{200000}$; Port Royal sound and vicinity, scale $\frac{1}{60000}$; progress sketches, projections for field parties, projects, projections on copper, diagrams, and verifications. He has also continued the hydrography of coast map and chart No. 7, from Muscongus bay to Portland harbor, Me., scale $\frac{1}{80000}$; and has now in hand a chart of part of the western coast, from Bodega Head to Point Pinos, including the bay of San Francisco, scale $\frac{1}{200000}$.

Mr. L. D. Williams has continued the topography of Hudson river, sheet No. 1, from entrance to Sing Sing, scale $\frac{1}{60000}$; lettered coast map and chart No. 21, New York bay and harbor, scale $\frac{1}{80000}$; revised hydrography on coast map and chart No. 12, Monomoy and Nantucket shoals to Muskeget channel, Mass., scale $\frac{1}{80000}$; drawn additional topography to map of Savannah river, Ga., scale $\frac{1}{40000}$; completed topography and part of hydrography of preliminary chart of Potomac river, sheet No. 2, from Piney Point to Lower Cedar Point, scale $\frac{1}{60000}$. He has also been engaged upon projects, projections for field parties, projections on copper, verifications, and has made the annual additions to the Congress map. He has now on hand finished map of San Francisco bay, (lower part,) scale $\frac{1}{50000}$.

Mr. H. Lindenkohl, who is equally efficient as a draughtsman and engraver, has been chiefly employed in the Lithographic division, where he has made numerous drawings and engravings on stone. He has made the reduction of part of Potomac river, sheet No. 4, from Indian Head to Chain bridge, $\frac{1}{40000}$, and has engraved the topography of the entire sheet on stone. He has also been engaged upon projections for field parties, tracings, and miscellaneous maps.

Mr. F. Fairfax has completed the photographic outline of topography of Petaluma creek, Cal., scale

$\frac{1}{30000}$; photographic outline of topography of Napa creek, Cal., scale $\frac{1}{30000}$; preliminary chart of Koos bay, Oregon, scale $\frac{1}{20000}$; preliminary chart of Tomales bay, Cal., scale $\frac{1}{30000}$, and made tracings for photographic outline of same. He has also completed the preliminary chart of Mount Hope bay, R. I., scale $\frac{1}{40000}$, and has been employed upon projections for field parties, tracings, and statistics.

Mr. J. W. Maedel has drawn the preliminary chart of Calibogue sound and Skull creek, S. C., scales $\frac{1}{20000}$ and $\frac{1}{40000}$; made lithographic drawings, diagrams, lettered plane-table sheets, and made tracings of original sheets for photographing, under Mr. Hergesheimer's direction, and of various original sheets required for the use of the army and navy.

Mr. T. Petingale entered the office on the 21st of May, and since that time has been employed upon miscellaneous maps, tracings, and statistics.

Mr. T. R. Smith entered the office on the 25th of February, and has been engaged inking plane-table sheets in the vicinity of Washington, and upon tracings.

Mr. B. Hooe, Jr., has continued on tracings, statistics, and miscellaneous office-work.

Mr. W. Fairfax has been employed upon tracings, coloring proofs, statistics, and miscellaneous work.

Mr. W. B. McMurtrie was assigned to duty in the office in August, and has been engaged inking plane-table sheets and plotting hydrographic work.

List of maps and sketches completed or in progress during the year ending November 1, 1862, *arranged in order of Sections.*

Name.	Scale.	Description.	Remarks.
SECTION I.			
Progress sketch A	1–600,000		
Progress sketch A *bis*	1–400,000		
General coast chart, No. I, from Quoddy Head to Cape Cod, Mass.	1–400,000	Finished chart	In progress.
General coast chart, No. II, from Cape Ann to Gay Head, Mass.	1–400,000	do	Do.
Sheepscot and Kennebec rivers, Maine	1–40,000	Finished map	Do.
Barnstable harbor, Mass.	1–20,000	do	Completed.
Mount Hope bay, Rhode Island	1–40,000	Preliminary chart	Do.
Coast map and chart, No. 7, from Muscongus bay to Portland harbor, Maine.	1–80,000	Finished map and chart	In progress; outline by photography.
Coast map and chart, No 8, from Seguin Island light to Kennebunkport, Maine.	1–80,000	do	Do.
Coast map and chart, No. 9, from Cape Neddick, Maine, to Cape Ann, Mass.	1–80,000	do	Do.
Cape map and chart, No. 10, Massachusetts bay and harbor	1–80,000	do	Do.
SECTION II.			
Progress sketch B, No. 2	1–1,100,000 1–1,200,000		
Coast map and chart, No. 21, New York bay and harbor	1–80,000	Finished map and chart	In progress; outline by photography.
Hudson river, from entrance to Sing Sing, New York	1–60,000	Finished map	In progress.
Hudson river, from Sing Sing to Poughkeepsie, New York	1–60,000	do	Do.
SECTION III.			
Progress sketch C	1–400,000		
Potomac river, from entrance to Piney Point	1–60,000	Preliminary chart	Completed.
Potomac river, from Piney Point to Lower Cedar Point	1–60,000	do	Do.
Potomac river, from Lower Cedar Point to Indian Head	1–60,000	do	In progress.
Potomac river, from Indian Head to Chain Bridge	1–40,000	do	Do.
Norfolk harbor, Virginia, (lithograph drawing)	1–10,000	do	Completed.
Reconnaissance of Pamunky and Mattapony rivers, Virginia, (lithograph drawing).	1–60,000	do	Do.
SECTION IV.			
Progress sketch D	1–600,000		
Coast map and chart, No 41, Albemarle sound, (eastern part,) additions.	1–80,000	Finished map and chart	Do.

List of maps, sketches, &c.—Continued.

Name.	Scale.	Description.	Remarks.
Coast of North Carolina, (lithograph drawing)	1–400,000	Preliminary chart	Completed.
Hatteras inlet, North Carolina, (lithograph drawing)	1–20,000	......do	Do.
Beaufort harbor, North Carolina, (lithograph drawing)	1–20,000	......do	Do.
SECTION V.			
Progress sketch E	1–600,000		
Savannah river, (additions)	1–40,000	Finished map	Completed.
Tybee bar and Calibogue sound	1–60,000	Preliminary chart	Do
General coast chart, No. VII, from Winyah bay to St. John's river, Florida.	1–400,000	Finished chart	In progress.
Calibogue sound and Skull creek	1–40,000 1–20,000	Finished map	Do.
Coast of Georgia, (lithograph drawing)	1–200,000	Preliminary sketch	Completed.
St. Helena sound, (lithograph drawing)	1–40,000	Finished map	Do.
Coast of South Carolina, (lithograph drawing)	1–200,000	Preliminary sketch	Do.
Skull creek, South Carolina, (lithograph drawing)	1–20,000	Preliminary chart	Do.
Tybee bar and Calibogue sound, (lithograph drawing)	1–60,000	......do	Do.
Calibogue sound and Skull creek, (lithograph drawing)	1–40,000 1–20,000	......do	Do.
Charleston harbor, additions, (lithograph drawing)	1–30,000	......do	Do.
Stono inlet, South Carolina, (lithograph drawing)	1–20,000	......do	Do.
SECTION VI.			
Progress sketch F, (showing a general reconnaissance)	1–1,200,000		
Progress sketch F, (reefs and keys)	1–400,000		
General coast chart, No. X, from Cape Florida to Cape Sable, Fla.	1–400,000	Finished chart	In progress.
SECTION VII.			
Progress sketch G	1–600,000		
General coast chart, No. XIII, from Waccasassa bay to Choctawhatchee bay, Florida.	1–400,000	......do	In progress.
SECTION VIII.			
Progress sketch H	1–600,000		
Reconnaissance Southwest Pass, Mississippi river, (lithograph drawing.)	1–10,000	Preliminary sketch	Completed.
SECTION IX.			
Progress sketch I	1–600,000		
Coast map and chart, No. 108, Matagorda and Lavaca bays, Texas.	1–80,000	Finished map and chart	In progress.
General coast chart, No. XVI, from Galveston bay to the Rio Grande, Texas.	1–400,000	Finished chart	Do.
SECTION X.			
Progress sketch J, No. 2, (from Point Sal to Tomales bay)	1–600,000		
Napa creek, (new edition)	1–30,000	Finished map	Completed; outline by photography.
Tomales bay	1–30,000	Preliminary chart	Do.
Drake's bay, (new edition)	1–40,000	Finished map	In progress; outline by photography.
Petaluma creek	1–30,000	......do	Completed; outline by photography.
San Francisco bay, (lower part)	1–50,000	Finished map	In progress.
San Francisco bay and vicinity, from Bodega Head to Point Pinos.	1–200,000	Preliminary chart	Do.
SECTION XI.			
Progress sketch K	1–600,000		
Washington sound and approaches, (additions)	1–200,000	Preliminary chart	Completed.
Koos bay, Oregon	1–20,000	......do	Do.
MISCELLANEOUS.			
Diagram shrinkage of paper	....	Diagram	Completed.
Diagram to illustrate cotidal lines, Gulf of Mexico	....	......do	Do.

Report of Mr. Edward Wharton, acting in charge of Engraving Division.

U. S. COAST SURVEY OFFICE, *October* 31, 1862.

I have the honor to present the annual report of the operations of this division during the year ending October 31, 1862.

The division has remained under my charge since the date of the last report, and I have been very materially assisted in the discharge of its duties by *Mr. C. C. Callan* as clerk to the division, and whose valuable services, I regret to say, we have lately been deprived of by his transfer to the Adjutant General's office. The position of clerk is now filled by *Mr. G. J. Pinckard.*

The operations of the division have continued the same as in previous years, and the system of engraving upon copper from drawings reduced by photography has been further prosecuted with increasing success; and at the present time there are seven charts of the most important localities on our coast, of the $\frac{1}{80000}$ series, engraving from these reductions.

The practice of engraving the figures of soundings by means of punches has received continued attention, and promises to be successfully used for at least the second-class charts, if not for those executed in the highest style of art.

The engraving force has remained the same as last year, consisting of twenty-three engravers, of various degrees of skill. The usual detailed statement of the occupation of each is given below. During the last month the services of five of these have been dispensed with, owing to the necessity of a reduction in the office expenses, arising from the diminished appropriation for the year.

The engraving of the following finished maps and charts has been completed, viz: coast chart No. 35, Chesapeake bay, (No. 5,) from Pocomoke sound to York river, $\frac{1}{80000}$; Sapelo sound, Ga., $\frac{1}{30000}$; Ossabaw sound, Ga., $\frac{1}{30000}$; St. Simon's sound, Ga., $\frac{1}{40000}$; St. Mary's river and Fernandina harbor, Fla., $\frac{1}{20000}$; St. Augustine harbor, Fla., $\frac{1}{30000}$; and various corrections and additions to the following charts, previously reported as finished, have been made: coast chart No. 31, Chesapeake bay, (No. 1,) from head of bay to the Magothy river, $\frac{1}{80000}$; coast chart No. 32, Chesapeake bay, (No. 2,) from the Magothy to the Hudson river, $\frac{1}{80000}$; coast chart No. 33, Chesapeake bay, (No. 3,) from the Hudson to the Potomac river, $\frac{1}{80000}$; and coast chart No. 92, western part of Mississippi sound, from Round island to Grand island, $\frac{1}{80000}$.

The following maps and charts have been prepared for preliminary editions, viz: Barnstable harbor, Mass., $\frac{1}{20000}$; Mount Hope bay, R. I., $\frac{1}{40000}$; coast chart No. 21, New York bay and harbor, $\frac{1}{80000}$; Hudson river, (No. 2,) from Haverstraw to Poughkeepsie, $\frac{1}{60000}$; western part of St. George's sound, Fla., $\frac{1}{40000}$; Escambia and Santa Maria de Galvaez bays, Fla., $\frac{1}{30000}$; Petaluma and Napa creeks, Cal., $\frac{1}{30000}$; Tomales bay, Cal., $\frac{1}{30000}$; Coquille river, Oregon, $\frac{1}{10000}$; Koos bay, Oregon, $\frac{1}{20000}$; Shoalwater bay, Washington Territory, $\frac{1}{80000}$; and Washington sound, Washington Territory, (new edition,) $\frac{1}{200000}$.

Considerable progress has also been made towards completion upon the following important charts, viz: coast charts Nos. 8, 9, and 11, $\frac{1}{80000}$, embracing portions of the coast of Maine, all of New Hampshire, and part of Massachusetts; Sheepscot and Kennebec rivers, Me., $\frac{1}{40000}$; Portland harbor, Me., $\frac{1}{20000}$, now nearly completed; Hudson river, (No. 1,) $\frac{1}{60000}$, from entrance to Haverstraw; Patuxent river, Md., (lower sheet,) $\frac{1}{60000}$; coast chart No. 36, Chesapeake bay, (No. 6,) $\frac{1}{80000}$, from entrance to York river; coast chart No. 71, Florida reefs, from New-found Harbor key to Boca Grande key, $\frac{1}{80000}$; Savannah river, Ga., $\frac{1}{40000}$; general coast chart No. X, Florida reefs, from Key Biscayne to Marquesas keys, $\frac{1}{400000}$; coast chart No. 106, Galveston bay to Oyster bay, Texas, $\frac{1}{80000}$; San Pablo bay, Cal., $\frac{1}{50000}$, now nearly completed; and Drake's bay, Cal., $\frac{1}{40000}$.

The following important charts have been commenced, viz: coast chart No. 7, Muscongus bay to Portland, Me., $\frac{1}{80000}$; coast chart No. 10, Cape Ann to Plymouth, Mass., $\frac{1}{80000}$; Potomac river, (No. 3,) from Lower Cedar Point to Indian Head, $\frac{1}{60000}$; coast chart No. 37, from Cape Henry to Currituck sound, N. C., $\frac{1}{80000}$; coast chart No. 70, Long key to Big Pine key, Fla., $\frac{1}{80000}$; coast chart No. 81, Cedar keys to Chassahowitzka river, Fla., $\frac{1}{80000}$; coast chart No. 93, Lakes Borgne and Pontchartrain, La., $\frac{1}{80000}$; and general coast chart No. IV, from Cape May to Currituck, $\frac{1}{400000}$.

The engraving force has been principally employed as follows:

Mr. McCoy, topographical engraver, has continued the topography upon coast chart No. 11, Plymouth harbor to Hyannis harbor, Mass., $\frac{1}{80000}$, from photographic reductions; engraved a view upon Portland harbor, Me., $\frac{1}{40000}$, and one upon coast chart No. 8, Seguin island to Kennebunkport, Me., $\frac{1}{80000}$.

Mr. Knight, letter engraver, has engraved the title, notes, and general lettering upon coast chart No. 21, New York bay and harbor, $\frac{1}{80000}$; a portion of the soundings upon coast chart No. 9, Cape Neddick to Cape Ann, Mass., $\frac{1}{80000}$; and coast chart No. 11, Plymouth harbor to Hyannis harbor, Mass., $\frac{1}{80000}$; soundings and notes upon Hudson river, (No. 2,) from Haverstraw to Poughkeepsie, $\frac{1}{60000}$; additional soundings upon Hudson river, (No. 1,) from entrance to Haverstraw, $\frac{1}{60000}$; and various corrections and additions to other plates.

Mr. Rollé, topographical engraver, has been employed principally in continuing the topography upon coast chart No. 9, Cape Neddick to Cape Ann, Mass., $\frac{1}{80000}$, and coast chart No. 11, Plymouth harbor to Hyannis harbor, Mass., $\frac{1}{80000}$, entirely from photographic reductions.

Mr. Enthoffer, topographical engraver, has continued the topography upon coast chart No. 8, Seguin island to Kennebunkport, Me., $\frac{1}{80000}$, and has made considerable progress upon coast chart No. 7, Muscongus bay to Portland, Me., $\frac{1}{80000}$, both from photographic reductions.

Mr. Sengteller, topographical engraver, has completed the topography upon coast chart No. 36, Chesapeake bay, (No. 6,) York river to entrance of bay, $\frac{1}{80000}$; and has commenced the topography upon coast chart No. 37, from Cape Henry to Currituck sound, $\frac{1}{80000}$.

Mr. Phillips, topographical engraver, completed the topography and afterwards the sanding upon coast chart No. 35, Chesapeake bay, (No. 5,) from Pocomoke sound to York river, $\frac{1}{80000}$; and is at present employed upon the topography of coast chart No. 93, Lakes Borgne and Pontchartrain, La., $\frac{1}{80000}$.

Mr. Metzeroth, topographical engraver, completed the topography and a portion of the sand upon Portland harbor, Me., $\frac{1}{40000}$; has engraved some additional sand upon coast chart No. 12, Nantucket sound, Mass., $\frac{1}{80000}$, (lower half,) and coast chart No. 92, western part of Mississippi sound, from Round island to Grand island, $\frac{1}{80000}$; the dry sand upon coast chart No. 21, New York bay and harbor, $\frac{1}{80000}$; and is at present employed upon the views upon San Pablo bay, Cal., $\frac{1}{50000}$.

Mr. Blondeau, topographical engraver, has engraved the topography upon general coast chart No. X, Florida reefs, from Key Biscayne to Marquesas keys, $\frac{1}{400000}$; a portion of the topography upon coast chart No. 70, Long key to Big Pine key, Fla., $\frac{1}{80000}$; has completed the topography upon coast chart No. 71, Florida reefs, from New-found Harbor key to Boca Grande key, $\frac{1}{80000}$; and upon coast chart No. 81, from Cedar keys to Chassahowitzka river, Fla., $\frac{1}{80000}$.

Mr. Evans, topographical engraver, has continued the topography, as far as material in the office, upon Sheepscot and Kennebec rivers, Maine, $\frac{1}{40000}$; and is now engaged upon Hudson river No. 1, from entrance to Haverstraw, $\frac{1}{60000}$.

Mr. Barnard, topographical engraver, has engraved the sand upon general coast chart No. 10, Florida reefs, Key Biscayne to Marquesas keys, $\frac{1}{400000}$; coast chart No. 71, Florida keys, from New-found Harbor key to Boca Grande key, $\frac{1}{80000}$; a portion of the sand upon Sheepscot and Kennebec rivers, Maine, $\frac{1}{40000}$; and is now engaged upon the sand of coast chart No. 36, Chesapeake bay No. 6, from York river to entrance of bay, $\frac{1}{80000}$.

Mr. A. Maedel, topographical engraver, has completed the topography upon Sapelo sound, Georgia, $\frac{1}{30000}$; and is now engraving the topography upon Potomac river No. 3, from Lower Cedar Point to Indian Head, $\frac{1}{60000}$.

Mr. Kondrup, miscellaneous engraver, has engraved a portion of the topography upon Patuxent river, Md., (lower sheet,) $\frac{1}{60000}$; and is now engaged upon the outlines of coast chart No. 10, Cape Ann to Plymouth, Mass., $\frac{1}{80000}$.

Mr. E. A. Maedel, letter engraver, engraved the title, and general lettering upon Hudson river No. 2, from Haverstraw to Poughkeepsie, $\frac{1}{60000}$; a portion of the soundings and general lettering upon Sheepscot and Kennebec rivers, Maine, $\frac{1}{40000}$; and miscellaneous corrections and additions in hydrography and lettering upon various charts, Nos 8, 9, 14, 21, 71, and 92; and is now engaged upon the soundings of general coast chart No. 4, from Cape May to Currituck, $\frac{1}{400000}$.

Mr. Ogilvie, miscellaneous engraver, has completed the sand upon Savannah river, Georgia, $\frac{1}{40000}$; San Pablo bay, California, $\frac{1}{50000}$; and upon coast chart No. 106, from Galveston bay to Oyster bay, Texas, $\frac{1}{80000}$.

Mr. Langran, letter engraver, has finished the notes upon Cedar keys, Florida, $\frac{1}{50000}$; the sailing directions, and corrections in soundings on Rappahannock No. 6, (lower sheet,) $\frac{1}{60000}$; additional soundings on Washington sound, Washington Territory, (new edition,) $\frac{1}{200000}$; the outlines of Barnstable harbor, Mass., $\frac{1}{20000}$; and some miscellaneous work.

Mr. Petersen, miscellaneous engraver, has engraved the topography on Ossabaw sound, Georgia, $\frac{1}{30000}$;

the outlines, soundings, title, and general lettering on Petaluma and Napa creeks, California, $\frac{1}{30000}$; the soundings, title, notes, and lettering on Tomales bay, California, $\frac{1}{30000}$; and on Barnstable harbor, Mass., $\frac{1}{20000}$; and miscellaneous work.

Mr. Bartle, topographical engraver, has completed the topography upon St. Mary's river and Fernandina harbor, Florida, $\frac{1}{20000}$; the dry sand upon Koos bay, Oregon, $\frac{1}{20000}$; and upon Petaluma and Napa creeks, California, $\frac{1}{30000}$; and some miscellaneous work; and is now engaged upon the wet sand of Petaluma and Napa creeks, California.

Mr. W. A. Thompson, topographical engraver, has engraved the topography upon St. Simon's sound, Georgia, $\frac{1}{40000}$; and upon Escambia and Santa Maria de Galvaez bays, Florida, $\frac{1}{30000}$; and corrections and additions to the progress sketches; and is now employed upon Drake's bay, California, $\frac{1}{40000}$, in engraving a system of hill curves or contour lines.

Mr. Benner, miscellaneous engraver, has engraved the sand and topography upon Shoalwater bay, Washington Territory, $\frac{1}{80000}$; a portion of the topography on Savannah river, Georgia, $\frac{1}{40000}$; the sand on Hudson river No. 2, from Haverstraw to Poughkeepsie, $\frac{1}{60000}$; besides progress sketches and miscellaneous work.

Mr. Klakring, miscellaneous engraver, has engraved the topography, sand, title, notes, and lettering on Coquille river, Oregon, $\frac{1}{10000}$; the soundings, title, notes, and lettering on Koos bay, Oregon, $\frac{1}{20000}$; and a large amount of work on progress sketches, and miscellaneous retouching and correcting.

Mr. Sipe, miscellaneous engraver, was transferred to the printing division during the greater portion of the year, on account of the great press of work.

Since his return to this division, in June, he has engraved diagrams of magnetic observations at Girard College, Philadelphia; some work on progress sketches; and the outlines, title, notes, and lettering on Mount Hope bay, Rhode Island, $\frac{1}{40000}$.

Mr. J. G. Thompson, miscellaneous engraver, has engraved the topography upon St. Augustine harbor, Florida, $\frac{1}{30000}$; all the triangulation and lettering upon the new progress sketch, Sec. 1, (upper sheet,) $\frac{1}{400000}$, and miscellaneous work.

Mr. Buckle has punched the soundings on diagram expansion of drawing paper; on a basso of New London harbor, as a specimen; and on Mount Hope bay, Rhode Island; and has executed some miscellaneous work, and has perfected himself in the practice of punching.

Mr. Davis, apprentice, has been employed on miscellaneous work and practice.

List of maps, preliminary charts, and sketches engraved or engraving during the year ending October 31, 1862, *arranged in order of sections.*

Name.	Scale.	Description.	Remarks.
SECTION I.			
Progress sketch "A," upper sheet, (new plate)	1-400,000	Sketch	Engraved.
Do. "A," lower sheet	1-400,000	do	Do.
Do. "A" *bis*	1-600,000	do	Do.
Coast chart, No. 7, Muscongus bay to Portland harbor, Me.	1-80,000	Finished map and chart.	Engraving.
Coast chart, No. 8, Seguin island to Kennebunkport, Me.	1-80,000	do	Do.
Coast chart, No. 9, Cape Neddick to Cape Ann, Mass.	1-80,000	do	Do.
Coast chart, No. 10, Cape Ann to Plymouth, Mass.	1-80,000	do	Do.
Coast chart, No. 11, Plymouth to Hyannis, Mass.	1-80,000	do	Do.
Kennebec and Sheepscot rivers, Me.	1-40,000	Finished chart	Do.
Portland harbor, Me.	1-20,000	Finished harbor chart	Do.
Barnstable harbor, Mass.	1-20,000	do	Do.
Mount Hope bay, R. I.	1-40,000	Preliminary chart	Engraved.
Salem harbor, Mass., (corrections and additions)	1-25,000	Finished chart	Do.
SECTION II.			
Progress sketch New York bay and Hudson river	1-100,000 1-200,000	Sketch	Engraved.
Coast chart, No. 21, New York bay and harbor	1-80,000	Finished map and chart	Engraving.
Hudson river, No. 1, entrance to Haverstraw	1-60,000	Finished chart	Do.
Hudson river, No. 2, Haverstraw to Poughkeepsie	1-60,000	do	Do.

List of maps, preliminary charts, and sketches, &c.—Continued.

Name.	Scale.	Description.	Remarks.
SECTION III.			
Progress sketch "C"	1-400,000	Sketch	Engraved.
General coast chart, No. 4, Cape May to Currituck	1-400,000	Finished chart	Engraving.
Coast chart, No. 31, Chesapeake bay, No. 1, (corrections and additions)	1-80,000	Finished map and chart	Engraved.
Coast chart, No. 32, Chesapeake bay, No 2, (corrections and additions)	1-80,000	do	Do.
Coast chart, No. 33, Chesapeake bay, No. 3, (corrections and additions)	1-80,000	do	Do.
Coast chart, No. 35, Chesapeake bay, No. 5	1-80,000	do	Do.
Coast chart, No. 36, Chesapeake bay, No. 6	1-80,000	do	Engraving.
Patuxent river, Md., (lower sheet)	1-60,000	Finished chart	Do.
Potomac river, No 3, Lower Cedar Point to Indian Head	1-60,000	do	Do.
SECTION IV.			
Progress sketch "D"	1-400,000	Sketch	Engraved.
Coast chart, No. 37, from Cape Henry to Currituck	1-80,000	Finished chart	Engraving.
SECTION V.			
Progress sketch "E"	1-600,000	Sketch	Engraved.
Sapelo sound, Ga	1-30,000	Finished chart	Do.
St. Simon's sound, Ga	1-40,000	do	Do.
Ossabaw sound, Ga	1-30,000	do	Do.
Savannah river, Ga	1-40,000	do	Engraving.
SECTION VI.			
Progress sketch "F," Florida peninsula	1-1,200,000	Sketch	Engraved.
Progress sketch "F," *bis*, Florida reefs and keys	1-400,000	do	Do.
General coast chart, No. X, Key Biscayne to Marquesas keys, Fla.	1-400,000	General coast chart	Engraving.
Coast chart, No. 70, Garden key to Lower Metacombe key, Fla.	1-80,000	Coast map and chart	Do.
Coast chart, No. 71, Newfound Harbor key to Boca Grande key, Fla.	1-80,000	do	Do.
St. Mary's river and Fernandina harbor, Fla.	1-20,000	Finished chart	Engraved.
St. Augustine harbor, Fla	1-30,000	do	Do.
SECTION VII.			
Progress sketch "G"	1-600,000	Sketch	Engraved.
Coast chart, No. 81, Cedar keys to Chassahowitzka river, Fla.	1-80,000	Coast map and chart	Engraving.
Western part St. George's sound, Fla	1-40,000	Preliminary chart	Engraved.
SECTION VIII.			
Progress sketch "H"	1-600,000	Sketch	Engraved.
Coast chart, No. 92, western part of Mississippi sound, (additions and corrections)	1-80,000	Coast map and chart	Do.
Coast chart, No. 93, Lakes Borgne and Pontchartrain, La.	1-80,000	do	Engraving.
Escambia and Santa Maria de Galvaez bays, Fla	1-30,000	Preliminary chart	Engraved.
SECTION IX.			
Progress sketch "I"	1-600,000	Sketch	Engraved.
Coast chart, No. 106, Galveston bay to Oyster bay, Texas	1-80,000	Coast map and chart	Engraving.
SECTION X.			
Progress sketch "J," lower sheet	1-600,000	Sketch	Engraved.
Progress sketch "J," middle sheet	1-600,000	do	Do.
Drake's bay, Cal	1-40,000	Finished chart	Engraving.
San Pablo bay, Cal	1-50,000	Finished harbor chart	Do.
Petaluma and Napa creeks, Cal	1-30,000	do	Do.
Tomales bay, Cal	1-30,000	do	Do.
SECTION XI.			
Progress sketch "K"	1-600,000	Sketch	Engraved.
Coquille river, Oregon	1-10,000	do	Do.
Koos bay, Oregon	1-20,000	Finished chart	Engraving.
Washington sound, W. T., (new edition)	1-200,000	Preliminary chart	Engraved.
MISCELLANEOUS.			
Diagram magnetic horizontal intensity observations		Diagram	Engraved.
Diagram contraction and expansion of drawing paper		do	Do.
Diagram eclipse of 1860		do	Do.

LIST OF COAST SURVEY MAPS, PRELIMINARY CHARTS, AND SKETCHES, ENGRAVED, GEOGRAPHICALLY ARRANGED.

1. *List of maps and charts engraved.*

No.		
1.	Richmond's island, Maine	1–20,000
2.	Newburyport harbor, Massachusetts	1–20,000
3.	Ipswich and Annisquam harbors, Massachusetts	1–20,000
4.	Rockport harbor … do	1–20,000
5.	Gloucester harbor … do	1–20,000
6.	Salem harbor … do	1–25,000
7.	Lynn harbor … do	1–20,000
8.	Boston harbor, (new edition,) 1859 … do	1–40,000
9.	Plymouth harbor … do	1–20,000
10.	Wellfleet harbor … do	1–50,000
11.	Provincetown harbor … do	1–50,000
12.	Bass River harbor … do	1–40,000
13.	Nantucket harbor … do	1–20,000
14.	Muskeget channel, Massachusetts, (new edition)	1–60,000
15.	Hyannis harbor … do	1–30,000
16.	Harbor of Edgartown … do	1–20,000
17.	Harbor of Wood's Hole … do	1–20,000
18.	Harbor of Holmes's Hole and Tarpaulin Cove	1–20,000
19.	Harbor of New Bedford, Massachusetts	1–40,000
20.	General chart of the coast from Gay Head to Cape Henlopen	1–40,000
21.	Fisher's Island sound, Connecticut	1–40,000
22.	Harbor of New London … do	1–20,000
23.	Mouth of Connecticut river … do	1–20,000
24.	Harbor of New Haven … do … (new edition,) 1852	1–30,000
25.	Harbors of Black Rock and Bridgeport, Connecticut, (new edition,) 1852	1–20,000
26.	Harbors of Sheffield and Caukin's islands, (new edition,) 1852	1–20,000
27.	Huntington bay, New York	1–30,000
28.	Oyster bay or Syosset harbor, New York	1–30,000
29.	Harbors of Captain's island, east and west, Connecticut	1–20,000
30.	Hempstead harbor, Long Island, New York	1–20,000
31.	Hart and City island, and Sachem's Head harbor, New York	1–20,000 & 1–10,000
32.	Hell Gate … do	1–5,000
33.	Coast chart No. 15, Long Island sound—east	1–80,000
34.	Do … No. 16 … do … do … middle	1–80,000
35.	Do … No. 17 … do … do … west	1–80,000
36.	Do … No. 18 … do … do … south coast, west	1–30,000
37.	Do … No. 19 … do … do … do … middle	1–80,000
38.	Do … No. 20 … do … do … do … east	1–80,000
39.	New York bay and harbor, and the environs of New York, No. 1	1–30,000
40.	Do … do … do … do … No. 2	1–30,000
41.	Do … do … do … do … No. 3	1–30,000
42.	Do … do … do … do … No. 4	1–30,000
43.	Do … do … do … do … No. 5	1–30,000
44.	Do … do … do … do … No. 6	1–30,000
45.	Do … do … do … do	1–80,000
46.	Little Egg harbor, New Jersey	1–30,000
47.	Coast chart No. 25, Delaware bay and river, sheet No. 1, Delaware	1–80,000
48.	Coast chart No. 26, Delaware bay and river, sheet No. 2, Delaware, New Jersey, and Pennsylvania	1–80,000
49.	Coast chart No. 27, Delaware bay and river, sheet No. 3	1–80,000

No. 50.	Coast chart No. 31, Chesapeake bay No. 1, (upper series)	1–80, 000
51.	Do.....No. 32......do.......No. 2..... do	1–80, 000
52.	Do.....No. 33......do.......No 3..... do	1–80, 000
53.	Do.....No. 35......do.......No. 5, (lower series)	1–80, 000
54.	Patapsco river, Maryland	1–60, 000
55.	Harbor of Annapolis and Severn river, Maryland	1–60, 000
56.	Mouth of Chester river.................do	1–40, 000
57.	St. Mary's river, Cornfield harbor and Point Lookout, Maryland	1–60, 000
58.	Rappahannock river, sheet No. 1, from Fredericksburg to Moss Neck, Virginia	1–60, 000
59.	Do.........sheet No. 2, from Moss Neck to Port Royal......do	1–60, 000
60.	Do.........sheet No. 6, from entrance to Deep creek........do	1–60, 000
61.	York river, from entrance to King's creek..................do	1–60, 000
62.	Do....from King's creek to West Point.........................do	1–60, 000
63.	Pasquotank river, North Carolina	1–60, 000
64.	Coast chart No. 40, Albemarle sound, North Carolina, west	1–80, 000
65.	Do.....No. 41........do.............do...... east	1–80, 000
66.	Beaufort harbor.........................do	1–20, 000
67.	Cape Fear river, from entrance to Federal Point, North Carolina	1–30, 000
68.	Do....do...from Federal Point to Wilmington ....do	1–30, 000
69.	Charleston harbor, South Carolina, (new edition,) 1858	1–30, 000
70.	North Edisto river....do........(new edition)	1–50, 000
71.	Ossabaw sound, Georgia	1–30, 000
72.	Sapelo sound....do	1–30, 000
73.	St. Simon's sound, Brunswick harbor, and Turtle river, Georgia	1–40, 000
74.	St. Mary's river and Fernandina harbor, Florida	1–20, 000
75.	St. John's river, from entrance to Brown's creek, Florida	1–25, 000
76.	St. Augustine harbor..........................do	1–30, 000
77.	Key West harbor and approaches................do	1–50, 000
78.	Coast chart No. 68, Florida reefs, Key Biscayne to Carysfort reef, Florida	1–80, 000
79.	Entrance to Pensacola bay	1–30, 000
80.	Entrance to Mobile bay, Alabama	1–40, 000
81.	Coast chart No. 90, Mobile bay, Alabama	1–80, 000
82.	Do.....No. 91, eastern part of Mississippi sound, Bonsecour's bay to Round island	1–80, 000
83.	Do.....No. 92, western part of Mississippi sound, Round island to Grand island	1–80, 000
84.	Cat and Ship Island harbors, Mississippi	1–40, 000
85.	Entrance to Galveston bay, Texas, (new edition,) 1856	1–40, 000
86.	San Diego bay, California	1–40, 000
87.	Entrance to San Francisco bay, California	1–50, 000
88.	Mare Island straits..............do	1–30, 000

2. *List of preliminary charts and sketches engraved.*

No. 1.	Alden's rock, Maine	1–1000
2.	Edgemoggin reach, Maine	1–20, 000
3.	Kennebec river......do	1–30, 000
4.	Portland harbor.....do	1–20, 000
5.	Do.....(commisioner's line,) Maine	1–10, 000
6.	York river harbor..................do	1–20, 000
7.	Portsmouth harbor, New Hampshire	1–20, 000
8.	Stellwagen's bank, (second edition,) Massachusetts	1–400, 000
9.	Boston bay......................do	1–175, 000
10.	Current chart, Boston bay..............do	1–100, 000
11.	Minot's Ledge....................do	1–10, 000
12.	Sea-coast United States No. 4, south part of Massachusetts	1–200, 000
13.	Barnstable harbor, Massachusetts	1–20, 000

No. 14.	Nantucket shoals Massachusetts, (new edition)	1-200, 000
15.	Tidal currents, Nantucket shoals, Massachusetts	1-300, 000
16.	Sow and Pigs reef.......do	1-240, 000 & 1-20, 000
17.	Mount Hope bay, Rhode Island	1-40, 000
18.	Tidal currents, Long Island, New York	1-800, 000
19.	Coast chart No. 21, New York bay and harbor, New York	1-80, 000
20.	Pot rock and Way's reef.......do	
21.	Hudson river No. 1, from entrance to Haverstraw..do	1-60, 000
22.	Do....No. 2, from Haverstraw to Poughkeepsie, New York	1-60, 000
23.	Buttermilk channel.......do	1-5, 000
24.	Beacon ranges.......do	1-40, 000
25.	Romer shoals and Flynn's Knoll.......do	1-40, 000
26.	Changes in Sandy Hook, New Jersey	1-10, 000 & 1-40, 000
27.	Sea-coast, Delaware, Maryland, and part of Virginia	1-200, 000
28.	Delaware and Chesapeake bays	1-400, 000
29.	Patuxent river, Maryland, (upper sheet)	1-30, 000
30.	Do........do .....(lower sheet)	1-60, 000
31.	Chincoteague inlet, Virginia	1-40, 000
32.	Sea-coast of Virginia and entrance to Chesapeake bay	1-200, 000
33.	James river, (upper sheet,) Virginia	1-40, 000
34.	Rappahannock river, No. 3....do	1-20, 000
35.	Do......No. 4....do	1-20, 000
36.	Do..... No. 5....do	1-60, 000
37.	Wachapreague, Machipongo, and Metompkin inlets, Virginia	1-40, 000
38.	Ship and Sand Shoal inlets	1-40, 000
39.	Entrance to Chesapeake bay	1-100, 000
40.	Cape Charles and vicinity	1-80, 000
41.	Cherrystone inlet	1-40, 000
42.	Pungoteague inlet	1-40, 000
43.	Fishing or Donoho's battery, Maryland	1-80, 000
44.	Albemarle sound, North Carolina	1-200, 000
45.	North Landing river, Virginia and North Carolina	1-40, 000
46.	Diagrams showing the effect of the wind in elevating and depressing the water in Albemarle sound	
47.	Hatteras shoals, North Carolina	1-120, 000
48.	Cape Hatteras......do	1-20, 000
49.	Hatteras inlet...... do...... (fourth edition)	1-20, 000
50.	Ocracoke inlet...... do	1-40, 000
51.	Sea-coast of North Carolina, from Cape Hatteras to Ocracoke	1-200, 000
52.	Wimble shoals, North Carolina	1-80, 000
53.	Beaufort harbor......do	1-20, 000
54.	New river and bar....do	1-15, 000
55.	Frying Pan shoals....do	1-120, 000
56.	Cape Fear river and New inlet, North Carolina	1-40, 000
57.	Gulf Stream explorations, 1853	1-5, 000, 000
58.	Diagrams, Gulf Stream explorations, 1853	
59.	Gulf Stream explorations, 1854	1-5, 000, 000
60.	Diagrams, Gulf Stream explorations, 1854	
61.	Gulf Stream explorations, 1855	1-5, 000, 000
62.	Diagrams, Gulf Stream explorations, 1859	
63.	Do.....do..........do......1860	
64.	Gulf Stream chart, from 1845 to 1860	
65.	Cape Roman shoals, South Carolina	1-100, 000
66.	Sea-coast of the United States, No. 14, South Carolina	1-200, 000

No. 67.	Winyah bay and Cape Roman shoals, South Carolina	1–100, 000
68.	Do.... and Georgetown harbor .... do	1–40, 000
69.	Bull's bay .... do	1–40, 000
70.	Comparative chart, Maffitt's channel, South Carolina, (new edition)	1–5, 000
71.	Maffitt's channel, sections, South Carolina	
72.	Romerly marshes .... do	1–10, 000
73.	Savannah river entrance, Georgia	1–30, 000
74.	Savannah city, front and back rivers, Georgia	1–20, 000
75.	Savannah river .... do	1–40, 000
76.	Doboy bar and inlet .... do	1–40, 000
77.	St. Simon's sound and Brunswick harbor .. do	1–40, 000
78.	St. Andrew's shoal .... do	1–60, 000
79.	St. Mary's bar and Fernandina harbor, Florida, comparative chart	1–20, 000
80.	Mosquito inlet .... do	1–40, 000
81.	Cape Cañaveral .... do	1–60, 000
82.	Florida reefs .... do	1–200, 000
83.	Turtle harbor .... do	1–40, 000
84.	Beacons on Florida reefs .... do	
85.	Coffin's Patches .... do	1–20, 000
86.	Key Biscayne, Cape sable and bases .... do	1–60, 000 & 1–400, 000
87.	Legaré anchorage .... do	1–20, 000
88.	Key West harbor, (second edition) .... do	1–100, 000
89–94.	Do.... tidal diagrams .... do	
95.	Rebecca shoals .... do	1–600, 000
96.	Reconnaissance of vicinity of Cedar keys .. do	1–300, 000
97.	Channel No. 4, Cedar keys .... do	1–30, 000
98.	Cedar keys and approaches, (new edition) .. do	1–50, 000
99.	Ocilla river .... do	1–20, 000
100.	St. Mark's bar and channel .... do	1–40, 000
101.	Middle or main and western entrances, St. George's sound, Florida	1–80, 000
102.	Eastern part of St. George's sound .... do	1–40, 000
103.	Western .. do ...... do .... do	1–40, 000
104.	St. Andrew's bay .... do	1–40, 000
105.	Escambia and Santa Maria de Galvaez bays .... do	1–30, 000
106.	Sea-coast of part of Alabama and Mississippi	1–200, 000
107.	Mobile bay, (second edition,) Alabama	1–200, 000
108.	Horn Island pass and Grand bay, Mississippi	1–300, 000
109.	Do....... (new edition) .... do	1–40, 000
110.	Pascagoula river .... do	1–20, 000
111.	Biloxi bay .... do	1–40, 000
112–121.	Cat island tidal diagrams .... do	
122.	Pass Christian .... do	1–40, 000
123.	Delta of the Mississippi, Louisiana	1–60, 000
124.	Passe à l'Outre .... do	1–20, 000
125.	Gulf of Mexico, with profiles of deep-sea soundings, (new edition)	1–2, 400, 000
126.	Barataria bay entrance, Louisiana	1–30, 000
127.	Pass Fourchon .... do	1–10, 000
128.	Timballier bay entrance .... do	1–20, 000
129.	Isle Dernière or Ship Island shoals, Louisiana	1–80, 000
130.	Atchafalaya bay .... do	1–50, 000
131.	Entrance to Vermilion bay and Calcasieu river, Louisiana	1–30, 000 & 1–40, 000
132.	Sabine Pass, Texas	1–40, 000
133.	Sea-coast of Texas, from Galveston, south	1–200, 000
134.	Sea-coast of United States, No. 31, part of Texas	1–200, 000

No. 135.	San Luis Pass, Texas	1–20, 000
136.	Aransas Pass, (second edition,) Texas	1–30, 000
137.	Entrance to Brazos river........do	1–10, 000
138.	Do...to Rio Grande river....do	1–20, 000
139.	Diagrams of heights and luni-tidal intervals of diurnal and semi-diurnal tides in the Gulf of Mexico	
140–141.	Co-tidal lines, Gulf of Mexico, (2 plates)	
142.	Type curves......do	
143.	Wind curves, Cat island	
144.	Alden's reconnaissance, western coast, lower sheet, San Francisco to San Diego, (new edition,) California	1–1, 200, 000
145.	Cortez bank	1–100, 000 & 1–1, 200, 000
146.	San Diego entrance, (new edition,) California	1–150, 000 & 1–25, 000
147.	Geological map of San Diego........do	1–1, 608, 000
148.	Catalina harbor....................do	1–15, 000
149.	San Pedro anchorage and vicinity of Santa Barbara, California	1–20, 000 & 1–40, 000
150.	Anacapa island, (sketch,)........................do	
151.	Do......and east end of Santa Cruz island.....do	1–30, 000
152.	Prisoner's harbor, Cuyler's harbor, and north anchorage, San Clemente island, California	1–20, 000
153.	Santa Barbara, California	1–20, 000
154.	Eastern entrance to Santa Barbara channel, California	1–80, 000
155.	San Simeon, Santa Cruz, San Luis Obispo, and Coxo harbors, California	1–20, 000 & 1–40, 000
156.	Point Conception....................do	1–40, 000
157.	Point Piños....................do	1–20, 000
158.	Monterey harbor....................do	1–40, 000
159.	Monterey bay....................do	1–60, 000
160.	Geological map of Monterey....................do	1–150, 000
161.	Santa Cruz and Año Nuevo harbors....................do	1–1, 200, 000 & 1–40, 000
162.	San Pedro harbor....................do	1–20, 000
163.	Entrance to San Francisco bay....................do	1–400, 000
164.	San Francisco city, (new edition)....................do	1–10, 000
165.	Geological map of San Francisco....................do	1–150, 000
166.	South Farrallone island....................do	
167.	Tidal diagrams, Rincon Point....................do	
168.	Pulgas base....................do	1–400, 000
169.	San Antonio creek....................do	1–20, 000
170.	Petaluma and Napa creeks....................do	1–30, 000
171.	Alden's reconnaissance, western coast, middle sheet, San Francisco to Umpqua river, California and Oregon	1–1, 200, 000
172.	McArthur's reconnaissance, western coast, from Monterey to mouth of Columbia river, sheet No. 1, (third edition)	
173.	McArthur's reconnaissance, western coast, from Monterey to mouth of Columbia river, sheet No. 2, (third edition)	
174.	McArthur's reconnaissance, western coast, from Monterey to mouth of Columbia river, sheet No. 3, (third edition)	
175.	Alden's reconnaissance, western coast, northern sheet	1–1, 200, 000
176.	Point Reyes and Drake's bay, California	1–40, 000
177.	Drake's bay....................do	1–40, 000
178.	Geological map of Point Reyes.. do	
179.	Tomales bay....................do	1–30, 000
180.	Humboldt bay, (new edition)....do	1–30, 000
181.	Trinidad bay....................do	1–20, 000

No. 182.	Shelter Cove, Mendocino City, Crescent City harbors, and Port Orford, or Ewing harbor, California and Oregon	1–20, 000
183.	Crescent City harbor, California	1–20, 000
184.	Coquille river, Oregon	1–10, 000
185.	Koos bay......do	1–20, 000
186.	Umpqua river..do	1–20, 000
187.	Mouth of Columbia river, Oregon, (second edition)	1–40, 000
188.	Do.........do.......do	1–200, 000
189.	Entrance to Columbia river.do	1–40, 000
190.	Tidal diagrams, Rincon Point, San Diego and Astoria, California and Oregon	
191.	Cape Disappointment, Washington Territory	1–20, 000
192.	Shoalwater bay, Washington Territory	1–80, 000
193.	Alden's reconnaissance, western coast, from Gray's harbor to Admiralty inlet, Washington Territory	1–600, 000
194.	Greuville harbor, Washington Territory	1–20, 000
195.	Cape Flattery and Neè-ah harbor, Washington Territory	1–40, 000
196.	False Dungeness..........do	1–30, 000
197.	New Dungeness..........do	1–40, 000
198.	Washington sound, (new edition)..........do	1–200, 000 & 1–600, 000
199.	Port Townshend......do..........do	1–40, 000
200.	Duwamish bay and Seattle harbor..........do	1–10, 000
201.	Smith's or Blunt's island..........do	1–20, 000
202.	Port Ludlow..........do	1–20, 000
203.	Port Gamble..........do	1–20, 000
204.	Olympia harbor..........do	1–20, 000
205.	Steilacoom harbor..........do	1–30, 000
206.	Bellingham bay..........do	1–40, 000
207.	Blakely harbor..........do	1–10, 000
208.	Semi-ah-moo bay..........do	1–30, 000
209.	Base apparatus	
210.	Co-tidal lines, Atlantic coast	1–10, 000, 000
211.	Do....Pacific coast	1–10, 000, 000
212.	Self-registering tide-gauge	
213.	Craven's current indicator	
214.	Craven's specimen box for deep-sea soundings	
215.	Mitchell's sea-coast tide-gauge	
216.	Figures to illustrate Appendix No. 33, 1854	
217.	Diagrams of secular variation of magnetic dip, Atlantic coast	
218.	Diagrams of secular variation in magnetic declination, 1855	
219.	Lines of equal magnetic declination	1–1, 500, 000
220.	Boutelle's scaffold for stations, and Farley's signals	
221.	Boutelle's apparatus for measuring preliminary bases	
222.	Diagrams to illustrate earthquake waves at San Diego and San Francisco	
223.	Diagrams of secular variation in magnetic declination, 1856	
224.	Sands's gas-pipe tripod	
225.	Sands's specimen box for deep-sea soundings and revolving heliotropes	
226.	Map of magnetic declination	
227.	Map of magnetic dip and intensity	
228.	Apparatus for measuring minor bases	
229.	Polyconic development of sphere	
230.	Diagrams illustrating telegraphic methods for difference of longitude	
231.	Diagrams showing injury to boiler of steamer Hetzel	
232.	Project limits for charts $\frac{1}{200000}$ and $\frac{1}{400000}$	
233.	Diagrams of winds of the western coast	

Report of Mr. George Mathiot, in charge of the Electrotype and Photographic Division.

COAST SURVEY OFFICE, *Washington, October* 1, 1862.

I respectfully present the following report of the operations of the Electrotype and Photographic Division since October 1, 1861.

By the electrotype process we have made forty-three plates. Of this number twenty-seven were "altos," or moulds, and sixteen were "bassos," or duplicates of engraved plates.

The electrotype work in this office is now conducted with so much facility, certainty, and regularity, by means of the improved apparatus which has been introduced from time to time, keeping pace with the progress of physical science, that there now remains but little experimental interest in the work. Improvement in the process has ceased to be made, from the perfection attained; but experiment has, nevertheless, continued. The great improvement in the carbon plates employed for telegraphic batteries has induced me to test the practicability of employing these plates for the negative plates of our galvanic batteries. The experiment has shown that the substitution would be practicable, though not advantageous. I find a carbon plate possesses about one-half the energy of a silver plate of the same extent of surface, but that it has several "working" advantages over the latter. The first of these is in the exemption of the carbon from that liability of the silver to get amalgamated by the mercury on the zinc plates, which is not only a cause of great expense and annoyance, but completely prostrates the electrical action of the plate. The carbon appears also to be free from the deposits of copper and other base metals incidentally present in the batteries, which sometimes coat the silver plates and decrease their action. This last peculiar advantage of the carbon is probably owing to the porosity of the plate, by which the deposited metal is dissipated over a very large surface, and its action thus destroyed. But that the deposition really takes place, though rendered inactive by its great distribution, is shown by the fact that, with a strong metallic solution and long-continued action, the deposited metal at length appears on the surface. In this way I completely silver-plated a carbon plate; the silver was, however, all dissolved off again in the course of a couple of days by the action of the cyanogen retained in the pores of the plate. I also find that the carbon plates, as well as the silver plates, can have their action advantageously increased by platinizing.

During the year occasion has been taken to renew entirely the platinized silver as well as the zinc plates of the batteries, and to put the electrotype apparatus in complete order; it is now more effective than it has been at any former time.

The photographic reduction of the plane-table sheets of the survey has continued in successful operation, and maintains that high importance and utility which I announced for it in my last annual report. The number of sheets reduced has indeed fallen off, from the effect of the current war on the operations of the survey, but this falling off in our own appropriate work has been more than made up by photographs for our army. That facility which photography presents for rapidly copying has caused this division to be busy in multiplying important plans, maps, and reconnaissances connected with the operations of our armies in the field. During the year we have photographed forty-four separate military maps, and furnished five hundred and sixty-two copies of the same. Of the value of these maps, and their aid in the prosecution of the war, my position or information does not enable me to judge. I do know, however, that if these photographs were of aid to our commanding generals, the country is indebted for that aid particularly to the survey; for it is only by the perfection of the photographic apparatus and methods of this office that those large and detailed military maps could have been photographed as required.

The photographic art has lately been enriched by the production of a new form of lens by our countryman, Mr. C. C. Harrison, the well-known working optician of New York. I have been so fortunate as to procure from Mr. Harrison the very first lens of this manufacture, but the few weeks that I have had it in hand have not sufficed for me to test all its qualities as I could wish for a definite statement to accompany this report. Its superiority, however, over all other forms of lenses I find to be conspicuous, and immediately strikes the observer. Its angle of vision is surprisingly great, with a very flat field; it also bears more light and has a better defining power than other lenses. With this improved lens I expect to greatly increase the utility of our photographic operations, by being able to make single photographs of thirty inches square, if not greater.

During the year I have paid much attention to the new art called photo-lithography. The result of all my observations has been to confirm me in the opinion which I formerly expressed, that this process, as at present known, is too coarse and mechanical in its nature and uncertain in practice to be of *practical* service in copying maps or drawings possessing any fineness of outline or delicacy of finish.. The new lens of which I have spoken above will, however, enable us to obtain such negatives as will do away with much of the uncertainty which attends the process. I will, therefore, again endeavor to apply photo-lithography to the coarser maps and drawings of the survey.

During the year I have been assisted by Mr. D. Hinkle, with his usual industry and fidelity.

Tables of the electrotypes and photographs produced during the year are appended:

List of plates electrotyped in "Alto."

Name of chart.	No. made.
Coast chart No. 14, from entrance to Buzzard's bay to Block island	1
Coast chart No. 13, from Muskeget channel to Buzzard's bay	1
Coast chart No. 12, from Monomoy to Hyannis	1
Coast chart No. 40, Albemarle sound	1
Shoalwater bay	1
Chesapeake bay, No. 1	1
Chesapeake bay, No. 2	1
Chesapeake bay, No. 3	1
Coast chart No. 106, Galveston bay to Oyster bay	1
Salem harbor	1
St. George's sound	1
General coast chart No. III, Gay Head to Cape Henlopen	1
Lake Huron	1
Barnstable harbor	1
New York bay and harbor	1
Escambia and Santa Maria de Galvaez bays	1
Coast chart No. 68, Florida reefs	1
Ossabaw sound	1

Name of chart.	No. made.
Entrance to the Rio Grande	1
Bull's bay	1
Drake's bay	1
Preliminary sea-coast chart No. 31, Texas	1
Doboy bar and inlet	1
Winyah bay and Cape Roman shoals	1
Coast chart No. 40, Albemarle sound	1
Mississippi sound, middle part	1

List of plates electrotyped in "Basso."

Coast chart No. 40, Albemarle sound	1
Preliminary sea-coast chart No. 31, Texas	1
Mississippi sound, middle part	1
Coast chart No. 68, Florida reefs	1
Coast chart No. 41, Albemarle sound	1
New London harbor	1
Chesapeake bay, No. 1	1
Chesapeake bay, No. 2	1
Chesapeake bay, No. 3	1
York river entrance	1
Salem harbor	1
St. George's sound	1
General coast chart No. III, from Gay Head to Cape Henlopen	1
Barnstable harbor	1
Lake Huron	1
New York bay and harbor	1

Table of photographs.

Prototypes.	Scale.	POSITIVES.		NEGATIVES.		PRINTS.	
		No.	Scale.	No.	Scale.	No.	Scale.
Map of the District of Columbia, by A. Boschke	4 inches to 1 mile			1	1-30,000	19	1-30,000
Map of the District of Columbia, by A. Boschke	do			1	1-40,000	1	1-40,000
A tracing from a map of Loudon county, Virginia				1	½ inch to 1 mile	25	½ inch to 1 mile.
A tracing from a map of Jefferson county, Virginia				1	do	25	do
A tracing from a map of Berkeley county, Virginia				1	do	25	do
Map of the physical geography of Virginia				1		6	
A tracing from topographical sheet No. —, (Patuxent river)	1-20,000	1	1-60,000	1	1-60,000	1	1-60,000
A tracing from topographical sheet No. —, (Napa creek)	1-10,000	1	1-60,000	1	1-60,000	1	1-60,000
A tracing from topographical sheet No. 381, (Patuxent river)	1-20,000	1	1-60,000	1	1-60,000	1	1-60,000
A tracing from topographical sheet No. 388, (Patuxent river)	1-20,000	1	1-60,000	1	1-60,000	1	1-60,000
Map of the approaches to Washington on the northwest	1-15,000			1	1-30,000	29	1-30,000
Map of the south side of the Potomac river, above Washington	1-15,000			1	1-30,000	29	1-30,000

Table of photographs—Continued.

Prototypes.	Scale.	Positives.		Negatives.		Prints.	
		No.	Scale.	No.	Scale.	No.	Scale.
Map of Anne Arundel county, Maryland, (traced)				1	½ inch to 1 mile	10	½ inch to 1 mile.
Map of Howard county, Md., (traced)				1	do	11	do
Map of Washington county, Maryland, (traced)				1	do	55	do
Plane-table sheet No. —, (not yet registered.) San Pablo bay	1-10,000			1	1-40,000	1	1-40,000
Plane-table sheet No. —, (not yet registered,) San Pablo bay	1-10,000			1	1-40,000	1	1-40,000
A tracing from plane-table sheet No. —, San Pablo bay	1-10,000			1	1-40,000	1	1-40,000
A tracing from plane-table sheet No. —, San Pablo bay	1-10,000			1	1-40,000	1	1-40,000
A tracing from plane-table sheet No. —, San Pablo bay	1-10,000			1	1-40,000	1	1-40,000
A tracing from plane-table sheet No. —, San Pablo bay	1-10,000			1	1-40,000	1	1-40,000
Plane-table sheet No. 400, (not yet registered,) San Pablo bay	1-10,000			1	1-40,000	1	1-40,000
Plane-table sheet No. 334, (not yet registered,) San Pablo bay	1-10,000			1	1-40,000	1	1-40,000
Plane-table sheet No. 472, (not yet registered,) San Pablo bay	1-10,000			1	1-80,000	1	1-80,000
Plane-table sheet No. 415, (not yet registered,) San Pablo bay				1	1-80,000	1	1-80,000
Plane-table sheet No. 321, (not yet registered,) San Pablo bay				1	1-80,000	1	1-80,000
Plane-table sheet No. 361, (not yet registered,) San Pablo bay				1	1-80,000	1	1-80,000
A tracing—reconnaissance of part of Montgomery county, Maryland	1-15,000			1	1-30,000	25	1-30,000
A drawing—topographic survey near Alexandria, Virginia	1-15,000			1	1-30,000	10	1-30,000
A tracing from plane-table sheet No. 728, coast map, No. 7	1-10,000	1	1-80,000	2	1 of 1-40,000 1 of 1-80,000	2	1 of 1-40,000 1 of 1-80,000
A tracing from plane-table sheet No. 728, coast map, No. 7	1-10,000	1	1-80,000	2	1 of 1-40,000 1 of 1-80,000	2	1 of 1-40,000 1 of 1-80,000
A tracing from plane-table sheet Nos. 801 and 802, coast map, No. 7	1-10,000	1	1-80,000	2	1 of 1-40,000 1 of 1-80,000	2	1 of 1-40,000 1 of 1-80,000
A tracing map of Frederick county, Md				1	½ inch to 1 mile	40	½ inch to 1 mile.
A tracing map of Baltimore county, Md				1	do	10	do
A tracing map of Harford county, Md				1		10	do
A tracing map of Prince George's Co., Md				1		5	do
A map of Henrico county, Va., (traced)				1	1 inch to 1 mile	12	1 inch to 1 mile.
Plane-table sheet No. 578, western coast	1-10,000			1	1-40,000	1	1-40,000
Plane-table sheet No. 818, western coast	1-10,000			1	1-40,000	1	1-40,000
Plane-table sheet No. 817, western coast	1-10,000			1	1-40,000	1	1-40,000
Plane-table sheet No. 552, western coast	1-10,000			1	1-40,000	1	1-40,000
A tracing from plane-table sheet No. 795, coast chart No. 11	1-10,000	1	1-80,000	1	1-80,000	1	1-80,000
A tracing from plane-table sheet No. 464, Maryland	1-10,000			1	1-80,000	1	1-80,000
A tracing from plane-table sheet No. 572, coast chart No. 81	1-10,000			1	1-80,000	1	1-80,000
A tracing from plane-table sheet No. 734, coast chart No. 21	1-10,000	1	1-80,000	1	1-80,000	1	1-80,000
A tracing from plane-table sheet No. 751, coast chart No. 21	1-10,000	1	1-80,000	1	1-80,000	1	1-80,000
A tracing from plane-table sheet No. 734, coast chart No. 21	1-10,000	1	1-80,000	1	1-80,000	1	1-80,000
Railroad from Harper's Ferry to Winchester, (traced)				1	1-30,000	20	1-30,000
Chart of the Mississippi river in vicinity of Fort Jackson	1-10,000			1	1-20,000	4	1-20,000
A tracing—map of the boundary between Eastern Virginia and Maryland				1	1-20,000	3	1-20,000
A drawing—reconnaissance near Mount Vernon, Virginia	1-15,000			1	1-40,000	1	1-40,000
A tracing—city of Richmond, Virginia	1-10,000			1	1-10,000	27	1-10,000

Table of photographs—Continued.

Prototypes.	Scale.	Positives. No.	Positives. Scale.	Negatives. No.	Negatives. Scale.	Prints. No.	Prints. Scale.
A tracing—Henrico county, Virginia				1	1 inch to 1 mile	22	1 inch to 1 mile.
A tracing from plane-table sheet No 563, Mare island	1-10,000	1	1-40,000	1	1-40,000	1	1-40,000
A tracing from plane-table sheet No. 303, coast chart No 10	1-10,000	2	1-80,000	2	1-80,000		
A tracing from plane-table sheet No. 304, coast chart No. 10	1-10,000	3	1-80,000	2	1-80,000		
A tracing from plane-table sheet No. 305, coast chart No. 10	1-10,000	2	1-80,000	1	1-80,000		
A tracing from plane-table sheet No. 340, coast chart No. 10	1-10,000	1	1-80,000	1	1-80,000		
Part of the Potomac river, (traced for lithographing)	1-10,000			1	1-40,000	2	1-40,000
Drawing—Fort Jackson, Miss—showing effects of the bombardment				1	1-10,000	18	1-10,000
Drawing—reconnaissance near Drainesville, Virginia				1	1-30,000	5	1 30,000
Tracing from plane-table sheet No. 403, Drake's bay	1-10,000			1	1-40,000	1	1-40,000
Tracing from plane table sheet No. 456, Drake's bay	1-10,000			1	1-40,000	1	1-40,000
Tracing from plane-table sheet No. 805, Drake's bay	1-10,000			1	1-40,000	1	1-40,000
Tracing from plane-table sheet No. 806, Drake's bay	1-10,000			1	1-40,000	1	1-40,000
Tracing from plane-table sheet No. 807, Drake's bay	1-10,000			1	1-40,000	1	1-40,000
Tracing—Henrico county, Virginia, with some additions				1	½ inch to 1 mile	12	½ inch to 1 mile.
Chart of the harbor of Charleston, S. C., by Navy Department				1	1-40,000	1	1-40,000
Map of Rockbridge county, Va., (traced)				1	½ inch to 1 mile	5	½ inch to 1 mile.
Map of Frederick county, Va, (traced)				1	do	5	do
Chart of James river, in vicinity of Fort Darling	1-10,000			1	1-10,000	18	1-10,000
Map of Henrico county, Virginia, with some further additions				1	½ inch to 1 mile	27	½ inch to 1 mile.

Report of Mr. W. L. Nicholson, in charge of the Lithographing Division.

COAST SURVEY OFFICE, *Washington, November* 1, 1862.

The following report of the operations of the Lithographing Division is respectfully submitted:

This division, organized and added to the regular establishment of the office during the month of May, 1861, to meet the increased calls made for charts arising out of the exigencies of the war, has been continued in active operation, employing two presses in printing transfers from some of the copper-plate engravings of the survey, and a large number of original drawings engraved or drawn on stone, or transferred to stone from prepared tracings or drawings.

Mr. C. G. Krebs has been engaged in part as printer, but for the greater portion of his time in engraving or drawing on stone and making transfers.

Mr. H. Lindenkohl has been during the greater part of the year detailed from the Drawing Division and employed in engraving and drawing on stone, in which his experience and skill as a draughtsman have been of much service.

Mr. D. B. Morgan, assisted by *Mr. William Morgan*, and recently, since his resignation, by *Mr. W. Benner*, have been employed as printers.

A list of the charts put on stone during the past year is appended, as also the number of sheets of one hundred and ten charts and sketches printed during the year, (30,838 in number.) Their distribution will be found included in the report of the Miscellaneous Division.

To the ten memoirs descriptive of the coast south of Delaware bay, mentioned in my last year's report as having been lithographed and distributed with the appropriate charts bound up, two other memoirs were added, prepared in similar manner by and under the direction of *Professor A. D. Bache*, Superintendent, and by *Captain C. P. Patterson*, hydrographic inspector Coast Survey; and copies of all the memoirs have continued to be issued to commanding officers of expeditions along the coast, amounting in all, since August 1, 1861, to the number of three hundred and eighty-five copies, in about equal portions to officers acting under the War and Navy Departments.

These memoirs have been bound up by *Mr. M. T. Johnstone*, before and since his assignment from this division to the care of the map room, in August last.

In accordance with the uniform practice of this office in offering every aid practicable in assisting the other departments of the public service, several maps prepared by topographical engineers attached to the army and others for the use of the quartermaster's department have been put on stone, and copies printed and furnished with a rapidity and economy not to be easily obtained in such sudden calls for work; in some cases many copies of important maps of surveys have been in a condition to be issued on the same day, in a few hours after being handed to us for multiplication.

In addition to the printing of our charts proper, a map representing the seat of war in Virginia was, at the suggestion of the Superintendent, compiled by myself during the past year, and printed in colors, partly as an experiment in that class of work, and partly to meet the popular demand for information on the movements of our armies. This map has met with unexpected success, and has been much called for, and copies quite freely distributed; but, in order to cover the expenses of its getting up and printing, a number of copies have been placed in the hands of our sale agents, the proceeds of which have more than covered expenses; in all, some five thousand five hundred copies have been printed, over twenty-five hundred sold, and nearly three thousand copies gratuitously distributed.

Our experience with this color-printing has been of service in the proposed treatment of some of our regular preliminary charts and sketches by representing gradations of soundings, land, sand-banks, &c., by a system of light coloring. This method will be prosecuted as the pressure of work may permit.

In conclusion, I would bear testimony to the assiduity of all the employés in this division during the past year of incessant demands upon our care and attention.

Drawings, transfers, and engravings on stone made in the Lithographing Division during the year ending October 31, 1862.

SECTION III.

Potomac river, sheet No. 1, (entrance.)
Potomac river, sheet No. 2.
Potomac river, sheet No. 3.
Potomac river, sheet No. 4.
James river, lower part, (new edition.)
Reconnaissance of Pamunky and Mattapony rivers.
Chincoteague bay.
Hampton roads.
Road map of District of Columbia, for the quartermaster general of the army of the Potomac.
Plan of wharfage at Alexandria, for the quartermaster general of the army of the Potomac.
Map of Alexandria, for the Sanitary Commission.
Military map (in nine sheets) of southeastern Virginia, for Major General J. A. Dix, U. S. A.

SECTION IV.

Atlantic coast, Chesapeake bay entrance to Ocracoke inlet.
Sketch of coast of North Carolina and Virginia.
Hatteras inlet, (survey of November, 1861.)
Coast of North Carolina, from Oregon inlet to Ocracoke inlet.
Beaufort harbor, N. C., survey of 1862, (in colors.)

SECTION V.

Sketch of coast of South Carolina and Georgia.
Charleston harbor, S. C., with additions of Stono inlet and river, &c.
Stono inlet, S. C., (survey of 1862.)
St. Helena sound, S. C.
Port Royal entrance, S. C., (new edition.)
Skull creek, Hilton Head island, S. C.
Calibogue sound and Skull creek, S. C., (1862.)
Tybee bay and Calibogue sound, (from survey of Lieutenant C. Wilkes, U. S. N., 1838.)
Savannah river, (with additions.)
Atlantic coast, from Savannah river, Ga., to St. Mary's river, Fla.
Depths on Wassaw bar, Ga., with directions for entering.

SECTION VI.

Sketch of the Tortugas islands, Fla.

SECTION VII.

Entrance to Santa Rosa bay, Fla., (from survey of Lieutenant Colonel Perrault, U. S. Topographical Engineers, 1826.)

SECTION VIII.

Reconnaissance of the Southwest Pass and bar of the Mississippi river, 1862.

DIAGRAMS.

Magnetic declinations on the Atlantic coast, 1860.
Magnetic declinations on the Gulf of Mexico, 1860.

Report of Mr. W. L. Nicholson, in charge of the Miscellaneous Division.

COAST SURVEY OFFICE, *Washington, November* 1, 1862.

The following report of the operations of the Miscellaneous Division is respectfully submitted.

This division, consisting of the copperplate printing office, map-room, and office for the distribution of maps and reports, has been under my general supervision since the 1st of June, when *Assistant E. Goodfellow* left the office for duty with the Superintendent's party in the field. The records have been kept by *Mr. Charles Balmain*, who has been also engaged since the 1st of August in the preparation of miscellaneous copy and abstracts.

The map-room, including, besides the regular supply on hand of our own charts, a very large collection of miscellaneous maps presented by foreign governments and from other sources, has been, since the 1st of August, under the charge of *Mr. M. T. Johnstone*, who has re-arranged and is engaged in cataloguing these maps for ready reference.

Mr. John Rutherdale, assisted by *Mr. John Barrett*, (and since his decease, March 24, by *Mr. J. Fries*,) has printed most of the maps (from the copperplates) issued from the office; *Mr. Henry C. Benner* and *Mr. E. A. Sipe* having been occasionally engaged as printers when the exigencies of the demand for charts pressed too closely upon our usual arrangements.

The preparation of backed chart-paper for the topographic and hydrographic parties, of the presentation copies of maps, and the repairs of sheets in use, are in charge of *Mr. W. Mertz*, who was assisted until July 19th by *Mr. F. Housam.*

The usual statements, (with, as I believe, a better and more systematic exhibit and classification than hitherto adopted,) showing the distribution of maps, charts, and sketches during the year; the distribution of the annual reports of the Superintendent; and the number of maps, charts, and sketches, printed in the copperplate printing office, are herewith appended.

These statements, to harmonize with the date of the other division reports, have been brought up to November 1, although the report of my predecessor was brought up only to the 1st of October of last year.

During the above period the aggregate number of sheets printed by the copperplate presses has been 23,584, in addition to 30,838 sheets printed by the lithographic presses, mentioned in my report on the lithographing division; in all 54,422 sheets were turned into our map-room for distribution. The total number of copperplates printed from was 177, and of lithographs 129.

During the above period 47,652 copies of printed maps, charts, and sketches have been issued from the office, a relative amount of distribution much more than double that of the preceding year, and upwards of five times the average annual distribution of former years.

Of these charts 25,925 copies were distributed through the Naval Observatory, and 1,863 copies were supplied directly to captains and pilots (223 in number) of vessels engaged in the government transport service, calling on us with vouchers from the Quartermaster's department.

An abstract of the distribution may be thus stated:

Coast survey maps, charts, sketches, and diagrams distributed during the year ending October 31, 1862.

Distributed to—	Number of sheets.			Total number of sheets.
	Finished charts.	Preliminary charts.	Sketches and diagrams.	
Navy Department and naval officers	12,155	9,827	7,983	29,965
Captains and pilots (223) government transport service	562	834	467	1,863
Military officers	2,073	1,920	1,403	5,396
Sale agents	2,251	920	45	3,216
Miscellaneous*	3,018	1,712	2,482	7,212
Total	20,059	15,213	12,380	47,652

* Including a large number of charts furnished to Coast Survey parties accompanying naval squadrons on active service.

To furnish this great amount of published matter, much of it got up with all rapidity possible to meet the urgent calls of the War and Navy Departments, has demanded the constant and unwearied attention of all engaged in printing, assorting, and despatching the charts, and I am happy to be able to testify to the general assiduity of all concerned.

The distribution of the Superintendent's report of 1860 has, as in the case of that of 1859, been confined to individuals and institutions in the loyal States of the Union. The usual foreign distribution of reports through the Smithsonian Institution has been suspended for the present.

During the past year 4,028 copies of reports for various years have been distributed, an abstract of which may be thus stated.

Distribution made during the year of reports of the United States Coast Survey for the years 1851, 1852, 1853, 1854, 1855, 1856, 1857, 1858, 1859, *and* 1860.

Names of States, &c.	Report, 1851.		Report, 1852.		Report, 1853.		Report, 1854.		Report, 1855.		Report, 1856.		Report, 1857.		Report, 1858.		Report, 1859.		Report, 1860.		Total number of copies distributed during the year.
	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	Individuals.	Institutions.	
Maine					1						2		1		2		9		111	7	133
New Hampshire	2		1		1		1		1		3		3		5		4		72	17	110
Vermont															1				35	10	46
Massachusetts	3	1	3		2		3		4		7	1	10		10		32	3	308	32	419
Rhode Island			1						1				2		2		6		56	17	85
Connecticut	3		3		4		3		3		6		6		5		17		144	9	203
New York	8		8		7		8		8		11		15		28		66		479	62	700
New Jersey																	7		98	12	117
Pennsylvania	7		6		5		7		7		5	1	3	1	9	1	27	2	253	67	401
Delaware																			8		8
Maryland			1	1	1	1	1	1	1	1	1	1	1	1	1	1	4	2	16	1	37
District of Columbia	2		3		3		3		4		3		5		8		13		64	3	111
South Carolina													1		1		3				5
Ohio											1		1		2		12		127	26	169
Kentucky																	1		2		3
Indiana	1		1		1		1		1		2		4		6		6		65	6	94
Illinois	2		3		3		3		2		3		4		7		7		56	23	113
Missouri																	1		1		2
Kansas																	1		2		3
Michigan																	1		43	13	57
Iowa	3		2		1		1		1		1		1		2		3	1	25	10	51
Wisconsin													2		2		2		42	8	56
California	1		1		1		1		1		1		1		1		1		3	5	17
Minnesota															1		2		7	7	17
Oregon																			1		1
Nebraska Territory																			9		9
Washington Territory																			1		1
Members of Congress	16		15		16		15		16		17		16		20		57		19		207
Officers of the navy															1		6		8		15
Officers of the army	1		1		2		1		1		1		2		2		6		1		18
Executive departments	5		3		3		3		3		2		5		6		6		184	2	222
Naval Observatory																			59		59
Light House Board																			20		20
Smithsonian Institution																	1		3		4
Coast Survey Office and assistants					3								1		4		6		176		190
Newspapers																			282		282
Foreign			4		4		4		4		4		4		5		8		6		43
Total	54	1	56	1	58	1	55	1	58	1	70	3	88	2	131	2	315	8	2,786	337	4,028

There now remains on hand a limited number of back copies of the years 1851 to 1860, of which, for the years 1851, 1855, 1857, there were on hand at 1st of November, 220, 420, and 328 copies, respectively, while for the years 1853, 1856, 1859, and 1860 there were on hand 1,514, 1,551, 2,883, 4,710 copies, respectively.

This decidedly unequal number of copies of various back years would seem to render it necessary that a careful discrimination should be used in their issue, while it is also to be borne in mind that for the years 1859 and 1860 no copies have been sent to the insurgent States. To provide for a selected issue of these remaining reports, (1851 to 1860,) a circular has been sent to the principal libraries in the more important cities, and to those of universities, colleges, and other institutions, inquiring into the state of their deficiencies in this respect, and proposing to fill such up, so that complete sets of these reports may in future be within easy reach for reference in all parts of the country.

I have the honor to enclose along with this report the statistical table prepared by me showing the field and office work of the survey, brought up to the close of the year 1861, to form, as usual, one of the appendices to the Superintendent's annual report.

Archives and library.—The archives and library have continued under the care of *Mr. E. Fitzgerald.*

During the past year three hundred and ninety-nine volumes of original and duplicate records, one hundred and twelve volumes and cahiers of computations and reductions, one hundred and sixteen rolls from self-registering tide-gauges, and fifty-seven original topographical and hydrographical sheets, have been added to the archives of the survey; also one hundred and eighty-six sea-bottom specimens.

Fifty-eight volumes have been purchased for the library, and one hundred and five volumes, including thirty-three volumes of publications of the Royal Observatory, Greenwich, added by presentation during the same period.

The records of triangulation, astronomical, and magnetic work, executed under the superintendency of Mr. Hassler, have been re-arranged by Mr. Rumpf, of the computing division, and a new register made which greatly facilitates reference to them. With the assistance of Mr. Donegan, of the tidal division, the self-registering tide-gauge rolls have been arranged by stations and years, put up in separate packages and registered. The total number of self-registering tide-gauge rolls now in the archives, as shown by the register, is eleven hundred and twenty-eight. A new set of sketches showing the limits of all the registered topographical and hydrographical sheets, to take the place of the set now in use in the archives, which is nearly worn out, has been commenced and considerable progress made upon it.

Carpentry.—In the carpenters' shop, *Mr. A. Yeatman* remains in charge, as master carpenter, assisted by one workman and an apprentice. The work executed during the year consists of 54 fine new cases for instruments of various kinds, 6 cases for duplicate records, 2 large cases for Coast Survey charts, 2 large cases for copperplates, 3 cases for photographic negatives, woodwork complete for 2 new plane-tables, 8 new plane-table boards, 4 new stands for plane-tables, 3 stands for theodolites, 5 frames for photographic and 18 for electrotype purposes, 8 battery cells, and 5 vats, for electrotype division; 6 rods and 6 signal poles for field parties have been painted and graduated, and 20 tin cases for original sheets have been painted and numbered, 6 large paneled frames for backing purposes have been made, as also one writing table for office. A large amount of miscellaneous work has been done, and the woodwork of instruments returned from the field have been carefully repaired; 90 running feet of new fencing has been put up, and the office buildings kept in repair.

Instrument shop.—The force of this shop consists of *Mr. J. Vierbuchen,* master instrument-maker, three workmen, and two apprentices. During the year 4 sounding apparatus, 12 specimen cups for sea soundings, 1 winding machine for deep-sea soundings, 2 plane-tables complete, 26 metre scales, 2 theodolites, 4 reconnoitring telescopes, 2 heliotropes, 5 prismatic compasses, 2 beam compasses, 5 half-round protractors, 13 metre chains, and 1 clock for office, have been made; and all the repairs of instruments used during the year have been made, consisting in part of 2 sounding apparatus, 2 deep-sea thermometers, 5 self-registering tide-gauges, 27 sextants, 30 theodolites, 29 plane-tables, 6 reconnoitring telescopes, 11 heliotropes, 4 prismatic and 7 surveying compasses, 28 metre chains, 15 marine spy-glasses, 1 dividing machine, and 6 beam compasses, in addition to a variety of miscellaneous work for the use of the office and parties in the field.

APPENDIX No. 12.

REPORT OF PROFESSOR BENJAMIN PEIRCE, OF HARVARD, ON THE COMPUTATIONS OF THE OCCULTATIONS OF THE PLEIADES FOR LONGITUDE.

CAMBRIDGE, MASS., *November* 1, 1862.

SIR: The computation of the group of the occultations of the Pleiades, from 1838–1842, inclusive, and the corresponding determination of the longitude of America from Europe, are now far advanced, and several of the special reports upon the individual occultations will soon be sent to the office in their completed form The conformity of the observations with theory is quite remarkable, and shows that this, the most delicate of all the observations of the moon, demands and justifies the utmost precision of calculation. The final determination of the longitude will, undoubtedly, surpass all other in precision.

There were eighteen different nights of occultation in the group of 1838–'42, which I will number in the inverse order of their occurrence.

I. The immersions of April 13, 1842, which were observed at Edinburgh.

II. The immersions of January 21, 1842, which were observed at Washington and Cambridge in Massachusetts.

III. The immersions of November 27, 1841, which were observed at Cambridge in England and at Washington. These observations were made within seventeen hours of full moon, and I have thought that twenty-four hours from full moon was as near an approach to this phase as it would be safe to admit.

IV. The emersions of October 31, 1841, which were observed at Dorpat, Pulkova, Vienna, and Wilna. The moon was so nearly full that these observations are omitted.

V. The emersions of September 6, 1841, which were observed at Washington.

VI. The emersions of August 10, 1841, which were observed at Altona, Berlin, Copenhagen, Edinburgh, Geneva, Hamburgh, Leyden, and Pulkova.

VII. The immersions of February 27, 1841, which were observed at Edinburgh and Leyden.

VIII. The immersions of January 31, 1841, which were observed at Pulkova.

IX. The immersions of December 7, 1840, which were observed at Altona, Breslau, Copenhagen, Gottingen, Hamburgh, and Kremsmunster.

X. The emersions of October 13, 1840, which were observed at Ashurst, Breslau, Edinburgh, Greenwich, Vienna, Cambridge, (Mass.,) and Washington.

XI. The immersions of January 14, 1840, which were observed at Apenrade, Berlin, Bonn, Breslau, Cracow, Gera, Grisswald, Hamburgh, Konigsberg, Kremsmunster, Leyden, and Vienna.

XII. The occultations of November 20, 1839, which were observed at Cambridge, Leyden, St. Louis, Pulkova, Dorchester, Washington, and Port Royal, (Jamaica,) which occurred at the time of full moon, and are consequently omitted.

XIII. The emersions of September 26, 1839, which were observed at Ashurst, Berlin, Breslau, Greenwich, Rista, Cambridge, Philadelphia, Southwick, and Washington.

XIV. The emersions of August 30, 1839, which were observed at Breslau, Cambridge, (England,) Hamburgh, and Leyden.

XV. The emersions of July 6, 1839, which were observed at Hudson, Philadelphia, Washington, and Yorktown.

XVI. The immersions of March 19, 1839, which were observed at Ashurst, Cambridge, (England,) Dorpat, Greenwich, Konigsberg, and Leyden.

XVII. The immersions of December 27, 1839, which were observed at Ashurst, Breslau, Cambridge, (England,) Cracow, Dover, Edinburgh, Greenwich, Boston, Dorchester, Southwick, Princeton, and Philadelphia.

XVIII. The emersions of November 2, 1838, which were observed at Philadelphia, and may need to be neglected on account of the proximity to full moon.

Of these observations, therefore, III, IV, XII, and probably XVIII, will be rejected, and the other 14 occultations will be retained. The occultations X, XIII, and XVII were the only ones which were observed in Europe as well as in America, and which can be used independently of the others and without regard to the accuracy of the tables of the moon's longitude, for the determination of the longitude. These occultations, together with the others observed in Europe, namely, the I, VI, VII, VIII, IX, XI, and XIV, will serve to determine the errors of the tables, and thence the corrections which must be applied to the tables, to compute the occultations II, V, XV, and XVIII, which were only observed in America, and thence to get a second determination of the longitude. The various observations will also serve the subsidiary purpose of determining the relative longitudes of the different places which are upon the same continent, either of Europe or America, and also to correct the places of the stars, and finally to determine the value of the lunar semidiameter and the necessity of having regard to the protuberances of the moon in the complete solution of the problem.

Although this plan of combining the occultations will be carefully followed, yet reports will be made upon the several occultations independently, and the equations of correction will be given for each as separate results.

Very respectfully,

BENJAMIN PEIRCE.

Professor A. D. BACHE,

Superintendent of the Coast Survey.

APPENDIX No. 13.

UPON THE TABLES OF THE MOON, USED IN THE REDUCTION OF THE PLEIADES, BY PROFESSOR BENJAMIN PEIRCE, OF HARVARD.

NOVEMBER, 1862.

SIR: It is expedient that I should address you a special letter upon the tables of the moon used in the reduction of the observations of the Pleiades. They are those constructed by Hansen. I adopted them because they were the most recent, and had, therefore, the advantage of all previous experience. They purport to be the pure results of theory, and while, upon the one hand, I had full confidence in the accuracy and ability of their author, I was, upon the other hand, persuaded, from the use of the tables which I had myself constructed for the Nautical Almanac, under the direction of Captain Davis, that analysis without empiricism was adequate to the construction of the lunar theory and tables. The testimony to this point furnished by Lubbock, in a memoir *on the Lunar Theory* in the thirteenth volume of the *Memoirs of the Royal Astronomical Society*, is full and generous. The following passage occurs upon page 12 of his memoir:

"As it appeared to me that astronomers would view with greater confidence a comparison of places given by the American tables, made by persons who could have no interest in enhancing their value, I made application to Mr. Hind, the Superintendent of the *Nautical Almanac*, and in consequence he directed Mr. Farley to procure places of the moon from the *American Almanac* and compare them with the observations made at Greenwich for the years 1856, 1857, and 1858; and as Mr. Hind has kindly allowed me to publish them with this paper, any one can see at once how extremely accurate the places given by these tables are, and how much more so than places given by Burckhardt's tables."

Lubbock goes on to make claims upon these tables in the following passages:

"In these American tables, coefficients are employed, with very few exceptions, and those of no moment, founded upon our labors—that is, M. Plana's, M. de Pontécoulant's, and my own—and due to theory alone. I am confident, therefore, that a just posterity will give to us—that is, to Plana, Pontécoulant, and Lubbock, who in 1846 furnished the means of constructing tables of the moon without any empirical hypothesis—the credit of first bringing the errors of the lunar theory within the limits of the errors of observation, and thereby of bringing to perfection the solution of the problem of finding the longitude at sea by means of lunar observations."

The American tables were actually constructed, as they profess to be, "from Plana's theory, with Airy's and Longstreth's corrections, Hansen's two inequalities of Long period arising from the action of Venus, and Hansen's values of the secular variations of the mean motion and of the motion of the Perigee." But Lubbock contends that all of Longstreth's corrections of Plana were those of coefficients which had been designated as erroneous by Pontécoulant, "and in eight out of eleven instances the values of Pontécoulant were employed" instead of those of Plana. There is even a suspicion expressed that Longstreth had been unfair to Pontécoulant, and appropriated his corrections without acknowledgment. This suspicion, however, was expressed before having seen the original memoir of Longstreth, the examination of which instantly exonerates Longstreth from so unjust a charge, for Longstreth expressly says: "The coefficients deduced from theory by Damoiseau, Plana, Pontécoulant, and those deduced from observation by Burckhardt, (though differing considerably,) give the moon's place with nearly the same accuracy; when a difference exists, I have carefully compared them with observation, and deduced the most probable value." In the only three cases (see the note at the end) in which Longstreth has rejected Pontécoulant's terms, and thereby declared them to be wrong, the subsequent investigations of Pontécoulant himself, which are published by Lubbock, show that Pontécoulant was in error, although right in the other cases, and, consequently, the skill and accuracy of Longstreth's comparisons and the justness of his verdict are triumphantly sustained.

In regard to the decisions of posterity I may be mistaken; but it seems to me that the whole series of reductions of the lunar observations of Greenwich from 1750 to 1851, made under the direction of the astronomer royal, and of the comparisons with Plana's theory, demonstrate that to Plana alone will be given the credit of first bringing the lunar theory to a degree of perfection sufficient for the practical "solution of the problem of finding the longitude at sea by means of lunar observations."

I am moreover convinced that a still higher claim can be established for Lubbock and Pontécoulant. The ordeal to which I have been subjecting the tables of Hansen is much more severe than that of meridian observations of the moon; and so far as I have gone, they have stood it wonderfully. The mean error of the tables in longitude seems to be less than a second of arc, during the period embraced by my investigations. It is thought that more recent observations indicate wider discrepancies; but if this be so, I believe that it will be found to arise from some accidental cause of non-conformity which can be easily remedied. I am equally confident that when our American tables are revised, as they soon must be, the small differences between them and the corrected theories of Lubbock and Pontécoulant will disappear, and they will then assume the same degree of accuracy which I am now disposed to attribute to those of Hansen. The time, then, seems to be at hand when meridional observations of the moon will no longer serve to test the accuracy of the tables; when extra-meridional observations will be set aside as useless and cumbersome superfluity; when the observations of occultations on the dark limb of the moon will assume a new importance; and when it will be admitted that a single observation of an occultation reduced by the exclusive aid of the lunar tables without any use of simultaneous observations, will determine a longitude with a probable error not exceeding a second of time. The geometers to whom the final credit of this great result must be given are Lubbock and Pontécoulant. What test is reserved for the ultimate comparison of the theories of Pontécoulant, Hansen, and Delaunay?

Very respectfully,

BENJAMIN PEIRCE.

Professor A. D. BACHE,

Superintendent of the Coast Survey.

NOTE.—There is still a fourth coefficient, that of argument 22, in which Plana's coefficient of 3".309 was rejected, and Lubbock inconsiderately attributes to Longstreth the new coefficient 0".8, which is adopted in the American tables and attributed to Plana. But it was taken by me from Airy's table of coefficients in the *reduction of the Greenwich observations of the moon*, and no other origin of the coefficients of that table but PLANA is acknowledged in that work. The answer to the question of authority in this case must, therefore, be sought by MR. LUBBOCK from the ASTRONOMER ROYAL.

APPENDIX No. 14.

REPORT OF DR. B. A. GOULD ON THE PROGRESS OF COMPUTATIONS FOR DEDUCING LONGITUDE FROM OBSERVATIONS BY TELEGRAPH BETWEEN CALAIS, ME., AND NEW ORLEANS, LA.

CAMBRIDGE, *November* 13, 1862.

DEAR SIR: During the last year the Coast Survey operations under my direction have consisted exclusively of computations and reductions, the field-work being suspended in consequence of the war. The same cause has acted to retard the progress of the reductions to a considerable extent, and but for the diminution of my party which it has occasioned, I might at present enjoy the satisfaction of reporting the whole of the longitude work as completely reduced. No small progress has, however, been made, and the work has been completed upon four of the campaigns, viz: Calais—Bangor; Apalachicola—Eufaula; Macon—Eufaula; Pensacola—Mobile.

The discussion of these observations, although extended and minute, has elicited few results of general scientific interest which have not been brought to light by the computation of former longitude measurements. The phenomena attending the transmission of signals have been similar in these and in former campaigns, showing in all approximately the same velocity of transmission, and the same dependence upon the position and strength of the batteries.

So, too, the same results have been deduced from the examination of the personal differences of observers; and it is now beyond question that, by the chronographic method, at least, the personal equations, although manifest, are very far from constant, varying greatly with external circumstances and with physical condition. Indeed, their variability is so decided as to lead me, in the discussion of the observations, to aim always at their elimination, rather than at their determination, contrary to the course originally pursued.

The mean error of observations appears to vary but little for the same observer, its average ranging, for different observers, between nine and fourteen hundredths of a second for a single tap.

The changes of azimuth during the period of observation have been referred to in previous reports, and constitute one of the most interesting and striking phenomena which the computations have brought to light. In all the telegraphic longitude measurements without exception, both in summer and winter, in the northern and the southern States, the transit instruments have been found affected by a motion in azimuth differing in amount and in regularity at different stations, but almost without exception having the same general tendency, viz: a motion of the westerly end of the axis towards the south as the night advanced. The only apparent exceptions in twenty-five series of observations are at Macon in 1856, and at Mobile in 1858; but the series at Macon in 1855 and 1860, and Mobile in 1857 and 1861, confirm the general rule, and I suspect the exceptions to be rather apparent than real. I do not mean to say that the change has been in this direction on every night, at each station, in every campaign, but that the apparent exceptions have been so few and so marked as to lead to the conviction that they are due to some special and abnormal influence, such as a jar to the instrument or some erroneous observation.

The uniform occurrence of this azimuthal change, and the uniformity of its direction, naturally lead us to seek its origin, not in local disturbance, but in some geognostic law. The conviction has been forced upon my mind that the change is due to the diminution of temperature of the earth's surface travelling westward with the diurnal rotation. These changes in azimuth seem, in some degree at least, to depend on the thermal changes over an area too large to enable us to connect them with the thermometric variations at the place of observation; or, if they should in fact be functions of these local variations, the laws by which the changes of surface temperature follow the atmospheric changes are not sufficiently understood to render the investigation easy, even with fuller detail than our observations permit.

Nowhere have these changes been so great and so uniform as at the station Lower Peach Tree, on the Alabama river, about midway between Montgomery and Mobile. All attempts to exchange longitude signals between these two cities directly having proved unavailing, it became necessary to establish an intermediate station. An astronomical station was therefore constructed at Lower Peach Tree, and its differences of longitude from Montgomery and from Mobile were determined separately. At this station the average change in azimuth on eight "telegraph nights," between the first and last observations, was $+0s.57$; the mean hourly change being $+0s.052$ during the first ten days of April, and averaging $+0s.145$ during the period between the 19th and 28th of the same month. Upon five nights between May 21 and June 7 the total change averaged $+0s.697$, and the mean hourly change was $+0s.123$. On only one night out of sixteen for which the observations have been carefully studied does there appear any exception to the direction of this change. On this date the azimuthal change between the earliest and latest observations was negative, but there is strong reason to suspect some disturbance of the adjustments during the exchange of signals on that night, and all the more as each of the two series of observations for azimuth, treated by itself, gives unmistakable indications of the same positive change observed on other nights.

It has been impossible to do justice to the observations at this station without the regular employment of a term dependent upon the time in the adopted value of the azimuth. Such a term has, indeed, been habitually employed in discussing the results of other campaigns, but hitherto rather as a refinement than as a necessity. It has, in practice, been made directly proportional to the time during the night's work, but there are some indications that the change was less rapid in the early part of the evening than in the later hours.

The simultaneous changes at Montgomery, though much less in amount, were none the less decided. Here, on eight telegraph nights, the average hourly variation was $+0s.013$; and the examination of the shorter series of observations made on other nights gives the same value.

It should be stated that, for the instrument at Peach Tree, motions in azimuth were so great as to render it necessary to adjust the position of the axis at the commencement of every night's work. The instrument used was the Coast Survey transit instrument No. 8, which has been employed in most of the previous longitude measurements, and, like the others used for the same purpose, consists of a forty-six inch telescope, of which the axis is supported by a cast-iron frame, formed of a single piece, so that the two Y beds are parts of one and the same casting. This frame is ordinarily made to rest upon a granite block, three feet wide and one foot thick, sunk in the ground to the depth of more than three feet, and rising to a height of thirty inches above the surface; but, in the unexpected contingency of the establishment of the station at Peach Tree, it became necessary to use wood, since there was neither granite in the region nor time to obtain it from the north. The wooden block was, however, hard and well seasoned, and the experience of former years, when the employment of wood became necessary, affords no reason for supposing the azimuthal changes to have been in any way connected with the material of the pier. The soil of the region consists of red clay, covered to the depth of about six inches with sandy loam. The wooden support of the instrument was imbedded to the depth of three and a half feet, resting on a compact bed of sand, placed there for the purpose, and surrounded by sand well rammed down between the surrounding clay and the pier.

Among the observations of the Macon-Eufaula and Pensacola-Mobile campaigns are several series of clock signals, or simultaneous records of the beats of the clocks at both stations, recorded on all the registers. These clock signals were made alternately with series of observations for time, in the hope that some method might yet prove equal in accuracy to that of star signals, which should be at the same time less tedious, laborious, and expensive. The experiment has been thus again fairly tried, but, I regret to say, found wanting. At least, with the portable instruments which from the very nature of the case we most use, the error and rate of the clocks cannot be determined closely enough to give differences of longitude equal in accuracy to those obtained by the method of star signals. The accordance of results during any one series is admirable and seductive; but the comparison of the results of different series and on different dates unmasks the delusion, and shows that the clock rates cannot be relied upon as sufficiently constant, although the clocks are of the best workmanship of Kessels, Hardy, and Krille.

During the past year the circumpolar and time star lists to which I have frequently alluded in former reports, and which had been improved from time to time during the past eight years, have been adopted by the Naval Observatory and by the Nautical Almanac as standards of right ascension, and have been printed together with tables of mean places of each of the one hundred and seventy-six stars for the beginning of the thirteen years 1851–1863. The methods and details of their formation, together with the discussion of the systematic differences of the several catalogues and series of observations employed, are prepared in full detail for publication with the "Records and Results" of the Coast Survey. The equinoctial point corresponding to Argelander's "*DLX Stellarum Fixarum Positiones Mediæ*" was selected as the fundamental zero for both catalogues, and all the materials employed were subjected to the corrections requisite for referring them to this zero before they were introduced into the equations of condition. All observations since the time of Bradley which seemed likely to add to the precision of resultant values were incorporated in the determinations, and I think we may be justified in regarding the positions and proper-motions of these lists as commensurate in accuracy with the present condition of practical astronomy, and therefore not unworthy of the title "standard right ascensions."

The beginning of the year 1855 was chosen as the epoch of the two star lists, primarily because it was a date near to, yet in advance of, the time at which their preparation was begun, viz: 1852; but there seemed an additional appropriateness, inasmuch as this epoch is precisely one century later than that to which Bradley's observations are referred in the *Fundamenta Astronomiæ*.

The right ascensions deducible from the field observations of the telegraph parties, although made with small portable instruments and a magnifying power never exceeding one hundred, have, to my astonishment and delight, been proved by these computations to surpass in accuracy a majority of the observations upon which the determination of the "standard places" was necessarily based. I have, therefore, taken steps towards collecting the observations of the stars of our lists from the records of the several campaigns, with the purpose of employing them in the next revision to which the increase of observations and the lapse of time may render it desirable to subject them.

Moreover, as each successive longitude campaign has been computed, the right ascensions of the signal stars employed have been deduced and placed on record; and I hope before long to submit a catalogue of the right ascensions of between five and six hundred of these signal stars, as an incidental fruit of the careful zeal of the observers, especially of Messrs. Dean and Goodfellow, by whom far the greater part of the observations have been made.

Since my last report I have, to my great regret, lost the services of two accomplished and valued aids, Messrs. James H. Toomer and John S. Bradford, the former by resignation, the latter by his transfer to a wider field of usefulness. I have, however, been aided, as in former years, by Professor George Searle and Mr. Cleveland Abbe, to whose assiduity and care the value of the work done is in great measure due.

Very respectfully and truly, yours,

B. A. GOULD.

Professor A. D. BACHE,
Superintendent United States Coast Survey.

APPENDIX No. 15.

DISCUSSION OF THE MAGNETIC AND METEOROLOGICAL OBSERVATIONS MADE AT THE GIRARD COLLEGE OBSERVATORY, PHILADELPHIA, IN 1840, 1841, 1842, 1843, 1844, AND 1845. PART IV.—INVESTIGATION OF THE ELEVEN (OR TEN) YEAR PERIOD, AND OF THE DISTURBANCES OF THE HORIZONTAL COMPONENT OF THE MAGNETIC FORCE. BY A. D. BACHE, LL D., SUPERINTENDENT UNITED STATES COAST SURVEY.

Volume XI of the Smithsonian Contributions to Knowledge contained a discussion, in three parts, of the observations for magnetic declination; the first part referring to the eleven (or ten) years period in the amplitude of the solar diurnal variation, and of the disturbances of the magnetic declination; the second, to the annual inequality of the solar diurnal variation; and the third, to the influence of the moon on the magnetic declination. The present discussion refers to the changes of horizontal force, and will be carried on in the same order as the former, so as to dispense with explanations in the mode of treatment, unless in those portions involving the peculiarities of the horizontal-force instrument and record. Charles A. Schott, esq., has rendered me the same assistance in this work stated in the introduction to Part I.

The horizontal-force instrument was one of Gauss's large bifilar magnetometers, made by Meyerstein, of Göttingen, the weight of the magnetic bar being about twenty-five pounds, and its length being thirty-six inches and five-eighths. The suspension wires were slightly inclined, the smaller distances between them being above the larger. The value of one division of the scale in parts of the horizontal force was determined to be: in May, 1840, 0.000035; in June, 1841, 0.000038. The mean, or 0.0000365, is the value used throughout the series. The sensibility of the instrument was thus very considerable. The instrument having been properly adjusted with the bar at right angles to the mean magnetic meridian, the torsion angle Z was found to be 71° 43′. The relation $k = a \cot an.\ Z$ expresses the value of one scale division k in parts of the horizontal force, a being the value of a scale division in parts of the radius; or 0.00011 = 0′.38, and Z the angle of torsion. Increase of readings on the scale corresponded to decrease of horizontal force.

The instruments were placed in position by the equations deduced by Professor Lloyd for the case of the declinometer in equilibrium with the horizontal and vertical force magnetometers, the position of instable equilibrium being taken necessarily from the form and position of the observatory. The effect of the small vertical-force bar at first used upon the bifilar was quite insensible, and that of the declinometer bar affected the value of the scale but slightly, the effect of both instruments changing the value of the scale divisions only in the ratio of 1 to 0.9956.

A thermometer, by Francis, of Philadelphia, divided to half degrees of Fahrenheit's scale, and easily read to tenths, was placed in the box of the horizontal-force magnetometer, and as near as practicable to the bar.

After the bifilar was set up, a motion commenced in the direction indicating decrease of force; it was progressive, though not steadily so. After a time an extra scale was required on occasions of auroral or other disturbances, and finally the ordinary readings were upon this extra scale. On the occasion of the change of the vertical-force magnetometer, in January, 1841, by the substitution of Saxton's balance magnetometer for Lloyd's, the magnetism of the horizontal-force bar was examined and found to have sensibly decreased; its force amounted to 0.9601 of its original force, in May, 1840. The experiments were made by means of deflections with a subsidiary declinometer bar, the only means then available. A further experiment of the loss of force was made in June, 1841, when the instrument was accidentally disturbed by one of the observers. The loss of magnetism then found, by means of a new determination of the angle Z, was 0.0314 of its amount in January, 1841. To ascertain the change of magnetism of the bars of the magnetometers, vibrations were also made use of, but they led to no satisfactory result. The progressive change of the scale readings from the change of the horizontal force and loss of magnetism of the bar will be investigated further on.

The observations between June, 1840, and September, 1843, were made bi-hourly, and from October, 1843, to the close of the series, hourly. The series, extending over five years, is not quite continuous. No observations were made on eleven days in January, 1841, on the occasion of the introduction of a new vertical force magnetometer, and the consequent necessity of readjusting the instruments; in January, February, and March, 1843, the work was reduced to but a single reading a day, by circumstances elsewhere stated; there are also some minor disturbances at other times, when the differences in the readings, however, were ascertained and allowed for. Full statements bearing on the continuity of the series will be given in subsequent pages.

The reduction proper necessarily commences with the operation of bringing all the readings to the same standard temperature, to render them comparable among themselves.

Correction of the readings of the bifilar magnetometer for changes of temperature.

The care bestowed on the experiments to ascertain the effect of the temperature on the instrument, and the perseverance with which they were carried out, were not rewarded with a corresponding degree of agreement in the results obtained by the various processes employed. This, it will be recollected, was also the case at other observatories. The subject of the coefficient of temperature for the bifilar magnet is fully treated in the preface to the three volumes containing the record, and it will, therefore, in this place only be necessary to recapitulate in general the results, and to state the nature of the experiments there described.

The first observations for the temperature coefficient were made on July 16, 1840. Oscillations were observed alternately at the ordinary temperature and near the freezing point, obtained by surrounding the box containing the magnet with ice; at the same time, comparative oscillations of a bar in another building were observed to furnish the necessary data to correct the bifilar results for any change in the horizontal force during the progress of the experiments. The value deduced was 2.8 scale divisions for a change of 1° Fahrenheit. No reliance was placed on this result, on account of the comparatively rude indications of the subsidiary instrument, and also on account of an irregularity at a certain point in the curve representing the connexion of change of force with change of temperature.

The method of deflections was tried and abandoned on account of the small amount of deflection at a distance sufficiently great to prevent the chance of permanent changes from the mutual action of the bars.

On the 22d of February, 1841, comparisons by vibrations were again resorted to, but with no better success, the correction for change of force during the interval being unsatisfactory. The result deduced was 3.0 scale divisions for 1° Fahrenheit.

Applying the results to the readings of the bar when mounted on the bifilar suspension wires in the observatory, they were so little satisfactory that it was determined to get the change of intensity of the bar by heating and cooling the observatory while the bar remained *in situ*.

In January and February, 1842, a continuous series of observations was made by allowing the observatory to attain the winter temperature on one day, and obtaining thus a result by comparison with the preceding and succeeding days, when the room was artificially warmed. The value found was 1.55 scale divisions for 1° Fahrenheit. At this time the observatory was warmed by a soapstone stove with copper fixtures.

About the close of the year 1842 an efficient set of subsidiary instruments was mounted in one of the college buildings, the bifilar magnet being about nine inches in length. After the relative value of the scales of the instruments had been ascertained, comparative observations were made, six each day, in the morning and afternoon. These observations and results are given in a table extending over eleven months in 1843, and over eleven months in 1844. The results were fluctuating, and the discrepancies proved, conclusively, that other causes were at work which would not be accounted for. The changes in the force were generally small. In the course of these experiments I found, beyond a doubt, that instruments of the same dimensions were required to give comparative results. During an aurora the small instrument in the college gave by no means the same results as the large instrument in the observatory. There were numerous comparisons determining this. I had reason also to believe that the large bar had its induced magnetism easily disturbed, and not regularly renewing itself, so that the correction for temperature may be supposed compound, one part permanent and one part temporary. The following results were obtained:

Observations between	February and June, 1843,	2.50	scale	divisions.
" "	July and December, 1843,	2.28	"	"
" "	January and June, 1844,	1.94	"	"
" "	July and December, 1844,	2.00	"	"

for 1° Fahrenheit. It may also be stated that no reasonable supposition in regard to differences of temperature between the indications of the thermometer and magnetic bar, or to changes in the coefficient varying with the temperature, will explain all the cases of discrepancies. In these comparisons, always near each other in time, small differences in intensity, as shown by the subsidiary instrument, were allowed for, but the corrections for temperature of this latter instrument were neglected, as the changes of temperature in the building where it was placed were small.

Another method, not quite so unobjectionable as the preceding one, was tried; it consisted in taking the results corresponding to the highest temperatures during each winter, and comparing them with those corresponding to the lowest temperatures, a correction being made to reduce the changes of force by means of the secondary instrument. These comparisons were liable to be affected by the unequal distribution of the results used over the different parts of the month. The result was: for combinations and comparisons, from

January, 1844, to June, 1844,	2.03	scale divisions
July, 1844, to December, 1844,	2.29	" "

for each degree of Fahrenheit's scale.

The mean value of all the results obtained by the various processes explained, is 2.6 scale divisions, and, as a preliminary measure, it was supposed that the coefficient was changeable; and hence a correction for change of temperature was applied, varying from 3.2 scale divisions in 1840, to 2.0 scale divisions in 1844.

On resuming the discussion it was thought desirable to deduce a value for this coefficient directly from the entire mass of observations, as this could not fail to satisfy the whole series. For this purpose it was indispensable to make the series of observations continuous, or, in other words, to refer the readings, extending over five consecutive years, to the same initial division of the scale. This is, therefore, a proper place for stating all cases when the instrument suffered any disturbance, and the amount of scale correction required. All necessary explanations are given in the record.

The first break in the series occurred August 27, 1840, at $12^h\ 22^m$ (Philadelphia time,) when the mirror was accidentally deranged. The observed numbers from this date to September 22, at $12^h\ 22^m$, have been brought to comparison with former numbers by the mean position of the bar for six previous days, (in some cases seven,) and by the hours, from $0^h\ 22^m$ to $22^h\ 22^m$ inclusive. This correction is already applied in the record; its probable error is given as 3.3 scale divisions.

On September 22, 1840, the instrument was readjusted.

An interruption of eleven days occurred in January, 1841, owing to the introduction of a reflecting vertical-force magnetometer, and requiring a new arrangement of the instruments. The horizontal-force magnetometer was left in its place. The mean values for January, viz: 944.6 divisions for the bifilar, and 36°.5 for the corresponding temperature, as given in volume 1 of the record, may be reduced to the true mean by the interpolation of values between December 31 and January 12. The daily mean (at 32°) on December 31 was 842.3, and on January 12, 913.0; hence, omitting the readings for January 3d and 10th, as Sundays, the complete monthly mean should be 18.6 divisions less, or equal 926.0.

The observations were resumed on the 12th, and continued to February 8th at $22^h\ 49\frac{1}{2}^m$, when the wires were found to have been slightly deranged. Two days previously, February 6, $18^h\ 22^m$ (Philadelphia time,) a great change in the position was noticed; on re-arranging the instrument, it did not return to its former readings. A correction of +116 has been applied (in the record) to the previous *mean* readings only in this month, and in consequence +116 divisions should be added to each individual reading from the commencement of the series; but on account of another disturbance of the instrument, on the 22d, at $16^h\ 22^m$ (Philadelphia time,) a further correction of +92.8 scale divisions should be applied. The total correction is, therefore, +208.8. Besides these corrections, the readings on the 22d from $0^h\ 22^m$ (Philadelphia time) to $10^h\ 22^m$ (Philadelphia time) inclusive, should be increased by +25.1 divisions, the alhidade of the instrument having been disturbed.*

On the 2d of June, 1841, the suspension wires were struck accidentally, deranging the instrument; the readings were then near the end of the subsidiary scale, and in re-arranging the instrument the new readings were brought near the middle of the scale. The total difference between the old and new scale readings, the latter commencing with the first of the month, is 900 scale divisions. The means between June 1st and

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* The corrected daily means for the month of February, 1841, should, therefore, read as follows—

1st	1163.5	10th	1131.1	19th	1127 9
2d	1144 8	11th	1103.8	20th	1130 0
3d	1141.9	12th	1082.5	22d	1182 9
4th	1133 0	13th	1083.5	23d	1182.6
5th	1138.1	15th	1100 0	24th	1128 0
6th	1138.6	16th	1122 1	25th	1107.7
8th	1181.2	17th	1139 7	26th	1144.6
9th	1150.6	18th	1137.0	27th	1162.3
Mean					1135.7

5th are already corrected in the record, but the individual bi-hourly readings require a correction of +213* scale divisions to produce these means. It was thought best not to apply this correction of −900 divisions to the observations between June, 1840, and June, 1841, but simply to state the quantity, since it can be applied easily to any result hereafter.

At the close of 1842 the regular observations were discontinued for three months, during January, February, and March, 1843; a daily reading was taken at $14^h\ 22^m$ (Philadelphia time,) in order to keep up a continuity in the series. By means of the reduced readings in the same months in the other years, it was found that a correction of $-3^d.4$ $-3^d.7$ and $+1^d.5$ for January, February, and March, respectively, was required to refer the mean at $14^h\ 22^m$ to the mean of a complete bi-hourly daily series. Applying these corrections, the corrected monthly means become—

For January, 1843 .... $803^d.7$ at $59^\circ.2$
For February, 1843 .... $798^d.9$ at $51^\circ.9$
For March, 1843 .... $815^d.1$ at $48^\circ.7$

On the 15th of April, 1843, the instrument was carefully examined and found in adjustment.

At $6^h\ 50^m$ on May 4, 1843, the bifilar was disturbed, but readjusted on May 5, before the regular observation at $2^h\ 21^m$ p. m. A correction of −16 divisions during the interval is to be applied to the readings. After this date the instrument remained undisturbed.

We have, therefore, for discussion the following continuous series of monthly means of the readings of the bifilar magnetometer with its corresponding mean temperature. The series extends over five years and one month. To obtain a better view of the series, the correction of −900 divisions for the first twelve months has been applied; it gives a negative value to the June mean of 1840.

TABLE I.

Recapitulation of monthly mean readings of the bifilar magnetometer, corrected so as to present a continuous series.

	BIFILAR MAGNETOMETER.					TEMPERATURE.				
	1840–41.	1841–42.	1842–43.	1843–44.	1844–45.	1840–41.	1841–42.	1842–43.	1843–44.	1844–45.
June	− 85.4	+432.3	+663.5	+901.0	+1092.0	+72°.1	+74°.1	+71°.3	+75°.1	+72°.9
July	+ 90.1	463.9	710.2	946.5	1126.6	75.6	77.3	76.8	76.8	77.8
August	146.2	511.6	718.1	956.3	1149.5	75.5	75.4	74.7	77.2	75.8
September	162.1	537.9	740.3	985.4	1124.8	65.0	70.6	72.5	73.1	71.5
October	149.4	515.6	768.8	988.6	1140.7	58.7	53.7	67.9	66.3	68.8
November	136.8	503.1	777.8	983.7	1135.1	47.4	47.1	61.8	60.5	61.5
December	156.0	535.4	775.9	986.1	1191.3	35.7	55.4	57.3	57.7	57.4
January	234.8	561.0	803.7	988.3	1227.2	36 5	61.5	59.2	51.7	58.8
February	235 7	576 4	798.9	1018.1	1221.6	34.7	60.5	51.9	54.6	53.6
March	248.9	572.1	815.1	1052.1	1235.3	43.5	64.1	48.7	62.8	58.2
April	266.5	606.7	869.5	1067.6	1257.3	50 5	65.5	67.4	63.8	64.1
May	307.8	625.1	873.6	1072.4	1250.8	60.3	68.3	68.4	68.9	64.3
June	....	....	....	....	1291.7	....	....	....	....	74.8

Under the supposition of a uniform progression in the change of the mean monthly readings (due to change in the horizontal force and loss of magnetism of the bar) the bifilar readings for a given period may be represented by the form—

$$B = B_m + \triangle e\, x + \triangle t\, y$$

where B_m a mean bifilar reading for the period.

x the change during a period.

y the change in the reading due to a change of 1° Fahr.

$\triangle e$ = difference between any single period and the mean epoch.

$\triangle t$ = " " any temperature and the mean temperature.

The formula was first applied to the monthly means resulting from five years of observation; it gave $y = +1.0$ scale division; but the remaining differences showed that the irregular changes between June and

* For the first day only +142, according to the mean in the record.

July, and December and January, of the years 1840–'41, had an undue effect on the result. The first year's observations were, therefore, omitted, and the process repeated for the remaining four years. The twelve conditional equations gave the normal equations—

$$+2143.15 = +143x - 200.4y.$$
$$-2549.73 = -200.4x + 711.1y.$$

whence x = monthly effect of the progression = +16.5 scale divisions.

y = temperature correction for 1° Fahr. = + 1.8 " "

An examination of the observed and computed values showed that the introduction of a term $\triangle t^2 z$ would improve the agreement. Solving the three normal equations we found—

$$x = +17.6$$
$$y = + \ 1.62$$
$$z = - \ 0.31$$

The following table shows the comparison of the observed and computed monthly mean readings of the bifilar:

1841—1845.	Mean temperature.	Mean observed bifilar reading.	Mean computed.	Difference c. — 0.	C. — 0. + 3.5.
June	73°.3	772.2	779 2	+ 7.0	+10.5
July	77.2	811.8	806 2	— 5.6	— 2.1
August	76.5	833 9	824.7	— 9.2	— 5.7
September	71.9	847.1	837.0	—10.1	— 6.6
October	61.2	853 4	843.3	—10.1	— 6.6
November	57.7	849.9	851.4	+ 1.5	+ 5.0
December	57.0	872.2	867.8	— 4.4	— 0.9
January	57.8	895.0	886.0	— 9.0	— 5.5
February	55.2	903.8	897.9	— 5.9	— 2.4
March	58.5	918.6	919.3	+ 0.7	+ 4.2
April	65.2	950.3	945.4	— 4.9	— 1.4
May	67.5	955.5	963.5	+ 8.0	+11.5
Mean	65.17	872.0			

Adding +3.5 scale division to the mean value of B_m the above differences will balance. According to the above results, the annual progressive change is $+17.6 \times 12 = 211.2$ scale divisions, and the change in magnetic moment of the bar for a change of 1° Fahr. in the temperature, or $q = +1.62 \times 0.0000365 = 0.0000591$. This agrees with the best direct determination, being the one in which the observatory was alternately heated and cooled.

To test these results, a combination of the six warmest months with the six coldest months, by alternate means, furnished several values for q depending merely on the assumption of a gradual regular progressive change during each year and a half, for which separate results were deduced; this series commences with May, 1841, and ends with April, 1845, and contains, therefore, the same number of months as the first combination, excluding at the same time the two defective portions noticed above. This combination also possesses the advantage of showing the variations in the values of q.

Combination by alternate means of the warmer months, from May to October inclusive, with the colder months, from November to April inclusive.

	Bifilar.	Temperature.	Alternate means.		$\Delta d.$	$\Delta t.$	q in scale divisions.
May, 1841, to Oct., 1841....	461.5	68.57	....	....	....	....	....
Nov., 1841, to April, 1842....	559.1	59.05	582.9	70.25	23.8	11.20	+ 2.1
May, 1842, to Oct., 1842....	704.3	71.92	683.0	58.38	21.3	13.54	+ 1.6
Nov., 1842, to April, 1843....	806.8	57.72	823.1	72.37	16.3	14.65	+ 1.1
May, 1843, to Oct., 1843....	941.9	72.82	911.4	58.12	30.5	14.70	+ 2.1
Nov., 1843, to April, 1844....	1016.0	58.52	1029.8	72.72	13.8	14.20	+ 1.0
May, 1844, to Oct., 1844....	1117.7	72.62	1113.6	58.72	4.1	13.90	+ 0.3
Nov., 1844, to April, 1845....	1211.3	58.93	....	....	....	....	....
Sum...............	....	....	....	....	109.8	82.19	Mean + 1.3

The result from this combination +1.3 confirms the preceding value. The result according to weight or +1.5 scale divisions, or $q = 0.0000548$ in parts of the horizontal force, has, therefore, been adopted in the reduction of the bifilar readings to a standard temperature, for which +63°.0 Fahrenheit has been determined upon as the mean temperature of the magnetic bar during the five years' series of observations.

The difference in the resulting value for q, when obtained from deflections or vibrations, and from combinations of the bifilar readings themselves, has been remarked before, and no satisfactory explanation has as yet been given of it. Thus, for instance, at Toronto, the two respective values were 2.69 and 1.63 scale divisions, as shown in General Sabine's remarks (Vol. III.) The existence of a similar discrepancy in the case of the Makerstown bifilar has been detected by Mr. Broun. Whatever may be the cause of the difference, there can be no hesitation in saying that the result derived from the bifilar observations themselves is the one to be preferred. At St. Helena, (Vol. II, London, 1860,) the two values were 1.45 and 0.98. The half-yearly comparisons at this station even show a less value, viz., 0.88 scale divisions; 0.98 (for convenience 1.0) was adopted in the reduction. Dr. Lamont, in his Handbook of Terrestrial Magnetism, (p. 206, edition of 1849,) says: "It deserves to be remarked that the value obtained by comparing monthly mean readings of the bifilar at high and low temperatures is smaller than that obtained by direct observation."

In the present discussion the value $\frac{q}{k} = \frac{0.0000548}{0.0000365} = 1.5$ has been adopted. At Toronto this value was $\frac{q}{k} = \frac{0.000142}{0.000087} = 1.63$, and at St. Helena $\frac{q}{k} = \frac{0.00019}{0.00019} = 1.0$.

It will be seen from these values that the Philadelphia bifilar magnetometer was very sensitive; its scale value in parts of the horizontal force is but four-tenths of the Toronto value, and only two-tenths of that of the St. Helena instrument.

In the computations which follow the tenths of scale readings have been omitted, (keeping only the nearest unit,) as contributing nothing to the accuracy of the results, and merely increasing the labor of reduction. The uncertainty in the readings arising from the uncertainty in the value of q probably affects the units, and the same may be said of the declination changes, so that in extreme (individual) cases the next higher figure may be affected.

The next step of the reduction consisted in transcribing the whole body of the observations after correcting them individually for differences of temperature; the adopted standard temperature being 63° Fahrenheit.

The following table contains the monthly means of the bifilar readings reduced to the standard temperature; the series has been made continuous by the application of certain corrections explained before.

The readings are in scale divisions of 0.0000365 parts of horizontal force; increasing numbers denote decrease of force. The time is Observatory mean time, counted to twenty-four hours for convenience sake.

Table II.

Monthly means of the bifilar readings, taken at intervals of two hours and reduced to the standard temperature, 63° Fahrenheit.

	Philadelphia time, (A. M.)						Philadelphia time, (P. M.)					
	0h. 22m.	2h. 22m.	4h. 22m.	6h. 22m.	8h. 22m.	10h. 22m	12h. 22m.	14h. 22m.	16h. 22m.	18h. 22m	20h. 22m.	22h. 22m.
1840.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.
June	−96	−98	−101	−113	−102	−79	−94	−115	−117	−96	−88	−90
July	+74	+67	+63	+60	+86	+100	+81	+52	+41	+74	+79	+79
August	129	117	117	113	146	157	137	113	110	129	126	133
September	158	147	143	138	169	201	183	157	152	153	157	153
October	155	149	137	140	153	179	177	161	155	157	158	152
November	160	157	149	141	153	171	179	165	167	159	160	164
December	203	192	184	178	184	210	218	206	192	196	202	202
1841.	0h. 22m.	2h. 22m.	4h. 22m.	6h. 22m.	8h. 22m.	10h. 22m	12h. 22m.	14h. 22m.	16h. 22m.	18h. 22m.	20h. 22m.	22h. 22m.
January	296	287	286	276	272	294	322	306	289	298	294	298
February	279	270	265	256	261	286	303	295	276	283	289	2.5
March	276	273	267	260	272	298	299	272	279	281	282	280
April	285	278	268	265	287	312	314	282	273	280	289	286
May	311	312	311	303	318	335	323	304	298	307	312	315
June	420	417	414	405	418	427	406	402	408	416	426	427
July	444	440	435	436	447	457	449	429	430	442	453	448
August	490	490	485	481	499	515	500	479	481	496	501	497
September	517	520	517	514	534	561	538	522	521	528	523	524
October	528	520	517	518	532	540	545	535	529	530	531	530
November	523	529	522	515	525	535	539	525	523	525	528	529
December	545	541	537	534	539	551	562	550	547	553	553	551
1842.	0h. 21½m	2h. 21½m.	4h. 21½m.	6h. 21½m.	8h. 21½m.	10h. 21½m.	12h. 21½m.	14h. 21½m.	16h. 21½m	18h. 21½m.	20h. 21½m.	22h. 21½m.
January	560	558	557	554	553	575	579	564	559	568	565	565
February	582	576	574	568	570	580	593	582	578	583	589	582
March	573	564	561	561	567	589	577	567	568	574	576	577
April	605	599	598	593	601	618	612	596	592	605	607	607
May	618	614	609	609	624	632	622	607	609	618	620	622
June	652	655	649	641	652	664	654	642	639	652	655	656
July	684	689	682	683	695	710	698	681	674	687	693	697
August	702	695	695	693	712	722	703	689	690	700	704	703
September	721	723	719	712	732	746	734	722	718	729	730	727
October	757	750	747	747	755	774	778	772	766	764	765	762
November	780	774	772	769	778	791	786	782	778	778	781	785
December	783	780	778	776	779	793	800	791	780	781	784	785
1843.	0h. 21½m	2h. 21½m.	4h. 21½m.	6h. 21½m.	8h. 21½m.	10h. 21½m	12h. 21½m.	14h. 21½m.	16h. 21½m.	18h. 21½m	20h. 21½m.	22h. 21½m.
January	……	……	……	……	……	……	……	813	……	……	……	……
February	……	……	……	……	……	……	……	819	……	……	……	……
March	……	……	……	……	……	……	……	835	……	……	……	……
April	860	859	853	853	867	880	875	860	859	863	866	859
May	866	864	862	860	875	877	862	855	856	863	873	870
June	884	883	879	876	886	895	887	873	873	884	887	888
July	924	921	921	920	933	940	932	920	916	921	931	929
August	932	931	931	928	950	957	944	924	925	930	936	935
September	968	967	962	957	977	990	981	966	968	970	970	966

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1843.	0h. 21⅓m.	1h. 21⅓m.	2h. 21⅓m.	3h. 21⅓m.	4h. 21⅓m.	5h. 21⅓m.	6h. 21⅓m.	7h. 21⅓m.	8h. 21⅓m.	9h. 21⅓m.	10h. 21⅓m.	11h. 21⅓m.
	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.
October	983	978	980	978	976	978	977	980	984	987	991	992
November	988	987	986	984	983	981	981	984	988	992	994	994
December	996	994	993	992	990	988	988	988	992	992	993	998

	12h. 21⅓m.	13h. 21⅓m.	14h. 21⅓m.	15h. 21⅓m.	16h. 21⅓m.	17h. 21⅓m.	18h. 21⅓m.	19h. 21⅓m.	20h. 21⅓m.	21h. 21⅓m.	22h. 21⅓m.	23h. 21⅓m.
October	991	989	985	983	983	983	985	985	985	984	983	984
November	992	990	988	987	985	985	987	987	988	988	989	989
December	1000	999	997	994	992	991	993	996	996	996	998	999

1844.	0h. 21⅓m.	1h. 21⅓m.	2h. 21⅓m.	3h. 21⅓m.	4h. 21⅓m.	5h. 21⅓m.	6h. 21⅓m.	7h. 21⅓m.	8h. 21⅓m.	9h. 21⅓m.	10h. 21⅓m.	11h. 21⅓m.
January	1009	1007	1006	1004	1002	1002	1001	1001	1004	1007	1010	1013
February	1031	1031	1031	1029	1026	1026	1026	1028	1029	1030	1034	1036
March	1050	1048	1047	1046	1045	1044	1045	1046	1051	1058	1060	1062
April	1067	1066	1065	1062	1059	1059	1062	1062	1067	1075	1079	1079
May	1066	1066	1064	1063	1063	1062	1062	1065	1069	1075	1076	1071
June	1080	1079	1078	1079	1079	1077	1075	1079	1082	1084	1086	1083
July	1103	1104	1106	1107	1107	1106	1105	1105	1110	1117	1119	1115
August	1129	1130	1130	1130	1129	1127	1126	1131	1139	1148	1149	1143
September	1108	1108	1108	1109	1105	1107	1106	1113	1123	1129	1133	1129
October	1132	1128	1127	1123	1122	1124	1125	1130	1137	1143	1146	1141
November	1136	1135	1133	1132	1131	1127	1128	1129	1134	1141	1147	1149
December	1203	1201	1198	1196	1194	1192	1188	1191	1192	1196	1207	1215

	12h. 21⅓m.	13h. 21⅓m.	14h. 21⅓m.	15h. 21⅓m.	16h. 21⅓m.	17h. 21⅓m.	18h. 21⅓m.	19h. 21⅓m.	20h. 21⅓m.	21h. 21⅓m.	22h. 21⅓m.	23h. 21⅓m.
January	1011	1008	1005	1001	1000	1002	1004	1005	1005	1006	1007	1009
February	1035	1032	1028	1028	1032	1031	1032	1033	1034	1033	1034	1033
March	1067	1063	1056	1049	1052	1054	1054	1053	1051	1052	1052	1051
April	1074	1069	1063	1059	1051	1059	1065	1067	1068	1069	1066	1069
May	1065	1058	1054	1054	1052	1055	1060	1064	1065	1065	1064	1064
June	1079	1074	1069	1067	1067	1069	1073	1075	1077	1079	1079	1080
July	1107	1101	1097	1094	1093	1094	1097	1100	1102	1103	1104	1105
August	1134	1125	1117	1115	1117	1123	1130	1131	1132	1131	1132	1131
September	1119	1108	1102	1100	1101	1105	1108	1110	1111	1111	1112	1116
October	1139	1134	1128	1129	1128	1132	1133	1133	1135	1132	1133	1130
November	1146	1145	1139	1137	1138	1138	1138	1143	1141	1138	1135	1139
December	1215	1210	1205	1200	1195	1196	1197	1197	1197	1201	1201	1201

1845.	0h. 21⅓m.	1h. 21⅓m.	2h. 21⅓m.	3h. 21⅓m.	4h. 21⅓m.	5h. 21⅓m.	6h. 21⅓m.	7h. 21⅓m.	8h. 21⅓m.	9h. 21⅓m.	10h. 21⅓m.	11h. 21⅓m.
January	1233	1230	1231	1229	1227	1225	1224	1226	1230	1238	1244	1248
February	1232	1234	1232	1230	1230	1227	1224	1228	1234	1238	1246	1249
March	1237	1237	1235	1236	1235	1235	1231	1234	1242	1250	1256	1262
April	1253	1250	1249	1247	1245	1243	1241	1247	1255	1270	1280	1279
May	1249	1248	1246	1245	1241	1238	1235	1242	1254	1264	1265	1263
June	1274	1274	1274	1273	1268	1267	1262	1266	1273	1284	1290	1289

	12h. 21⅓m.	13h. 21⅓m.	14h. 21⅓m.	15h. 21⅓m.	16h. 21⅓m.	17h. 21⅓m.	18h. 21⅓m.	19h. 21⅓m.	20h. 21⅓m.	21h. 21⅓m.	22h. 21⅓m.	23h. 21⅓m.
January	1245	1241	1238	1235	1233	1236	1237	1233	1232	1231	1231	1229
February	1251	1247	1240	1236	1235	1233	1234	1236	1236	1232	1232	1233
March	1261	1254	1246	1240	1241	1243	1245	1242	1241	1238	1241	1240
April	1271	1267	1255	1253	1249	1251	1254	1257	1257	1254	1251	1252
May	1256	1248	1242	1242	1242	1246	1251	1251	1251	1253	1251	1245
June	1282	1278	1269	1267	1266	1269	1274	1278	1277	1276	1275	1275

The monthly means are contained in the following table:

TABLE III.

Monthly means of the preceding bifilar readings reduced to the standard temperature 63° Fahrenheit.

	1840-'41.	1841-'42.	1842-'43.	1843-'44.	1844-'45.
	Divs.	Divs.	Divs.	Divs.	Divs.
June	— 99	....	....	....	....
July	+ 71	443	689	926	1104
August	127	493	701	935	1130
September	159	527	726	970	1112
October	156	530	761	984	1132
November	160	527	780	987	1138
December	197	547	784	994	1199
January	*274	563	‡808	1005	1233
February	278	589	‡814	1031	1235
March	278	570	‡835	1052	1243
April	285	603	863	1066	1255
May	312	617	865	1064	1249
June	†415	651	883	1077	1274

Correction for progressive change in the readings.—The observations having been referred to a uniform temperature, still require a correction for the effect of the progressive change during each month before Peirce's criterion can be applied for the purpose of separating the disturbances. We have seen that the mean monthly value of this change due to loss of magnetism of the bar and to change in the horizontal force itself was 17.6 scale divisions; on the average, therefore, a correction must be applied to the observations on the first and last day of each month of +8.8 and −8.8 scale divisions, and in proportion for the intermediate days. At Toronto, also, the progressive change in some months was so great as to present a practical difficulty by its interference with the proper comparability of the observations, and in these cases new means at shorter intervals than a month were taken. At Philadelphia the progressive change is so large as to require a systematic correction throughout the series. In the manuscript tables used for the preparation of the monthly normals and containing the observations reduced to 63° Fahrenheit, the readings corrected for progressive change were written in blue ink underneath each observation. If the monthly differences are taken from Table No. III, it is apparent that the change is irregular, and in three cases at least it is certain that other causes were in operation, which produced larger monthly differences than could be attributed to the gradual loss of magnetism. These cases are the following (already noticed in the preceding temperature discussion:) between June and July, 1840, a difference of 170 divisions; between December and January, 1840-'41, a difference

* The actual mean of 17 days was 293; to reduce this to the mean of 27 days, 19 scale divisions were subtracted, resulting from an interpolation between January 1 and January 12; the mean of 7 days preceding and following the gap was made use of.

† Owing to causes already explained, the means of May and June differ so much as to affect the continuity of the series; the same is to be said of the differences between June and July, 1840, and between December, 1840, and January, 1841: the corresponding differences between the same months in the other four years furnish us with the means of correcting the series for the first year, as will be seen hereafter; it also appeared advisable to omit the readings in June, 1840, altogether, the instrument not having been in stable adjustment.

‡ The numbers in table II have been slightly changed, to refer the mean of the hour of observation to the mean resulting from observation of 12 hours a day. Comparing the mean at 14*h*. 22*m*. in each month with the respective monthly means in the other four years the above corrections became −5, −5 and 0 for January, February, and March.

The bar between September and October, 1843, separates the means from the bi-hourly and the hourly series.

In the application of the reduction for temperature no attempt whatever has been made at interpolation in the magnetic series, but whenever a temperature reading was accidentally omitted, it has been supplied by comparison with the observed temperature immediately preceding and following. No magnetic reading can be supplied by interpolation, however short the interval, as long as the law of the occurrence of the disturbances remains unknown.

of 77; and between May and June, 1841, a difference of 103 divisions. They require separate treatment, as will be presently explained. For the correction of the progressive changes the mean reading from *one* month's series was made out for the first, middle, and last of each month. By this process of taking the mean from 14 days preceding and 14 days following each of the epochs the lunar effect on the solar variation is practically eliminated from the resulting mean value.* These means corresponding in time to the beginning, the middle, and the end of each month, furnish the *rate* of change for the first and second half of the month, and by simple interpolation give the correction for progressive change for each day. If the rates for the first and second half of the month are different, the monthly means of each hour (from the blue figures) will differ by a small but *constant* quantity from the former monthly means. Thus, for instance, for the month of June, 1842, the monthly mean is 651 divisions, corresponding in time to the middle of the month; the mean of the readings (at 63°) for the second half of May and the first half of June is 641, corresponding in time to the first of June; and the mean of the readings (at 63°) of the second half of June and the first half of July is 673, corresponding in time to the last of June; the correction applied to the bi-hourly readings (at 63°) on June 1 was +10, and to the readings on June 30 was −22 divisions. At the middle of the month the correction is zero, and for the intermediate days it is in proportion to their respective distances from the middle. The algebraic sum of the daily corrections divided by the number of days of observation is −3, which gives the new monthly mean 648, as corrected for irregularity in the progressive change. In the exceptional case of a break, or beginning and termination, the required rate of change for half the month was found by a similar process, using half-monthly and quarterly means.

The following table, No. IV, contains the monthly means of the bi-hourly and hourly readings of the bifilar magnetometer referred to a uniform temperature (63° Fahrenheit,) and corrected for irregularity in the progressive change. It is here inserted for the purpose of comparing it with the monthly normals, showing the change produced by the exclusion of the disturbances. The means in the month of June, 1840, are suppressed, and the readings between June 1 and June 5, 1841, were not used.

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* In connexion with this subject, the first part of an interesting paper by Mr. Broun may be consulted, viz: "On the lunar diurnal variation of the magnetic declination at the magnetic equator."—*Proceedings Royal Society, Vol. X, No.* 39, 1860.

TABLE IV.

Monthly means of the bi-hourly and hourly readings of the bifilar magnetometer, reduced to a uniform temperature and corrected for irregularity in the progressive change.

	PHILADELPHIA TIME (A. M.)						PHILADELPHIA TIME (P. M.)					
Year.	0h. 22m	2h 22m.	4h. 22m	6h. 22m.	8h 22m	10h. 22m.	12h. 22m.	14h 22m.	16h 22m.	18h. 22m	20h. 22m.	22h. 22m.
1840.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.
July	90	83	79	76	102	116	97	68	57	90	95	95
August	130	118	118	114	147	158	139	115	112	130	127	134
September	161	150	146	141	172	204	186	160	155	156	160	156
October	153	147	135	138	151	177	175	159	153	155	156	150
November	155	152	144	136	148	166	174	160	162	154	155	159
December	202	191	183	177	183	209	217	205	191	195	201	201
1841.	0h. 22m.	2h. 22m.	4h. 22m.	6h. 22m.	8h. 22m.	10h. 22m.	12h. 22m.	14h. 22m.	16h. 22m.	18h. 22m.	20h. 22m.	22h. 22m.
January *	300	291	290	280	276	298	326	310	293	302	298	302
February	279	270	265	256	261	286	303	295	276	283	289	275
March	276	273	267	260	272	298	299	272	279	281	282	280
April	283	275	265	262	284	309	311	279	270	277	286	283
May	307	308	307	299	314	331	319	300	294	303	308	312
June †	392	390	389	383	400	406	390	380	386	392	402	400
July	445	441	436	437	448	458	450	430	431	443	454	449
August	492	492	487	483	501	517	502	481	483	498	503	499
September	519	522	519	516	536	562	540	524	523	530	525	526
October	527	519	516	517	531	539	541	534	528	529	530	529
November	525	526	519	512	522	532	536	522	520	522	525	526
December	546	542	538	535	540	552	563	551	518	554	554	552
1842.	0h. 21½m.	2h. 21½m.	4h. 21½m.	6h. 21½m	8h. 21½m.	10h 21½m	12h. 21½m	14h. 21½m.	16h. 21½m	18h. 21½m	20h. 21½m.	22h. 21½m.
January	558	556	555	552	551	573	577	562	557	566	563	563
February	585	579	577	571	573	583	596	585	581	586	592	585
March	569	560	557	557	563	576	573	563	564	570	572	573
April	610	604	603	598	606	623	617	601	597	610	612	612
May	614	610	606	605	621	629	618	604	606	615	617	619
June	649	652	645	638	649	661	651	639	636	649	652	653
July	687	692	685	686	698	713	700	684	677	690	696	700
August	701	694	695	692	711	721	702	688	689	699	703	702
September	723	725	720	713	734	748	736	724	720	731	732	729
October	761	754	751	751	759	778	782	776	770	768	769	766
November	779	773	771	768	777	790	785	781	777	777	780	784
December	780	777	775	773	776	790	797	788	777	778	721	782
1843.	0h. 21½m.	2h. 21½m.	4h. 21½m.	6h. 21½m.	8h. 21½m	10h. 21½m	12h. 21½m.	14h. 21½m	16h. 21½m	18h. 21½m.	20h. 21½m.	22h. 21½m.
January	....	....	....	....	....	....	....	818	....	....	....	....
February	....	....	....	....	....	....	....	819	....	....	....	....
March	....	....	....	....	....	....	....	831	....	....	....	....
April	863	862	856	856	870	883	878	853	862	866	869	862
May	865	863	861	859	874	876	861	854	855	862	872	869
June	881	880	876	873	883	892	884	870	870	881	884	885
July	927	924	924	923	936	943	935	923	919	924	934	932
August	931	930	930	927	949	956	943	923	924	929	935	934
September	971	970	965	960	980	993	984	969	971	973	973	969

* The mean of 17 days is given; to refer it to a complete month subtract 19 divisions.
† The mean of 19 days is given; to refer it to a complete month add 8 divisions.

TABLE IV—Continued.

HOURLY SERIES.

Year.	0h.21½m.	1h.21½m.	2h.21½m.	3h.21½m.	4h.21½m.	5h.21½m.	6h.21½m.	7h.21½m.	8h.21½m.	9h.21½m.	10h.21½m.	11h.21½m.
1843.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.
October	983	978	980	978	976	978	977	980	984	987	991	992
November	987	986	985	983	982	980	980	983	987	991	993	993
December	995	993	992	991	989	987	987	987	991	991	992	997
	12h.21½m.	13h.21½m.	14h.21½m.	15h.21½m.	16h.21½m.	17h.21½m.	18h.21½m.	19h.21½m.	20h.21½m.	21h.21½m.	22h.21½m.	23h.21½m.
October	991	989	985	983	983	983	985	985	985	984	983	984
November	991	989	987	986	984	985	986	986	987	987	988	988
December	999	998	996	993	991	990	992	995	995	995	997	998
1844.	0h.21½m.	1h.21½m.	2h.21½m.	3h.21½m.	4h.21½m.	5h.21½m.	6h.21½m.	7h.21½m.	8h.21½m.	9h.21½m.	10h.21½m.	11h.21½m.
January	1007	1005	1004	1002	1000	1000	999	999	1002	1005	1008	1011
February	1031	1031	1031	1029	1026	1026	1026	1028	1029	1030	1034	1036
March	1051	1049	1048	1047	1046	1045	1046	1047	1052	1059	1061	1063
April	1070	1069	1068	1065	1062	1062	1065	1065	1070	1078	1082	1082
May	1055	1065	1063	1062	1062	1061	1061	1064	1038	1074	1075	1070
June	1078	1077	1076	1077	1077	1075	1073	1077	1080	1082	1084	1081
July	1102	1103	1105	1106	1106	1105	1104	1104	1109	1116	1118	1114
August	1133	1134	1134	1134	1133	1131	1130	1135	1143	1152	1153	1147
September	1102	1102	1102	1103	1099	1101	1100	1107	1117	1123	1127	1123
October	1136	1132	1131	1127	1126	1128	1129	1134	1141	1147	1150	1145
November	1132	1131	1129	1128	1127	1123	1124	1125	1130	1137	1143	1145
December	1205	1203	1200	1198	1196	1194	1190	1193	1194	1198	1209	1217
	12h.21½m.	13h.21½m.	14h.21½m.	15h.21½m.	16h.21½m.	17h.21½m.	18h.21½m.	19h.21½m.	20h.21½m.	21h.21½m.	22h.21½m.	23h.21½m.
January	1009	1006	1003	999	998	1000	1002	1003	1003	1004	1005	1007
February	1035	1032	1028	1028	1032	1031	1032	1033	1034	1033	1034	1033
March	1068	1064	1057	1059	1053	1055	1055	1054	1052	1053	1053	1052
April	1077	1072	1066	1062	1064	1062	1068	1070	1071	1072	1069	1072
May	1064	1057	1053	1053	1051	1054	1059	1063	1064	1064	1063	1063
June	1077	1072	1067	1065	1065	1067	1071	1073	1075	1077	1077	1078
July	1106	1100	1096	1093	1092	1093	1096	1099	1101	1102	1103	1104
August	1138	1129	1121	1119	1121	1127	1131	1135	1136	1135	1136	1135
September	1113	1102	1096	1094	1095	1099	1102	1104	1105	1105	1106	1110
October	1143	1138	1132	1133	1132	1136	1137	1137	1139	1135	1137	1134
November	1142	1141	1135	1133	1134	1134	1134	1139	1137	1134	1131	1135
December	1217	1212	1207	1202	1197	1198	1199	1199	1199	1203	1203	1203
1845.	0h.21½m.	1h.21½m.	2h.21½m.	3h.21½m.	4h.21½m.	5h.21½m.	6h.21½m.	7h.21½m.	8h.21½m.	9h.21½m.	10h.21½m.	11h.21½m.
January	1234	1231	1232	1230	1228	1226	1225	1227	1231	1239	1245	1249
February	1231	1233	1231	1229	1229	1226	1223	1227	1233	1237	1245	1248
March	1236	1236	1234	1235	1234	1234	1230	1233	1241	1249	1255	1261
April	1255	1252	1251	1249	1247	1245	1243	1249	1257	1272	1282	1281
May	1244	1243	1241	1240	1236	1233	1230	1237	1249	1259	1260	1258
June	1281	1281	1281	1280	1275	1274	1269	1273	1280	1291	1297	1296
	12h.21½m.	13h.21½m.	14h.21½m.	15h.21½m.	16h.21½m.	17h.21½m.	18h.21½m.	19h.21½m.	20h.21½m.	21h.21½m.	22h.21½m.	23h.21½m.
January	1246	1242	1239	1236	1234	1237	1238	1234	1233	1232	1232	1230
February	1250	1246	1239	1235	1234	1232	1233	1235	1235	1231	1231	1232
March	1260	1253	1245	1239	1240	1242	1244	1241	1240	1237	1240	1239
April	1273	1269	1257	1255	1251	1253	1256	1259	1259	1256	1253	1251
May	1251	1243	1237	1237	1237	1241	1246	1246	1246	1248	1246	1240
June	1289	1285	1276	1274	1273	1276	1281	1285	1284	1283	1282	1282

TABLE V.

Monthly means of the preceding bifilar readings referred to a uniform temperature and corrected for irregularity in the progressive change.

The column 1840–'41 contains a double set of figures: the first are the monthly means directly obtained from table IV; the second contains the means when the series is made continuous for the two breaks already noticed. The mean difference between May and June (from four years) is twenty-five scale divisions, and between December and January it is twenty-two scale divisions; these corrections were applied in the second set of figures.

	1840–'41.		1841–'42.	1842–'43	1843–'44.	1844–'45.	Monthly means of series.
	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	
July	87	215	444	692	929	1103	677
August	128	256	495	700	934	1134	704
September	162	290	529	728	973	1106	725
October	154	282	529	765	984	1136	739
November	155	283	524	779	986	1134	741
December	196	324	548	781	993	1201	769
January	297—19	346	561	813	1003	1234	791
February	278	346	583	814	1031	1234	802
March	278	346	566	831	1053	1242	808
April	282	350	608	866	1069	1257	830
May	308	376	614	864	1063	1244	832
June	393+8	401	648	880	1075	1281	857
Annual means		318	554	793	1008	1192	773

The differences in the successive annual means indicate that the progressive change may be assumed to have been uniforn from year to year, and applying the usual method we find an annual progressive change of 220 scale divisions.

Introduction of the horizontal intensity in absolute measure and separation of the effect of the loss of magnetism of the bifilar bar from the effect due to the secular change of the horizontal intensity.—Although some experiments were made to determine the gradual loss of magnetism of the bar, as, for instance, in January, 1841, when the amount was found to be 0.9601 of the force in May, 1840, and again in June, 1841, when the amount was 0.9686 of its amount in January, 1841, yet the experiments do not extend over the whole period of observation, and consequently we are obliged to deduce the effect of the secular change of the horizontal intensity from other independent means, and, after converting it into scale divisions, we can assign the proper proportion of what is due to secular change and to loss of magnetism, in the whole progressive change of 220 scale divisions in a year.

In connexion with the operations of the United States Coast Survey, Assistant Schott has investigated* the secular change of the horizontal intensity at a number of stations on the Atlantic and Pacific coasts. At several stations the results were subsequently improved by a discussion of my observations for intensity, made in part in connexion with a magnetic survey of Pennsylvania, and also extending into adjoining States, and, in one of the journeys, into Canada. From the complete material the values in the following table of observed horizontal and total intensities have been collected. The horizontal intensity X and total intensity φ are expressed in absolute measure (grains and feet.)

* Report to Superintendent, dated January 19, 1861.

No.	Year.	Observer.	References from which the values were derived or taken.	X.	φ.
1	1835.0	Bache and Courtenay	Trans. Amer. Phil. Soc., vol. V, 1837	4.195	13.58
2	1836.7	Bache		4.159	13.46
3	1839.5	Loomis	Trans. Amer. Phil. Soc., vol. VIII	4.149	13.41
4	1840.9	Bache			13.41
5	1841.5	Locke	Phil. Trans. Roy. Soc., 1846	4.172	13.51
6	1841.8	Bache			13.46
7	1842.5	Locke	Phil. Trans. Roy. Soc., 1846	4.174	13.52
8	1842.8	Lefroy	Phil Trans. Roy. Soc., 1846	4.176	13.50
9	1843.6	Bache		4.172	13.46
10	1844.5	Locke	Phil. Trans. Roy. Soc., 1846	4.162	13.47
11	1846.4	Locke	U. S. Coast Survey records	4.143	13.42
12	1855.7	Schott	U. S. Coast Survey records	4.226	13.89
*13	1862.6	Schott	U. S. Coast Survey records	4.088	13.30

* Added while this paper is passing through the press.

The first three observations were not made at the Girard College grounds; and it appears from Professor Loomis's observation, when compared with Dr. Locke's, that a correction of 0.023 in the value of X should be added to these. To the twelfth observation I have assigned only half weight. It was, probably, made during a disturbance. From the general discussion an annual diminution in the horizontal force of 0.0011 parts was deduced for a number of stations on the Atlantic coast. At Toronto (vol. III of General Sabine's Discussion) the annual decrease was found 0.0010 in parts of the horizontal force. Being somewhat guided by these results, after several trials, the following combination of the results in the table has been adopted, as perhaps best representing the values for the time during which the Girard College observations were made, these latter being merely of a differential character:

Combination.	Mean epoch.	Mean horz'l int. X.
1, 2, 3	1837.1	4.191
5, 7, 8, 9	1842.6	4.174
10, 11, 12, 13	1852.3	4.145

The annual diminution of X is 0.0030, or, when expressed in parts of the horizontal force, = 0.0007; its equivalent in scale divisions is 19.2. The total annual change was found to be 220 scale divisions; hence, 200.8 scale divisions of annual change is due to loss of magnetism of the bar.

The mean epoch is 1844.0, and the corresponding mean X = 4.170; the mean epoch of the observation taken at the Girard College is January, 1843, for which, therefore, the mean value of X = 4.173. This value has been adopted whenever it was desirable to introduce the horizontal force in absolute measure.

Separation of the larger disturbances.—The observations having been referred to a uniform temperature, and corrected for progressive change, Peirce's criterion was applied separately to each month. For this purpose, a systematic application was made extending over the whole series of observations, commencing with the hour 0 and the month of July, next with the hour 2 and August, followed by hour 4 and September, and so on in regular progression. This process eliminates from the result the diurnal variation and the annual variation of the disturbances themselves. The value for 0^h in July, 1840, was omitted as affected by two very large disturbances. The following table shows the limiting value of difference from the mean (the monthly mean for the respective hour,) also the number of observations in each year subjected to the process:

Limits of rejection by Peirce's Criterion.

1840-41	*ex* =	53	*n* = 241
1841-42	"	44	312
1842-43	"	37	309
1843-44	"	28	313
1844-45	"	33	313
Mean value,		**39**	**Sum, 1488**

The limiting value derived from nearly 1,500 observations is 39 scale divisions, and the separate annual values show plainly the effect of the eleven (ten?) year period, the year 1843–4 being a minimum year. Certain limits in the adoption of a separating value are allowable, and upon trial as to the actual number of disturbances separated, the value 33 scale divisions was finally adopted. Any observation differing 33 divisions or more from its respective monthly mean was, therefore, marked and excluded from the mean. 33 divisions equal 0.0012 parts of the horizontal force, and in the value of the absolute scale it amounts to 0.005. At Toronto the limiting value was 14 divisions, = 0.0012 parts of the horizontal force, equal to 0.004 in the absolute scale.—(Vol. III of the Toronto Observations.)

TABLE VI

Shows the number of observations and the number of the larger disturbances separated by the value 33, as the limit, for each month, year, and the whole period.

Month.	1840—1841.		1841—1842.		1842—1843.		1843—1844.		1844—1845.	
	Obser's.	Dist's.	Obser's.	Dist's.	Obser's	Dist's.	Obser's.	Dist's.	Obser's.	Dist's.
July	323	165	323	26	308	24	312	15	648	0
August	308	73	312	17	321	3	324	11	648	4
September	312	54	310	41	308	44	312	16	600	27
October	323	68	308	28	310	53	624	3	648	32
November	293	49	312	32	312	15	624	1	624	42
December	321	120	323	26	323	5	624	0	624	46
January	*201	23	311	14	‡26	0	646	3	648	27
February	288	50	287	37	‡24	1	600	5	576	18
March	320	62	323	26	‡27	1	624	29	624	3
April	309	48	309	38	300	14	624	16	624	33
May	310	46	300	29	324	25	648	3	648	19
June	†225	13	311	16	312	4	600	0	600	56
Sums	3,533	770	3,729	330	2,895	189	6,562	102	7,512	307
Ratio	1 dist. in 4.6 ob's.		1 dist. in 11.3 ob's.		1 dist. in 15.3 ob's.		1 dist. in 64.3 ob's.		1 dist. in 24.4 ob's.	

* In 17 days. † In 19 days. ‡ One observation a day.

Total number of observations 24,231
Total number of disturbances 1,698

The limiting value separated, therefore, one in every 14.3 observations. At Toronto one in every 12.5 was marked as a disturbance.

The larger disturbances having been excluded, new monthly means were taken, and the process was repeated several times, when required, until all readings differing 33 scale divisions or more had been excluded; the final means constitute the normals as given in the following table:

TABLE VII.

Monthly normal of the bi-hourly and hourly readings of the bifilar magnetometer, reduced to a normal temperature and corrected for irregularity in the progressive change.

	PHILADELPHIA TIME (A. M.)						PHILADELPHIA TIME (P. M.)					
Year.	0h. 22m.	2h. 22m.	4h. 22m.	6h. 22m.	8h. 22m.	10h. 22m.	12h. 22m.	14h. 22m.	16h. 22m.	18h. 22m.	20h. 22m.	22h. 22m.
1840.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.
July	113	97	89	50	112	116	94	59	52	92	93	108
August	108	112	117	106	138	153	134	103	111	114	124	126
September	155	147	139	141	189	202	177	155	153	158	157	150
October	142	137	122	128	153	166	159	158	148	146	148	151
November	155	150	144	133	144	154	175	157	151	148	144	160
December	196	188	176	166	178	208	217	193	182	185	200	194
1841.	0h. 22m.	2h. 22m.	4h. 22m.	6h. 22m.	8h. 22m.	10h. 22m.	12h. 22m.	14h. 22m.	16h. 22m.	18h. 22m.	20h. 22m.	22h. 22m.
January *	298	300	294	284	281	302	326	311	289	296	301	302
February	269	261	264	257	265	288	297	289	275	274	275	272
March	268	272	267	257	271	294	286	267	266	282	264	272
April	273	271	262	262	283	317	315	279	268	271	283	280
May	311	305	306	297	306	323	313	301	294	306	309	313
June †	392	390	392	386	400	401	395	382	385	392	402	392
July	442	442	435	435	447	458	449	428	430	444	448	439
August	490	494	487	482	501	518	502	483	483	497	500	495
September	510	514	515	508	531	542	537	516	519	520	515	515
October	521	517	518	514	526	537	547	530	525	527	529	528
November	519	517	515	509	518	529	531	514	518	513	516	518
December	546	541	538	535	537	548	562	549	545	547	550	552
1842.	0h. 21½m.	2h. 22½m.	4h. 21½m.	6h. 21½m.	8h. 21½m.	10h. 21½m.	12h. 21½m.	14h. 21½m.	16h. 21½m.	18h. 21½m.	20h. 21½m.	22h. 21½m.
January	561	556	555	558	553	573	577	559	554	564	563	564
February	580	573	572	567	568	582	589	578	578	580	590	578
March	565	559	557	554	563	574	575	561	565	571	567	566
April	595	598	597	594	604	620	618	603	598	607	608	611
May	614	610	611	605	621	630	622	606	607	615	618	619
June	649	652	646	638	649	659	650	639	638	649	648	650
July	692	686	682	678	695	708	700	680	677	690	694	700
August	699	694	695	692	711	721	700	688	689	701	703	702
September	726	733	722	717	739	750	737	730	727	737	737	734
October	764	759	757	757	764	781	783	776	776	768	769	764
November	774	770	771	768	777	789	787	781	778	775	776	776
December	780	777	775	773	776	790	795	786	773	776	781	782
1843.	0h. 21½m.	2h. 21½m.	4h. 21½m.	6h. 21½m.	8h. 21½m.	10h. 21½m.	12h. 21½m.	14h. 21½m.	16h. 21½m.	18h. 21½m.	20h. 21½m.	22h. 21½m.
January	....	....	....	....	....	....	....	818	....	....	....	....
February	....	....	....	....	....	....	....	817	....	....	....	....
March	....	....	....	....	....	....	....	829	....	....	....	....
April	861	861	854	854	868	883	878	863	860	861	865	859
May	864	862	858	857	875	872	864	855	856	862	867	863
June	881	879	876	873	883	894	884	870	870	881	881	885
July	927	924	924	923	935	941	934	923	916	921	928	931
August	931	930	931	927	947	954	938	921	924	929	932	933
September	974	967	965	960	980	992	985	972	972	975	974	973

* The mean of 17 days.

† The mean of 19 days.

TABLE VII—Continued.

HOURLY SERIES.

Year.	0h. 21½m.	1h. 21½m.	2h. 21½m.	3h. 21½m.	4h. 21½m.	5h. 21½m.	6h. 21½m.	7h. 21½m.	8h. 21½m.	9h. 21½m.	10h. 21½m.	11h. 21½m.
1843.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.	Divs.
October	983	978	983	978	976	978	977	980	983	987	991	992
November	987	986	985	983	982	980	980	983	987	991	992	993
December	995	993	992	991	989	987	987	987	991	991	992	997
	12h. 21½m.	13h. 21½m.	14h. 21½m.	15h. 21½m.	16h. 21½m.	17h. 21½m.	18h. 21½m.	19h. 21½m.	20h. 21½m.	21h. 21½m.	22h. 21½m.	23h. 21½m.
October	991	989	985	983	983	983	985	985	985	986	983	981
November	991	989	987	986	984	985	986	985	987	987	988	988
December	999	998	996	993	991	990	992	995	995	995	997	998
1844.	0h. 21½m.	1h. 21½m.	2h. 21½m.	3h. 21½m.	4h. 21½m.	5h. 21½m.	6h. 21½m.	7h. 21½m.	8h. 21½m.	9h. 21½m.	10h. 21½m.	11h. 21½m.
January	1006	1005	1004	1002	1000	1000	999	999	1002	1005	1008	1011
February	1031	1031	1031	1029	1026	1026	1026	1028	1029	1030	1034	1034
March	1048	1047	1046	1046	1046	1043	1043	1047	1050	1054	1057	1063
April	1070	1069	1068	1065	1063	1062	1054	1051	1057	1074	1078	1078
May	1065	1065	1063	1062	1062	1061	1061	1064	1068	1076	1077	1070
June	1078	1077	1076	1077	1077	1075	1073	1077	1080	1082	1084	1081
July	1102	1103	1105	1106	1106	1105	1104	1101	1109	1116	1118	1114
August	1133	1134	1134	1133	1133	1131	1130	1135	1143	1152	1153	1147
September	1106	1104	1107	1105	1101	1101	1100	1107	1117	1125	1128	1125
October	1133	1132	1131	1127	1124	1125	1129	1134	1141	1149	1152	1145
November	1131	1130	1127	1126	1125	1123	1122	1125	1130	1135	1128	1142
December	1213	1202	1200	1198	1196	1194	1190	1193	1194	1197	1209	1217
	12h. 21½m.	13h. 21½m.	14h. 21½m.	15h. 21½m.	16h. 21½m.	17h. 21½m.	18h. 21½m.	19h. 21½m.	20h. 21½m.	21h. 21½m.	22h. 21½m.	23h. 21½m.
January	1009	1006	1003	999	998	1000	1002	1003	1003	1004	1004	1005
February	1035	1032	1028	1028	1030	1031	1032	1033	1034	1033	1032	1030
March	1063	1061	1057	1050	1051	1050	1050	1052	1050	1048	1050	1048
April	1077	1071	1066	1062	1064	1062	1068	1068	1071	1071	1068	1069
May	1064	1057	1053	1053	1051	1054	1059	1063	1064	1064	1065	1063
June	1077	1072	1067	1065	1065	1067	1071	1073	1075	1077	1077	1073
July	1106	1100	1096	1093	1092	1093	1096	1099	1101	1102	1103	1104
August	1138	1129	1121	1119	1121	1127	1134	1135	1135	1134	1135	1135
September	1115	1104	1097	1095	1095	1100	1102	1104	1104	1108	1107	1108
October	1145	1137	1134	1130	1132	1134	1135	1137	1138	1134	1137	1135
November	1136	1133	1129	1127	1124	1131	1128	1129	1130	1130	1131	1131
December	1220	1212	1209	1202	1201	1201	1203	1198	1200	1204	1206	1206
1845.	0h. 21½m.	1h. 21½m.	2h. 21½m.	3h. 21½m.	4h. 21½m.	5h. 21½m.	6h. 21½m.	7h. 21½m.	8h. 21½m.	9h. 21½m.	10h. 21½m.	11h. 21½m.
January	1233	1228	1231	1230	1228	1226	1225	1226	1231	1241	1248	1252
February	1230	1230	1231	1229	1229	1226	1223	1227	1231	1236	1243	1244
March	1236	1236	1234	1235	1234	1234	1231	1233	1241	1249	1255	1261
April	1252	1250	1249	1247	1245	1243	1241	1244	1253	1268	1278	1281
May	1244	1243	1241	1239	1236	1233	1229	1236	1251	1261	1262	1258
June	1280	1281	1281	1281	1275	1271	1266	1273	1282	1293	1295	1292
	12h. 21½m.	13h. 21½m.	14h. 21½m.	15h. 21½m.	16h. 21½m.	17h. 21½m.	18h. 21½m.	19h. 21½m.	20h. 21½m.	21h. 21½m.	22h. 21½m.	23h. 21½m.
January	1249	1242	1239	1233	1229	1230	1233	1231	1230	1230	1229	1229
February	1250	1242	1238	1231	1233	1229	1231	1233	1235	1231	1231	1232
March	1260	1253	1245	1239	1240	1242	1244	1240	1239	1237	1240	1239
April	1268	1267	1255	1252	1248	1253	1256	1254	1254	1253	1250	1254
May	1253	1244	1238	1236	1237	1239	1245	1246	1246	1248	1247	1242
June	1286	1280	1272	1269	1269	1273	1278	1281	1280	1277	1279	1280

Increase of scale readings corresponds to decrease of force. Value of one division of the scale = 0.0000365 parts of the horizontal force, or in the absolute scale equal to 0.0001523.

Investigation of the Eleven-Year (also called Ten-Year) Period, as shown in the Changes of the Amplitude of the Solar Diurnal Variation of the Horizontal Force.—The variation in the amplitude of the diurnal motion of the horizontal force is subject to the same inequality of about eleven years as the declination, and the means of investigation will be analogous to those used in Part I of this discussion. For greater convenience, the preceding monthly normals were united into annual means and the results put into an analytical form, using Bessel's function applicable to periodical phenomena, and determining the numerical quantity by the application of the method of least squares.

In the following table of the regular solar diurnal variation of the horizontal force the means for 1842–'43 depend only on nine months of observation; the correction given to refer them to twelve months of observation depends on the mean difference between the results of the same nine months and twelve months of the preceding and following year; this correction is nearly constant, and the same within one scale division for the adjacent years. In the second corrected column for 1842–'43 the effect of the annual inequality is thus eliminated. In the year 1843–'44 the results from nine months of observation at the odd hours were reduced to twelve months by means of corresponding differences in the series of even hours; thus (omitting the minutes) at hour 2, mean of 12 months = 1006, mean of 9 months = 1028; at hour 3 for the same 9 months, mean = 1026, or 2 divisions less; at hour 3 for 12 months the mean is therefore 1004, and the same result is found by comparing with the following hour 4; the mean is given in case of a difference in the two results.

TABLE VIII.

Regular solar diurnal variation of the horizontal force for each year of observation, expressed in scale divisions.

Increased numbers indicate decrease of force. The minutes at the head of each column are to be added to the hours given in the first vertical column. Each year commences with the month of July.

Hour of the day.	1840–'41. 22m.	1841–'42. 21¾m.	1842-'43 (9 months.) 21½m.	Correction.	1842–'43. 21½m.	1843–'44. 21½m.	1844–'45. 21½m.
	Divisions.	Divisions.	Divisions.	Divisions.	Divisions.	Divisions.	Divisions.
0 (a. m.)	223	549	782	+6	788	1008	1191
1						1007	1189
2	219	548	780	+6	786	1006	1189
3						1004	1188
4	214	545	777	+6	783	1003	1186
5						1002	1184
6	206	542	774	+6	780	1002	1182
7						1005	1186
8	226	552	788	+5	793	1010	1194
9						1013	1202
10	244	564	799	+5	804	1017	1206
11						1016	1207
12 (p. m.)	241	563	792	+6	798	1014	1202
13						1010	1195
14	221	547	781	+7	788	1005	1189
15						1002	1186
16	215	547	778	+7	785	1002	1185
17						1004	1188
18	222	553	783	+7	790	1006	1190
19						1008	1191
20	225	554	786	+7	793	1008	1191
21						1009	1191
22	227	553	785	+6	791	1008	1191
23						1008	1191
Mean	223.5	551.5			789.9	1007.4	1191.4

(Philadelphia local time, counted from midnight to midnight, 24 hours.)

The preceding mean diurnal variations were put in the following analytical form, in which the angle θ counts from midnight at the rate of 15° an hour:

Year 1840–'41 $H = 223^{d}.5 + 5^{d}.98 \sin(\theta + 252^{\circ}\ 14') + 11^{d}.68 \sin(2\theta + 121^{\circ}\ 16') + 5^{d}.89 \sin(3\theta + 314^{\circ}\ 42')$

" 1841–'42 $H = 551.5 + 4.03 \sin(\theta + 244\ \ 07) + 6.58 \sin(2\theta + 131\ \ 32) + 4.48 \sin(3\theta + 312\ \ 19)$

" 1842–'43 $H = 789.9 + 4.14 \sin(\theta + 250\ \ 06) + 7.07 \sin(2\theta + 132\ \ 24) + 3.74 \sin(3\theta + 323\ \ 06)$

" 1843–'44 $H = 1007.4 + 2.14 \sin(\theta + 273\ \ 55) + 5.09 \sin(2\theta + 128\ \ 58) + 2.35 \sin(3\theta + 317\ \ 58)$

" 1844–'45 $H = 1191.4 + 4.40 \sin(\theta + 271\ \ 13) + 6.86 \sin(2\theta + 123\ \ 25) + 4.11 \sin(3\theta + 321\ \ 26)$

To show the degree of correspondence in the formulæ when deduced from the observations of the even and odd hours separately, the results for the last year have been added, viz:

Even hours $H = 1191^{d}.3 + 4^{d}.20 \sin(\theta + 271^{\circ}\ 28') + 6^{d}.98 \sin(2\theta + 122^{\circ}\ 36') + 4^{d}.11 \sin(3\theta + 322^{\circ}\ 35')$

Odd hours $H = 1191.5 + 4.60 \sin(\theta + 270\ \ 59) + 6.73 \sin(2\theta + 124\ \ 13) + 4.12 \sin(3\theta + 320\ \ 17)$

The close agreement between the observed and computed values is shown generally in diagram A, of Part IV, Sketch No. 50.

The following table exhibits the differences for the year 1842–'43, as an example of the numerical correspondence:

A. M.	Computed.	Observed.	C—O.	P. M.	Computed.	Observed.	C—O.
0*m* 21½*h*	788.7	788	+0.7	12*m* 21½*h*.	799.5	798	+1.5
2 "	786.6	786	+0.6	14 "	787.6	788	—0.4
4 "	781.3	783	—1.7	16 "	784.5	785	—0.5
6 "	781.2	780	+1.2	18 "	790.2	790	+0.2
8 "	792.5	793	—0.5	20 "	792.9	793	—0.1
10 "	803.3	804	—0.7	22 "	720.5	791	—0.5

The differences, using three terms in the equations, are within the uncertainty of the observed values. The probable error of a single representation is ±0.6 rule divisions, or ±0.00009 in the absolute scale.

The curves show a double progression in the daily motion, with a principal maximum of horizontal force in the morning, a principal minimum before noon, and a secondary maximum in the afternoon; the precise epochs (to the nearest five minutes) and extreme values were computed by means of the preceding formulæ.

Year. From July to July.	Principal a. m. maximum of horizontal force.		Principal a. m. minimum of horizontal force.		Diurnal range in—			Secondary p. m. maximum of hor. force.		Less than a. m. max. by divis.
	Epoch.	Amount. Divis.	Epoch.	Amount. Divis.	Scale divis.	Parts of horizontal force.	Value in absol. scale.	Epochs.	Amount. Divis.	
1840–'41	5*h*. 45*m*	207.3	11*h* 0*m*.	246.1	38.8	0.00142	0.0059	4*h*. 05*m*	213.5	6.2
1841–'42	5 50	541.7	11 5	565.5	23.8	0.00087	0.0036	3 50	545.1	3.4
1842–'43	5 30	779.8	10 55	803.9	24.1	0.00088	0.0037	3 50	784.0	4.2
1843–'44	5 40	1001.7	10 50	1016.9	15.2	0.00055	0.0023	4 0	1002.0	0.3
1844–'45	5 40	1182.4	10 50	1206.6	24.2	0.00088	0.0037	4 0	1184.8	2.4
Mean	5 41	....	10 56	....	....	....	0.0038	3 57	....	....

The secondary maximum is reached about 8*h*. 30*m*. p. m. with a comparatively small range.

The mean value of the force is attained about 7*h*. 55*m*. a. m., and again about 1*h*. 55*m*. p. m., with considerable regularity; it is again reached at 6¾*h*. and 11½*h*. p. m., though with less regularity.

At Toronto (see vol. II of the Toronto observations) the diurnal variation of the horizontal force has a principal maximum at a little after 4 p. m., and a principal minimum at 10 or 11 a. m.; the secondary maximum occurs about 6 a. m. There is, therefore, this specific difference in the diurnal motion at these two stations: in that at Philadelphia the morning maximum is the higher of the two, while at Toronto it is the afternoon maximum. The difference between the two maxima, as shown above, is almost nothing in the minimum year 1843–'44, but increases before (and after) this epoch in proportion to the interval. At Toronto the daily range seems to be slightly greater. The secondary minimum at Toronto occurs about 2 or 3 a. m., or about six hours later than at Philadelphia; this is a second though less significant point of difference.

The minimum daily range occurs in 1843–'44; its value is then less than one-half what it was in 1840–'41.

The following equation expresses the mean diurnal range in scale divisions:

$$R = +19.68 - 3.78\,(t - 1843) + 2.77\,(t - 1843)^2.$$

It represents the observed values as follows:

	Observed range.	Computed range.
January, 1841	38.8	38.3
" 1842	23.8	26.2
" 1843	24.1	19.7
" 1844	15.2	18.7
" 1845	24.2	23.2

The minimum range as given by the formula is in September, 1843. In Part I of the discussion we found the minimum range of the declination in May, 1843, and the minimum from the disturbances of the declination in August, 1843.

Before proceeding to the discussion of the disturbances in the horizontal force, the formulæ given for the diurnal variation require to be put in a different form for future use, and for convenience of comparison with other places.

The scale divisions were multiplied by the value of one division of the scale (0.0000365) and again by the value of X found for the year, the numerical constant was replaced by X, and the angular quantities were changed by 180°, so as to make increasing numbers correspond to increase of force; we then obtain in absolute measure the following expressions for the regular solar diurnal variation of the horizontal force at the Girard College:

Year 1840–'41 $H = 4.178 + 0.00091 \sin(\theta + 72° 14') + 0.00178 \sin(2\theta + 301° 16') + 0.00090 \sin(3\theta + 134° 42')$

" 1841–'42 $H = 4.175 + 0.00061 \sin(\theta + 64\ \ 07) + 0.00100 \sin(2\theta + 311\ \ 32) + 0.00069 \sin(3\theta + 132\ \ 19)$

" 1842–'43 $H = 4.173 + 0.00063 \sin(\theta + 70\ \ 06) + 0.00108 \sin(2\theta + 312\ \ 24) + 0.00057 \sin(3\theta + 143\ \ 06)$

" 1843–'44 $H = 4.170 + 0.00033 \sin(\theta + 93\ \ 55) + 0.00078 \sin(2\theta + 308\ \ 58) + 0.00036 \sin(3\theta + 137\ \ 58)$

" 1844–'45 $H = 4.168 + 0.00067 \sin(\theta + 91\ \ 13) + 0.00104 \sin(2\theta + 303\ \ 25) + 0.00063 \sin(3\theta + 141\ \ 26)$

The angle θ counts from midnight; the middle epoch to which each equation refers is January.

Investigation of the Eleven (Ten?) Year Inequality in the Disturbances of the Horizontal Magnetic Force.—In Table VI the number of disturbances in each month has been given as found from the observations; these numbers are, however, not directly comparable with one another—first, on account of some omissions in the record; and secondly, on account of the change from a bi-hourly to an hourly series. For any incomplete month the number of disturbances for the whole month is obtained by simple proportion from the number during the part of the month recorded; for January, 1841, the total number becomes 35; for June, 1841, the total number is 18. For January, February, and March, 1843, the mean total number of the disturbances, as found in the same months in the preceding and following year, was substituted; this mean gave 8, 20, and 20, respectively. The number of disturbances after October, 1843, were halved to make them comparable with the bi-hourly series. There were two anomalous months, July and December, 1840, in which the disturbances amount to 165 and 120, with an annual mean of 64, whereas in the same months in the following year they only amount to 26 and 26 respectively, with an annual mean of 27; the mean annual difference 37 was applied to the numbers found in 1841, which give 63 and 63 as a substitute for the anomalous values in July and December, 1840. This anomaly does not exist in the phenomenon itself, but is unquestionably due to the irregularity in the progressive change.

Table IX contains the number of disturbances as distributed over the several years and months, all referred to a uniform series of bi-hourly observations. To this table the monthly means and their ratio, when compared with the annual mean, have been added; also for comparison, the corresponding ratios found in Part I of the discussion of the disturbances of the declination.

Month.	1840–'41.	1841–'42.	1842–'43.	1843–'44.	1844–'45.	Mean.	Hor. force. Ratio.	Declination. Ratio.
July	(63)	26	24	15	0	26	1.09	0.86
August	73	17	3	11	2	21	0.89	1.59
September	54	41	44	16	13	34	1.43*	1.36
October	63	28	53	2	16	33	1.39	2.12*
November	49	32	15	0	21	24	1.00	1.08
December	(63)	26	5	0	23	23	0.97	1.00
January	35	14	8	1	13	14	0.59	0.77
February	50	37	20	3	9	24	1.00	0.52
March	61	25	20	14	2	25	1.06	0.68
April	48	38	14	8	16	25	1.06	0.91
May	46	30	25	2	10	23	0.97	0.58
June	18	15	4	0	28	13	0.55*	0.53*
Sums	628	330	235	72	153	285	12.00	12.00
Mean	52	28	20	6	13	24	----------	----------

In the columns of ratios the principal maxima and minima are indicated by an asterisk.

The annual means exhibit plainly the eleven-year inequality; they have been represented by the formula:

$$N = +14.4 - 10.2\,(t-1843) + 4.8\,(t-1843)^2.$$

	Observed N.	Computed N.
January, 1841	52	24
" 1842	28	29
" 1843	20	14
" 1844	6	9
" 1845	13	13

According to the formula, the minimum occurs in January, 1844.

We have next to consider the eleven-year inequality in the magnitude of the disturbances of the horizontal force. Table X contains the aggregate amount of the disturbances expressed in scale divisions, and also their mean amount obtained by application of the number of disturbances already given in Table VI.

For reasons already explained, the amount of disturbances in July, 1840, equal to 10761 scale divisions, has been diminished in the ratio of 165 : 63. The ratio of each monthly mean to the mean amount of the year is also given, together with a column of corresponding ratios derived from the disturbances of the declination, as made out in Part I of the discussion.

TABLE X.

Aggregate and mean amount of the disturbances of the horizontal force, expressed in scale divisions.

Month.	1840-'41.	1841-'42.	1842-'43.	1843-'44.	1844-'45	Mean amount.	Hor. force. Ratio.	Declinat'n. Ratio.
July	(4089)	1157	1295	669	0	56	1.10	0.87
August	4084	755	131	471	142	52	1.03	1.61
September	3092	3075	2099	660	1228	56	1.11*	1.56
October	3720	1284	2399	169	1412	49	0.97	2.06*
November	2390	1991	915	34	2173	54	1.06	1.06
December	6515	1225	239	0	2283	52	1.03	1.00
January	1186	601	0	111	1402	49	0.97	0.72
February	2664	1822	44	200	806	50	0.99	0.54
March	3112	1176	39	1412	127	49	0.97	0.66
April	2138	2075	676	861	1604	49	0.97	0.94
May	2456	1211	1187	131	789	47	0.93	0.56
June	560	794	164	0	2390	44	0.87*	0.42*
Mean amount	53.9	52.0	48.6	46.3	46.8	50.6	1.00	1.00

Maxima and minima in the columns of ratios are marked with an asterisk.

The inequality in the mean amount of the horizontal force disturbances in each year, indicates the year 1843-'44 as the minimum year.

From the preceding results, we may assume the month of November, 1843, as the epoch for the minimum of the eleven (ten?) year inequality, as far as indicated by the differential observations of the horizontal force.

Further Analysis of the Disturbances of the Horizontal Force.—The distribution of the disturbances in number and mean amount over the several months of the year has been given in Tables IX and X. From Table IX we learn that the disturbances are greatest in number in September and March or April, or about the time of the equinoxes, and least in number about January and June, or about the time of the solstices. At the autumnal equinox the numbers exceed those of the vernal equinox; the same law was found at Toronto; also the numbers are smaller at the summer solstice than at the winter solstice, in perfect accordance with the result found at Toronto. These results are shown graphically on Diagram B of Part IV, (Sketch No. 50,) which contains also the ratio of the disturbances for the declination in which the same law is apparent.

Table X shows that, in reference to the average magnitude of the disturbances, the same law holds good, to wit: the greatest relative magnitude occurring about the time of the equinoxes; the greater amount corresponding to the autumnal equinox, and the least to about the time of the solstices, the smaller amount occurring near the summer solstice. The average magnitude of the disturbances of the declination was found subject to the same law.

If we separate the disturbances which increase the force from those which decrease it, we may form the two following tables of the distribution of the disturbances in number and average amount over the several months of the years.

TABLE XI.

Annual inequality in the number of disturbances increasing and decreasing the horizontal force.

	1840–'41.		1841–'42.		1842–'43.		1843–'44.		1844–'45.		Sum.		Ratios.	
	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.
July	(38)	(25)	6	20	5	19	1	14	0	0	50	78	1. 2	1. 0
August	18	55	6	11	1	2	2	9	0	2	27	79	0. 7	1. 0
September	25	29	5	36	38	6	11	5	9	4	88	80	2. 1*	1. 1
October	18	50	11	17	37	16	1	1	8	8	75	92	1. 8	1. 2
November	13	36	1	31	4	11	0	0	0	21	18	99	0. 4	1. 3*
December	(25)	(38)	8	18	0	5	0	0	15	8	48	69	1. 1	0. 9
January	19	16	6	8	3	5	0	1	3	10	31	40	0. 8	0. 6
February	15	35	4	33	2	18	0	3	0	9	21	98	0. 5	1. 2
March	17	44	10	16	3	17	0	14	1	1	31	92	0. 8	1. 2
April	18	30	14	24	1	13	1	7	0	16	34	90	0. 8	1. 2
May	24	22	16	13	10	15	1	1	5	5	56	56	1. 3	0. 7
June	9	9	6	10	1	3	0	0	7	21	23	43	0. 5*	0. 6*
Sum	239	389	93	237	105	130	17	55	48	105	502	916	12. 0	12. 0

In each year the number of disturbances increasing the force is less than the number which decrease it; the numbers of increase are to the numbers of decrease as 1 : 1.8. The numbers of the monthly ratio for the increasing disturbances exhibit the same law as found in Table IX: with respect to the numbers for the decreasing force the law is apparently less distinctly marked; the maximum seems to occur about two months later, (before the winter solstice,) at a time when the number for increasing force is apparently at its minimum. This indistinctness in the law may possibly be due to an irregular distribution in reference to the hours of the day, and could only disappear through a longer series of observations.

TABLE XII.

Annual inequality in the mean amount of the disturbances of the horizontal force. Aggregate amount for increasing and decreasing disturbances, expressed in scale divisions.

Month.	1840–'41.		1841–'42.		1842–'43.		1843–'44.		1844–'45.		1840–'45.		Average amount.		Ratios.	
	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.	Inc.	Dec.
July	(2202)	(1887)	214	943	292	1003	41	628	0	0	2749	4461	55*d*	57*d*	1.2	1.1
August	794	3290	261	494	51	80	69	402	0	142	1175	4408	44	54	1.0	1.0
September	1082	2010	186	2889	1857	242	452	208	873	355	4450	5704	45	56	1.0	1.1
October	726	2994	421	863	1685	714	128	41	691	721	3651	5333	44	53	1.0	1.0
November	520	1870	35	1956	185	730	0	34	0	2173	740	6763	41	56	0.9	1.1
December	2204	4311	289	936	0	239	0	0	1483	800	3976	6286	47	56	1.0	1.1
January	723	463	231	370	0	0	0	111	302	1100	1256	2044	48	50	1.1	0.8
February	649	2015	140	1682	0	44	0	200	0	806	789	4747	42	52	1.0	1.0
March	643	2469	415	761	0	39	0	1412	37	90	1095	4771	39	52	0.9	1.0
April	732	1406	550	1525	54	622	75	786	41	1563	1452	5902	40	52	0.9	1.0
May	1000	1456	696	515	412	775	83	48	398	391	2589	3185	42	52	1.0	1.0
June	307	253	284	510	50	114	0	0	604	1786	1245	2663	44	44	1.0	0.8
Sum	11582	24424	3722	13444	4586	4602	848	3870	4429	9927	25167	56267	....	....	12.0	12.0
Number	254	414	93	237	97	92	20	82	96	211	560	1036	....	....	....	....
Mean	46	59	40	57	47	50	42	47	46	47	45	54	....	....	....	....

The average amount of a disturbance increasing the horizontal force is 45 scale divisions, or 0.0069 in absolute measure; the average amount of a disturbance decreasing the same is 54 scale divisions, or 0.0082 in absolute value. The ratio of these numbers is as 1 : 1.2, whereas at Toronto the ratio is 1 : 6.4.

The law of the monthly inequality for amount of increasing or decreasing disturbances is, as in the preceding case, very indistinct and further obscured by the small absolute amount of variation.

In the following table, XIII, the larger disturbances have been distributed over the different hours of their occurrence; in this combination the bi-hourly series (of the even hours) of observation has been used throughout.

Hour.	Aggregate amount in scale divis.	Number of occurrences.	Average amount.	Ratio of numbers.
0 (midnight)	8116	142	57	1.12
2	5967	109	55	0.86
4	4961	93	53	0.73*
6	4751*	94	51	0.74
8	5562	104	53	0.83
10	7721*	146	53	1.15
12 (noon)	6825	161	42	1.27*
14	6636	127	52	1.09
16	6634	135	49	1.07
18	6894	132	52	1.05
20	7574	139	55	1.09
22	7358	139	53	1.09

Directing our attention to the columns of aggregate amount and of ratios of number of occurrence, we find the principal maximum about 11 a. m., which seems to correspond to the *secondary* maximum of corresponding ratios at Toronto occurring about three hours earlier; the principal minimum occurs about 5 a. m., which corresponds to the *secondary* minimum at Toronto occurring between 5 and 6 a. m.; again at Philadelphia the secondary maximum at midnight is about two hours earlier than the *principal* maximum at Toronto, and the secondary minimum about 4 p. m. corresponds in time to the *principal* minimum at Toronto occurring between 2 and 6 p. m. Thus, the curves at the two stations, representing the diurnal variation of the disturbances (irrespective of increase or decrease) of the horizontal force, is double crested with an exchange of the principal and secondary maximum, and also of the principal and secondary minimum.

In the next table, XIV, the diurnal variation of the disturbances is exhibited separately for disturbances increasing and disturbances decreasing the horizontal force.

Hour.	DISTURBANCES INCREASING HORIZONTAL FORCE			DISTURBANCES DECREASING HORIZONTAL FORCE.			Excess of aggregate decrease over aggregate increase.
	Number of occurrences	Aggregate amount.	Ratio.	Number of occurrences.	Aggregate amount.	Ratio.	
0 (midnight)	57	2878	1.28	85	5238	1.21	2360
2	44	2173	0.97	65	3794	0.87	1621
4	42	1998	0.89	51	2963*	0.68	965
6	28	1213*	0.54	66	3538	0.81	2325
8	48	2345	1.04	56	3217	0.74	872
10	61	2732	1.22	85	4989	1.15	2257
12 (noon)	74	3134*	1.39	87	3691	0.85	557
14	48	2239	1.00	79	4397	1.01	2158
16	49	2200	0.98	86	4434	1.03	2234
18	45	2005	0.89	87	4889	1.13	2884
20	39	1758	0.78	100	5816*	1.34	4058
22	50	2296	1.02	89	5062	1.18	2766
Sums	585	26971	12.00	936	52028	12.00	25057

The disturbances increasing and those decreasing the horizontal force evidently follow different laws; at Toronto they were found completely opposed; they are less so at Philadelphia. The principal maximum of increasing disturbances (at noon) seem to be cotemporaneous with a secondary minimum of the decreasing disturbances; again the principal maximum of the decreasing disturbances (at 8 p. m.) corresponds to a secondary minimum of the increasing disturbances. In reference to the main feature, the maximum disturbance of those increasing the force and of those decreasing the force, the Philadelphia ratios show even a greater resemblance to the results at St. Helena and the Cape of Good Hope than to those at Toronto. At the two southern stations the maximum in the disturbances which increase occurs at 11 a. m. and the maximum in the disturbances which decrease occurs about 6 or 7 p. m.—(See vol. II of the St. Helena Observations.)

Table XIV contains also the hourly excess of the aggregate amount of the disturbances which decrease the horizontal force over those which increase the same. If we divide the numbers by the whole number of days of observation (nearly 1500) we obtain the diurnal disturbance variation expressed in scale divisions.

TABLE XV.

Diurnal disturbance variation.

Hour.	S. D.	In absolute measure.	Hour.	S. D.	In absolute measure.
0 (midnight)	1.6	0.00024	12 (noon)	0.4	0.00006
2	1.1	17	14	1.4	21
4	0.7	11	16	1.5	23
6	1.6	24	18	2.0	30
8	0.6	09	20	2.8	43
10	1.5	23	22	1.9	29

The average amount by which the disturbances tend to decrease the diurnal variation of the horizontal force is 1.4 scale divisions, or 0.00021 in the absolute scale. The maximum effect takes place at 8 p. m., at exactly the same hour when the declination disturbances reach their greatest effect.

In the preceding tables, XIII, XIV, and XV, to the hours indicated 21½ minutes should be added, the observations being made so much later than the even hours.

The preceding discussion shows that for two stations, even at a comparatively short distance, as for Philadelphia and Toronto, there are, generally speaking, some close coincidences in the laws derived from independent observations; but there are also certain differences in other results; yet it must not be forgotten that for a strict comparability we require, if not simultaneous observations, at least observations extending over similar parts or the whole of an eleven-year period. The Philadelphia series includes a minimum year of that inequality, with the greater extent of observations before that epoch, whereas at Toronto the series begins after the minimum epoch, and barely extends to a maximum year.

For the purpose of obtaining a better view of the absolute amount of the disturbances and their frequency of occurrence,* they were classified in nine groups of equal differences of 20 scale divisions; the number of disturbances in each was found as follows:

* A table analogous to that given above, showing the distribution of the disturbances in *declination*, is here added for comparison:

LIMITS ADOPTED.		Number of disturbances.
In scale divis.	In minutes of arc	
8 to 16	3'.6 to 7'.2	1856
16 " 24	7.2 " 10.8	333
24 " 32	10.8 " 14.4	105
32 " 40	14.4 " 18.1	42
40 " 48	18.1 " 21.7	16
48 " 56	21.7 " 25.3	2
56 " 64	25.3 " 29.0	2
64 " 72	29.0 " 32.6	1
Beyond.	....	0

LIMITS ADOPTED.			Number of disturbances.
In scale divis.	In parts of hor force.	In the absolute scale.	
33 to 53	0.0012 to 0.0019	0.005 to 0.008	1159
53 " 73	19 " 27	08 " 11	348
73 " 93	27 " 34	11 " 14	93
93 " 113	34 " 41	14 " 17	45
113 " 133	41 " 48	17 " 20	27
133 " 153	48 " 55	20 " 23	14
153 " 173	55 " 62	23 " 26	4
173 " 193	62 " 70	26 " 29	6
193 " 213	0.0070 " 0.0077	0.029 " 0.032	2
Beyond.	....	....	0

The numbers in the last column cannot be considered as entirely independent of the eleven-year period, and in attempting to apply the theory of probabilities in reference to the number of disturbances which ought to occur between the assigned limits, it became apparent that the larger disturbances greatly preponderate—a fact no doubt intimately connected with the difficulty in correctly allowing for the progressive change during the first year of observation.

APPENDIX No. 16.

DISCUSSION OF THE MAGNETIC AND METEOROLOGICAL OBSERVATIONS MADE AT THE GIRARD COLLEGE OBSERVATORY, PHILADELPHIA, IN 1840, 1841, 1842, 1843, 1844, AND 1845.—PART V.

Investigation of the Solar-Diurnal Variation, and of the Annual Inequality of the Horizontal Component of the Magnetic Force. By A. D. Bache, LL. D., Superintendent United States Coast Survey.

The discussion of the diurnal and annual variations of the horizontal force is based on the resulting monthly normal values for each observation hour as given in the preceding part (IV,) in which the horizontal force has been discussed in relation to the ten or eleven year period, and which also contains the investigation of the disturbances; in the same part all necessary statements are given relating to the instrumental data and the absolute values of the horizontal force.

The normals, as has been shown, are referred to a uniform standard temperature; they are corrected for irregularity in the progressive change, and are necessarily freed from all the larger disturbances. The use of the normals instead of the simple means of the readings (corrected for difference of temperature) will insure greater regularity in the variations of the horizontal force, now under consideration.

The diurnal variation requires an arrangement of the five-year series of monthly normals according to the months of the year and hours of the day. In general, the method of interpolation for an occasional omission in either a month or hour, is the same as that used in Part II of the discussion of the Girard College observations; there is, however, this difference in the tabulation of the monthly values, that in the present case the results are consolidated in a five years' arrangement, and in consequence the year commences with the month of July. This arrangement was preferred, particularly since it was found desirable to make no use of the observations in the first month of the series.

Tabulation of monthly normals for each observing hour, and each observing year, beginning and ending with July. The individual values are taken from Table VII of the preceding part, (IV.)

After applying the corrections of —19 scale divisions to the normals for January, 1841, and of +8 scale divisions to those of June, 1841, to allow for defective number of observations in these months, a further correction of +68 scale divisions was applied to all values between July, 1840, and May, 1841, inclusive, and of +60 to all values between July, 1840, and December, 1840, inclusive, to allow for defects in the regularity of the progressive change, thus making the total correction for the latter months =128 scale divisions. The above corrections, when divided by 5, in order to give the correction to the means derived from five years, become, therefore: for months between July and December inclusive, +26; for January, +10; for February, March, April, and May, +14; for June, +2. These corrections are constant for each hour of the day in any one month, and consequently do not affect the diurnal variation; but they have nevertheless been applied at once to facilitate subsequent deductions. Their origin has also been explained in the remarks accompanying Table V of the preceding part.

The following example of the process of interpolation for the odd hour values will suffice for all similar cases: Required the mean normal from the five-year series for $5h.\ 21\frac{1}{2}m.$ a. m., in June, (see tabular values and results below.) The mean normals for the two last years at $4h.\ 21\frac{1}{2}m.$, $5h.\ 21\frac{1}{2}m.$, and $6h.\ 21\frac{1}{2}m.$, are 1176, 1173, and 1169, respectively; the mean at $5h.\ 21\frac{1}{2}m.$ is therefore 3 divisions less than the mean at $4h.\ 21\frac{1}{2}m.$; and since the mean of the five-year series at $4h.\ 21\frac{1}{2}m.$ is 853, the result for $5h.\ 21\frac{1}{2}m.$ becomes 849. Again, adding 4 divisions to 847, the mean at $6h.\ 21\frac{1}{2}m.$, we find 851; the mean of the two values, or 850, is that given in the table, to which +2 has been added, making the final result 852. The means of the odd hours, thus found from the adjacent even hours, in general, do not differ by as much as a scale division.

The time given in the tables of the normals is mean local time, counting from midnight to midnight to twenty-four hours. The observations were taken (on the average) $21\frac{1}{2}$ minutes after the full hours, as indicated in the tables. Increase of scale readings indicates decrease of horizontal force; the value of a scale division equals 0.0000365 parts of the horizontal force, or 0.0001523 in absolute measure, the mean horizontal force being 4.173 (in absolute measure.) Proper weights have been given to the normals of the even and odd hours, in proportion to the number of observations, as will be seen hereafter. Other special remarks will be found at the end of the month to which they refer.

Tabulation of the hourly normals for each month and the mean of the five-year series, expressed in scale division readings and reduced to the standard temperature of 63°, (Fahrenheit's scale,) also corrected for all irregularities in the progressive change. The regular progressive and secular change, therefore, remains in the tabular quantities.

Normals of the horizontal force for July.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	+ 21½m.
1840	113	......	97	......	89	......	50	......	112	......	116	......	94	......	59	......	52	......	92	......	93	......	108	......	......
1841	442	......	442	......	435	......	435	......	447	......	458	......	449	......	428	......	430	......	444	......	448	......	439	......	......
1842	692	......	686	......	682	......	678	......	695	......	708	......	700	......	680	......	677	......	690	......	694	......	700	......	......
1843	927	......	924	......	924	......	923	......	935	......	941	......	934	......	923	......	916	......	921	......	928	......	931	......	......
1844	1102	1103	1105	1106	1106	1105	1104	1104	1109	1116	1118	1114	1106	1100	1096	1093	1092	1093	1096	1099	1101	1102	1103	1104	......
Mean	605	......	651	......	647	......	638	......	660	......	668	......	657	......	637	......	633	......	649	......	653	......	656	......	......
Referred mean	......	653	......	649	......	642	......	647	......	666	......	664	......	646	......	634	......	640	......	651	......	655	......	657	......
Constant correction + 26. Normals	681	679	677	675	673	668	664	673	686	692	694	690	683	672	663	660	659	666	675	677	679	681	682	683	......

Monthly mean normal from the even hours (+ 21½m.) 676.3, weight 5. Monthly mean normal from the odd hours (+ 21½m.) 676.3, weight 1.

Normals of the horizontal force for August.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	+ 21½m.
1840	108	......	112	......	117	......	106	......	138	......	153	......	134	......	103	......	111	......	114	......	121	......	126	......	......
1841	490	......	494	......	487	......	482	......	501	......	518	......	502	......	483	......	483	......	497	......	500	......	495	......	......
1842	699	......	694	......	695	......	692	......	711	......	721	......	700	......	688	......	689	......	701	......	703	......	702	......	......
1843	931	......	930	......	931	......	927	......	947	......	954	......	938	......	921	......	924	......	929	......	932	......	933	......	......
1844	1133	1134	1134	1133	1133	1131	1130	1135	1143	1152	1153	1147	1138	1129	1121	1119	1121	1127	1134	1135	1135	1134	1135	1135	......
Mean	672	......	673	......	673	......	667	......	688	......	700	......	682	......	663	......	656	......	675	......	678	......	678	......	......
Referred mean	......	673	......	672	......	669	......	676	......	698	......	692	......	672	......	662	......	670	......	677	......	677	......	676	......
Constant correction + 26. Normals	698	699	699	698	699	695	693	702	714	724	726	718	708	698	689	688	692	696	701	703	704	703	704	702	......

Monthly mean normal from the even hours (+ 21½m.) 702.2, weight 5. Monthly mean normal from the odd hours (+ 21½m.) 702.2, weight 1.

Normals of the horizontal force for September.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	+ 21½m.
1840	155	......	147	......	139	......	141	......	180	......	202	......	177	......	155	......	153	......	158	......	157	......	150	......	......
1841	510	......	514	......	515	......	508	......	531	......	542	......	537	......	516	......	519	......	520	......	515	......	515	......	......
1842	726	......	733	......	722	......	717	......	739	......	750	......	737	......	730	......	727	......	737	......	737	......	734	......	......
1843	974	......	967	......	965	......	960	......	980	......	992	......	985	......	972	......	972	......	975	......	974	......	973	......	......
1844	1106	1104	1107	1105	1101	1101	1100	1107	1117	1125	1128	1125	1115	1104	1097	1095	1095	1100	1102	1104	1104	1108	1107	1108	......
Mean	694	......	694	......	688	......	685	......	709	......	723	......	710	......	694	......	693	......	698	......	697	......	696	......	......
Referred mean	......	692	......	692	......	687	......	695	......	718	......	720	......	700	......	692	......	697	......	699	......	699	......	696	......
Constant correction + 26. Normals	720	718	720	718	714	713	711	721	735	744	749	746	736	726	720	718	719	723	724	725	723	725	722	722	......

Monthly mean normal from the even hours (+ 21½m.) 724.4, weight 5. Monthly mean normal from the odd hours (+ 21½m.) 724.9, weight 1.

Normals of the horizontal force for October.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	+ 21½m.
1840	142	......	137	......	122	......	138	......	153	......	166	......	159	......	158	......	148	......	146	......	148	......	151	......	....
1841	521	......	517	......	518	......	514	......	526	......	537	......	547	......	530	......	525	......	527	......	529	......	528	......	....
1842	764	......	759	......	757	......	757	......	764	......	781	......	783	......	776	......	776	......	768	......	769	......	764	......	....
1843	983	978	983	978	976	978	977	980	983	987	991	992	991	989	985	983	983	983	985	985	985	986	983	984	....
1844	1133	1132	1131	1127	1124	1125	1129	1134	1141	1149	1152	1145	1145	1137	1134	1130	1132	1134	1135	1137	1138	1134	1137	1135	....
Mean	709	......	705	......	699	......	703	......	713	......	725	......	725	......	717	......	713	......	712	......	714	......	713	......	....
Referred mean	......	705	......	701	......	702	......	708	......	720	......	724	......	721	......	714	......	713	......	713	......	713	......	712	....
Constant correction + 26. Normals	735	731	731	727	725	728	729	734	739	746	751	750	751	747	743	740	739	739	738	739	740	739	739	738	....

Monthly mean normal from the even hours (+ 21½m.) 738.3, weight 5. Monthly mean normal from the odd hours (+ 21½m.) 738.2, weight 2.

Normals of the horizontal force for November.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	+ 21½m.
1840	155	......	150	......	144	......	133	......	144	......	154	......	175	......	157	......	151	......	148	......	144	......	160	......	....
1841	519	......	517	......	515	......	509	......	518	......	529	......	531	......	514	......	518	......	513	......	516	......	518	......	....
1842	774	......	770	......	771	......	768	......	777	......	789	......	787	......	781	......	778	......	775	......	776	......	776	......	....
1843	987	986	985	983	982	980	980	983	987	991	992	993	991	989	987	986	984	985	986	986	987	987	988	988	....
1844	1131	1130	1127	1126	1125	1123	1122	1125	1130	1135	1138	1142	1136	1133	1129	1127	1124	1131	1128	1129	1130	1130	1131	1131	....
Mean	713	......	710	......	707	......	702	......	711	......	720	......	724	......	714	......	711	......	710	......	711	......	715	......	....
Referred mean	......	712	......	708	......	704	......	706	......	717	......	725	......	720	......	712	......	713	......	710	......	713	......	714	....
Constant correction + 26. Normals	739	738	736	734	733	730	728	732	737	743	746	751	750	746	740	738	737	739	736	736	737	739	741	740	....

Monthly mean normal from the even hours (+ 21½m.) 738.3, weight 5. Monthly mean normal from the odd hours (+ 21½m.) 738.8, weight 2.

Normals of the horizontal force for December.

Year.	0h	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	+ 21½m.
1840	196	......	168	......	176	......	166	......	178	......	208	......	217	......	193	......	182	......	185	......	200	......	194	......	....
1841	546	......	541	......	538	......	535	......	537	......	548	......	562	......	549	......	545	......	547	......	550	......	553	......	....
1842	780	......	777	......	775	......	773	......	776	......	790	......	795	......	786	......	773	......	776	......	781	......	782	......	....
1843	995	993	992	991	989	987	987	987	991	991	992	997	999	998	996	993	991	990	992	995	995	995	997	998	....
1844	1213	1202	1200	1198	1196	1194	1190	1193	1194	1197	1209	1217	1220	1212	1209	1202	1201	1201	1203	1198	1200	1204	1206	1206	....
Mean	746	......	740	......	735	......	730	......	735	......	749	......	759	......	747	......	738	......	741	......	745	......	746	......	....
Referred mean	......	741	......	738	......	733	......	732	......	740	......	757	......	752	......	742	......	739	......	742	......	746	......	745	....
Constant correction + 26. Normals	772	767	766	764	761	759	756	758	761	766	775	783	785	778	773	768	764	765	767	768	771	772	772	771	....

Monthly mean normal from the even hours (+ 21½m.) 768.6, weight 5. Monthly mean normal from the odd hours (+ 21½m.) 768.2, weight 2.

Normals of the horizontal force for January.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	+ 21½m.
1841	298		300		294		284		281		302		306		311		289		296		301		302		
1842	561		556		555		558		553		573		577		559		554		564		563		561		
1843	(820)		(817)		(814)		(815)		(814)		(827)		(830)		818		(813)		(820)		(820)		(821)		
1844	1006	1005	1004	1002	1000	1000	999	999	1002	1005	1008	1011	1009	1006	1003	999	998	1000	1002	1003	1003	1004	1004	1005	
1845	1233	1228	1231	1230	1228	1226	1225	1226	1231	1241	1248	1252	1249	1242	1239	1233	1225	1230	1233	1231	1230	1230	1229	1229	
Mean	784		782		778		776		776		792		798		786		777		783		783		784		
Referred mean		782		780		777		774		785		798		791		780		780		784		784		786	
Constant correction + 10. Normals	794	792	792	790	788	787	786	784	786	795	802	808	808	801	796	790	787	790	793	794	793	794	794	796	

Monthly mean normal from the even hours (+ 21½m.) 793.3, weight 4. Monthly mean normal from the odd hours (+ 21½m.) 793.4, weight 2.

The values for 1843 within brackets are interpolated by means of the continued readings at 14h. 21½m.; at this hour the difference of reading from the preceding year is 259, which added to the values of 1842 gave resulting normals for 1843; in the same manner the reading in 1843 at 14h. 21½m. when compared with the reading in the following year (1844) leaves the difference 185, which quantity, when subtracted from each hourly value in 1844, gives a second determination for the year 1843; the mean of the two determinations for each hour has been inserted above.

Normals of the horizontal force for February.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	+ 21½m.
1841	269		261		264		257		265		288		297		289		275		274		275		272		
1842	580		573		572		567		568		582		589		578		578		580		590		578		
1843	(820)		(816)		(813)		(810)		(812)		(822)		(825)		817		(818)		(820)		(826)		(819)		
1844	1031	1031	1031	1029	1026	1026	1026	1028	1029	1030	1034	1034	1035	1032	1028	1028	1030	1031	1032	1033	1034	1033	1032	1030	
1845	1230	1230	1231	1229	1223	1226	1223	1227	1231	1236	1243	1244	1250	1242	1238	1231	1233	1229	1231	1233	1235	1231	1231	1232	
Mean	786		782		781		777		781		794		799		790		787		787		792		786		
Referred mean		784		782		779		779		786		796		794		786		786		790		788		786	
Constant correction + 14. Normals	800	798	796	796	795	793	791	793	795	800	808	810	813	808	804	800	801	800	801	804	806	802	800	800	

Monthly mean normal from the even hours (+ 21½m.) 800.8, weight 4. Monthly mean normal from the odd hours (+ 21½m.) 800.4, weight 2.
The values of 1843 enclosed in brackets are derived from the reading at 14h. 21½m. in the same manner as explained in the preceding month.

Normals of the horizontal force for March.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	+ 21½m.
1841	268		272		267		257		271		294		286		267		266		282		264		272		
1842	565		559		557		554		563		574		575		561		565		571		567		566		
1843	(827)		(823)		(822)		(819)		(827)		(836)		(839)		829		(828)		(831)		(828)		(828)		
1844	1048	1047	1046	1046	1046	1043	1043	1047	1050	1054	1057	1063	1063	1061	1057	1050	1051	1050	1050	1052	1050	1048	1050	1048	
1845	1236	1236	1234	1235	1234	1234	1231	1253	1241	1249	1255	1261	1260	1253	1245	1239	1240	1242	1244	1240	1239	1237	1240	1239	
Mean	789		787		785		781		790		803		805		792		790		796		790		791		
Referred mean		788		786		783		785		798		808		800		787		793		794		789		790	
Constant correction + 14. Normals	803	802	801	800	799	797	795	799	804	812	817	822	819	814	806	801	804	807	810	808	804	803	805	804	

Monthly mean normal from the even hours (+ 21½m.) 805.6, weight 4. Monthly mean normal from the odd hours (+ 21½m.) 805.8, weight 2.
The values for 1843 are interpolated as in the preceding two months.

Normals of the horizontal force for April.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	+ 21½m.
1841	273	......	271	......	262	......	262	......	283	......	317	......	315	......	279	......	268	......	271	......	283	......	280	......	....
1842	595	......	598	......	597	......	594	......	604	......	620	......	618	......	603	......	598	......	607	......	608	......	611	......	....
1843	861	......	861	......	854	......	854	......	868	......	883	......	878	......	863	......	860	......	861	......	865	......	859	......	....
1844	1070	1069	1068	1065	1063	1062	1064	1061	1067	1074	1078	1078	1077	1071	1066	1062	1064	1062	1068	1068	1071	1071	1068	1069	....
1845	1252	1250	1249	1247	1245	1243	1241	1244	1253	1268	1278	1281	1268	1267	1255	1252	1248	1253	1256	1254	1254	1253	1250	1254	....
Mean	810	......	809	......	804	......	803	......	815	......	835	......	831	......	813	......	808	......	813	......	816	......	814	......	....
Referred mean	......	809	......	806	......	803	......	806	......	827	......	837	......	825	......	810	......	808	......	813	......	816	......	813	....
Constant correction + 14. Normals	824	823	823	820	818	817	817	820	829	841	849	851	845	839	827	824	822	822	827	827	830	830	828	827	....

Monthly mean normal from the even hours (+ 21½m.) 828.2, weight 5. Monthly mean normal from the odd hours (+ 21½m.) 828.4, weight 2.

Normals of the horizontal force for May.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	+ 21½m.
1841	311	......	305	......	306	......	297	......	306	......	323	......	313	......	301	......	294	......	306	......	309	......	313	......	....
1842	614	......	610	......	611	......	605	......	621	......	630	......	622	......	606	......	607	......	615	......	618	......	619	......	....
1843	864	......	862	......	858	......	857	......	875	......	872	......	864	......	855	......	856	......	862	......	867	......	863	......	....
1844	1065	1065	1063	1062	1062	1061	1061	1064	1068	1076	1077	1070	1064	1057	1053	1053	1051	1054	1059	1063	1064	1064	1065	1063	....
1845	1244	1243	1241	1239	1236	1233	1229	1236	1251	1261	1262	1258	1253	1244	1238	1236	1237	1239	1245	1246	1246	1248	1247	1242	....
Mean	820	......	816	......	815	......	810	......	824	......	833	......	823	......	811	......	809	......	817	......	821	......	821	......	....
Referred mean	......	819	......	815	......	812	......	815	......	832	......	829	......	816	......	810	......	811	......	818	......	822	......	818	....
Constant correction + 14. Normals	834	833	830	829	829	826	824	829	838	846	847	843	837	830	825	824	823	825	831	832	835	836	835	832	....

Monthly mean normal from the even hours (+ 21½m.) 832.3, weight 5. Monthly mean normal from the odd hours (+ 21½m.) 832.1, weight 2.

Normals of the horizontal force for June.

Year.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	+ 21½m.
1841	392	......	390	......	392	......	386	......	400	......	401	......	395	......	382	......	385	......	392	......	402	......	392	......	....
1842	649	......	652	......	646	......	638	......	649	......	659	......	650	......	639	......	638	......	649	......	648	......	650	......	....
1843	881	......	879	......	876	......	873	......	883	......	894	......	884	......	870	......	870	......	881	......	881	......	885	......	....
1844	1078	1077	1076	1077	1077	1075	1073	1077	1080	1082	1084	1081	1077	1072	1067	1065	1065	1067	1071	1073	1075	1077	1077	1078	....
1845	1260	1281	1281	1281	1275	1271	1266	1273	1282	1293	1295	1292	1286	1280	1272	1269	1269	1273	1278	1281	1280	1277	1279	1280	....
Mean	856	......	856	......	853	......	847	......	859	......	867	......	858	......	846	......	845	......	854	......	857	......	857	......	....
Referred mean	......	856	......	856	......	850	......	853	......	865	......	864	......	853	......	845	......	849	......	856	......	856	......	857	....
Constant correction + 2. Normals	858	858	858	858	855	852	849	855	861	867	869	866	860	855	848	847	847	851	856	858	859	858	859	859	....

Monthly mean normal from the even hours (+ 21½m.) 856.6, weight 5. Monthly mean normal from the odd hours (+ 21½m.) 857,0, weight 2.

Table I.

Recapitulation of the hourly normals of the horizontal force (expressed in scale divisions) for each month of the year. Increase of scale readings denotes decrease of force.

1840–1845.	0*h*.	1*h*.	2*h*.	3*h*.	4*h*.	5*h*.	6*h*.	7*h*.	8*h*.	9*h*.	10*h*.	11*h*.	+ 21½*m*.
July	681	679	677	675	673	668	664	673	686	692	694	690	....
August	698	699	699	698	699	695	693	702	714	724	726	718	....
September	720	718	720	718	714	713	711	721	735	744	749	746	....
October	735	731	731	727	725	728	729	734	739	746	751	750	....
November	739	738	736	734	733	730	728	732	737	743	746	751	....
December	772	767	766	764	761	759	756	758	761	766	775	783	....
January	794	792	792	790	788	787	786	784	786	795	802	808	....
February	800	798	796	796	795	793	791	793	795	800	808	810	....
March	803	802	801	800	799	797	795	799	804	812	817	822	....
April	824	823	823	820	818	817	817	820	829	841	849	851	....
May	834	833	830	829	829	826	824	829	838	846	847	843	....
June	858	858	858	858	855	852	849	855	861	867	869	866	....
Year	771.5	769.8	769.1	767.4	765.7	763.7	761.9	766.7	773.7	781.3	786.1	786.5	....
Summer	769.2	768.3	767.8	766.3	764.7	761.8	759.7	766.7	777.2	785.7	789.0	785.7	....
Winter	773.8	771.3	770.3	768.5	766.8	765.7	764.2	766.7	770.3	777.0	783.2	787.3	....

	12*h*.	13*h*.	14*h*.	15*h*.	16*h*.	17*h*.	18*h*.	19*h*.	20*h*.	21*h*.	22*h*.	23*h*.	+ 21½*m*.
July	683	672	663	660	659	666	675	677	679	681	682	683	....
August	708	698	689	688	692	696	701	703	704	703	704	702	....
September	736	726	720	718	719	723	724	725	723	725	722	722	....
October	751	747	743	740	739	739	738	739	740	739	739	738	....
November	750	746	740	738	737	739	736	736	737	739	741	740	....
December	785	778	773	768	764	765	767	768	771	772	772	771	....
January	808	801	796	790	787	790	793	794	793	794	794	796	....
February	813	808	804	800	801	800	801	804	806	802	800	800	....
March	819	814	806	801	804	807	810	808	804	803	805	804	....
April	845	839	827	824	822	822	827	827	830	830	828	827	....
May	837	830	825	824	823	825	831	832	835	836	835	832	....
June	860	855	848	847	847	851	856	858	859	858	859	859	....
Year	782.9	776.2	769.5	766.5	766.2	768.6	771.6	772.6	773.4	773.5	773.4	772.8	....
Summer	778.2	770.0	762.0	760.2	760.3	763.8	769.0	770.3	771.7	772.2	771.7	770.8	....
Winter	787.7	782.3	777.0	772.8	772.0	773.3	774.2	774.8	775.2	774.8	775.2	774.8	....

In the preceding table the normals for the summer half year comprise the months between April and September inclusive; those for the winter half year comprise the months between October and March inclusive.

The following table contains the mean values of the normals for each month and season:

Table II.

1840–1844.	Normal.	1841–1845.	Normal.	1840–1845.	Normal.
July	676.3	January	793.3	Year	772.1
August	702.2	February	800.6	Summer	770.1
September	724.6	March	805.7	Winter	774.1
October	738.2	April	828.3		
November	738.5	May	832.2		
December	768.4	June	856.8		

Regular Solar-Diurnal Variation of the Horizontal Force.—If we subtract the hourly normals of Table I from their respective monthly mean value as given in Table II, the difference (in scale divisions) will represent the regular solar-diurnal variation for each month in the year. In like manner we obtain the diurnal variation of the horizontal force—free of the larger disturbances—for the summer and winter half, and for the whole year. Table III will exhibit these differences after their conversion from scale divisions into parts of the horizontal force (one scale division equalling 0.0000365 parts of the horizontal force.) The tabular numbers are expressed in units of the sixth place of decimals. A plus sign indicates a greater force, a minus sign a less force, than the mean value. Casting the eye over the vertical columns, we obtain also a view of the annual inequality of the diurnal variation, which will be examined further on.

Table III.

Regular solar-diurnal variation of the horizontal component of the magnetic force expressed in parts of the horizontal force.

A plus sign indicates greater force than the mean. For convenience sake, the first three decimals (0.000) have been placed on the side of the table.

0.000

1840–1845.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	+ 21⅓m.
July	— 171	— 098	— 025	+ 047	+ 120	+ 303	+ 449	+ 120	— 353	— 572	— 646	— 499	....
August	+ 153	+ 116	+ 116	+ 153	+ 116	+ 262	+ 335	+ 007	— 430	— 795	— 868	— 576	....
September	+ 168	+ 241	+ 168	+ 241	+ 387	+ 423	+ 481	+ 131	— 380	— 708	— 891	— 781	....
October	+ 116	+ 262	+ 262	+ 408	+ 481	+ 372	+ 335	+ 153	— 029	— 284	— 467	— 430	....
November	— 018	+ 018	+ 091	+ 164	+ 200	+ 310	+ 383	+ 237	+ 054	— 161	— 273	— 456	....
December	— 131	+ 051	+ 088	+ 161	+ 270	+ 343	+ 453	+ 380	+ 270	+ 088	— 241	— 533	....
January	— 025	+ 047	+ 047	+ 120	+ 193	+ 230	+ 266	+ 339	+ 266	— 061	— 318	— 536	....
February	+ 022	+ 095	+ 146	+ 168	+ 204	+ 277	+ 350	+ 277	+ 204	+ 022	— 270	— 313	....
March	+ 098	+ 134	+ 171	+ 207	+ 244	+ 317	+ 390	+ 244	+ 061	— 230	— 412	— 595	....
April	+ 157	+ 193	+ 193	+ 303	+ 376	+ 412	+ 412	+ 303	— 025	— 463	— 755	— 828	....
May	— 065	— 029	+ 080	+ 116	+ 116	+ 226	+ 299	+ 116	— 211	— 503	— 540	— 394	....
June	— 043	— 043	— 043	— 043	+ 065	+ 175	+ 284	+ 065	— 153	— 372	— 445	— 335	....
Year	+ 022	+ 082	+ 108	+ 170	+ 231	+ 304	+ 370	+ 198	— 060	— 337	— 511	— 526	....
Summer	+ 033	+ 063	+ 082	+ 136	+ 197	+ 300	+ 377	+ 127	— 259	— 570	— 691	— 569	....
Winter	+ 010	+ 101	+ 134	+ 205	+ 265	+ 308	+ 363	+ 272	+ 138	— 105	— 330	— 482	....

0.000

	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	+ 21⅓m.
July	— 244	+ 157	+ 485	+ 595	+ 631	+ 376	+ 047	— 025	— 098	— 171	— 244	— 244	....
August	— 211	+ 153	+ 481	+ 518	+ 372	+ 225	+ 043	— 029	— 065	— 029	— 065	+ 007	....
September	— 416	— 051	+ 168	+ 241	+ 204	+ 058	+ 022	— 015	+ 058	— 015	+ 095	+ 095	....
October	— 467	— 321	— 175	— 065	— 029	— 029	+ 007	— 029	— 065	— 029	— 029	+ 007	....
November	— 419	— 273	— 054	+ 018	+ 054	— 018	+ 091	+ 091	+ 054	— 018	— 091	— 054	....
December	— 606	— 350	— 168	+ 015	+ 161	+ 124	+ 051	+ 015	— 095	— 131	— 131	— 095	....
January	— 536	— 317	— 098	+ 120	+ 230	+ 120	+ 011	— 025	+ 011	— 025	— 025	— 098	....
February	— 453	— 270	— 124	+ 022	— 015	+ 022	— 015	— 124	— 197	— 051	+ 022	+ 022	....
March	— 485	— 303	— 011	+ 171	+ 061	— 047	— 157	— 088	+ 061	+ 098	+ 025	+ 061	....
April	— 609	— 390	+ 047	+ 157	+ 230	+ 230	+ 047	+ 047	— 061	— 061	+ 011	+ 047	....
May	— 175	+ 080	+ 262	+ 299	+ 335	+ 262	+ 043	+ 007	— 102	— 138	— 102	+ 007	....
June	— 116	+ 065	+ 321	+ 357	+ 357	+ 211	+ 029	— 043	— 080	— 043	— 080	— 080	....
Year	— 395	— 152	+ 095	+ 204	+ 216	+ 128	+ 018	— 019	— 049	— 051	— 051	— 027	....
Summer	— 295	+ 002	+ 294	+ 361	+ 355	+ 227	+ 037	— 009	— 058	— 076	— 064	— 028	....
Winter	— 494	— 306	— 105	+ 047	+ 077	+ 029	— 002	— 027	— 039	— 026	— 038	— 036	....

TABLE IV.

Table IV is derived from Table III by multiplication with the absolute value of the horizontal force, (4.173;) *it contains, therefore, the regular solar-diurnal variation of the horizontal force in absolute measure.*

A plus sign indicates greater force than the mean. Two places of decimals have been placed on the side of the table.

0.00

1840–1845.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	+ 21⅓m.
July	− 071	− 041	− 010	+ 020	+ 050	+ 127	+ 188	+ 050	− 147	− 239	− 270	− 208	....
August	+ 064	+ 048	+ 048	+ 064	+ 048	+ 109	+ 140	+ 003	− 180	− 332	− 362	− 241	....
September	+ 070	+ 101	+ 070	+ 1.1	+ 162	+ 177	+ 201	+ 055	− 159	− 296	− 372	− 326	....
October	+ 048	+ 109	+ 109	+ 170	+ 201	+ 155	+ 140	+ 064	− 012	− 119	− 195	− 180	....
November	− 008	+ 008	+ 038	+ 068	+ 083	+ 129	+ 160	+ 099	+ 022	− 068	− 114	− 190	....
December	− 055	+ 021	+ 037	+ 067	+ 113	+ 143	+ 189	+ 159	+ 113	+ 037	− 101	− 223	....
January	− 010	+ 020	+ 020	+ 050	+ 081	+ 096	+ 111	+ 14[illegible]	+ 111	− 025	− 132	− 224	....
February	+ 009	+ 040	+ 061	+ 070	+ 085	+ 116	+ 146	+ 116	+ 085	+ 009	− 113	− 143	....
March	+ 041	+ 056	+ 071	+ 086	+ 102	+ 132	+ 163	+ 102	+ 025	− 096	− 172	− 248	....
April	+ 066	+ 081	+ 081	+ 127	+ 157	+ 172	+ 172	+ 127	− 010	− 193	− 315	− 346	....
May	− 027	− 012	+ 033	+ 048	+ 048	+ 094	+ 125	+ 048	− 088	− 210	− 226	− 165	....
June	− 018	− 0.8	− 018	− 018	+ 027	+ 0.3	+ 119	+ 027	− 064	− 155	− 186	− 140	....
Year	+ 009	+ 034	+ 045	+ 071	+ 096	+ 127	+ 155	+ 083	− 025	− 141	− 213	− 220	....
Summer	+ 014	+ 026	+ 034	+ 057	+ 082	+ 125	+ 157	+ 053	− 108	− 238	− 289	− 238	....
Winter	+ 004	+ 042	+ 056	+ 086	+ 111	+ 129	+ 152	+ 114	+ 058	− 044	− 138	− 201	....

0.00

	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	+ 21⅓m.
July	− 102	+ 065	+ 203	+ 248	+ 263	+ 157	+ 020	− 010	− 041	− 071	− 102	− 102	....
August	− 088	+ 064	+ 201	+ 216	+ 155	+ 094	+ 018	− 012	− 027	− 012	− 027	+ 003	....
September	− 174	− 021	+ 070	+ 101	+ 085	+ 024	+ 009	− 006	+ 024	− 006	+ 040	+ 040	....
October	− 195	− 134	− 073	− 027	− 012	− 012	+ 003	− 012	− 027	− 012	− 012	+ 003	....
November	− 175	− 114	− 022	+ 008	+ 022	− 008	+ 038	+ 038	+ 022	− 008	− 038	− 022	....
December	− 253	− 146	− 070	+ 006	+ 067	+ 052	+ 021	+ 006	− 040	− 055	− 055	− 040	....
January	− 224	− 132	− 041	+ 050	+ 095	+ 050	+ 005	− 010	+ 005	− 010	− 010	− 041	....
February	− 189	− 113	− 052	+ 009	− 006	+ 009	− 006	− 052	− 082	− 021	+ 009	+ 009	....
March	− 203	− 127	− 005	+ 071	+ 025	− 020	− 065	− 037	+ 025	+ 041	+ 010	+ 025	....
April	− 254	− 163	+ 020	+ 065	+ 096	+ 096	+ 020	+ 020	− 025	− 025	+ 005	+ 020	....
May	− 073	+ 033	+ 109	+ 125	+ 140	+ 109	+ 018	+ 003	− 043	− 058	− 043	+ 003	....
June	− 048	+ 027	+ 134	+ 149	+ 149	+ 088	+ 012	− 018	− 033	− 018	− 033	− 033	....
Year	− 165	− 063	+ 040	+ 085	+ 090	+ 053	+ 008	− 008	− 020	− 021	− 021	− 011	....
Summer	− 123	+ 001	+ 123	+ 151	+ 148	+ 095	+ 015	− 004	− 024	− 032	− 027	− 012	....
Winter	− 206	− 128	− 044	+ 020	+ 032	+ 012	− 000	− 011	− 016	− 011	− 016	− 010	....

Annual Inequality in the Diurnal Variation of the Horizontal Force.—The distinctive feature of the diurnal variation is shown in diagram (A,) Part V, Sketch No. 48, constructed from the mean annual and half-yearly values given in the preceding table, IV. It exhibits in the annual mean, as its characteristic type, a maximum value about 6 a. m., a minimum value about 11 a. m., a secondary maximum value about 3½ p. m., and a secondary minimum about 9 p. m. For the half year when the sun has north declination, the morning minimum becomes smaller and the afternoon maximum larger, thus increasing the diurnal range; the converse takes place in the other half of the year, when the sun has south declination. The 6 a. m. maximum remains nearly unchanged throughout the year. The average summer range (April to September inclusive) is 0.0046, and the average winter range (October to March inclusive) is 0.0025, both expressed in absolute measure. The range between the morning maximum and the morning minimum is 0.0045 in summer and 0.0036 in winter, as will be explained further on.—(See diagram A of Part V, Sketch No. 48.)

This semi-annual change in the diurnal amplitude is more conspicuously represented in diagram B, (derived from diagram A,) by straightening out the annual curve, and using it as an axis of abscissæ for laying off the differences between the annual values and the summer and winter values at the same respective hours of the day.

This diagram (B) may, with advantage, be compared with the analogous one representing the annual change of the diurnal variation of the declination, as given in Part II of this discussion. The construction is the same in either case.

At 6 a. m. there is hardly any change throughout the year. The maximum variation, in the course of a year, takes place at 9 a. m. (range 0.00194 in absolute measure;) about $11\frac{1}{2}$ a. m. there is an epoch of no variation; at 2 p. m. a second maximum is reached (range 0.00167;) again at $7\frac{1}{2}$ and 11 p. m. points of no variation are reached. Owing to the prominent annual variation near 2 p. m., the range of the diurnal variation between the morning minimum at 11 a. m. and the afternoon maximum at $3\frac{1}{2}$ p. m. is of more interest in the discussion of the diurnal fluctuation of the horizontal force than the 6 a. m. and 11 a. m. range, which latter range, as we have seen, is slightly greater than the first one.

To find the turning epochs of the annual variation, the monthly values for the hours 9 a. m. and 2 p. m., when it is best developed, were taken from Table IV, and each value was again compared with its annual mean.

TABLE V.—*Annual variation at the hours 9 a. m. and 2 p. m.*

Month.	9 a. m. 0.00	Differences. 0.00	2 p. m. 0.00	Differences. 0.00	Mean difference. 0.00
January	—025	+116	—041	—081	+099
February	+009	+150	—052	—092	+121
March	—096	+045	—005	—045	+045
April	—193	—052	+020	—020	—016
May	—210	—069	+109	+069	—069
June	—155	—014	+134	+094	—054
July	—239	—098	+203	+163	—130
August	—332	—191	+201	+161	—176
September	—296	—155	+070	+030	—092
October	—119	+022	—073	—113	+046
November	—068	+073	—022	—062	+068
December	+037	+178	—070	—110	+144
Mean	—141	....	+040	....	....

Casting the eye over the columns headed "differences," we see by the change of sign and the magnitude of the values that the transition from a positive to a negative value occurs some time after the equinoxes, and that the maximum variation is reached about the time of the solstices—a result in close correspondence with the conclusions reached in the discussion of the annual inequality in the diurnal variation of the declination, (Part II of the discussion.) For convenience in the analytical treatment, a column headed "mean difference" has been added to Table V, obtained by changing the signs of the 2 p. m. differences (the annual variation being then opposite to the morning values,) and taking the mean of the 9 a. m. and 2 p. m. differences. The values in this column are tolerably well represented by the following formula:

$$\Delta_a = +0.00129 \sin(\theta + 79^\circ) + 0.00018 \sin(2\theta + 191^\circ,)$$

the angle θ counting from January 1, at the rate of 30° a month. Accordingly, we find the transition to take place shortly before the middle of April and October, or about twenty-two days after the equinoxes. This is about twelve days later than the epoch found in Part II for the declination.

Analysis of the Solar-Diurnal Variation of the Horizontal Force.—For convenience of investigation and proper comparison with similar results at other localities, the values given in Table I have been put in an analytical form, and are represented by the following expressions. It will be seen that the difference between any monthly normal mean and the corresponding mean in Table V of Part IV, which latter mean is affected with the disturbances, does not exceed $2\frac{1}{2}$ scale divisions. This small difference includes also a small effect due to the necessity of different methods of interpolation in the construction of the two tables. In the determination of the numerical quantities (by application of the method of least squares) in the monthly equations, due attention was paid to the relative weights of the values for the even and odd hours. The coefficients are expressed in scale divisions, (increasing numbers denoting decrease of force,) and the angle θ counts from midnight at the rate of 15° an hour.

For January .... $\Delta_h = + 793^d.3 + 3^d.77 \sin(\theta + 236^\circ 52') + 6^d.56 \sin(2\theta + 96^\circ 52')$
$+ 3^d.99 \sin(3\theta + 282^\circ 13') + 2^d.00 \sin(4\theta + 97^\circ)$

For February ...... $\Delta_h = + 800^d.6 + 5^d.50 \sin(\theta + 218^\circ 26') + 4^d.57 \sin(2\theta + 102^\circ 29')$
$+ 3^d.27 \sin(3\theta + 282^\circ 40') + 1^d.66 \sin(4\theta + 121^\circ)$

For March .... $\Delta_h = + 805^d.7 + 6^d.56 \sin(\theta + 243^\circ 31') + 5^d.35 \sin(2\theta + 114^\circ 14')$
$+ 4^d.23 \sin(3\theta + 316^\circ 04') + 1^d.91 \sin(4\theta + 113^\circ)$

For April.......... $\Delta_h = + 828^d.3 + 7^d.65 \sin(\theta + 257^\circ 37') + 9^d.55 \sin(2\theta + 123^\circ 06')$
$+ 5^d.15 \sin(3\theta + 306^\circ 44') + 1^d.18 \sin(4\theta + 163^\circ)$

For May .... $\Delta_h = + 832^d.2 + 2^d.24 \sin(\theta + 311^\circ 31') + 7^d.81 \sin(2\theta + 140^\circ 53')$
$+ 4^d.40 \sin(3\theta + 330^\circ 05') + 1^d.34 \sin(4\theta + 214^\circ)$

For June .... $\Delta_h = + 856^d.8 + 2^d.12 \sin(\theta + 356^\circ 03') + 6^d.40 \sin(2\theta + 140^\circ 32')$
$+ 4^d.48 \sin(3\theta + 327^\circ 14') + 0^d.92 \sin(4\theta + 216^\circ)$

For July .... $\Delta_h = + 676^d.3 + 3^d.42 \sin(\theta + 4^\circ 11') + 11^d.50 \sin(2\theta + 139^\circ 14')$
$+ 6^d.14 \sin(3\theta + 330^\circ 15') + 0^d.78 \sin(4\theta + 210^\circ)$

For August .... $\Delta_h = + 702^d.2 + 5^d.32 \sin(\theta + 310^\circ 58') + 10^d.37 \sin(2\theta + 153^\circ 46')$
$+ 6^d.79 \sin(3\theta + 335^\circ 55') + 2^d.88 \sin(4\theta + 203^\circ)$

For September ..... $\Delta_h = + 724^d.6 + 8^d.02 \sin(\theta + 271^\circ 57') + 9^d.59 \sin(2\theta + 137^\circ 25')$
$+ 7^d.08 \sin(3\theta + 345^\circ 17') + 1^d.99 \sin(4\theta + 215^\circ)$

For October .... $\Delta_h = + 738^d.2 + 8^d.06 \sin(\theta + 237^\circ 57') + 6^d.40 \sin(2\theta + 123^\circ 37')$
$+ 1^d.34 \sin(3\theta + 325^\circ 20') + 0^d.29 \sin(4\theta + 174^\circ)$

For November ...... $\Delta_h = + 738^d.5 + 4^d.13 \sin(\theta + 237^\circ 36') + 6^d.08 \sin(2\theta + 100^\circ 01')$
$+ 1^d.93 \sin(3\theta + 310^\circ 45') + 0^d.46 \sin(4\theta + 211^\circ)$

For December ...... $\Delta_h = + 768^d.4 + 5^d.63 \sin(\theta + 212^\circ 48') + 8^d.07 \sin(2\theta + 94^\circ 14')$
$+ 3^d.98 \sin(3\theta + 269^\circ 17') + 1^d.31 \sin(4\theta + 88^\circ)$

We have also: For summer half-year (April to September inclusive,) for winter half-year (October to March inclusive,) and for the whole year, the following expressions for the regular solar-diurnal variations:

For summer .... $\Delta_h = + 770^d.1 + 3^d.79 \sin(\theta + 293^\circ 49') + 9^d.11 \sin(2\theta + 139^\circ 10')$
$+ 5^d.36 \sin(3\theta + 329^\circ 17') + 1^d.42 \sin(4\theta + 202^\circ)$

For winter .... $\Delta_h = + 774^d.1 + 5^d.36 \sin(\theta + 231^\circ 36') + 6^d.04 \sin(2\theta + 104^\circ 46')$
$+ 2^d.88 \sin(3\theta + 293^\circ 54') + 1^d.11 \sin(4\theta + 108^\circ)$

For year .... $\Delta_h = + 772^d.1 + 3^d.95 \sin(\theta + 256^\circ 19') + 7^d.25 \sin(2\theta + 125^\circ 05')$
$+ 3^d.96 \sin(3\theta + 317^\circ 31') + 0^d.86 \sin(4\theta + 165^\circ)$

The following expressions for January may serve as specimens of the agreement of the result derived from the even and odd hours independently:

From even hours .... $\Delta_h = 793^d.3 + 3^d.81 \sin(\theta + 238^\circ 01') + 6^d.56 \sin(2\theta + 94^\circ 32')$
$+ 4^d.10 \sin(3\theta + 280^\circ 19') + 2^d.08 \sin(4\theta + 86^\circ)$

From odd hours .... $\Delta_h = 793^d.4 + 3^d.71 \sin(\theta + 234^\circ 35') + 6^d.56 \sin(2\theta + 101^\circ 32')$
$+ 3^d.76 \sin(3\theta + 286^\circ 00') + 1^d.85 \sin(4\theta + 119^\circ)$

Giving to the first equation the weight 2, and to the second the weight 1, we obtain the equation as given above.

The following comparison will show the agreement of the observed and computed values we have for August:

(A. M.)	Computed.	Observed.	Δ	(P. M.)	Computed.	Observed.	Δ
$0^h\ 21\frac{1}{2}^m$	698. 3	698	0	$12^h\ 21\frac{1}{2}^m$	707. 7	708	0
1..."....	698. 3	699	—1	13..."....	695. 1	698	—3
2..."....	699. 6	699	+1	14..."....	688. 4	689	—1
3..."....	699. 7	698	+2	15..."....	888. 7	688	+1
4..."....	697. 6	699	—1	16..."....	692. 5	692	0
5..."....	694. 3	695	—1	17..."....	697. 1	696	+1
6..."....	694. 5	693	+1	18..."....	700. 3	701	—1
7..."....	701. 2	702	—1	19..."....	702. 6	703	0
8..."....	712. 7	714	—1	20..."....	704. 5	704	0
9..."....	723. 6	724	0	21..."....	704. 8	703	+2
10..."....	727. 1	726	+1	22..."....	703. 3	704	—1
11..."....	720. 4	718	+2	23..."....	700. 6	702	—1

Diagrams C and D (of Part V, Sketch No. 48) exhibit the regular solar-diurnal variation of the horizontal force; the dots represent the observations directly taken from Table I; the curves give the computed values from the preceding equations. These diagrams also exhibit the general agreement between the observed and computed values. The summer months are represented on diagram C, the winter months on diagram D; their comparison shows plainly the much greater range of the diurnal variation when the sun is north of the equator than when south of it, as was also the case with the magnetic declination.

Table VI contains the coefficients B_1 B_2 B_3 B_4 of the general equation:

$$\triangle_h = A + B_1 \sin(\theta + C_1) + B_2 \sin(2\theta + C_2) + B_3 \sin(3\theta + C_3) + B_4 \sin(4\theta + C_4)$$

expressed in parts of the horizontal force, by multiplying the corresponding quantities in the preceding equations with the value of a scale division. The angles C_1 C_2 C_3 C_4 will be found in Table VII; they are the same as given before, increased by 180°, so as to make a corresponding change in the direction of the scale readings; increasing numbers will now indicate increasing force.

The first three decimals (0.000) have been placed in front of the table.

TABLE VI.

Month.		B_1	B_2	B_3	B_4
January		138	239	146	073
February		202	167	119	060
March		239	195	154	070
April		279	349	188	043
May		082	285	161	049
June	0.000	077	234	161	034
July		125	420	224	029
August		194	579	248	105
September		295	350	258	073
October		294	234	048	011
November		151	222	071	017
December		184	295	145	048
Summer	------	138	333	196	052
Winter	------	196	220	105	040
Year	------	144	265	145	031

In Table VII the same quantities are given in absolute measure; the first two places of decimals (0.00) are placed at the head of the columns. (Increasing numbers denote increase of force.) The numerical values of A will be found in connexion with the discussion of the annual variation of the horizontal force.

TABLE VII.

Month.	B_1 0.00	C_1	B_2 0.00	C_2	B_3 0.00	C_3	B_4 0.00	C_4
January	057	56° 52′	100	276° 52′	061	102° 13′	030	277°
February	084	38 26	070	282 29	050	102 40	025	301
March	100	63 31	082	294 14	064	136 04	029	293
April	117	77 37	146	303 06	079	126 44	018	343
May	034	134 31	119	320 53	067	150 05	020	34
June	032	176 03	098	320 32	068	147 14	014	36
July	052	184 11	175	319 14	094	150 15	012	30
August	081	130 58	158	333 46	104	155 55	044	23
September	122	91 57	146	317 25	108	165 17	030	35
October	123	57 57	098	303 37	020	145 20	005	354
November	063	57 36	093	230 01	029	130 45	007	31
December	077	32 48	123	274 14	061	89 17	020	268
Summer	058	113 49	139	319 10	082	149 17	022	22
Winter	082	51 36	092	284 46	044	113 54	017	288
Year	060	76 19	111	305 05	060	137 31	013	345

On diagram E (of Part V, Sketch No. 48) the average value of the diurnal variation throughout the year, together with the summer and winter value, has been represented as resulting from the numerical quantities in the above table. It exhibits the noticeable feature in the annual curve of a greater morning maximum (about 6 a. m.) than afternoon maximum (about $3\frac{1}{2}$ p. m.,) whereas in the summer curve it is the afternoon maximum which is the greater of the two.* In the winter season the contrast is more marked, the morning maximum being considerably greater. These curves also show the gradual shifting of the maxima and minima to a later hour in winter than in summer, a phenomenon also well exhibited in the preceding diagrams C and D. The numerical values of this change of hours will be given in tabular form further on. The small afternoon minimum about 9 p. m. is less distinctly marked than any other feature of the diurnal curve.

Table VIII contains the computed values of the time and amount of the morning maximum and minimum, and of the afternoon maximum. The values for the secondary afternoon minimum are taken from the diagrams. The time of the a. m. maximum and minimum is within the nearest eighth minute; that of the p. m. maximum within the nearest tenth minute. The time for the p. m. secondary minimum is within the nearest hour. The amount of change of horizontal force is expressed in scale divisions.

TABLE VIII.

Month.	Morning maximum.		Morning minimum.		Afternoon maximum		Secondary afternoon minimum.		Interval a m. min to p. m max.
	h. m.	*d.*	*h. m*	*d.*	*h. m.*	*d*	*h.*	*d.*	*h. m.*
January	7 10	— 9.2	11 50	+15.7	4 10	— 5.3	11	+2	4 20
February	7 15	— 9.6	11 40	+12.7	4 00	— 0.9	7	+2	4 20
March	6 15	— 9.2	11 30	+16.4	3 20	— 2.3	6	+3	3 50
April	6 00	—12.3	11 20	+22.5	3 55	— 6.6	9	+3	4 35
May	5 50	— 7.9	10 25	+15.5	3 10	— 9.8	9	+4	4 45
June	5 50	— 6.3	10 30	+12.5	3 20	—10.4	8	+3	4 50
July	5 35	— 9.9	10 30	+19.3	3 25	—17.5	9	+6	4 55
August	5 55	— 8.5	10 10	+24.8	2 45	—14.2	9	+3	4 35
September	5 35	—14.9	10 20	+25.9	3 05	— 6.7	7	—1	4 45
October	5 00	—12.6	11 15	+13.7	5 10	— 0.1	9	+2	5 55
November	6 00	— 9.8	11 25	+11.0	5 15	— 3.0	11	+0	5 50
December	7 05	—12.1	12 05	+16.1	4 35	— 5.1	10	+4	4 30
Summer	5 50	— 9.8	10 30	+19.6	3 25	—10.5	$20\frac{1}{2}$	+3	4 55
Winter	6 15	— 9.4	11 45	+13.9	4 10	— 2.2	21	+2	4 25
Year	5 55	— 9.6	11 00	+15.6	3 35	— 6.0	$20\frac{3}{4}$	+2.5	4 35

The extreme variation in the epoch of the a. m. maximum is therefore 2*h.* 15*m.*; the variation for the a. m. minimum is 1*h.* 55*m.*; for the p. m. maximum it is 2*h.* 30*m.*; and for the secondary afternoon minimum between 3 and 4 hours. In all cases, the earlier hours occur in the summer season.

Table IX shows the diurnal range, expressed in scale divisions, parts of the horizontal force and in absolute measure. In the second column the range between the a. m. maximum and minimum is given; in the third column that between the a. m. minimum and the p. m. maximum. These two amplitudes for a. m. and for a. m. and p. m., are further illustrated in diagram F, (of Part V, Sketch No. 48,) which shows the curve to be double crested, with maxima near the time of the equinoxes, and the greater of these near the autumnal equinox.

* The same is the case at Prague; in May, June, and July, the afternoon maximum was the greater of the two. Karl Kreil, in vol. VIII Proceedings of the Academy of Sciences of Vienna, 1855: "Resultate aus den magnetischen Beobachtungen zu Prag."

TABLE IX.—*Amplitude of the diurnal variation of the horizontal force.*

Month.	For a. m.	For a. m. and p. m.	For a. m.	For a. m. and p. m.	For a. m.	For a. m. and p. m.
	d.	*d.*				
January	24.9	21.0	0.00091	0.00077	0.0038	0.0032
February	22.3	13.6	081	050	34	21
March	25.6	18.7	093	068	39	29
April	34.8	29.1	127	106	53	45
May	23.4	25.3	085	092	36	38
June	18.8	22.9	069	084	29	35
July	29.2	36.8	106	134	45	56
August	33.3	39.0	122	142	51	59
September	40.8	32.6	149	119	62	50
October	26.3	13.6	096	050	40	21
November	20.8	14.0	076	051	32	21
December	28.2	21.2	0.00103	077	0.0043	0.0032
Summer	29.4	30.1	0.00107	0.00110	0.0045	0.0046
Winter	23.3	16.1	0.00085	0.00059	0.0036	0.0025
Year	25.2	21.6	0.00092	0.00079	0.0038	0.0032
	In scale divisions.		In parts of horizontal force.		In absolute measure.	

The next table contains the epochs when the mean horizontal force is reached in each day, as computed by the preceding formulæ. The diurnal curves intersect the axis of abscissæ four times, of which the table contains only the a. m. and first p. m. intersection: those later in the afternoon and near midnight occur in summer, winter, and whole year at 7 p. m., $5\frac{3}{4}$ p. m., and $6\frac{1}{2}$ p. m., respectively, and at $11\frac{1}{4}$ p. m., 12 p. m., and $11\frac{3}{4}$ p. m., respectively.

TABLE X.

Principal epochs of mean horizontal force.

Month.	A. M.	P. M.
January	9h 26m	2h 36m
February	9 23	2 58
March	8 42	2 28
April	8 14	2 19
May	7 44	0 59
June	7 47	0 48
July	7 57	0 53
August	7 28	0 44
September	7 42	1 29
October	8 08	5 00
November	8 40	3 28
December	9 34	3 03
Summer	7 45	1 12
Winter	9 00	3 07
Year	8 14	1 54

The above times are generally correct within two minutes (according to the formulæ.) The morning hour of average daily horizontal force is less variable in the course of a year than the afternoon hour.

The following table contains the computed diurnal variation of the horizontal force. The values have been expressed in absolute measure. It compares directly with Table IV, which contains the observed values. It will be useful for the interpolation of observations, or for their reduction to the mean value of the day from observations taken at irregular hours. The table also forms the basis for the construction of diagram G (of Part V, Sketch No. 48.)

TABLE XI.

Computed solar-diurnal variation of the horizontal force in absolute measure.

The first two places of decimals (0.00) are placed in front of the table.

	1840-1845.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.	$+21\frac{1}{2}m.$
0.00	July	− 061	− 061	− 030	+ 015	+ 091	+ 137	+ 137	+ 046	− 107	− 244	− 290	− 244	....
	August	+ 122	+ 061	+ 030	+ 030	+ 061	+ 122	+ 122	+ 015	− 167	− 335	− 381	− 274	....
	September	+ 061	+ 061	+ 061	+ 107	+ 182	+ 229	+ 198	+ 061	− 152	− 320	− 381	− 320	....
	October	+ 046	+ 091	+ 122	+ 167	+ 182	+ 182	+ 137	+ 076	− 030	− 122	− 182	− 213	....
	November	000	+ 015	+ 030	+ 061	+ 107	+ 152	+ 152	+ 122	+ 030	− 061	− 137	− 167	....
	December	− 046	000	+ 030	+ 061	+ 091	+ 137	+ 167	+ 182	+ 122	+ 015	− 122	− 229	....
	January	− 030	000	+ 030	+ 046	+ 061	+ 091	+ 107	+ 122	+ 091	− 015	− 137	− 229	....
	February	+ 030	+ 061	+ 076	+ 076	+ 091	+ 107	+ 137	+ 152	+ 137	+ 015	− 107	− 182	....
	March	+ 046	+ 061	+ 076	+ 107	+ 107	+ 137	+ 137	+ 122	+ 030	− 076	− 198	− 244	....
	April	+ 061	+ 076	+ 091	+ 107	+ 137	+ 167	+ 182	+ 122	− 015	− 198	− 320	− 351	....
	May	000	000	000	+ 030	+ 061	+ 107	+ 107	+ 046	− 076	− 198	− 244	− 182	....
	June	− 015	− 030	− 030	000	+ 046	+ 091	+ 091	+ 046	− 061	− 152	− 182	− 305	....
		12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.	$+21\frac{1}{2}m.$
0.00	July	− 091	+ 076	+ 213	+ 259	+ 229	+ 152	+ 046	− 015	− 061	− 091	− 076	− 076	....
	August	− 091	+ 107	− 213	+ 198	+ 152	+ 076	+ 030	− 015	− 030	− 046	− 015	+ 015	....
	September	− 152	− 015	+ 091	+ 107	+ 076	+ 046	+ 015	000	+ 030	+ 030	+ 046	+ 076	....
	October	− 182	− 137	− 076	− 030	− 015	000	000	− 015	− 015	− 030	− 015	+ 015	....
	November	− 137	− 091	− 046	000	+ 030	+ 046	+ 046	+ 030	+ 015	000	− 015	− 015	....
	December	− 244	− 182	− 076	+ 015	+ 061	+ 061	+ 015	− 015	− 046	− 061	− 076	− 061	....
	January	− 229	− 137	− 030	+ 061	+ 076	+ 046	+ 015	− 015	− 030	− 015	− 015	− 030	....
	February	− 182	− 107	− 030	+ 015	+ 015	− 015	− 030	− 030	− 030	− 015	− 015	000	....
	March	− 198	− 107	000	+ 046	+ 015	− 015	− 046	− 030	+ 015	+ 046	+ 046	+ 046	....
	April	− 274	− 137	000	+ 076	+ 091	+ 061	+ 030	000	− 030	− 030	000	+ 030	....
	May	− 076	+ 046	+ 122	+ 152	+ 122	+ 076	+ 030	− 015	− 046	− 061	− 046	− 015	....
	June	− 046	+ 061	+ 137	+ 167	+ 137	+ 076	+ 030	− 015	− 030	− 046	− 030	− 015	....

Diagram G exhibits the changes in the horizontal force (in absolute measure) from the monthly normal value for each hour of the day and for each month of the year. The three variables are: the hour of the day, the month of the year, and the difference of the horizontal force from the normal. The contour lines of the magnetic surface differ 0.0005 of horizontal force in absolute measure. Full lines indicate greater value, lines of dashes less value, than the mean; dotted lines represent the normal value.

Annual Variation of the Horizontal Force.—For the discussion of the annual variation we make use of the monthly normal readings of the horizontal force as given in Table II. If m equals the monthly effect of the total progressive change, we obtain from the twelve equations, by the usual method, the value $m = +15.49$, and the correction for progressive change for July and June, for instance, becomes $+5.5\ m$ and $-5.5\ m$ respectively. The following table contains the monthly normals uncorrected and corrected for progressive change; also the differences from the mean for each month, constituting the annual variation.

TABLE XII.

Month.	Normals.	Corrected for progressive change.	Corrected normals.	Differences, or annual variation.		
					0. 000	0. 00
July	676. 3	+85. 2	761. 5	+10. 6	+39	+16
August	702. 2	+69. 7	771. 9	+ 0. 2	+01	+00
September	724. 6	+54. 2	778. 8	— 6. 7	—24	—10
October	738. 2	+38. 7	776. 9	— 4. 8	—17	—07
November	738. 5	+23. 2	761. 7	(+10. 4)	(+38)	(+16)
December	768. 4	+ 7. 7	776. 1	— 4. 0	—15	—06
January	793. 3	— 7. 7	785. 6	—13. 5	—49	—20
February	800. 6	—23. 2	777. 4	— 5. 3	—19	— 08
March	805. 7	—38. 7	767. 0	+ 5. 1	+19	+08
April	828. 3	—54. 2	774. 1	— 2. 0	— 7	—03
May	832. 2	— 69. 7	762. 5	+ 9. 6	+35	+15
June	856. 8	—85. 2	771. 6	+ 0. 5	+02	+01
Mean	772. 1	0. 0	772. 1	In scale divisions.	In parts of the horizontal force.	In absolute measure.

With the exception of the month of November, the values given above for the annual variation are tolerably regular in their progression, and considering the delicacy of the test applied to the observations in deducing the annual variation, this exceptional irregularity in the November value will not affect the general conclusion. We have as the general result: a greater horizontal force in summer (from April to August) and a smaller horizontal force in winter (from September to March) than the average annual value. The maximum occurs in July, (at Toronto in June,) and the minimum in January, (at Toronto in December.)

For Toronto we have the expression for the annual variation:

$$3.531 + 0.002 \sin (\theta + 312^\circ.)$$

For Philadelphia (omitting the November value:)

$$4.176 + 0.001 \sin (\theta + 306^\circ;)$$

the angle θ in both equations counting from January 15.

The annual range is 0.0021 (in absolute measure.) The transition appears to take place about the time of the equinoxes or a short time before.

Table XIII contains the monthly normal values of the horizontal force in absolute measure, obtained by adding (algebraically) 4.1730 to the values in the last column of Table XII. These numbers, it will be observed, are corrected for secular change; if we apply the same, we obtain the resulting monthly mean values of the horizontal force answering to the epoch January, 1843. The quantity A, mentioned in the explanatory remarks to Table VII, is given in the last column of Table XIII.

TABLE XIII.

Month.	Normals corrected for secular change.	Monthly means (affected with secular change.)
July	4.1746	4.1759
August	4.1730	4.1740
September	4.1720	4.1727
October	4.1723	4.1728
November	4.1746	4.1749
December	4.1724	4.1725
January	4.1710	4.1709
February	4.1722	4.1719
March	4.1738	4.1733
April	4.1727	4.1720
May	4.1745	4.1735
June	4.1731	4.1718
Mean	4.1730	4.1730

APPENDIX No. 17.

DISCUSSION OF THE MAGNETIC AND METEOROLOGICAL OBSERVATIONS MADE AT THE GIRARD COLLEGE OBSERVATORY, PHILADEPHIA, IN 1840, 1841, 1842, 1843, 1844, AND 1845. PART VI.—BY A. D. BACHE, LL.D., SUPERINTENDENT UNITED STATES COAST SURVEY.

Investigation of the influence of the Moon on the Magnetic Horizontal Force.

The method pursued in the investigation of the lunar effect on the horizontal force is, in general, the same as that explained in Part III of the discussions of the Girard College observations. The process may be briefly recapitulated as follows: Each horizontal force observation, after it had been corrected for the effect of difference from the standard temperature and for progressive change, the disturbed readings being omitted, (as fully explained in Part IV,) was marked with its corresponding lunar hour. The observation nearest to the time of the moon's upper transit over the true meridian of the observatory was marked 0^h, that nearest to the lower transit was marked 12^h, and the observations between, for western and eastern hour angles of the moon, were marked with the proper lunar hour by interpolation. In the hourly series where thirteen observations are recorded in twelve lunar hours, that observation which is nearest midway between any two consecutive lunar hours was omitted. Each observation and reduced reading thus marked with its corresponding lunar hour was subtracted from the monthly normal belonging to its respective hour, and these differences were set down in tabular form, arranged according to lunar hours and keeping each monthly result separate for future combination. Let $n =$ any normal belonging to any reduced reading r, the following tables contain the mean monthly values of the differences $n-r$; a positive sign, therefore, indicates greater force, a negative sign less force than the normal. It need hardly be repeated that in the original record of the horizontal force increasing numbers denote a decrease of the force. The greatest possible difference is 33, the number of scale divisions, which, according to the criterion, separates a disturbed from an undisturbed observation. For the formation of these differences, which amount to more than 22,000, the manuscript tables of the reduced record were used. These tables have already been referred to in the preceding Part IV.

The units in which the differences $n-r$ are expressed are scale divisions, one division being equal to 0.0000365 parts of the horizontal force, or equal to 0.000152 in absolute measure, the mean X being $= 4.173$ (in units of grains and feet.)

The lunar effect on terrestrial magnetism being exceedingly minute, the process required for its elucidation is proportionally delicate; all the regular and irregular deviations arising from other sources must first be eliminated. In the method, as indicated above, the magnetic disturbances (as far as they could be recognized as such,) the diurnal and annual solar variation, as well as the eleven (or ten) year inequality and secular change, are all eliminated, leaving numbers fitted for the lunar research.

The readings taken in the month of June, 1840, have not been used in this discussion, (these had likewise been rejected in the two preceding parts,) on account of the imperfect manner in which the allowance for the progressive change could only be made at that time. For the lunar hour 21 in July, 1840, the number of differences is so small that the mean had necessarily to be reduced; one-fourth of its amount was set down in the table. In January, February, and March, 1843, the observations were discontinued, excepting a single daily reading. These months, therefore, do not occur in the lunar discussion.

The number of observations used are distributed over the several months and years, as shown in the following table:

TABLE I.

Number of observations for lunar discussion.

Month.	1840–1841.	1841–1842.	1842–1843.	1843–1844.	1844–1845.	Sum.
July	157	297	281	294	627	1659
August	235	295	318	313	622	1783
September	258	269	265	296	556	1644
October	255	281	257	*602	597	1992
November	245	279	297	603	564	1988
December	199	297	318	603	559	1976
January	179	298	....	621	601	1699
February	238	250	....	575	541	1604
March	260	297	....	576	601	1734
April	262	271	286	586	575	1980
May	264	271	299	623	612	2069
June	212	295	309	579	522	1917
Sum	2764	3400	2633	6271	6977	22045

* Commencement of the hourly series.

TABLE II.

Distribution of the number of observations according to western and eastern hour angles of the moon.

Year.	Western hour angles.	Eastern hour angles.
1840–'41	1371	1393
1841–'42	1683	1712
1842–'43	1320	1313
1843–'44	3138	3133
1844–'45	3499	3478
Sum	11016	11029

Tables III, IV, V, VI, and VII, contain the monthly and annual means of the lunar-diurnal variation for the years 1840 to 1845. The numbers are expressed in scale divisions.

Table III.

Differences from the monthly normals, 1840–'41, *western hour angles of the moon.*

1840–'41.	0h. Up. cul.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
July	+ 2	+ 1	+ 3	− 9	+ 3	+ 7	− 1	−17	+12	− 4	− 3	− 8
August	0	− 4	+ 3	− 5	+ 6	+ 2	− 4	− 4	− 2	+ 2	+ 5	− 1
September	− 2	0	+ 8	+ 1	0	− 4	− 5	+ 2	− 4	− 7	+ 8	+ 4
October	− 3	− 1	− 1	+ 1	0	− 4	− 4	+ 1	− 7	+ 7	+ 4	+10
November	− 6	+ 3	0	− 4	+ 1	− 5	+ 4	− 4	− 4	+ 1	+ 6	− 1
December	− 4	− 3	+ 3	+ 4	+ 2	− 7	− 5	− 3	0	+ 3	− 8	+ 9
January	+ 1	+ 3	− 1	+ 8	− 7	+ 3	− 8	+ 1	− 9	− 4	0	+ 2
February	+ 7	+ 5	0	+ 6	− 3	+ 4	− 2	0	− 4	0	− 2	0
March	− 4	+ 4	+ 1	0	+ 3	+ 3	− 7	− 1	+ 8	+ 1	+ 3	− 2
April	0	+ 6	+ 1	− 2	− 2	− 1	− 1	+ 3	− 1	− 2	+ 1	− 1
May	+ 3	− 3	+ 1	− 1	− 8	+ 2	− 1	− 1	− 6	0	+ 2	− 5
June	− 1	− 5	0	− 3	+ 4	+ 4	+ 5	+ 8	− 1	+ 1	− 1	− 8
Mean	− 0.4	+ 0.5	+ 1.5	− 0.3	− 0.1	+ 0.3	− 2.4	− 1.3	− 1.5	− 0.2	+ 1.3	− 0.1
	12h. Low. cul	13h.	14h.	15h.	16h.	17h.	18h	19h.	20h.	21h.	22h.	23h.
July	+ 11	− 9	− 5	+ 2	+ 6	0	− 2	− 5	+ 6	− 5	− 4	− 2
August	+ 7	+ 6	+ 9	+ 1	+ 5	+ 2	+ 5	− 3	+ 5	−11	0	2
September	− 2	− 1	+ 2	+ 6	+ 5	+ 4	− 4	+ 1	− 2	− 3	− 1	− 2
October	− 16	+14	− 9	+ 4	− 7	+ 3	−10	− 2	− 1	+ 6	− 3	+ 5
November	− 2	+ 1	− 1	+ 4	− 6	0	+ 1	− 1	+ 4	+ 6	+ 1	+ 5
December	+ 6	+ 9	+ 2	+10	− 3	+ 2	− 6	−12	− 3	− 6	+ 3	+ 5
January	− 2	− 4	+ 3	− 1	+ 1	− 1	+ 4	− 2	− 2	+ 1	+ 3	+ 7
February	− 5	+ 4	− 4	− 7	− 6	+ 5	+ 1	+ 2	+ 1	− 5	+ 3	+ 4
March	− 4	0	− 5	+ 2	− 1	+ 4	−10	+ 2	− 2	− 2	+ 2	+ 2
April	− 1	− 3	+ 3	− 8	− 3	− 4	0	+ 3	− 2	+ 2	+ 4	+ 2
May	+ 8	− 3	0	− 3	0	0	− 2	+ 8	+ 3	− 2	− 2	+ 2
June	+ 8	− 4	+ 6	− 5	+ 7	− 8	− 5	− 7	0	− 7	+ 1	−11
Mean	+ 1.0	+ 0.8	+ 0.1	+ 0.4	− 0.2	+ 0.6	− 2.3	− 1.3	+ 0.6	− 2.1	+ 0.6	+1.2

Table IV.

Differences from the monthly normals, 1841–'42, *western hour angles of the moon.*

1841–'42.	0h. Up. cul.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
July	+ 4	+ 5	0	+ 8	− 4	0	0	− 2	0	− 8	+ 2	0
August	− 1	0	− 2	+ 2	+ 2	+ 3	+ 3	0	− 5	0	+ 1	+ 5
September	− 3	+ 8	+ 2	− 1	0	− 1	− 5	− 3	+ 1	0	− 3	+10
October	+ 7	− 1	+ 4	+ 4	0	+ 1	− 1	+ 4	+ 1	− 2	0	+ 1
November	0	+ 6	− 3	+ 1	− 7	0	− 3	− 1	+ 6	+ 3	+ 1	+ 3
December	+ 8	− 4	+12	− 2	− 1	− 3	+ 2	− 3	− 2	− 1	− 3	0
January	− 2	+ 8	+ 2	+ 2	− 1	+ 7	0	+ 3	− 2	+ 1	+ 5	0
February	− 5	+ 1	− 1	− 3	+ 4	+ 2	+ 4	− 7	− 5	+ 5	0	+ 2
March	+ 4	+ 3	+ 2	− 1	+ 2	− 1	+ 2	0	− 1	− 1	− 2	− 3
April	0	0	+ 1	0	0	+ 4	+ 1	+ 3	+ 2	− 1	0	+ 1
May	0	− 2	+10	+ 1	+ 5	+ 4	+ 6	− 4	+ 5	− 7	− 3	− 4
June	+ 1	0	+ 3	0	+ 4	− 3	− 1	− 3	− 5	− 5	0	− 3
Mean	+ 1.1	+ 2.0	+ 2.5	+ 0.9	+ 0.3	+ 1.1	+ 0.7	− 1.1	− 0.4	− 1.3	− 0.2	+ 1.0

TABLE IV.—*Differences from the monthly normals,* 1841–'42, *western hour angles of the moon*—Continued.

	12*h*. Low. cul.	13*h*.	14*h*.	15*h*.	16*h*.	17*h*.	18*h*.	19*h*.	20*h*.	21*h*	22*h*.	23*h*.
July	+ 4	− 5	+ 3	+ 5	+ 1	− 1	− 8	− 4	+ 1	− 1	− 1	+ 3
August	+ 1	+ 3	0	+ 2	+ 1	− 5	− 1	+ 3	− 4	− 3	− 5	− 1
September	+ 3	+ 2	+ 2	− 6	+ 5	− 1	− 5	− 2	+ 1	+ 4	− 5	+ 6
October	+ 4	− 1	− 3	− 5	− 4	− 3	+ 7	− 3	− 1	− 3	− 1	+ 1
November	− 1	+ 4	+ 3	− 6	− 1	− 5	+ 1	− 2	0	− 3	− 4	− 3
December	− 1	0	− 1	+ 2	− 4	− 3	− 1	+ 1	+ 1	+ 1	+ 6	+ 1
January	+ 4	− 2	− 2	− 4	− 1	− 5	− 3	− 3	+ 5	0	− 3	+ 2
February	+ 7	+ 1	+ 1	− 2	− 3	0	− 8	+ 6	− 7	+ 1	+ 3	+ 2
March	− 2	+ 3	− 2	0	− 6	− 1	0	− 2	− 1	+ 2	− 6	− 1
April	+ 1	+ 1	+ 3	− 3	+ 1	− 1	− 3	+ 2	− 5	− 3	− 2	+ 1
May	0	− 5	− 3	− 3	+ 4	− 6	+ 6	− 4	0	+ 3	+ 4	+ 2
June	− 4	− 2	− 4	+ 2	0	+ 2	+ 2	+ 6	+ 6	− 2	+ 2	+ 4
Mean	+ 1.2	− 0.1	− 0.2	− 1.5	− 0.6	− 2.4	− 1.1	− 0.2	− 0.3	− 0.3	− 1.0	+ 1.4

TABLE V.

Differences from the monthly normals, 1842–'43, *western hour angles of the moon.*

1842–'43.	0*h*. Up. cul.	1*h*.	2*h*.	3*h*.	4*h*.	5*h*.	6*h*.	7*h*.	8*h*.	9*h*.	10*h*.	11*h*.
July	+ 3	− 3	+ 2	− 1	+ 1	0	+ 7	+ 2	0	− 4	+ 1	− 8
August	+ 3	+ 1	− 3	0	− 1	− 4	− 3	+ 4	+ 2	+ 1	+ 1	+ 3
September	+ 3	− 6	− 1	+ 9	+ 4	− 1	+ 7	+ 1	0	+ 2	− 3	0
October	+ 2	− 7	0	+ 1	− 6	+ 3	− 1	+ 3	− 3	+ 5	− 3	+ 2
November	+ 1	+ 3	− 1	+ 2	+ 1	+ 1	0	− 2	− 2	− 1	− 4	+ 1
December	− 2	− 3	− 6	+ 1	− 5	0	− 2	0	+ 1	− 1	+ 5	0
January	......	......	......	......	......	......	......	......	......	......	......	......
February	......	......	......	......	......	......	......	......	......	......	......	......
March	......	......	......	......	......	......	......	......	......	......	......	......
April	− 1	+ 2	0	+10	+ 4	+ 9	− 1	+ 1	− 3	− 1	+ 1	− 4
May	+ 3	− 2	+ 2	+ 5	+ 3	+ 4	− 1	+ 9	− 1	+ 1	− 6	+ 3
June	− 6	+ 7	− 4	− 1	0	+ 2	0	− 1	− 5	+ 4	− 1	+ 3
Mean	+ 0.7	− 0.9	− 1 0	+ 2.9	+ 0.1	+ 1.6	+ 0.7	+ 1 9	− 1.2	+ 0.7	− 1.0	0.0
	12*h*. Low. cul.	**13*h*.**	**14*h*.**	**15*h*.**	**16*h*.**	**17*h*.**	**18*h*.**	**19*h*.**	**20*h*.**	**21*h*.**	**22*h*.**	**23*h*.**
July	+ 1	+ 1	+ 4	− 2	+ 4	− 3	− 4	− 1	0	− 2	+ 3	− 1
August	− 2	+ 1	+ 1	+ 2	+ 2	− 4	+ 3	− 5	− 1	+ 2	+ 2	− 2
September	+ 6	− 1	− 1	− 8	− 3	− 1	− 4	− 1	− 2	− 7	+ 1	− 6
October	− 7	− 3	+ 2	− 1	+ 1	0	− 1	+ 4	+ 4	− 3	+11	+ 3
November	− 2	− 2	− 1	− 3	+ 1	+ 4	− 1	+ 6	0	+ 1	+ 1	+ 2
December	+ 3	+ 3	+ 2	+ 1	+ 3	0	+ 1	+ 2	− 2	+ 4	− 3	+ 3
January	......	......	......	......	......	......	......	......	......	......	......	......
February	......	......	......	......	......	......	......	......	......	......	......	......
March	......	......	......	......	......	......	......	......	......	......	......	......
April	+ 2	− 2	+ 3	+ 2	0	− 2	− 5	0	− 3	− 2	+ 1	− 1
May	0	+ 1	+ 4	0	+ 1	− 4	− 3	− 1	− 1	− 1	− 1	− 2
June	0	+ 3	− 1	+ 4	− 2	+ 2	− 3	− 3	+ 2	+ 1	− 7	+ 4
Mean	+ 0.1	+ 0.1	+ 1.4	− 0.6	+ 0.8	− 0.9	− 1.9	+ 0.1	− 0.3	− 0.8	+ 0.9	0.0

TABLE VI.

Differences from the monthly normals, 1843–'44, western hour angles of the moon.

1843-'44.	0h. Up. cul.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
July	+ 6	+ 4	+ 2	+ 4	+ 5	− 4	+ 3	+ 1	+ 1	− 2	− 5	− 2
August	+ 2	+ 2	0	− 1	+ 2	+ 1	− 3	+ 4	0	− 1	− 2	− 2
September	+ 1	− 1	− 3	+ 6	0	− 2	− 1	− 4	− 1	0	− 2	0
October	− 1	+ 4	+ 3	+ 5	+ 2	+ 3	+ 2	+ 1	0	− 2	− 1	− 3
November	+ 1	+ 1	0	0	0	0	0	− 2	0	0	+ 1	+ 1
December	+ 2	+ 1	+ 2	0	0	− 2	− 1	− 1	− 1	− 2	+ 1	− 1
January	+ 1	0	0	0	− 1	− 1	+ 1	+ 1	+ 1	0	− 1	0
February	− 1	− 1	+ 1	+ 2	+ 1	− 1	0	0	+ 3	0	− 1	+ 2
March	− 1	− 3	+ 1	+ 1	+ 1	+ 1	+ 2	+ 2	0	+ 2	+ 1	+ 1
April	+ 2	+ 2	+ 3	+ 2	0	0	+ 1	+ 1	− 1	− 2	− 3	− 2
May	− 2	− 2	0	− 1	− 2	0	− 1	− 1	− 2	− 1	0	− 1
June	0	− 2	0	0	+ 2	+ 2	+ 2	+ 2	+ 1	− 1	− 2	0
Mean	+ 0.9	+ 0.4	+ 0.8	+ 1.5	+ 0.9	− 0.3	+ 0.4	+ 0.3	+ 0.1	− 0.8	− 1.2	− 0.6
	12h. Low. cul	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
July	− 2	− 7	− 2	− 3	− 3	− 1	+ 4	− 2	+ 1	− 1	+ 2	+ 2
August	+ 4	0	+ 2	− 1	− 2	0	+ 2	+ 1	+ 1	− 2	+ 4	0
September	+ 3	0	+ 3	+ 3	+ 8	+ 2	− 6	− 1	− 6	− 3	− 2	0
October	− 3	− 4	− 2	− 1	− 2	0	0	− 1	− 1	+ 1	− 2	− 1
November	+ 1	+ 2	+ 2	+ 2	+ 2	0	− 1	− 2	− 1	− 1	0	− 1
December	0	+ 1	+ 1	0	+ 1	− 1	− 3	− 4	− 4	− 3	− 2	0
January	+ 1	+ 2	− 1	− 1	− 1	− 2	0	− 1	+ 1	+ 2	+ 1	+ 2
February	2	+ 1	+ 1	+ 2	+ 2	− 3	− 2	+ 1	− 2	− 1	− 1	− 2
March	+ 1	0	− 1	0	0	0	− 1	− 1	− 1	− 1	+ 1	− 3
April	− 4	0	0	0	+ 2	0	0	+ 1	0	0	− 1	0
May	0	0	− 2	0	0	− 2	− 3	+ 1	+ 1	+ 1	+ 2	+ 1
June	0	+ 2	+ 1	+ 3	+ 2	0	− 1	0	0	− 1	− 2	0
Mean	+ 0.3	− 0.2	+ 0.2	+ 0.3	+ 1.3	− 0.6	− 0.9	− 0.7	− 0.9	− 0.8	0.0	− 0.2

Equal weight has been given to each monthly result in the formation of the annual mean.

TABLE VII.

Differences from the monthly normals, 1844–'45, western hour angles of the moon.

1844–'45.	0h. Up. cul.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
July	0	+ 1	+ 1	+ 1	0	+ 1	+ 2	+ 2	0	+ 1	0	− 2
August	− 3	+ 1	− 1	0	+ 2	0	+ 1	+ 3	+ 1	− 3	− 2	+ 1
September	− 2	0	− 1	0	− 2	+ 2	0	+ 3	+ 2	+ 2	+ 2	+ 4
October	0	+ 4	+ 5	+ 2	+ 3	4	+ 2	0	0	+ 1	− 3	0
November	− 1	+ 3	+ 1	+ 2	+ 1	+ 3	+ 3	+ 3	+ 3	+ 3	+ 2	− 1
December	− 1	0	− 1	0	− 2	− 3	− 3	− 2	− 1	− 1	+ 1	− 1
January	+ 1	+ 2	+ 4	− 2	− 3	− 4	− 1	− 3	0	− 1	+ 4	+ 2
February	+ 1	+ 1	0	0	+ 1	+ 1	+ 1	+ 2	− 1	− 2	0	+ 4
March	+ 1	− 3	− 3	− 3	0	0	+ 1	+ 1	0	+ 1	+ 1	0
April	− 4	+ 2	+ 2	+ 2	0	+ 2	0	+ 2	− 2	− 2	− 1	− 1
May	+ 2	0	+ 2	+ 2	0	− 2	0	− 1	− 2	− 2	+ 1	0
June	− 5	− 4	− 3	− 1	0	+ 3	+ 1	+ 1	+ 1	0	− 5	− 4
Mean	− 0.9	+ 0.6	+ 0.5	+ 0.3	0.0	+ 0.6	+ 0.6	+ 0.9	+ 0.1	− 0.3	0.0	+ 0.2

TABLE VII.—*Differences from the monthly normals*, 1844–'45, *western hour angles of the moon*—Cont'd.

	12h. Low. cul.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
July	0	0	+ 1	0	− 1	0	0	0	− 2	− 2	− 2	− 3
August	+ 3	+ 2	+ 3	− 1	0	− 2	0	0	− 3	− 3	0	− 2
September	2	+ 3	+ 1	+ 1	− 1	− 2	− 3	− 3	− 4	− 3	− 4	− 4
October	+ 1	+ 2	+ 1	+ 2	0	− 2	− 2	− 4	− 4	− 5	0	− 2
November	− 1	− 4	0	− 2	0	0	− 3	− 2	− 1	+ 1	− 4	− 3
December	+ 1	0	− 1	+ 2	0	+ 2	+ 2	+ 1	0	+ 3	+ 2	0
January	+ 4	0	+ 2	− 1	− 5	− 4	− 4	− 4	0	+ 2	+ 1	+ 2
February	+ 1	+ 2	+ 1	− 1	− 3	− 1	− 2	− 1	− 5	− 1	− 1	− 1
March	+ 1	+ 2	− 1	0	+ 4	+ 3	+ 2	+ 1	− 3	− 2	− 1	− 3
April	− 2	+ 1	0	0	+ 1	+ 1	+ 3	− 1	− 3	− 4	− 3	− 4
May	+ 1	− 2	− 2	− 2	− 2	0	− 1	0	+ 1	− 3	0	+ 2
June	+ 1	− 1	+ 1	+ 2	− 1	+ 4	+ 4	+ 3	+ 2	+ 2	0	− 1
Mean	+ 1.0	+ 0.4	+ 0.5	0.0	− 0.7	− 0.1	− 0.3	− 0.8	− 1.8	− 1.2	− 1.0	− 1.6

TABLE VIII.

Recapitulation of the annual means exhibiting the lunar diurnal variation, from 22,045 *observations between* 1840 *and* 1845, *expressed in scale divisions.*

July to July.	0h. Up. cul.	1h.	2h.	3h.	4h.	5h.	6h	7h.	8h.	9h.	10h.	11h.
1840–'41	− 0.4	+ 0.5	+ 1.5	− 0.3	− 0.1	+ 0.3	− 2.4	− 1.3	− 1.5	− 0.2	+ 1.3	− 0.1
1841–'42	+ 1.1	+ 2.0	+ 2.5	+ 0.9	+ 0.3	+ 1.1	+ 0.7	− 1.1	− 0.4	− 1.3	− 0.2	+ 1.0
1842–'43	+ 0.7	− 0.9	− 1.0	+ 2.9	+ 0.1	+ 1.6	+ 0.7	+ 1.9	− 1.2	+ 0.7	− 1.0	0.0
1843–'44	+ 0.9	+ 0.4	+ 0.8	+ 1.5	+ 0.9	− 0.3	+ 0.4	+ 0.3	+ 0.1	− 0.8	− 1.2	− 0.6
1844–'45	− 0.9	+ 0.6	+ 0.5	+ 0.3	+ 0.0	+ 0.6	+ 0.6	+ 0.9	+ 0.1	− 0.3	0.0	+ 0.2
Mean	+ 0.3	+ 0.5	+ 0.9	+ 1.1	+ 0.2	+ 0.7	0.0	+ 0.1	− 0.6	− 0.4	− 0.2	+ 0.1
	12h. Low. cul.	**13h.**	**14h.**	**15h.**	**16h.**	**17h.**	**18h.**	**19h.**	**20h.**	**21h.**	**22h.**	**23h.**
1840–'41	+ 1.0	+ 0.8	+ 0.1	+ 0.4	− 0.2	+ 0.6	− 2.3	− 1.3	+ 0.6	− 2.1	+ 0.6	+ 1.2
1841–'42	+ 1.2	− 0.1	− 0.2	− 1.5	− 0.6	− 2.4	− 1.1	− 0.2	− 0.3	− 0.3	− 1.0	+ 1.4
1842–'43	+ 0.1	+ 0.1	+ 1.4	− 0.6	+ 0.8	− 0.9	− 1.9	+ 0.1	− 0.3	− 0.8	+ 0.9	0.0
1843–'44	+ 0.3	− 0.2	+ 0.2	+ 0.3	+ 1.3	− 0.6	− 0.9	− 0.7	− 0.9	− 0.8	0.0	− 0.2
1844–'45	+ 1.0	+ 0.4	+ 0.5	0.0	− 0.7	− 0.1	− 0.3	− 0.8	− 1.8	− 1.2	− 1.0	− 1.6
Mean	+ 0.7	+ 0.2	+ 0.4	− 0.3	+ 0.1	− 0.7	− 1.3	− 0.6	− 0.5	− 1.0	− 0.1	+ 0.2

If we give weight to the annual means according to the number of observations, they would be, one for the first and second year, three-fourths for the third year, one and three-fourths for the next year, and two for the last year. A general examination, however, shows that, owing to the disturbing effect of the progressive change, the monthly means are very nearly of equal value, derived either from the bi-hourly or the hourly series. It will also be shown in the sequel that the lunar diurnal variation is nearly the same in the summer and winter seasons. The means of Table V and the final means of Table VIII have, therefore, been adopted without reference to combinations or weights.

A comparison of the values of Table VIII among themselves shows them to be very irregular, although derived from many thousand observations. A five-year series of observations seems barely sufficient to exhibit a tolerably regular progression. In the following table two groups have been formed, one of results from three years, 1840 to 1843, comprising 8,797 observations, the other from the remaining two years comprising 13,248 observations. From these it appears that the lunar diurnal variation during these two periods exhibits the same general character.

Lunar-diurnal variation during the periods 1840–'43 *and* 1843–'45.

Groups.	0h.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
1840–'43	+ 0.5	+ 0.5	+ 1.0	+ 1.2	+ 0.1	+ 1.0	− 0.3	− 0.2	− 1.0	− 0.3	0.0	+ 0.3
1843–'45	0.0	+ 0.5	+ 0.7	+ 0.9	+ 0.4	+ 0.3	+ 0.5	+ 0.6	+ 0.1	− 0.6	− 0.6	− 0.2
	12h.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
1840–'43	+ 0.8	+ 0.3	+ 0.4	− 0.6	0.0	− 0.9	− 1.8	− 0.5	0.0	− 1.2	+ 0.2	+ 0.9
1843–'45	+ 0.7	+ 0.1	+ 0.4	+ 0.2	+ 0.3	− 0.4	− 0.6	− 0.7	− 1.3	− 1.0	− 0.5	− 0.9

Before proceeding to the analysis of the final result of Table VIII, the separate results have been combined into summer and winter groups; the first group comprising the months from April to September, the second group the months from October to March.

Table IX exhibits the lunar-diurnal variation of the horizontal force during the summer and winter seasons.

TABLE IX.

Lunar-diurnal variation in summer.

(In scale divisions.)

April to September.	0h. Up. cul.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
1840–'41	+ 0.7	− 0.9	+ 2.7	− 3.2	+ 0.5	+ 1.7	− 1.1	− 1.5	− 0.3	− 1.7	+ 2.0	− 3.2
1841–'42	+ 0.2	+ 1.8	+ 2.3	+ 1.7	+ 1.2	+ 1.2	+ 0.7	− 1.5	− 0.3	− 3.5	− 0.5	+ 1.5
1842–'43	+ 0.8	− 0.2	− 0.7	+ 3.6	+ 1.8	+ 1.7	+ 1.5	+ 2.7	− 1.2	+ 0.5	− 1.2	− 0.5
1843–'44	+ 1.5	+ 0.5	+ 0.3	+ 1.7	+ 1.2	− 0.5	+ 0.2	0.5	− 0.3	− 1.2	− 2.3	− 1.2
1844–'45	− 2.0	0.0	0.0	+ 0.7	0.0	+ 1.0	+ 0.7	+ 1.7	0.0	− 0.7	− 0.8	− 0.3
Mean	+ 0.2	+ 0.2	+ 0.9	+ 0.9	+ 0.9	+ 1.0	+ 0.4	+ 0.4	− 0.4	− 1.3	− 0.6	− 0.7
	12h. Up. cul.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
1840–'41	+ 5.8	− 2.3	+ 2.5	− 1.2	+ 3.2	− 1.0	− 1.3	− 0.5	+ 1.7	− 4.3	− 0.3	− 2.2
1841–'42	+ 0.7	− 1.0	+ 0.2	− 0.5	+ 2.0	− 2.0	− 1.5	+ 0.2	− 0.2	− 0.3	− 1.2	+ 2.5
1842–'43	+ 1.2	+ 0.5	+ 1.7	− 0.3	+ 0.3	− 2.0	− 2.7	− 1.8	− 0.8	− 1.5	− 0.2	− 1.3
1843–'44	+ 0.2	− 0.8	+ 0.3	+ 0.3	+ 2.2	− 0.2	− 0.7	0.0	− 0.5	− 1.0	+ 0.5	+ 0.5
1844–'45	+ 0.8	+ 0.5	+ 0.7	0.0	− 0.7	+ 0.2	+ 0.5	− 0.2	− 1.5	− 2.2	− 1.5	− 2.0
Mean	+ 1.7	− 0.6	+ 1.1	− 0.3	+ 1.4	− 1.0	− 1.1	− 0.5	− 0.3	− 1.9	− 0.5	− 0.5

Lunar-diurnal variation in winter.

(In scale divisions.)

October to March.	0h. Up. cul.	1h.	2h.	3h.	4h.	5h.	6h.	7h.	8h.	9h.	10h.	11h.
1840–'41	− 1.5	+ 1.8	+ 0.3	+ 2.5	− 0.7	− 1.0	− 3.7	− 1.0	− 2.7	+ 1.3	+ 0.5	+ 3.0
1841–'42	+ 2.0	+ 2.2	+ 2.7	+ 0.2	− 0.5	+ 1.0	+ 0.7	+ 0.7	− 0.5	+ 0.8	+ 0.2	+ 0.5
1842–'43	+ 0.3	− 2.3	− 2.3	+ 1.3	− 3.3	+ 1.3	− 1.0	+ 0.3	− 1.3	+ 1.0	− 0.7	+ 1.0
1843–'44	+ 0.2	+ 0.3	+ 1.2	+ 1.3	+ 0.5	0.0	+ 0.7	+ 0.2	+ 0.5	− 0.3	0.0	0.0
1844–'45	+ 0.2	+ 1.2	+ 1.0	− 0.2	0.0	+ 0.2	+ 0.5	+ 0.2	+ 0.2	+ 0.2	+ 0.8	+ 0.7
Mean	+ 0.2	+ 0.6	+ 0.6	+ 1.0	− 0.8	+ 0.3	− 0.6	− 0.2	− 0.8	+ 0.6	+ 0.2	+ 1.0
	12h. Up. cul.	13h.	14h.	15h.	16h.	17h.	18h.	19h.	20h.	21h.	22h.	23h.
1840–'41	− 3.8	+ 4.0	− 2.3	+ 2.0	− 3.7	+ 2.2	− 3.3	− 2.2	− 0.5	0.0	+ 1.2	+ 4.7
1841–'42	+ 1.7	+ 0.8	− 0.7	− 2.5	− 3.2	− 2.8	− 0.7	− 0.5	− 0.5	− 0.3	− 0.8	+ 0.3
1842–'43	− 2.0	− 0.7	+ 1.0	− 1.0	+ 1.7	+ 1.3	− 0.3	+ 4.0	+ 0.7	+ 0.7	+ 3.0	+ 2.3
1843–'44	+ 0.3	+ 0.3	0.0	+ 0.3	+ 0.3	− 1.0	− 1.2	− 1.3	− 1.3	− 0.5	− 0.5	− 0.8
1844–'45	+ 1.2	+ 0.3	+ 0.3	0.0	− 0.7	− 0.3	− 1.2	− 1.5	− 2.2	− 0.3	− 0.7	− 1.2
Mean	− 0.5	+ 0.9	− 0.3	− 0.2	− 1.1	− 0.1	− 1.3	− 0.3	− 0.8	− 0.1	+ 0.5	+ 1.1

The results are exhibited in Diagram A of Part VI, Sketch No. 48. The number of observations (about 11,000 for each group) is evidently too small to eliminate the greater irregularities.

If there is any marked difference in the lunar-diurnal variation in the summer and winter season, the summer range is slightly greater than the winter range. As to the epoch, there is no doubt that in winter the lunar maxima and minima are earlier than in summer. It is a remarkable fact that we have found the same features in the lunar effect on the declination, viz: a greater amplitude in summer and an earlier occurrence of the maxima and minima in winter. The amount of the shifting of the two curves appears to be nearly the same. From the ten-year series of observations at Prague (1840-'49) Mr. Karl Kreil found a larger lunar effect in the summer months than in the winter months.

Recurring to the final values of the lunar-diurnal variation of the horizontal force as given in Table VIII, they can be represented by the usual Besselian form of periodic functions.

The angle θ counts from the moon's upper culmination westward at the rate of 15° to an hour; a + sign indicated greater, a — sign less force than the average normal. The observed values are represented by the following expression:

$$H☾ = -0.01 + 0.40 \sin(\theta + 13^\circ 29') + 0.60 \sin(2\theta + 38^\circ 43') + 0.155 \sin(3\theta + 244^\circ 31'.)$$

The three co-efficients are expressed in scale divisions. If expressed in parts of the horizontal force, the equation may be written as follows (M signifies millionth parts of the force:)

$$H☾ = \overset{M}{-0.36} + \overset{M}{14.60} \sin(\theta + 13^\circ.5) + \overset{M}{21.90} \sin(2\theta + 38^\circ.7) + \overset{M}{5.64} \sin(3\theta + 244^\circ.5.)$$

If expressed in absolute measure, and if n = number of hours after the upper culmination, it may be written

$$H☾ = \overset{M}{-1.5} + \overset{M}{61.0} \sin(15n + 13^\circ.5) + \overset{M}{91.5} \sin(30n + 39^\circ) + \overset{M}{23.6} \sin(45n + 244^\circ.5.)$$

The curve is double-crested and is exhibited, together with the observed values, in Diagram B, of Part VI, Sketch No. 50. It presents two maxima and two minima, which are found from the equation

$$\frac{dH}{d\theta} = 0 = +0.40 \cos(\theta + 13^\circ) + 1.20 \cos(2\theta + 39^\circ) + 0.45 \cos(3\theta + 245^\circ.)$$

The lunar effect on the declination we have found likewise to present two maxima and two minima.—(See Part III of the discussion, Coast Survey Report for 1860.)

We find:

Principal maximum	2h	52m	after	Upper	Culmination;	+0.87	scale divisions.
Secondary	"	1	7	" Lower	"	+0.51	" "
Principal minimum	6	41	"	"	"	—0.87	" "
Secondary	"	8	19	" Upper	"	—0.42	" "

The epoch of the horizontal-force tide for the high values is nearly two hours after the culminations, and for the low values it is 7½ hours after the same phases.

For Makerstown, in Scotland, at General Sir Thomas M. Brisbane's observatory, in 1843-'46, Mr. J. A. Broun found (Trans. Royal Society of Edinburgh, vol. XIX, p. 11, 1849) the smaller maximum of the horizontal force two hours after upper culmination, the greater maximum one and one-fourth hours after the lower culmination, the smaller minimum eight hours after the upper culmination, and the greater minimum nine hours after the lower culmination.

At Prague all extremes appear from two to three hours later. Mr. Karl Kreil (Denkschriften of the Imperial Academy of Sciences, at Vienna, vol. V, 1853) found from the ten-year series at Prague (1840-'49) maxima of horizontal force between four and five hours after the upper and lower culminations, the latter being the greater of the two; and minima between ten and eleven hours after the same epoch, that after the upper culmination being the greater of the two.

From the Toronto observations, continued for five years, Major General Sabine deduced the formula (see vol. III of the Toronto Magnetical and Meteorological Observations, London, 1857.)

$$\Delta_x = +0.05 + 0.215 \sin(a + 353^\circ.6) + 0.3324 \sin(2a + 13^\circ.5.)$$

The co-efficients are in decimals of scale divisions (1 div.=0.000087) parts of the horizontal force;) the angle a counts from the superior culmination, giving a curve of which the general features are in exact accordance with those deduced from the Philadelphia observations, viz: a principal maximum after upper culmination, followed by the secondary minimum; the secondary maximum after the lower culmination, followed by a principal maximum. The times and amount of these values are compared in the following Table X:

TABLE X.

Comparison of the lunar-diurnal variation of the horizontal component of the magnetic force as reduced from 22,045 observations between 1840 and 1845, at Philadelphia, and as deduced from 34,303 observations between 1844 and 1848, (a five-year series,) at Toronto, Canada.

	Philadelphia.	Toronto.
Time of principal maximum	2h. 9 after up. cul.	3h after up. cul.
Time of secondary minimum	8. 3 " "	9 " "
Time of secondary maximum	1. 1 " low. cul.	2 " low. cul.
Time of principal minimum	6. 7 " "	8 " "
	In parts of horizontal force.	
Amount of principal maximum	+0. 000032	+0. 000046
Amount of secondary minimum	—0. 000016	—0. 000010
Amount of secondary maximum	+0. 000019	+0. 000024
Amount of principal minimum	—0. 000032	—0. 000041
	In absolute measure.	
Amount of principal maximum	+0. 000133	
Amount of secondary minimum	—0. 000068	
Amount of secondary maximum	+0. 000078	
Amount of principal minimum	—0 000133	

Probable error of any single representation of the Philadelphia values $= \pm 0^{d}.25 = \pm 0.000009$ parts of the horizontal force $= \pm 0.000038$ in absolute measure.

Investigation of the horizontal force in reference to the lunar phases.—The following process of reduction has been adopted: After marking the days of the full and new moon, and also the days preceding and following, the daily means of the horizontal-force readings were taken (already corrected for difference of temperature and progressive change.) In the place of any disturbed observation, the monthly normal, belonging to the respective hour, was substituted before taking the daily mean. All accidental omissions in the record of the hourly or bi-hourly series were supplied by the hourly normal of the month. The means thus obtained are independent of the solar-diurnal variation. The monthly normal was next compared with each daily mean and the differences (normal, minus mean) were tabulated.

A positive sign signifies a greater, a negative sign a less force than the normal value. As the results deduced from a single year are yet too much affected by the incidental irregularities of the observations, the collective results from the five-year series (1840–'45) are herewith presented.

TABLE XI.

Influence of the lunar phases on the horizontal force.

	Scale divisions.	Parts of the hor. force.	In absolute measure.
One day before full moon	—1. 0	—0. 000036	—0. 00015
On the day of full moon	—1. 5	—0. 000055	—0. 00023
One day after full moon	—0. 2	—0. 000007	—0. 00003
One day before new moon	+0. 0	+0. 000000	+0. 00000
On the day of new moon	+2. 4	+0. 000091	+0. 00038
One day after new moon	+0. 9	+0. 000033	+0. 00014
Difference for new full moon	3. 9	0. 000146	0. 00061

The average number of observations from which any one of the above six means were deduced is over 800, and the probable error, in scale divisions, of any one of the results is ± 0.7 (nearly.)

From the Makerstown observations, Broun found for the years 1843–'46 a minimum at the time of the full moon, and a maximum at the time of the new moon. Kreil, from the Prague observations, between 1843–'46, found the same result, all in accordance with the Philadelphia results, as given above. It must be remarked, however, that after the year 1848 Kreil found that the signs were reversed, and consequently it appears that the lunar influence on the horizontal force is subject to a cycle of short period. This last remark does not apply to the effect of the moon's declination and variations in distance.

Influence of the moon's changes of declination on the horizontal force.—The method of investigation is precisely the same as that adopted for the phases. We find:

TABLE XII.

	s. d.	
One day before the greatest north declination	+0. 8	Mean +1. 1.
On the day of the greatest north declination	+0. 6	
One day after the greatest north declination	+2. 2	
Two days after the greatest north declination	+0. 9	
On the day of the moon's crossing the equator	—1. 2	Probable error of any one result ± 0. 9.
One day before the greatest south declination	—3. 4	Mean —0. 6.
On the day of the greatest south declination	—0. 9	
One day after the greatest south declination	+0. 9	
Two days after the greatest south declination	+1. 0	

It seems probable that the greatest effect takes place rather a day after than on the day of the moon's greatest declination. Taking means, as indicated in the above table, we find about the time of the maximum north declination an increase of horizontal force of 1.1 scale divisions (or 0.000040 parts of the horizontal force.) At the time of the moon's crossing the equator the force is decreased 1.2 scale divisions (or 0.000044 parts of the horizontal force.) The horizontal force also appears decreased about the time of the moon's greatest south declination. The amount is about half that of the other two cases, and is somewhat doubtful, from an apparently excessive value on the preceding day.

According to Broun, there is at Makerstown a maximum horizontal force at the time of the moon's greatest north and south declination, with a minimum force at the time of her crossing the equator. In two cases therefore, viz: for north declination and no declination, the Makerstown and Philadelphia results agree, while in the third case they disagree or remain doubtful. Kreil's results, from the Prague observations, do not appear to me sufficiently decisive and regular to admit of comparison.

Influence of the moon's variation in distance on the horizontal force.—By a process of reduction that followed in the preceding investigation we find:

TABLE XIII.

	s d.	s. d.
One day before perigee	—1. 5	Mean —1. 8
On the day of perigee	—1. 9	
One day after perigee	—2. 0	
One day before apogee	+2. 3	Mean —2. 4.
On the day of apogee	+2. 3	
One day after apogee	+2. 7	

The probable error of any one result is about the same as in the preceding results (Tables XI and XII.) The results for variation in the moon's distance are more consistent and satisfactory than those depending on the phases and declination changes. The lunar effect is to diminish the horizontal force by its 0.000066 part in perigee, and to increase it by its 0.000088 part when she is in apogee.

The Prague results are the same, viz: a greater horizontal force at and after the moon's apogee than at and after her perigee. A three-years' series of observations at Milan, however, do not agree therewith.

In no branch of magnetic research would additional results from independent observations, particularly at stations widely apart, be more acceptable and valuable than in the study of the lunar effect in its various manifestations.

APPENDIX No. 18.

Results from observations made by Assistant Charles A. Schott, in July and August 1862, for magnetic declination, dip, and horizontal intensity, in Pennsylvania, including also one station in the District of Columbia, and one in New York.

No.	Locality and station.	Date.	Latitude.	Longitude west of Greenwich.	Declinat'n west.	Dip.	Horizontal intensity.	Total intensities.
		1862.	° ′	° ′	° ′	° ′		
°1	Bath, N. Y., opposite post office	August 11	42 20. 8	77 21. 0	4 47. 9	74 26. 2	3. 639	13. 563
°2	Erie, Pa., Mr. Reed's, on 7th street	August 6-7	42 07. 5	80 06. 0	1 33. 0	73 52. 2	3. 728	13. 419
3	Williamsport, Pa., near academy	August 13	41 14. 0	77 02. 0	4 25. 7	72 51. 0	3. 924	13. 308
4	Harrisburg, Pa., State capitol	July 28-29	40 16. 0	76 53. 0	3 44. 5	72 31. 6	4. 012	13. 362
°5	Near Brownsville, Pa., Johnson's, now Hatfield's	July 31	39 59. 5	79 47. 8	1 13. 6	71 56. 9	4. 138	13. 354
6	Philadelphia, Girard College	Aug. 15-16	39 58. 4	75 10. 0	5 00. 0	72 05. 8	4. 088	13. 298
7	Washington, D. C., Coast Survey Office	Aug. 18-19	38 53. 1	77 00. 2	2 39. 4	71 19. 0	4. 255	13. 283

NOTE.—The units of intensity are the foot, the grain, and the second, of mean time. At Washington observations were also made July 21, 22, and September 4.

° Occupied at the expense of the Smithsonian Institution.

APPENDIX No. 19.

ABSTRACT OF RESULTS OF A MAGNETIC SURVEY OF PENNSYLVANIA AND PARTS OF ADJACENT STATES IN 1840 AND 1841, WITH SOME ADDITIONAL RESULTS OF 1843 AND 1862.—BY A. D. BACHE, SUPERINTENDENT UNITED STATES COAST SURVEY. (SKETCH 47.)

In the years 1840 and 1841 I made a detailed magnetic survey of Pennsylvania and adjacent parts of New York, Ohio, and Maryland, determining, at a number of stations, suitably selected with regard to the course of the isomagnetic lines, the magnetic declination, dip, and intensity. To these I added some observations for dip and intensity in 1843, while on a tour through western New York and Canada.

The total number of declination stations is 16, and of dip and intensity stations 48.

After assuming the duties of Superintendent of the United States Coast Survey in 1843, I could not find the necessary leisure to work up these observations, although Mr. J. S. Ruth and Mr. G. Davidson had commenced preparing, under my direction, a partial abstract, confined to dip and intensity observations, and to relative results. In the spring of 1862 I availed myself of the services of Charles A. Schott,† Assistant in the United States Coast Survey, who reduced, under my direction, the observations, discussed the distribution of the three magnetic elements, presenting the latter results, also, graphically, and prepared this report for the press.

† This work was done by Mr. Schott out of office hours, and at my own expense.

In the summer of 1862 Mr. Schott visited six of the stations previously occupied by me, and redetermined the magnetic elements. Three of these stations, falling within the scope of the operations of the United States Coast Survey, were at the expense of the Coast Survey. The observations at the three western stations were secured by the liberality of the Secretary of the Smithsonian Institution, who at the same time offered to publish the observations and results in the Smithsonian Contributions to Knowledge.

The observations of 1862 greatly enhance the value of my older operations, and furnish the means of presenting results for two epochs about twenty years apart, thus not only giving the most modern values, but also determining, by the known secular change of the three elements, any intermediate results.

The fruit of these labors, undertaken for this continent at a comparatively early period, and comprising the three elements, and the whole conducted systematically, with instruments well constructed for the time, will no doubt afford adequate means of watching hereafter the secular changes of terrestrial magnetism within the geographical extent of this survey.

The declinations were determined with a new Gambey declinometer belonging to the Girard College. The astronomical observations were made with a sextant and vertical circle and chronometer, (Grant, No. 3,861.) The dip was determined with a portable circle, by Robinson, and a magnetic bar and cylinder, according to the method described by me in the American Phil. Trans., vol. V, 1837, in which the vibrations are made in a rarified medium.

The full paper, with records, will shortly be printed in the Smithsonian Contributions to Knowledge.

Results of the magnetic declinations observed by A. D. Bache in Pennsylvania and adjacent States in 1840 *and* 1841.

These observations were made with a Gambey declinometer belonging to Girard College. One division (small) of the scale was found equal to 14.″54, as determined in 1844, at Sandy Hook, by Lieut. G. M. Bache, (see Coast Survey Records:) 1 large division = 60 small divisions.

The observations were made with telescope *direct*, with slit to the right hand, or *E.*, and with telescope *inverted*, with slit to the left, or *W.*; also with needle *direct*, or hairs *up*, and with needle *inverted*, or hairs *down*. With needle north, W. readings are +, E. readings —; with needle south, W. readings are —, E. readings +.

Throughout the record the *apparent* direction (E. or W.) is given; the same is to be understood in this reduction. Apparent E. is real W., and when the angle is W. of true north, apparent E. is + for the north of the needle; but as the azimuth circle reads from north to east, this sign is to be reversed, if we apply the correction directly to the circle reading.

Table of results for magnetic declination, 1840.

			°	′
1.	Harrisburg	July 25	3	12.5 W.
2.	Huntingdon	July 30	1	52.3 W.
3.	Homewood, near Pittsburg	Aug. 10	0	08.0 W.
4.	Johnson's Tavern, near Brownsville	Aug. 17	0	25.2 W.
5.	Irwin's Mill, near Mercersburg	Aug. 24	0	54.4 W.
6.	Baltimore	Aug. 27	2	16.5 W.

Table of results for magnetic declination, 1841.

			°	′
1.	Philadelphia	July 20 and Nov. 1	3	53.7 W.
2.	Easton	July 23	3	38.0 W.
3.	Williamsport	July 28	3	31.2 W.
4.	Curwinsville	Aug. 1	1	45.1 W.
5.	Mercer	Aug. 4	0	51.2 E.
6.	Erie	Aug. 9	0	30.0 W.
7.	Dunkirk	Aug. 12	0	52.5 W.
8.	Ellicottville	Aug. 14	2	35.7 W.
9.	Bath	Aug. 19	3	31.4 W.
10.	Silver Lake	Aug. 23	4	30.2 W.

Comparison of declination for secular change; results of 1840, 1841, and of 1862.

			1862. (Schott)	Annual increase.
		° ′	° ′	′
Philadelphia, (Girard College)	July and Nov., 1841	3 53.7 W.	5 00.0 W.	3.2
Harrisburg	July, 1840	3 12.5 W.	3 44.5 W.	1.5
Williamsport	July, 1841	3 31.2 W.	4 25.7 W.	2.6
Johnson's Tavern, near Brownsville	Aug. 1840	0 25.2 W.	1 13.6 W.	2.2
Erie	Aug. 1841	0 30.0 W.	1 33.0 W.	3.0
Bath	Aug. 1841	3 31.4 W.	4 47.9 W.	3.6
Mean				2.7

Harrisburg was occupied in July, 1862, and all the other stations of 1862 in August.

Chronometric results for longitude.

In the tour of 1840 the error and rate of chronometer determined at Philadelphia was depended upon for time. The longitudes of the stations were taken from the best authorities.

In the tour of 1841 observations for time were made at stations, and the error of the chronometer was determined at Philadelphia before setting out, and after return.

Table of geographical positions.

Taken from special observations, H. F. Walling's large map of Pennsylvania, J. H. French's large map of New York, the United States Coast Survey, and from railroad and canal map of Pennsylvania, Tanner, 1834, and other sources.

Tour of 1840, through southern Pennsylvania, and part of Ohio, Virginia, and Maryland:

	Latitude.	*Longitude.*
	° ′	° ′
Philadelphia, Girard College, Pa	39 58.4	75 10.0
Reading, Pa	40 19.	75 55.
Harrisburg, Pa	40 16.	76 53.
Duncan's Island, Pa	40 25.	77 01.
Lewistown, Pa	40 35.	77 36.
Huntingdon, Pa	40 30.5	78 02.
Armagh, Pa	40 29.	79 04.
Economy, Pa	40 37.	80 16.
Homewood, near Pittsburg, Pa	40 28.	79 59.5
Steubenville, Ohio	40 25.	80 39.
Wheeling, Va	40 08.	80 42.
Johnson's Tavern, near Brownsville, Va	39 59.5	79 47.8
Frostburgh, Va	39 41.	78 56.
Irwin's Mill, near Mercersburg, Va	39 47.	77 56.
Baltimore, Md	39 17.8	76 36.6
Frenchtown, Md	39 35.0	75 51.

Tour of 1841, through northern Pennsylvania, and part of Ohio and New York:

Doylestown, Pa	40 18.	75 10.
Easton, Pa	40 42.	75 15.
Wilkesbarre, Pa	41 14.	75 58.
Williamsport, Pa	*41 14.0	†77 02.
Bellefonte, Pa	40 55.	77 49.
Curwinsville, Pa	*40 57.7	†78 36.
Berlin's Tavern, Pa	41 16.	79 36.

	Latitude. ° ′	Longitude. ° ′
Mercer, Pa	41 13.8	80 16.
Warren, Ohio	41 17.	80 50.
Ashtabula Landing, Ohio	41 54.	80 47.
Erie, Pa.	*42 07.5	†80 06.
Dunkirk, N. Y.	*42 29.3	†79 23.
Ellicottville, N. Y	*42 18.1	†78 44.
Belvidere, N. Y.	42 13.	78 06.
Bath, N. Y.	*42 20.8	77 21.
Owego, N. Y.	42 08.	76 17.
Silver Lake, N. Y.	*41 56.6	†76 02.
Milford, Pa	41 19.	†74 51.5
Bushkill, Pa	41 07.	75 02.
Tour of 1843, through New York, part of Canada, and New Jersey :		
Princeton, N. J.	40 20.7	74 39.6
Schenectady, Union College, N. Y	42 48.	73 57.
Utica, N. Y.	43 05.	75 14.
Syracuse, N. Y	43 03.	**76 09.3
Geneva, N. Y.	42 53.	77 02.
West Point, N. Y.	41 23.4	73 57.
Rochester, N. Y	43 07.	77 39.
Niagara Falls, N. Y	43 04.	79 05.
Toronto, Canada West	43 39.5	79 21.5
Oswego, N. Y.	43 26.	76 35.
Ogdensburgh, N. Y	44 42.	75 31.
Quebec, Canada East	46 48.	71 14.
Montreal, Canada East	45 30.	73 35.
Troy, N. Y.	42 43.7	73 40.7

Distribution of the magnetic declination for the epoch 1842.0.

From the comparison of the observations for secular change we have :

	′
Harrisburg, annual increase	1.5
Johnson's Tavern, annual increase	2.2
Philadelphia, annual increase	3.2
Williamsport, annual increase	2.6
Erie, annual increase	3.0
Bath, annual increase	3.6
Mean	2.7
Toronto, between 1845 and 1855	2.3

(See Vol. III of the Observations.)

Latitudes determined astronomically are marked with an asterisk (*); longitudes determined astronomically, combined with other determinations, are maked with a cross (†). ** From telegraphic determination.—(See Report of the Regents of the University of the State of New York, 1862.)

General table of results referred to the common epoch 1842.0.

No.	Station.	Date.	Obs'd decl. W.	Red. to epoch.	Decl'n 1842. 0.
			° ″	′	° ′
1	Harrisburg	1840, July 25	3 12.5	+ 4.0	3 16.5
2	Huntingdon	1840, July 30	1 52.3	4.0	1 56.3
3	Near Pittsburg	1840, Aug. 10	0 08.0	4.0	0 12.0
4	Near Brownsville	1840, Aug. 17	0 25.2	4.0	0 29.2
5	Near Mercersburg	1840, Aug. 24	0 54.4	4.0	0 58.4
6	Baltimore	1840, Aug. 27	2 16.5	4.0	2 20.5
7	Philadelphia	1841, July 20 } 1841, Nov. 1 }	3 53.7	+ 0.7	3 54.4
8	Easton	1841, July 23	3 38.0	+ 1.3	3 39.3
9	Williamsport	1841, July 28	3 31.2	1.3	3 32.5
10	Curwinsville	1841, Aug. 1	1 45.1	1.3	1 46.4
11	Mercer	1841, Aug. 4	— 0 51.2	1.3	— 0 49.9
12	Erie	1841, Aug. 9	0 30.0	1.3	0 31.3
13	Dunkirk	1841, Aug. 12	0 52.5	1.3	0 53.8
14	Ellicottville	1841, Aug. 14	2 35.7	1.3	2 37.0
15	Bath	1841, Aug. 19	3 31.4	1.3	3 32.7
16	Silver Lake	1841, Aug. 23	4 30.2	1.3	4 31.5

No.	Station.	Latitude.	Longitude.	Decl. W., 1842. 0.
		°	°	°
1	Harrisburg	40.27	76.88	3.27
2	Huntingdon	40.51	78.03	1.94
3	Near Pittsburg	40.47	79.99	0.20
4	Near Brownsville	39.99	79.80	0.49
5	Near Mercersburg	39.78	77.93	0.97
6	Baltimore	39.30	76.61	2.34
7	Philadelphia	39.97	75.17	3.89
8	Easton	40.70	75.25	3.65
9	Williamsport	41.23	77.03	3.54
10	Curwinsville	40.96	78.60	1.77
11	Mercer	41.23	80.27	— 0.83
12	Erie	42.13	80.10	0.52
13	Dunkirk	42.49	79.38	0.90
14	Ellicottville	42.30	78.73	2.62
15	Bath	42.35	77.35	3.55
16	Silver Lake	41.94	76.03	4.52
	Means	40.98	77.95	2.08

The small extent of the survey, as well as the comparatively small number of observations, will not permit the introduction of curvature in the isogonic lines; they are therefore treated as straight lines. This assumption also serves for the recognition of any local disturbances, as indicated by the differences of observed and computed values.

Let $D = + 2^\circ.08 + x\,d\,L + y\,d\,M \cos. L,$
where $d\,L = \text{Lat.} - 40^\circ.98$
$d\,M = \text{Long.} - 77.95.$

The 16 conditional equations have been formed, and the values of x y D found from the normal equations are as follows:

$$x = +\ 0.5102$$
$$y = -\ 1.206$$
$$D = +\ 2^{\circ}.08 + 0.5102\ d\,L - 1.206\ d\,M \cos. L.$$

A comparison of the observed and computed declinations shows the necessity of introducing a term involving $d\,L\,d\,M \cos. L$. This has been done, and the solution of the normal equations gives us the following expression:

$$D = +\ 2^{\circ}.14 + 0.513\ d\,L - 1.231\ d\,M \cos. L - 0.203\ d\,L\,d\,M \cos. L.$$

Comparison of observed and computed values.

Station.	Observed declination.	Computed declination.	Observed—computed.
	°	°	′
Harrisburg	3.27	+ 2.67	+ 36
Huntingdon	1.94	1.82	+ 7
Near Pittsburg	0.20	0.13	+ 4
Near Brownsville	0.49	0.16	+ 20
Near Mercersburg	0.97	1.54	— 34
Baltimore	2.34	2.21	+ 8
Philadelphia	3.89	3.81	+ 5
Easton	3.65	4.41	— 46
Williamsport	3.54	3.16	+ 23
Curwinsville	1.77	1.51	+ 16
Mercer	— 0.83	0.04	— 52
Erie	0.52	0.44	+ 5
Dunkirk	0.90	1.29	— 23
Ellicottville	2.62	1.96	+ 40
Bath	3.55	3.50	+ 3
Siver Lake	4.52	4.66	— 8

The probable error of any single representation is $\pm$ 19′.4.

The curves of 0°, 2°, 4°, pass through the following positions:

0°	Lat. 41° 00′	Lat. 42° 30′	Lat. 39° 30′
	Long. 80 15	Long. 80 33	Long. 79 54
2	Lat. 41 00	Lat. 42 30	Lat. 39 30
	Long. 78 07	Long. 78 46	Long. 77 05
4	Lat. 41 00	Lat. 42 30	Lat. 39 30
	Long. 75 56	Long. 76 59	Long. 74 17

These curves have been finally adopted.

Distribution of the magnetic dip and construction of the isoclinal lines for 1842.

For the convenient application of the usual analytical expression for the representation of the observed dips and for their interpolation the stations have been divided into six groups, as follows:

GROUP I.

No.	Station.	Latitude.	Longitude.	Date.	Observed dip.
		° ′	° ′		° ′
1	Philadelphia*	39 58.4	75 10.0	Feb., 1842	71 57.1
2	Doylestown	40 18	75 10	July, 1841	72 23.1
3	Easton	40 42	75 15	July, 1841	72 39.0
4	Reading	40 19	75 55	July, 1840	72 32.2
5	Frenchtown	39 35	75 51	Aug., 1840	71 40.2
6	Baltimore	39 17.8	76 36.6	Aug., 1840	71 33.9
7	Washington†	38 53.1	77 00.2	Sept., 1841	71 15.9
8	Harrisburg	40 16	76 53	July, 1840	72 20.5
9	Duncan's Island	40 25	77 01	July, 1840	72 35.0
10	Near Mercersburg	39 47	77 56	Aug., 1840	71 47.3
	Mean	39 57.1	76 16.8	1841.0	72 04.4

* The dip is the mean from groups of December, 1840, October, 1841, and August, 1843.

† This station has been added to the discussion as we have observations in 1840 and 1841. (See Appendix No. 25, Coast Survey Report of 1858.) Mean dip from several observers in 1841.0, 71° 18′.3, and in 1842.5, 71° 13′.5. Mean, 71° 1.59′ in 1841.8.

GROUP II.

No.	Station.	Latitude.	Longitude.	Date.	Observed dip.
		° ′	° ′		° ′
1	Armagh	40 29	79 04	Aug., 1840	72 18.7
2	Frostburg	39 41	78 56	Aug., 1840	71 31.3
3	Near Brownsville	39 59.5	79 47.8	Aug., 1840	71 53.5
4	Near Pittsburg	40 28	79 59.5	Aug., 1840	72 32.1
5	Economy	40 37	80 16	Aug., 1840	72 35.0
6	Wheeling	40 08	80 42	Aug., 1840	72 08.9
7	Steubenville	40 25	80 39	Aug., 1840	72 32.8
	Mean	40 15.4	79 54.9	1840.6	72 13.2

GROUP III.

No.	Station.	Latitude.	Longitude.	Date.	Observed dip.
		° ′	° ′		° ′
1	Warren	41 17	80 50	Aug., 1841	72 59.9
2	Mercer	41 13.8	80 16	Aug., 1841	72 57.2
3	Ashtabula Landing	41 54	80 47	Aug., 1841	72 23.5
4	Erie	42 07.5	80 06	Aug., 1841	73 46.6
5	Dunkirk	42 29.3	79 23	Aug., 1841	74 17.2
6	Ellicottville	42 18.1	78 44	Aug., 1841	74 17.8
7	Berlin's Tavern	41 16	79 36	Aug., 1841	72 52.8
	Mean	41 48.0	79 57.4	1841.6	73 30.7

GROUP IV.

No.	Station.	Latitude.	Longitude.	Date.	Observed dip.
		° ′	° ′		° ′
1	Curwinsville	40 57.7	78 36	Aug., 1841	72 49.7
2	Belvidere	42 13	78 06	Aug., 1841	74 09.5
3	Bath	42 20.8	77 21	Aug., 1841	74 27.5
4	Owego	42 08	76 17	Aug., 1841	74 13.9
5	Silver Lake	41 56.6	76 02	Aug., 1841	73 41.5
6	Wilkesbarre	41 14	75 58	July, 1841	73 10.0
7	Williamsport	41 14.0	77 02	July, 1841	72 54.4
8	Bellefonte	40 55	77 49	July, 1841	72 42.3
9	Lewistown	40 35	77 36	July, 1840	72 30.0
10	Huntingdon	40 30.5	78 02	July, 1840	72 17.8
	Mean	41 24.5	77 16.9	1841.4	73 17.7

GROUP V.

No.	Station.	Latitude.	Longitude.	Date.	Observed dip.
		° ′	° ′		° ′
1	Niagara Falls	43 04	79 05	Aug., 1843	74 51.0
2	Toronto Observatory	43 39.5	79 21.5	Aug., 1843	75 11.4
3	Rochester	43 07	77 39	Aug., 1843	74 43.5
4	Geneva	42 53	77 02	July, 1843	74 33.2
5	Syracuse	43 03	76 09.3	July, 1843	74 51.2
6	Oswego	43 26	76 35	Aug., 1843	75 07.1
	Mean	43 12.1	77 38.6	1843.6	74 52.9

GROUP VI.

No.	Station.	Latitude.	Longitude.	Date.	Observed dip.
		° ′	° ′		° ′
1	Utica	43 05	75 14	July, 1843	74 50.3
2	Schenectady	42 48	73 57	July, 1843	74 54.8
3	Troy	42 43.7	73 40.7	Aug., 1843	74 47.9
4	West Point	41 23.4	73 57.0	July, 1843	73 12.2
5	New York*	40 46.1	73 56.3	Dec., 1841	72 39.6
6	Milford	41 19	74 51.5	Aug., 1841	73 47.6
7	Bushkill	41 07	75 0.2	Aug., 1841	73 31.4
8	Princeton	40 20.7	74 39.6	July, 1843	72 38.3
	Mean	41 41.6	74 24.8	1842.9	73 47.8

* See Appendix No. 32, Coast Survey Report of 1856. This station was added owing to the numerous observations taken in this locality. (At the Lunatic Asylum, dip, 1841.3, 72° 41′.0; in 1842.5, 72° 38′.3.)

RECAPITULATION.

	° ′	° ′	.	° ′
Group I, No. 10	39 57.1	76 16.8	1841.0	72 04.4
Group II, No. 7	40 15.4	79 54.9	1840.6	72 13.2
Group III, No. 7	41 48.0	79 57.4	1841.6	73 30.7
Group IV, No. 10	41 24.5	77 16.9	1841.4	73 17.7
Group V, No. 6	43 12.1	77 38.6	1843.6	74 52.9
Group VI, No. 8	41 41.6	74 24.8	1842.9	73 47.8
Means	41 23.1	77 34.9	1841.85	73 17.8

By comparing the differences in latitude and the corresponding differences in dip for each place with the mean values of the group their general accordance was ascertained. None of the differences were large enough to require an exclusion from the series. It need hardly be remarked that a slight consideration shows that the dip depends almost exclusively upon the latitude; the longitude factors will therefore necessarily be very small.

Method of discussion.—The interpolation formula, proposed by the Rev. H. Lloyd in 1838, (see the 8th report of the British Association, vol. VII, p. 91,) will be used here in a slightly altered form, to allow for the convergence of the meridians.

Let I = resulting dip or inclination.

I_o = assumed mean dip for the epoch adopted, (1842.0,) and the mean latitude and longitude; i its correction.

d L = difference of latitude, d M = difference of longitude.

x, y, z, p, q, as well as i, are to be determined by application of the method of least squares from the observations themselves.

$$I = I_o + i + x\,d\,L + y\,d\,M \cos. L + z\,d\,L\,d\,M \cos. L + p\,d\,L^2 + q\,d\,M^2 \cos^2. L.$$

Correction to epoch.—The mean epoch of the six groups is November, 1841, for which we can substitute without material loss of accuracy, January, 1842, (or 1842.0.) Comparing the observations made by Assistant Schott in July and August, 1862, with the corresponding observations about the epoch 1842, we have the following table of differences of results for an interval of nearly twenty years:

Station.	Date.	Dip.	Date.	Dip.	Average annual increase.
		° ′		° ′	′
Washington	Sept., 1841	71 15.9	Aug., 1862	71 19.0	+ 0.15
Harrisburg	July, 1840	72 20.5	July, 1862	72 31.6	+ 0.50
Near Brownsville	Aug., 1840	71 53.5	July, 1862	71 56.9	+ 0.15
Erie	Aug., 1841	73 46.6	Aug., 1862	73 52.2	+ 0.27
Bath	Aug., 1841	74 27.5	Aug., 1862	74 26.2	− 0.06
Williamsport	July, 1841	72 54.4	Aug., 1862	72 51.0	− 0.16
Philadelphia	Feb., 1842	71 57.1	Aug., 1862	72 05.8	+ 0.43
Mean					+ 0.18

Mean total change in 21 years = 3′.8.

The increase of the dip is therefore very slight; and if we consider that according to Mr. Schott's investigation (Appendix No. 32, Coast Survey Report for 1856) the dip near the Atlantic coast, about the year 1841 to 1844, was at its minimum value, and hence could not have changed sensibly for several years, we can without any sacrifice of accuracy in our reduction, use our results as if all belonged to the mean epoch 1842.0. No reduction to epoch has therefore been applied. It is probable that the present annual increase amounts to about 1′. At Toronto, between 1844 and 1855, (see vol. III,) the annual increase was 0′.8. In the formula of interpolation I retain the factor cos. L, thus making it comparable with similar expressions for other localities where the introduction of cos. L may be more important. The value of the magnetic survey of Pennsylvania is increased from the fact that the isoclinal lines are presented for an epoch at which the dip was probably near its minimum value. The conditional equations are of the form—

$$o = I_0 - I + i + x\, d\, L + y\, d\, M \cos. L + z\, d\, L\, d\, M \cos. L + p\, d\, L^2 + q\, d\, M^2 \cos^2. L.$$

We find from the solution of the normal equations the expression:

$$I = 73^{\circ}.26 + 0.876\, d\, L - 0.076\, d\, M \cos. L - 0.023\, d\, L\, d\, M \cos. L + 0.013\, d\, M^2 \cos^2. L + 0.007\, d\, L^2,$$

where $d\, L =$ Lat. $- 41^{\circ}.38$

$d\, M =$ Long. $- 77^{\circ}.58$.

This equation represents the mean values, as follows:

Group.	Latitude.	Longitude.	Observed dip.	Computed dip.	Observed—computed.
	′	′	′	′	′
Group I	39.95	76.28	72.07	72.06	+ 0.01
Group II	40.26	79.92	72.22	72.22	0.00
Group III	41.80	79.96	73.51	73.52	— 0.01
Group IV	41.41	77.28	73.30	73.30	0.00
Group V	43.20	77.64	74.88	74.87	+ 0.01
Group VI	41.69	74.41	73.80	73.80	0.00

The preceding investigation was made for the purpose of ascertaining what terms should be finally admitted in the discussion. Next, nine groups, of five or six observations in each, arranged in regard to their geographical position and area with as much regularity as the nature of the case admitted of, give:

$$I = 73^{\circ}.25 + 0.912\, d\, L - 0.069\, d\, M \cos. L.$$

This equation represents the observations, as follows:

Group.	Observed dip.	Computed dip.	Diff. observed—computed.
	°	°	°
I	72.47	72.54	— 0.07
II	71.73	71.68	+ 0.05
III	72.20	72.11	+ 0.09
IV	73.20	73.31	— 0.11
V	72.54	72.61	— 0.07
VI	74.56	74.47	+ 0.09
VII	73.50	73.51	— 0.01
VIII	74.74	74.76	— 0.02
IX	74.31	74.26	+ 0.05

The isoclinal lines of 71°, 72°, 73°, 74°, and 75°, pass through the following positions:

71°	Long. 77° 00′ Lat. 38 49		
72°	Long. 75 00 Lat. 39 49	Long. 78° 00′ Lat. 39 59	Long. 81° 00′ Lat. 40 10
73°	Long. 74 00 Lat. 40 50	Long. 78 00 Lat. 41 05	Long. 81 00 Lat. 41 15
74°	Long. 74 00 Lat. 41 57	Long. 78 00 Lat. 42 11	Long. 81 00 Lat. 42 22
75°	Long. 75 00 Lat. 43 07	Long. 77 00 Lat. 43 13	Long. 79 00 Lat. 43 20

These lines have been finally adopted.

Comparison of the observed and computed dip.

All stations where the dip has been found indirectly only, by means of the Lloyd needles, are marked with an asterisk—27 in number.

Groups.	Observed dip.	Computed dip.	Diff. observed—computed.	Remarks.
GROUP I.	°	°	°	
New York	72.66	72.93	— 0.27	
Easton*	72.65	72.80	— 0.15	
Princeton*	72.64	72.51	+ 0.13	
Doylestown*	72.39	72.44	— 0.05	
Reading*	72.54	72.42	+ 0.12	
Philadelphia	71.95	72.14	— 0.19	
GROUP II.				
Frenchtown*	71.67	71.75	— 0.08	
Baltimore	71.57	71.45	+ 0.12	
Washington	71.26	71.06	+ 0.20	
Harrisburg	72.34	72.32	+ 0.02	
Near Mercersburg	71.79	71.88	— 0.09	Total number of stations, 48
GROUP III.				
Frostburg*	71.52	71.67	— 0.15	
Near Brownsville	71.89	71.91	— 0.02	
Wheeling*	72.15	71.99	+ 0.16	
Steubenville*	72.56	72.26	+ 0.30	
Near Pittsburg	72.53	72.24	+ 0.29	
Economy*	72.58	72.46	+ 0.12	
GROUP IV.				
Berlin's Tavern*	72.88	73.09	— 0.21	
Mercer	72.95	73.02	— 0.07	
Warren*	73.00	73.03	— 0.03	
Ashtabula*	73.39	73.60	— 0.21	
Erie	73.78	73.85	— 0.07	
GROUP V.				
Duncan's Island*	72.58	72.45	+ 0.13	
Lewistown*	72.50	72.57	— 0.07	
Huntingdon	72.30	72.48	— 0.18	
Armagh*	72.31	72.40	— 0.09	
Bellefonte*	72.70	72.86	— 0.19	
Curwinsville	72.83	72.86	— 0.03	
GROUP VI.				
Belvidere*	74.16	74.03	+ 0.13	
Ellicottville	74.30	74.05	+ 0.25	
Dunkirk*	74.29	74.21	+ 0.08	
Niagara Falls*	74.85	74.76	+ 0.09	
Toronto	75.19	75.28	— 0.09	
GROUP VII.				
Bushkill*	73.52	73.19	+ 0.33	
Williamsport	72.91	73.19	— 0.28	
Wilkesbarre*	73.17	73.24	— 0.07	
Silver Lake	73.69	73.88	— 0.19	
Owego*	74.23	74.05	+ 0.18	

Comparison of the observed and computed dip—Continued.

Groups.	Observed dip.	Computed dip.	Diff. observed—computed.	Remarks.
GROUP VIII.	°	°	°	
Bath	74.46	74.19	+ 0.27	
Rochester*	74.72	74.87	— 0.15	
Geneva	74.55	74.69	— 0.14	
Syracuse	74.85	74.89	— 0.04	
Oswego*	75.12	75.21	— 0.09	
GROUP IX.				
West Point*	73.20	73.49	— 0.29	
Milford	73.79	73.38	+ 0.41	Maximum difference.
Utica*	74.84	74.96	— 0.12	=25′.
Schenectady	74.91	74.77	+ 0.14	
Troy*	74.80	74.72	+ 0.08	

The probable error of any single observation is ± 0°.12 = ± 7′.2. The probable error of any observation with the regular dip needles and the Lloyd needles combined is 0°.13; with the latter needles alone ± 0°.11. This shows that the irregularities in the observed dip are due to local attractions rather than to imperfections in the needles employed. It is proper, therefore, to assign equal weights to results by the direct and indirect method of observing.

If we apply Pierce's criterion for the rejection of observations differing too much from the regular value indicated by all other observations, we find the limit of rejection to be ± 0°.46, or ± 28′. The maximum difference in the preceding table is 25′; hence no observation is excluded.

General Sabine's resulting isoclinal lines, in his seventh contribution to terrestrial magnetism, (Phil. Trans. Roy. Soc., part III, 1846, p. 237,) refer to an average period between 1840 and 1842, and correspond in their position very closely to those now presented. They are deduced from independent data.

Distribution of the magnetic horizontal intensity and construction of isodynamic lines for 1842.

If we group the observed intensities in the same manner as the dip, the mean epoch 1842.0 may likewise be assumed, and all observed intensities be reduced to that date.

Correction to epoch.—We have the following direct comparisons:

Station.	Date.	X.	Date.	X.	X—X.₁	Annual decrease.
Washington*	January, 1843	4.320	August, 1862	4.255	0.065	0.0033
Harrisburg	July, 1840	4.078	July, 1862	4.012	0.066	0.0030
Near Brownsville	August, 1840	4.207	July, 1862	4.138	0.069	0.0031
Erie	August, 1841	3.792	August, 1862	3.728	0.064	0.0030
Bath	August, 1841	3.677	August, 1862	3.639	0.038	0.0018
Williamsport	July, 1841	3.983	August, 1862	3.924	0.059	0.0028
Philadelphia†	January, 1842	4.166	August, 1862	4.088	0.078	0.0039
Mean						0.0030

* From Coast Survey Report of 1861—1842.5, X = 4.347. Capt. Lefroy.
1843.5, = 4.292. Dr. Locke.

Mean, 1843.0, = 4.320.

† In July and November, 1840, X = 4.160
In July and November, 1841, = 4.166 } Mean, 4.166 for 1842.0.
In July 1843, = 4.172

The average annual decrease in the value of X between 1840 and 1862 is therefore 0.0030, or, when expressed in parts of X, equal to 0.00076. This result agrees tolerably well with that deduced by Assistant Charles A. Schott in the Coast Survey Report of 1861, where 0.00110 was found.

Supposing the dip to increase at the rate of 1′ a year, and the total intensity to remain constant, the corresponding decrease of the horizontal intensity would amount to nearly the quantity found above. We cannot, therefore, as yet decide whether the total intensity remains stationary or is slightly changing.

At Toronto (see vol. III) the annual decrease of X between 1845 and 1852 inclusive was 0.0037, (in absolute measure,) or, when expressed in parts of X, 0.00105.

Formation of groups for the analytical expression of the distribution of the magnetic horizontal force referred to the epoch 1842.0.

[At stations marked with an asterisk the horizontal force was determined by vibrations; at those not so marked the horizontal force was determined by Lloyd's statical method.]

Groups.	Date.	X.	Correction to epoch.	X 1842.0.
GROUP I.				
Philadelphia*	1842.0	4.166	0.000	4.166
Doylestown	1841.6	4.189	— 0.001	4.188
Easton	1841.6	4.121	— 0.001	4.120
Reading	1840.6	4.000	— 0.004	3.996
Frenchtown	1840.6	4.312	— 0.004	4.308
Baltimore*	1840.6	4.265	— 0.004	4.261
Washington	1843.0	4.320	+ 0.003	4.323
Harrisburg*	1840.6	4. [illegible]78	— 0.004	4.074
Duncan's Island	1840.6	3.963	— 0.004	3.959
Near Mercersburg*	1840.6	4.188	— 0.004	4.184
Mean				4.158
GROUP II.				
Armagh	1840.6	4.038	— 0.004	4.034
Frostburg	1840.6	4.298	— 0.004	4.294
Near Brownsville*	1840.6	4.207	— 0.004	4.203
Near Pittsburg*	1840.6	4.049	— 0.004	4.045
Economy	1840.6	4.008	— 0.004	4.004
Wheeling	1840.6	4.053	— 0.004	4.049
Steubenville	1840.6	3.947	— 0.004	3.943
Mean				4.082
GROUP III.				
Warren	1841.6	3.978	— 0.001	3.977
Mercer*	1841.6	4.000	— 0.001	3.999
Ashtabula Landing	1841.6	3.838	— 0.001	3.837
Erie*	1841.6	3.792	— 0.001	3.791
Dunkirk	1841.6	3.621	— 0.001	3.620
Ellicottville*	1841.6	3.726	— 0.001	3.725
Berlin's Tavern	1841.6	4.026	— 0.001	4.025
Mean				3.853

Formation of groups for the analytical expression, &c.—Continued.

Groups.	Date	X.	Correction to epoch.	X 1842. 0.
GROUP IV.				
Curwinsville*	1841. 6	3. 999	— 0. 001	3. 998
Belvidere	1841. 6	3. 669	— 0. 001	3. 668
Bath*	1841. 6	3. 677	— 0. 001	3. 676
Owego	1841. 6	3. 614	— 0. 001	3. 613
Silver Lake*	1841. 7	3. 782	— 0. 001	3. 781
Wilkesbarre	1841. 6	3. 961	— 0. 001	3. 960
Williamsport*	1841. 6	3. 983	— 0. 001	3. 982
Bellefonte	1841. 6	4. 069	— 0. 001	4. 068
Lewistown	1840. 6	3. 984	— 0. 004	3. 980
Huntingdon*	1840. 6	4. 109	— 0. 004	4. 105
Mean				3. 883
GROUP V.				
Niagara Falls*	1843. 6	3. 565	+ 0. 005	3. 570
Toronto Observatory*	1843. 6	3. 537	+ 0. 005	3. 542
Rochester	1843. 6	3. 560	+ 0. 005	3. 565
Geneva*	1843. 7	3. 635	+ 0. 005	3. 640
Syracuse*	1843. 6	3. 556	+ 0. 005	3. 561
Oswego	1843. 6	3. 467	+ 0. 005	3. 472
Mean				3. 558
GROUP VI.				
Utica	1843. 6	3. 541	+ 0. 005	3. 546
Schenectady*	1843. 6	3. 502	+ 0. 005	3. 507
Troy	1843. 6	3. 575	+ 0. 005	3. 580
West Point	1843. 6	4. 033	+ 0. 005	4. 038
New York†	1841. 9	4. 014	0. 000	4. 014
Milford*	1841. 7	3. 769	— 0. 001	3. 768
Bushkill	1841. 7	3. 866	— 0. 001	3. 865
Princeton	1843. 5	4. 222	+ 0. 005	4. 227
Mean				3. 818

RECAPITULATION.

Group.	No.	Latitude.	Longitude.	X 1842. 0.
		° ′	° ′	
I	10	39 57. 1	76 16. 8	4. 158
II	7	40 15. 4	79 54. 9	4. 082
III	7	41 48. 0	79 57. 4	3. 853
IV	10	41 24. 5	77 16. 9	3. 883
V	6	43 12. 1	77 38. 6	3. 558
VI	8	41 41. 6	74 24. 8	3. 818
Mean		41 23. 1	77 34. 9	3. 892

† At New York we have: 1841. 5, Dr. Locke, 4. 015; 1842. 7, Dr. Locke, 4. 008; 1842. 7, Capt. Lefroy, 4. 010. Mean, 4. 014 for 1841. 9.

Let X = resulting horizontal force.

X_0 = assumed mean horizontal for 1842.0 at the mean latitude and mean longitude; $\varkappa$ its correction.

d L = difference of latitude, d M = difference of longitude.

x, y, z, p, q, and $\varkappa$ to be determined from the observations.

$$X = X_0 + \varkappa + x\, d\, L + y\, d\, M \cos. L + z\, d\, L\, d\, M \cos. L + p\, d\, L^2 + q\, d\, M^2 \cos^2. L.$$

Forming the conditional and normal equations we find the expression:

$$X = 3.890 - 0.1787\, d\, L + 0.0085\, d\, M \cos. L + 0.0161\, d\, L\, d\, M \cos. L - 0.0017\, d\, L^2 + 0.0027\, d\, M^2 \cos^2. L,$$

where $d\, L = \text{Lat.} \quad - 41^\circ.38$

$d\, M = \text{Long.} - 77\ .58$

This formula is applied for determining the relative weights of the observations from vibrations and by deflections of the dipping needle; for this purpose the horizontal force was computed by the formula, and the results compared with observation.

From the differences we find the probable error of an observation, (and local irregularity,) = ± 0.036 for the bar and cylinder vibrations, and ± 0.062 for the Lloyd needle deflections and dip. The relative weights, therefore, become 754 for the former, and 257 for the latter, or nearly as 3 to 1. These weights have been adopted.

Nine groups, of five or six observations in each, with weights, were then formed.

Recapitulation of mean (weighted) values of groups.

Group.	Latitude.	Longitude.	X.
	°	°	
I	40. 39	74. 83	4. 107
II	39. 68	77. 01	4. 199
III	40. 22	79. 99	4. 103
IV	41. 61	80. 26	3. 912
V	40. 68	78. 14	4. 035
VI	42. 89	79. 00	3. 618
VII	41. 56	76. 27	3. 858
VIII	42. 85	77. 17	3. 606
IX	42. 17	74. 37	3. 665
Mean	41. 34	77. 45	3. 900

$$X = X_0 + \varkappa + x\, d\, L + y\, d\, M \cos. L + z\, d\, L\, d\, M \cos. L + p\, d\, L^2 + q\, d\, M^2 \cos^2. L,$$

$d\, L = \text{Lat.} \quad - 41^\circ.34$

$d\, M = \text{Long.} - 77\ .45$

Forming the conditional and normal equations we deduce:

$$X = 3.920 - 0.1936\, d\, L + 0.0146\, d\, M \cos. L + 0.0203\, d\, L\, d\, M \cos. L - 0.01587\, d\, L^2 - 0.0005\, d\, M^2 \cos^2. L.$$

It is, however, preferable to shorten the formula, and use instead the following:

$$X = 3.900 - 0.1934\, d\, L + 0.0134\, d\, M \cos. L + 0.02\, d\, L\, d\, M \cos. L.$$

Comparison of observed and computed values.

Group.	X observed.	X computed.	Observed —computed.
I	4. 107	4. 095	+ 0. 012
II	4. 199	4. 227	— 0. 028
III	4. 103	4. 100	+ 0. 003
IV	3. 912	3. 887	+ 0. 025
V	4. 035	4. 028	+ 0. 007
VI	3. 618	3. 651	— 0. 033
VII	3. 858	3. 842	+ 0. 016
VIII	3. 606	3. 599	— 0. 007
IX	3. 665	3. 670	— 0. 005

The next and last hypothesis:

$$X = 3.900 - 0.1934\, d\, L + 0.0134\, d\, M \cos. L,$$

in which the isodynamic lines are treated as straight lines, presents, perhaps, the best and most simple expression of the *irregular* distribution of the horizontal force. These lines run nearly parallel with the dip lines.

Comparison of observed and computed values on this hypothesis.

Group.	X observed.	X computed.	Observed—computed.
I	4. 107	4. 057	+ 0. 050
II	4. 199	4. 216	— 0. 017
III	4. 103	4. 143	— 0. 040
IV	3. 912	3. 876	+ 0. 036
V	4. 035	4. 035	0. 000
VI	3. 618	3. 616	+ 0. 002
VII	3. 858	3. 846	+ 0. 012
VIII	3. 606	3. 605	+ 0. 001
IX	3. 665	3. 708	— 0. 043

The difference between the lines of this and the previous hypothesis shows the large amount of local irregularity.

The lines of this hypothesis pass through the following positions:

4.2	Long.	81°0	Long.	77°5	Long.	74°0
	Lat.	39°58′	Lat.	39°47′	Lat.	39°36′
4.0	Long.	81°0	Long.	75°5	Long.	74°0
	Lat.	41°01′	Lat.	40°49′	Lat.	40°39′
3.8	Long.	81°0	Long.	77°5	Long.	74°0
	Lat.	42°02′	Lat.	41°51′	Lat.	41°41′
3.6	Long.	81°0	Long.	77°5	Long.	74°0
	Lat.	43°04′	Lat.	42°53′	Lat.	42°43′

The observed and computed values of X by the previous and last hypotheses compare as follows:

Station.	X observed.	X by previous hypothesis.	Δ	X by last hypothesis.	Δ
Philadelphia*	4.17	4.19	— 0.02	4.14	+ 0.03
Doylestown	4.19	4.11	+ 0.08	4.08	+ 0.11
Easton	4.12	4.02	+ 0.10	4.00	+ 0.12
Reading	4.00	4.10	— 0.10	4.08	— 0.08
Frenchtown	4.31	4.27	+ 0.04	4.22	+ 0.09
Baltimore*	4.26	4.32	— 0.06	4.29	— 0.03
Washington	4.32	4.38	— 0.06	4.37	— 0.05
Harrrisburg*	4.07	4.11	— 0.04	4.10	— 0.03
Duncan's Island	3.96	4.08	— 0.12	4.07	— 0.11
Near Mercersburg*	4.18	4.21	— 0.03	4.20	— 0.02
Armagh	4.03	4.06	— 0.03	4.08	— 0.05
Frostburg	4.29	4.20	+ 0.09	4.24	+ 0.05
Near Brownsville*	4.20	4.14	+ 0.06	4.19	+ 0.01
Near Pittsburg*	4.05	4.06	— 0.01	4.09	— 0.04
Economy	4.00	4.04	— 0.04	4.07	— 0.07
Wheeling	4.05	4.11	— 0.06	4.17	— 0.12
Steubenville	3.94	4.07	— 0.13	4.11	— 0.17
Warren	3.98	3.94	+ 0.04	3.95	+ 0.03
Mercer*	4.00	3.94	+ 0.06	3.95	+ 0.05
Ashtabula	3.84	3.80	+ 0.04	3.83	+ 0.01
Erie*	3.79	3.81	— 0.02	3.77	+ 0.02
Dunkirk	3.62	3.70	— 0.08	3.70	— 0.08
Ellicottville*	3.72	3.75	— 0.03	3.73	— 0.01
Berlin's Tavern	4.02	3.93	+ 0.09	3.94	+ 0.08
Curwinsville*	4.00	3.98	+ 0.02	3.99	+ 0.01
Belvidere	3.67	3.75	— 0.08	3.74	— 0.07
Bath*	3.68	3.70	— 0.02	3.70	— 0.02
Owego	3.61	3.73	— 0.12	3.74	— 0.13
Silver Lake*	3.78	3.76	+ 0.02	3.77	+ 0.01
Wilkesbarre	3.96	3.93	+ 0.03	3.91	+ 0.05
Williamsport*	3.98	3.92	+ 0.06	3.92	+ 0.06
Bellefonte	4.07	3.99	+ 0.08	3.99	+ 0.08
Lewistown	3.98	4.05	— 0.07	3.05	— 0.07
Huntingdon*	4.10	4.06	+ 0.04	4.07	+ 0.03
Niagara Falls*	3.57	3.62	— 0.05	3.58	— 0.01
Toronto*	3.54	3.53	+ 0.01	3.47	+ 0.07
Rochester	3.56	3.57	— 0.01	3.56	0.00
Geneva*	3.64	3.59	+ 0.05	3.60	+ 0.04
Syracuse*	3.56	3.53	+ 0.03	3.56	0.00
Oswego	3.47	3.46	+ 0.01	3.49	— 0.02
Utica	3.55	3.49	+ 0.06	3.54	+ 0.01
Schenectady*	3.51	3.51	0.00	3.58	— 0.07
Troy	3.58	3.52	+ 0.06	3.59	— 0.01
West Point	4.04	3.85	+ 0.19	3.86	+ 0.18
New York*	4.01	4.01	0.00	3.97	+ 0.04
Milford*	3.77	3.88	— 0.11	3.88	— 0.11
Bushkill	3.86	3.92	— 0.06	3.92	— 0.06
Princeton	4.23	4.07	+ 0.16	4.06	+ 0.17

For the last hypothesis (straight lines) we find the probable error of an observation and local irregularity from the bar and cylinder vibrations $\pm$ 0.029, and from the Lloyd needle deflections and dip $\pm$ 0.062. For the previous hypothesis these quantities are, respectively, $\pm$ 0.030 and $\pm$ 0.059; showing but little gain in the representation of the observations by the additional term d L d M cos. L.

For the general representation the probable errors are $\pm$ 0.050 and $\pm$ 0.051.

Representation of the total force.

From the expressions—

$$X = 3.900 - 0.1934\, d\,L + 0.0134\, d\,M \cos. L,$$
$$I = 73°.25 + 0.912\, d\,L - 0.0690\, d\,M \cos. L,$$

we have to deduce the total force $\varphi = X \sec. I$.

In the expression for X, d L = Lat. — 41°.34, and d M = Long. — 77°.45.

In the expression for I, d L = Lat. — 41°.32, and d M = Long. — 77°.39.

We have in

Long. 81°.00 Lat. 39.97	X = 4.200 I = 71°.828	φ = 13.47.
Long. 77°.50 Lat. 42.89	X = 3.600 I = 74°.676	φ = 13.62.
Long. 74°.00 Lat. 39.60	X = 4.200 I = 71°.861	φ = 13.49.

Assuming in the expression for the total force—

$\varphi = \varphi_0 + f + x\, d\,L + y\, d\,M \cos. L$, d L and d M, as in the expression for X, we find:

$$\varphi = 13.55 + 0.0451\, d\,L - 0.00682\, d\,M \cos. L.$$

The lines of equal total force of 13.45, 13.5, 13.55, and 13.6, pass through the following positions:

13.45	Long. 81° Lat. 39°31′	Long. 77°.5 Lat. 39°07′	
13.50	Long. 81° Lat. 40°37′	Long. 77°.5 Lat. 40°13′	Long. 74° Lat. 39°49′
13.55	Long. 81° Lat. 41°43′	Long. 77°.5 Lat. 41°19′	Long. 74° Lat. 40°55′
13.60	Long. 81° Lat. 42°49′	Long. 77°.5 Lat. 42°25′	Long. 74° Lat. 42°01′

The observed and computed values of φ at the stations where the bar and cylinder were employed compare as follows:

Station.	φ observed.	φ computed.	Observed—computed.
Philadelphia	13.45	13.50	— 0.05
Harrisburg	13.44	13.50	— 0.06
Huntingdon	13.51	13.51	0.00
Homewood	13.49	13.50	— 0.01
Johnson's Tavern	13.54	13.48	+ 0.06
Irwin's Mill	13.40	13.48	— 0.08
Baltimore	13.49	13.46	+ 0.03
Williamsport	13.55	13.55	0.00
Curwinsville	13.55	13.53	+ 0.02
Mercer	13.64	13.53	+ 0.11
Erie	13.57	13.57	0.00
Ellicottville	13.77	13.59	+ 0.18
Bath	13.72	13.60	+ 0.12
Silver Lake	13.47	13.58	— 0.11
Milford	13.50	13.56	— 0.06
Schenectady	13.45	13.63	— 0.18
Syracuse	13.61	13.63	— 0.02
Geneva	13.63	13.62	+ 0.01
Niagara Falls	13.64	13.62	+ 0.02
Toronto	13.84	13.65	+ 0.19

The probable error of any representation is $\pm$ 0.066.

APPENDIX No. 20.

Continuation of the list of magnetic stations and results given in Appendix No. 28, Coast Survey Report of 1856, No. 24, Coast Survey Report of 1858, and No. 28, Coast Survey Report of 1860.

Number.	Name of station.	Latitude.	Longitude west of Greenwich.	Magnetic declination.	Magnetic dip.	Horizontal intensity, English units.	Date.	Locality, geology, and remarks.
		° ′	° ′	° ′	° ′			
205	Aulezavik Island, Lab....	59 47.5	64 13.2	51 23.5 W.	82 13.3	1.696	1860. July 16–20	Northwest side of Aulezavik island, near Cape Chudleigh. The magnetic station is in a direction 33° 57′ west of south from the astronomical station, and distant from it 3,251 feet. Position marked by a tent pin driven into the ground; over this a bottle was placed, covered with a heap of stones. The surface of the ground is traversed by irregular ridges of rock. The geological formation consists of gneiss, with traces of sienitic rock; portions of which contain garnets. No indication of the presence of magnetic oxide of iron.
206	Gunstock, N. H..........	43 31.1	71 21.9	10 54.1 W.	75 43.6	3.401	July 16, 20, 25; Aug. 4.	Magnetic station near the summit of the mountain, 110 metres from the geodetic station, and in a northwesterly direction from it. The geological formation of the mountain appears to be chiefly felspathic granite intersected by dykes of trap rock. At several points considerable local attraction was detected.
207	Troy Village, N. H.......	42 49.7	72 10.6	9 03.3 W.	74 45.7	3.575	1861. Aug. 20–22	Magnetic station near the south side of "Old Muster Field," in a northerly direction from the Town Hall. The geological formation in the vicinity appears to be diluvium. At the station at Monadnock the dip is 74° 44′.4.
208	Wachusett, Mass...... ..	42 29.2	71 52.9	8 48.0 W.	74 28.8	3.622	1860. Sept. 19–Oct. 20.	Near the summit of the mountain, about 93 metres in a southerly direction from the geodetic station. The geological formation of the mountain appears to be chiefly gneiss, with some felspathic granite and loose rocks of talc.
209	Provincetown, Cape Cod.	42 03.2	70 10.8	11 23.5 W.	74 09.7	3.656	Sept. 14–15	On the western slope of the sand-hill, behind the Pilgrim's Home; flagstaff of Town Hall in range with the northern edge of the steeple of the Hall. The ground consists of white siliceous sand, alluvium.
210	Wellfleet, Cape Cod......	41 56.1	70 01.5	10 43.5 W.	74 20.2	3.638	Sept. 12–13	The station is on the right side of the road from the hotel to the harbor light, on the top of the first (lower) hill, near the corner of the fence, and distant about 250 yards from the hotel. The ground consists of white sand and pebbles, drift.
211	Chatham Lights, Cape Cod.	41 40.2	69 56.6	11 11.6 W.	73 46.2	3.744	Sept. 10–11	This station is in range with the two lights, and is 184¼ feet south and a little west of the southern light; it is also five feet north of the fence. The ground consists of white sand and pebbles, drift.
212	Bald Hill, Conn..........	41 58.3	72 11.3	8 50.4 W.	73 59.0	3.706	1861. Sept. 16–20	The magnetic station is near the summit of Bald Hill, 422 feet in a southerly direction from the geodetic station. The geological formation of the hill seems to be micaceous ferruginous gneiss. Dip about 100 metres north of the magnetic station, 73° 36′.0
213	Box Hill, Conn...........	41 47.9	72 27.0	8 30.4 W.	73 57.9	3.728	Oct. 16–25	The magnetic station is near the summit of the hill, about 185 feet in a southwesterly direction from the geodetic station. The geological formation of Box Hill seems to be chiefly mica slate.
214	Sag Harbor, Long Island..	40 59.9	72 17.1	8 27.7 W.	73 20.9	3.903	1860. Sept. 4–5	This station is situated on Mulford's Hill, nearly in the centre of an old redoubt of 1812. It is nearly in range with the old Episcopal church, and the old signal at Smith's farm. It is also nearly in range with the square-towered belfry and Cedar Island light. It is over the higher of two small gneiss ledges.
215	West Base, Fire Island...	40 37.8	73 12.5	7 45.7 W.	73 00.2	3.900	Sept. 1–2	The magnetic station is coincident with the west terminus of the Fire Island base line. The ground consists of white quartz sand, with shells.
72 (*b*)	Mount Prospect, Brooklyn	40 40.3	73 57.7	6 44.0 W.	72 40.8	4.052	Sept. 20–22	The magnetic station is on the southern corner of the reservoir at the outer edge of the coping, and is very near the place where the old trigonometrical signal stood. No iron in the immediate vicinity; the nearest iron pipes being 350 feet distant. The ground consists of small boulders and drift.
216	Barnegat Light	39 45.8	74 06.0	5 24.0 W.	72 05.3	4.108	Aug. 25–26	This station is situated on the road constructed for carrying materials to the light-house. It is on the 45th sleeper from the light-house fence, eight feet from Mr. Brown's fence, 47 feet from the southwest corner, and 67 feet from the southeast corner of the fence.

Continuation of the list of magnetic stations and results, &c.—Continued.

Number.	Name of station.	Latitude.	Longitude west of Greenwich.	Magnetic declination.	Magnetic dip.	Horizontal intensity, English units.	Date.	Locality, geology, and remarks.
		° ′	° ′	° ′	° ′		1860.	
217	Long Beach, coast of N. J.	39 32.0	74 15.3	5 18.5 W.	71 58.5	4.156	Aug. 21–28	The magnetic station is in range with the old Tucker Island light-house and the old Long Beach house; it is situated on the top of the nearest dune to the old house, and 123 feet distant. The ground consists of white quartz sand, with shells.
165(*d*)	Coast Survey Office, Washington, D. C.	38 53.1	77 00.2	2 26.7 W.	71 15.9	4.319	Aug. 16–24; Sept 25 26.	The station is in an enclosed lot adjoining the yard of Coast Survey office building, No. 577, New Jersey avenue, on the west slope of Capitol Hill; the same station as occupied in 1856 and 1859. Dip on July 27, 1861, 71° 18′.3.
218	Absecum Light..........	39 21.8	74 25.0	4 54.0 W.	71 47.0	4.205	Aug. 22–23	In Atlantic city. The magnetic station is in range between the southwest corner of the fence of the light house lot and that part of the light-house where the covered way from the keeper's house joins it. It is 37 feet from the fence corner and 171 feet from the light. The ground consists of white sea sand and sand dunes. The effect of the cast-iron winding staircase in the light-house was found insensible at the distance where the station is located.
219	Apalachicola, Florida	29 43.2	84 59.0	6 12.0 E.	60 19.4	6.163	Jan. 26, Feb. 4.	The magnetic station is 80.4 metres in a westerly direction from the geodetic station at Apalachicola. The geological formation is fine white sand.
220	Eufaula, Alabama........	31 53.7	85 08.4	5 12.1 E.	63 05.8	5.736	April 10–14	The magnetic station is near the west side of Forsyth street, a few metres north of Washington street, and at a point 594 metres due south from the longitude station. The geological formation is red clay, covered with a light sandy soil to the depth of two feet.
							1861.	
221	Barkley 2, Pensacola.....	30 24.6	87 12.3	6 42.2 E.	60 38.9	6.129	Jan. 5–11	The magnetic station is at a point 115 metres northerly of the geodetic station, Barkley 2. The geological formation is fine white sand.
							1860.	
222	Cote Blanche, La........	29 44.1	91 41.9	8 21.5 E.	59 08.8	6.369	March 3	The magnetic station is situated 50 metres south of the geodetic station, Cote Blanche, and is marked by a square post driven into the ground; it is on the highest part of the hill on the island. The soil consists of brown compact clay, overgrown with short thick grass
							1860.	
223	Ross Mountain, Cal	38 30.3	123 06.2	16 23.2 E.	....	....	Jan. 14–18	The magnetic station is accurately on the line between Ross Mountain and Sonoma Mountain stations, and distant 143 feet from the former.
224	Bodega Camp, Cal........	38 18.2	122 59.5	16 18.8 E.	....	....	July 23–27	The magnetic station is on the line from Station Bodega to the signal on Bodega rock, and is distant 679 yards from the former station on the side of the rise from the first gully south of Mr. Gill's house, and is about 162 feet above the ocean.

APPENDIX No. 21.

Report on observations of the solar spots, made at the Coast Survey Office, Washington, D. C., from January to August, 1862, *inclusive, by Assistant Charles A. Schott, (additional to Appendix No.* 25, *Coast Survey Report for* 1861.)

1862.	January.		February.		March.		April.		May.		June.		July.		August.	
	g.	s.	g.	s.	g.	s.	g.	s.	g.	s.	g.	s.	g.	s.	g.	s.
1	......	......	......	......	6	12	2	4	......	......	......	......	3	6	......	......
2	3	6	......	......	......	......	......	......	......	......	......	......	......	......	......	......
3	4	8	......	......	......	......	5	14	4	7	......	......	......	......	......	......
4	......	......	4	14	......	......	5	9	......	......	......	......	......	......	......	......
5	......	......	3	8	......	......	......	......	......	......	......	......	......	......	......	......
6	......	......	......	......	......	......	......	......	......	......	......	......	......	......	7	52
7	......	......	......	......	3	3	......	......	......	......	......	......	......	......	5	37
8	5	19	......	......	......	......	......	......	......	......	......	......	6	10	5	48
9	......	......	......	......	......	......	......	......	......	......	......	......	5	16	......	......
10	......	......	5	14	......	......	4	5	......	......	......	......	......	......	......	......
11	......	......	......	......	4	4	3	8	......	......	......	......	......	......	......	......
12	......	......	......	......	5	5	3	3	3	4	......	......	......	......	......	......

Report on observations of the solar spots, &c.—Continued.

1862.	January.		February.		March.		April.		May.		June.		July.		August.	
13	......	......	......	......	......	......	......	......	3	3	......	......	......	......	3	11
14	......	......	......	......	......	......	......	......	......	......	......	......	6	14	......	......
15	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
16	4	8	......	......	......	......	......	......	......	......	......	......	......	......	4	13
17	3	3	......	......	......	......	4	10	......	......	......	......	......	......	......	......
18	......	......	3	3	4	5	4	7	......	......	......	......	......	......	4	27
19	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
20	......	......	3	3	......	......	......	......	......	......	......	......	......	......	......	......
21	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
22	......	......	......	......	......	......	3	4	......	......	......	......	......	......	......	......
23	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
24	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
25	3	8	3	10	......	......	......	......	......	......	......	......	......	......	......	......
26	3	6	......	......	3	5	......	......	......	......	......	......	......	......	3	8
27	......	......	4	12	2	3	......	......	......	......	4	14	......	......	......	......
28	......	......	6	14	2	4	4	15	......	......	......	......	4	21	......	......
29	3	6	......	......	......	......	......	......	......	......	......	......	......	......	......	......
30	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
31	......	......	......	......	2	6	......	......	......	......	......	......	......	......	......	......
Mean	43.0		48.5		39.7		44.9		38.0		54.0		61.4		72.3	

APPENDIX No. 22.

DEVELOPMENT OF BESSEL'S FUNCTION FOR THE EFFECT OF PERIODIC FORCES, FOR DURATIONS OF PERIODS FREQUENTLY OCCURRING IN METEOROLOGICAL AND MAGNETICAL INVESTIGATIONS; WITH EXAMPLES.—COMMUNICATED BY CHARLES A. SCHOTT, ASSISTANT UNITED STATES COAST SURVEY.

The effect of the action of periodic forces can be expressed analytically by a function of the form:

$$\Psi = A + B_1 \sin (\theta + C_1) + B_2 \sin (2\,\theta + C_2) + B_3 \sin (3\,\theta + C_3) + - - - - -$$

where A represents the mean amount.

$B_1\ B_2\ B_3$ - - - the parameter of its fluctuations in the principal and subordinate periods; the period involving 2 θ, being of half the duration of the first; that involving 3 θ, of one-third the duration, &c.

θ represents an arc proportional to the time, and inversely proportional to the length of the period; which is represented by 360°.

$C_1\ C_2\ C_3$ - - - are angular constants, determining the epochs of their respective fluctuations.

The frequent and easy application of this function, especially in meteorological and magnetical investigations, also in tidal discussions, renders it convenient to have a collection of the forms, which the general expression assumes for such numbers of observations in a cycle, as most frequently occur. The general expression for the law of the formation of the quantities $A\ B_1\ C_1\ B_2\ C_2\ B_3\ C_3$ - - -, as well as a more complete exposition of the function, will be found in Sir John F. W. Herschel's article, "Meteorology," in the Encyclopædia Britannica, (8th edition.)

The maxima and minima of the function are obtained by differentiation, and the finding of the roots of the equation,

$$0 = B_1 \cos. (\theta + C_1) + 2\,B_2 \cos. (2\,\theta + C_2) + 3\,B_3 \cos. (3\,\theta + C_3) + - \quad - - - - -$$

The most probable numerical values for the co-efficients $A\ B_1\ C_1\ B_2\ C_2$ - - - -, for twenty-four *equidistant* observations, $S_1\ S_2\ S_3\ S_4$ - - - - S_{24} in a cycle, the same ending with S_{24}, are given by the following formulæ:

$$A = \tfrac{1}{24} (S_1 + S_2 + S_3 + - - - - - - + S_{24}.)$$

$$12\,a_1 = 0.966\,(S_1 - S_{11} - S_{13} + S_{23}) + 0.866\,(S_2 - S_{10} - S_{14} + S_{22}) + 0.707\,(S_3 - S_9 - S_{15} + S_{21}.)$$
$$+ 0.500\,(S_4 - S_8 - S_{16} + S_{20}) + 0.259\,(S_5 - S_7 - S_{17} + S_{19}) - S_{12} + S_{24}.$$

$$12\,b_1 = 0.259\,(S_1 + S_{11} - S_{13} - S_{23}) + 0.500\,(S_2 + S_{10} - S_{14} - S_{22}) + 0.707\,(S_3 + S_9 - S_{15} - S_{21}.)$$
$$+ 0.866\,(S_4 + S_8 - S_{16} - S_{20}) + 0\,966\,(S_5 + S_7 - S_{17} - S_{19}) + S_6 - S_{18}.$$

$$B_1 = \sqrt{a_1^2 + b_1^2} \text{ and } \tan.\ C_1 = \frac{a_1}{b_1}$$

{See Rep. … p. 141 for corrigenda

$$12\,a_2 = 0.866\,(S_1 - S_5 - S_7 + S_{11} + S_{13} - S_{17} - S_{19} + S_{23}) + 0.500\,(S_2 - S_4 - S_8 + S_{10} + S_{14} - S_{16} - S_{20} + S_{22}) - S_6 + S_{12} - S_{18} + S_{24}.$$

$$12\,b_2 = 0.500\,(S_1 + S_5 - S_7 - S_{11} + S_{13} + S_{17} - S_{19} - S_{23}) + 0.866\,(S_2 + S_4 - S_8 - S_{10} + S_{14} + S_{16} - S_{20} - S_{22}.)$$

$$B_2 = \sqrt{a_2^2 + b_2^2} \qquad \tan.\ C_2 = \frac{a_2}{b_2}$$

$$12\,a_3 = 0.707\,(S_1 - S_3 - S_5 + S_7 + S_9 - S_{11} - S_{13} + S_{15} + S_{17} - S_{19} - S_{21} + S_{23}) - S_4 + S_8 - S_{12} + S_{16} - S_{20} + S_{24}$$

$$12\,b_3 = 0.707\,(S_1 + S_3 - S_5 - S_7 + S_9 + S_{11} - S_{13} - S_{15} + S_{17} + S_{19} - S_{21} - S_{23}) + S_2 - S_6 + S_{10} - S_{14} + S_{18} - S_{22}.$$

$$B_3 = \sqrt{a_3^2 + b_3^2} \qquad \tan.\ C_3 = \frac{a_3}{b_3}$$

$$12\,a_4 = 0.500\,(S_1 - S_2 - S_4 + S_5 + S_7 - S_8 - S_{10} + S_{11} + S_{13} - S_{14} - S_{16} + S_{17} + S_{19} - S_{20} - S_{22} + S_{23}) - S_3 + S_6 - S_9 + S_{12} - S_{15} + S_{18} - S_{21} + S_{24}.$$

$$12\,b_4 = 0.866\,(S_1 + S_2 - S_4 - S_5 + S_7 + S_8 - S_{10} - S_{11} + S_{13} + S_{14} - S_{16} - S_{17} + S_{19} + S_{20} - S_{22} - S_{23}.)$$

$$B_4 = \sqrt{a_4^2 + b_4^2} \qquad \tan.\ C_4 = \frac{a_4}{b_4}$$

The next term, involving $5\,\theta$, comes rarely into use.

For twenty-four observations in a cycle—for instance, hourly observations in the diurnal period—it has been found advisable to separate the observations into two parts, as the formulæ for twenty-four values are not sufficiently convenient. Treating the bi-hourly observations at the even hours, and those at the odd hours, separately, we obtain, also, an advantageous check on the final expression. The most probable numerical values for the co-efficients A B_1 C_1 B_2 C_2 - - -, for twelve *equidistant* observations, S_1 S_2 S_3 - - - - S_{12} in a cycle, the same ending with S_{12}, are given by the following formulæ:

$$A = \tfrac{1}{12}\,(S_1 + S_2 + S_3 + \text{- - - - - - -} + S_{12}.)$$

$$6\,a_1 = 0.866\,(S_1 - S_5 - S_7 + S_{11}) + 0.5\,(S_2 - S_4 - S_8 + S_{10}) - S_6 + S_{12}.$$

$$6\,b_1 = 0.5\,(S_1 + S_5 - S_7 - S_{11}) + 0.866\,(S_2 + S_4 - S_8 - S_{10}) + S_3 - S_9.$$

$$B_1 = \sqrt{a_1^2 + b_1^2} \text{ and } \tan.\ C_1 = \frac{a_1}{b_1}$$

$$6\,a_2 = 0.5\,(S_1 - S_2 - S_4 + S_5 + S_7 - S_8 - S_{10} + S_{11}) - S_3 + S_6 - S_9 + S_{12}.$$

$$6\,b_2 = 0.866\,(S_1 + S_2 - S_4 - S_5 + S_7 + S_8 - S_{10} - S_{11}.)$$

$$B_2 = \sqrt{a_2^2 + b_2^2} \qquad \tan.\ C_2 = \frac{a_2}{b_2}$$

$$6\,a_3 = -S_2 + S_4 - S_6 + S_8 - S_{10} + S_{12}.$$

$$6\,b_3 = S_1 - S_3 + S_5 - S_7 + S_9 - S_{11}.$$

$$B_3 = \sqrt{a_3^2 + b_3^2} \qquad \tan.\ C_3 = \frac{a_3}{b_3}$$

The third term generally suffices. The fourth one is found from—

$$6\,a_4 = 0.5\,(-S_1 - S_2 - S_4 - S_5 - S_7 - S_8 - S_{10} - S_{11}) + S_3 + S_6 + S_9 + S_{12}.$$

$$6\,b_4 = 0.866\,(S_1 - S_2 + S_4 - S_5 + S_7 - S_8 + S_{10} - S_{11}.)$$

$$B_4 = \sqrt{a_4^2 + b_4^2} \qquad \tan.\ C_4 = \frac{a_4}{b_4}$$

For eight equidistant observations in a cycle we have the formulæ:

$$A = \tfrac{1}{8}\,(S_1 + S_2 + S_3 + S_4 + S_5 + S_6 + S_7 + S_8.)$$

$$4\,a_1 = 0.707\,(S_1 - S_3 - S_5 + S_7) - S_4 + S_8.$$

$$4\,b_1 = 0.707\,(S_1 + S_3 - S_5 - S_7) + S_2 - S_6.$$

$$4\,a_2 = (-S_2 + S_4 - S_6 + S_8.)$$

$$4\,b_2 = (S_1 - S_3 + S_5 - S_7.)$$

The next term is generally not required.

$$4\,a_3 = 0.707\,(-S_1 + S_3 + S_5 - S_7) - S_4 + S_8.$$

$$4\,b_3 = 0.707\,(S_1 + S_3 - S_5 - S_7) - S_2 + S_6.$$

The formation of B and C is the same as in the preceding cases.

For six equidistant observations in a cycle we have the formulæ:

$$A = \frac{1}{6} (S_1 + S_2 + S_3 + S_4 + S_5 + S_6.)$$
$$3\, a_1 = 0.5\, (S_1 - S_2 - S_4 + S_5) - S_3 + S_6.$$
$$3\, b_1 = 0.866\, (S_1 + S_2 - S_4 - S_5.)$$
$$3\, a_2 = 0.5\, (- S_1 - S_2 - S_4 - S_5) + S_3 + S_6.$$
$$3\, b_2 = 0.866\, (S_1 - S_2 + S_4 - S_5.)$$

The last term is not generally used.

$$3\, a_3 = (- S_1 + S_2 - S_3 + S_4 - S_5 + S_6.)$$
$$3\, b_3 = 0.$$

B's and C's are formed as before.

Examples: In part V of the discussion of the magnetic observations made at Girard College, Philadelphia, under the direction of Prof. A. D. Bache, the diurnal variation of the horizontal component of the magnetic force, during the years 1840 to 1845, is expressed by the following scale readings. Increasing numbers denote decrease of force, and one division of the scale equals 0.0000365 parts of the force. 700 has been omitted from each number:

Time, a. m.	Horizontal force reading.	Time.	Horizontal force reading.	Time, p. m.	Horizontal force reading.
h. m.	*d's.*	*h. m.*	*d's.*	*h. m.*	*d's.*
1 21.65	69.8	9 21.65	81.3	17 21.65	68.6
2 21.65	69.1	10 21.65	86.1	18 21.65	71.6
3 21.65	67.4	11 21.65	86.5	19 21.65	72.6
4 21.65	65.7	12 21.65	82.9	20 21.65	73.4
5 21.65	63.7	13 21.65	76.2	21 21.65	73.5
6 21.65	61.9	14 21.65	69.5	22 21.65	73.4
7 21.65	66.7	15 21.65	66.5	23 21.65	72.8
8 21.65	73.7	16 21.65	66.2	24 21.65	71.5

In this case the results at the even and odd hours have different weights, and the values were separated into two groups of 12 observations each.

We have for the even hours: $S_1 = 69.1$ $S_7 = 69.5$
$S_2 = 65.7$ $S_8 = 66.2$
$S_3 = 61.9$ $S_9 = 71.6$
$S_4 = 73.7$ $S_{10} = 73.4$
$S_5 = 86.1$ $S_{11} = 73.4$
$S_6 = 82.9$ $S_{12} = 71.5$

And substituting these values in the formulæ for twelve observations in a cycle, as given above, we find:

$$A = 72.1 \mid a_1 = -3.87 \mid a_2 = +5.08 \mid a_3 = -1.77 \mid a_4 = -0.11$$
$$\mid b_1 = -0.62 \mid b_2 = -5.23 \mid b_3 = +3.67 \mid b_4 = -0.83$$

whence the equation:

$$\Psi_{\text{i}} = 72.1 + 3.92 \sin (\theta + 260° 54') + 7.29 \sin (2\,\theta + 135° 35') + 4.08 \sin (3\,\theta + 334° 21') + 0.84 \sin (4\,\theta + 188°.)$$

The angular equivalent of $21^{m}.65$ being $5° 25'$, since 24 hours are represented by $360°$, we can refer the epoch of the above equation to midnight, by changing the angles $C_1\, C_2\, C_3$ - - - - by $- 5° 25'$, twice $- 5° 25'$, thrice $- 5° 25'$ - - - - - and find:

$$\Psi_{\text{ii}} = 72.1 + 3.92 \sin (\theta + 255° 29') + 7.29 \sin (2\,\theta + 124° 45') + 4.08 \sin (3\,\theta + 318° 06') + 0.84 \sin (4\,\theta + 166°.)$$

In like manner, we find for the odd hours, where $S_1 = 69.8$, $S_2 = 67.4$, $S_3 = 63.7$, &c., the equation referring to the epoch $23^{h}\ 21^{m}.65$:

$$\Psi_{\text{iii}} = 72.1 + 4.03 \sin (\theta + 249° 15') + 7.11 \sin (2\,\theta + 106° 54') + 3.58 \sin (3\,\theta + 287° 03') + 0.91 \sin (4\,\theta + 123°.)$$

Which becomes, when referred to midnight, as the epoch from which the angle θ counts, at the rate of 15° an hour:

$$\Psi_{iv} = 72.1 + 4.03 \sin(\theta + 258° 50') + 7.11 \sin(2\theta + 126° 04') + 3.58 \sin(3\theta + 315° 48') + 0.91 \sin(4\theta + 161°.)$$

The values in equation Ψ_{ii} have the weight 57; those in equation Ψ_{iv}, the weight 21. The mean, by weights, of the two equations, furnishes the final equation:

$$\Psi = 72.1 + 3.95 \sin(\theta + 256° 19') + 7.25 \sin(2\theta + 125° 05') + 3.96 \sin(3\theta + 317° 31') + 0.86 \sin(4\theta + 165°,)$$

which will be found to represent the observations very closely.

Maxima or minima occur at *5h. 55m.* a. m.; at *11h. 00m.* a. m.; at *15h. 35m.* (p. m.,) and about $20\frac{3}{4}$*h.* (p. m.)

To illustrate the use of the formulæ for eight observations in a cycle, I select an example from my discussion of the meteorological observations of Captain (now Sir Leopold) M'Clintock in the Arctic regions in 1857–'58–'59.

In Baffin Bay, latitude 72°.5, longitude 65°.8 W., the elevating and depressing influence of the wind from different directions was found as follows. + indicating a temperature above the mean; — below the mean:

True direction of wind.	Effect on temperature.
	°
N.	— 0.8
NE.	+ 0.
E.	+ 0.1
SE.	+ 3.0
S.	+ 0.4
SW.	— 1.7
W.	— 0.9
NW.	— 0.8

Counting θ from the north, in the direction E., S., &c., to 360°; putting $S_1 = + 0.7$, $S_2 = + 0.1$, &c., and working out the numerical equations according to preceding formulæ, we find:

$$\Psi = + 1°.5 \sin(\theta + 338°) + 0°.8 \sin(2\theta + 173°.)$$

The SE. wind is, therefore, the warmest, and elevates the temperature 2°.2; the SW. wind the coldest, and depresses the same 1°.4

In my discussion of the tides at Van Rensselaer Harbor, North Greenland, the form of the spring-tide wave is represented by the following ordinates, (in feet,) for twelve phases, from trough to trough. Selecting six of these for our example, we have:

Phase.	Ordinate.	
0	0.0	S_0
60	3.9	S_1
120	9.4	S_2
180	11.1	S_3
240	7.9	S
300	2.1	S

Applying the preceding formulæ for six observations in a cycle, we find:

$$\Psi = + 5.73 + 5.67 \sin(\theta + 280°) + 0.20 \sin(2\theta + 295°.)$$

Which formula represents the shape of the wave at spring tides, the total range being then 11.1 feet

APPENDIX No. 23.

DESCRIPTION OF A NEW MODE OF CONSTRUCTING THE AXLE OF A MAGNETIC DIPPING NEEDLE—BY ASSISTANT J. E. HILGARD.

In observations of the magnetic dip the mean result is cleared of the effects of collimation, balancing, and index errors, by the inversion of the needle in its bearings, the reversal of polarity and the reversal of the circle. The effect of the errors in the figure of the pivots alone remains uncompensated, except so far as the supporting on four different parts of the pivots has that effect. Nor can the agreement of the indications of the needle in its different positions increase our confidence in the absence of errors of that class, because they would be compensated in the adjustment for reducing the other errors to a minimum.

The necessity for repeating observations, with the needle resting on different portions of the pivots, has always been felt, not only in order to eliminate original errors in the figure of the pivots, but also in order to recognize and avoid the effects of minute particles of rust which are liable to be found, especially when the needles are exposed to the sea air. The method of effecting this, proposed by MAYER, of balancing the needle by means of weights, so as to assume various inclinations, has the disadvantage not only of the directive force being diminished, and the vibrations sluggish in certain positions, but also of the absolute strength of magnetization entering into the result, rendering it necessary that the magnetism of the needle should be the same before and after reversing its polarity—a condition difficult to accomplish.

The other modes in frequent use, of observing at different azimuths, fails in part, in high magnetic latidude, where only a small range of the circumference of the pivots becomes available, since all dips so observed must be between the true dip and 90°.

In the report on the magnetic survey of the British islands, 1839, Major SABINE states that some needles were used, in which the axle, instead of being permanently fixed to the needle, was secured in its place merely by strong friction, and could be taken out, turned a portion of a circle on its own centre of rotation, and replaced, thus enabling the points of the circumference of the axle, in contact with the supporting planes, to be varied in successive trials.

The plan seems to have worked well, but appears not to have been subsequently used. Whether this was owing to the more perfect figure afterwards given to the pivots of ordinary needles, by Gambey and Barrow, or to some defect in the construction of the revolving axles, is not understood. That principle of construction has, however, lately been revived, in, perhaps, a somewhat novel form, by Assistant J. E. Hilgard, and has been successfully executed by Mr. Wm. Würdemann, on needles Nos. 1 and 3 of the dip circle No. 10.

The axle admits of being turned about itself (without being removed) in the brass collar or arbor, by means of which it is attached to the needle. In this manner the needle may be made to rest on any portion of the pivots, and by means of an index on the square shoulder, by which the axle is turned, and a graduation on the brass collar, observations may be made in symmetrically arranged positions of the pivots. The axles fit closely into these arbors, and turn smoothly, yet with very sufficient friction.

In the pair of needles first furnished with these axles, the pivots are not perfectly concentric with the axles, as is apparent from the subjoined observations; but that defect should disappear for each position in the mean or the reversals. The positions marked 0 upon 0 are those in which the balance of the needles was adjusted.

Observations of magnetic dip, with needles No. 1 and No. 3, at the Coast Survey office, Washington city, September 12, 13, and 15, 1862, by C. A. Schott.

Position of axis.	Polarity of marked end.	Face of circle.	Needle No. 1. Observed dip.	Needle No. 1. Crossed means.	Needle No. 1. Mean dip.	Needle No. 3. Observed dip.	Needle No. 3. Crossed means.	Needle No. 3. Mean dip.
			° ′	′	° ′	° ′	′	° ′
0. upon 0.	North	East	71 20.7			71 14.8		
		West	16.9	22.8		14.5	20.1	
	South	West	24.9	22.0		25.4	19.2	
		East	27.2		71 22.4	23.9		71 19.7
0. upon 120.	South	East	70 50.7			71 30.9		
		West	48.9	16.6		08.0	12.7	
	North	West	71 42.5	18.9		70 54.5	10.8	
		East	49.0		71 17.8	71 13.6		71 11.7
0. upon 240.	North	East	71 39.2			70 41.5		
		West	35.8	09.1		32.8	09.0	
	South	West	70 39.1	06.8		71 35.5	09.1	
		East	37.9		71 08.0	45.5		71 09.1
0. upon 60.	South	East	71 13.3			71 42.1		
		West	70 51.7	15.0		12.9	25.8	
	North	West	71 16.7	12.2		09.5	05.4	
		East	32.7		71 13.6	70 58.0		71 15.6
0. upon 180.	North	East	72 05.3			71 12.2		
		West	71 56.4	23.7		70 52.5	37.7	
	South	West	70 42.1	20.0		72 03.2	25.6	
		East	43.7		71 21.8	71 58.7		71 31.7
0. upon 300.	South	East	70 56.2			71 53.2		
		West	57.0	09.1		51.4	21.2	
	North	West	71 22.1	13.4		70 49.2	18.9	
		East	29.9		71 11.3	46.4		71 20.0
						0. upon 180.		
0. upon 0.	North	East	71 17.9			71 02.8		
		West	14.0	17 6		70 55.2	25.6	
	South	West	17.3	19.2		71 48.4	22.6	71 24.1
		East	24.5		71 18.4	50.0		
						0. upon 300.		
0. upon 120.	South	East	70 53.5			71 40.0		
		West	71 00.9	19.7		33.0	12.6	
	North	West	46.0	29.7		70 45.3	11.0	
		East	58.6		71 24.7	49.1		71 11.8
						0. upon 60.		
0. upon 240.	North	East	71 49.0			70 56.1		
		West	44.5	12.7		55.9	10.5	
	South	West	70 36.5	12.6		71 24.9	11.5	
		East	40.7		71 12.7	27.1		71 11.0

RECAPITULATION.

	Needle No. 1.	Needle No. 3.
	° ′	° ′
September 12	71 16.1	71 13.5
September 13	15.6	22.4
September 15	18.6	15.6
Means	71 16.8	71 17.2

The above observations are so arranged, that in each position we have two results virtually cleared of collimation, balance, and index errors, the circle having been reversed, as well as the needle inverted, for each state of polarity. These separate results are brought out in the column of "crossed means." We see, in fact, in general, a very close agreement of the two values, while, in a few cases, there is a considerable difference. This is, doubtless, to be looked upon as arising from some accidental cause, as the attachment of some mote to the needle, and indicates that these observations ought to be repeated.

On each day the observations were made in three positions of the axle, and the mean, therefore, depends upon twelve different portions of the cylindrical surfaces of the pivots. The individual results show wider differences than we should have looked for, and we believe that a more perfectly cylindrical figure of pivots can be attained.

The close agreement of the means by both needles, nevertheless, points to a compensation of errors, and inspires confidence in the result.

APPENDIX No. 24.

NOTICE OF EARTHQUAKE WAVES ON THE WESTERN COAST OF THE UNITED STATES, ON THE 23d AND 25th DECEMBER, 1854.

[Communicated to the American Association for the Advancement of Science, by A. D. Bache, Superintendent, under authority of the Treasury Department.]

In February, 1855, I received from Lieut. W. P. Trowbridge, of the Corps of Engineers, assistant in the Coast Survey, in charge of the tidal observation on the Pacific coast, a letter calling my attention to the singular curves traced by the self-registering tide-gauge at San Diego, on the 23d and 25th of December, and remarking that the irregularities of the curve could not be produced by disturbances from storms, as the meteorological records for the whole coast showed a continuance at that time of an ordinary state of weather, and the length of the wave was too great to be explained by such action. "There is every reason to presume (he continues) that the effect was caused by a sub-marine earthquake." No shock, however, has been felt at San Francisco.

When the record sheet of the self-registering gauge at San Francisco was received, similar irregularities in the curves for the same days were found upon it. The sheet for Astoria presented little or no special irregularity. These were the only self-registering gauges actually in operation at this time.

Waves of short period would, of course, escape detection by the ordinary hourly or half-hourly observations.

About the 20th of June, we received accounts from Japan of a violent earthquake on the 23d of December, the notice of which was more circumstantial than usual, from the damage to the Russian frigate *Diana*, in the port of Simoda, on the island of Niphon, from the excessive and rapid rise and fall of the water.

A detailed account of the phenomena of this earthquake, and of the rise and fall of the sea produced by it in different places on the coasts of the Pacific, is much to be desired, and I have thought that by the publication of the results obtained by the Coast Survey, the publication of official reports of the phenomena might be induced. Perhaps even similar observations may have been made, and these registers of the self-acting tide-gauge will show what observations it is desirable to have for comparison.

Thus far we are left to the public prints for the information obtained,* and the different accounts are quite discrepant where they give details, and are usually, as intended merely for general information, too vague in the statements to give satisfactory means of comparison.

A correspondent of the New York Herald, writing from Shanghae, gives the following notes, stated to be derived from an officer of the frigate *Diana:*

"At 9 a. m. on the 23d of December, weather clear, thermometer 72°, barometer 30°, a severe shock of an earthquake was felt on board the frigate, shaking the ship most severely. This shock lasted full five minutes, and was followed at quick intervals by rapid and severe shocks for thirty minutes."

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* Since reading this paper I have received, through the kindness of Commodore M. C. Perry, a copy of a letter from Captain H. A. Adams, U. S. N., who visited Japan in the steamer Powhatan, to exchange ratifications of the treaty between Japan and the United States. Captain Adams says: "Simoda has suffered dreadfully since your visit there. On the 23d of December there were several shocks of earthquake. The sea rose in a wave five fathoms above its usual height, overflowing the town and carrying houses and temples before it in its retreat. When it fell, it left but four feet of water in the harbor. It rose and sunk this way five or six times, covering the shores of the bay with the wrecks of boats, junks, and buildings. Only sixteen houses were left standing in the whole place. The entire coast of Japan seems to have suffered by this calamity. Yedo itself was injured, and the fine city of Osaka entirely destroyed." Captain Adams then gives an account of the disaster to the Russian frigate Diana, Admiral Pontiatine commanding, which was so injured in the harbor of Simoda as to lead finally to her entire loss.

"At 9.30 a. m. the sea was observed washing into the bay in one immense wave, thirty feet high, with awful velocity; in an instant the town of Simoda was overwhelmed, and swept from its foundations." * * * * "This advance and recession of the water occurred five times. * * * By 2*h*. 30*m*. p. m. all was quiet."

A communication in the same paper, purporting to give an extract from the log-book of the *Diana*, states that—

"At a quarter past nine, without any previous indication, the shock of an earthquake, which lasted two or three minutes, causing the vessel to shake very much, was felt both on deck and in the cabin; at ten o'clock a large wave was observed entering the bay. * * * * The rising and falling of the water were very great, the depth varying from less than eight to more than forty feet; and these changes, at intervals o about five minutes, continued until noon. * * * * * Scarcely had half an hour elapsed when the rising and falling of the water became more violent than before. Between this time and a quarter past two (when the agitation again became much less) the frigate was left four times on her side, and once while thus, laid in only four feet of water."

"Continuing to decrease in violence and frequency, by three p. m. the agitation of the water, and the motion of the vessel consequent thereon, were very slow. * * * * At this time a fresh west wind was blowing, the barometer stood at 29.87, and the thermometer was 10.50 degrees R., (about 55.63 degrees F.")

The official report of the disaster to the frigate will probably contain further and more precise particulars of the phenomena.

Mr. P. W. Graves gives in the *Polynesian* a notice, for which I am indebted to Mr. Meriam, of an extraordinary rise and fall of the waters at Peel's island, one of the Bonin islands, on the 23d of December. The first rise noticed was fifteen feet above high water, followed by a fall which left the reefs entirely bare. The hour when this occurred is not stated. "The tide continued to rise and fall during the day at intervals of fifteen minutes, gradually lessening until the evening."

At Peel's island the waters rose, on the evening of the 25th of December, to the height of twelve feet I have not, however, seen any notice of an earthquake on that day.

I present to the association a copy of the curves traced by the self-registering gauges at the Coast Survey tidal stations at San Diego, San Francisco, and Astoria, on the 23d and 25th of December, 1854, (Plate No. 50.)

The curves, representing tides of short period, being traced upon the falling or rising curve of the regular tide, their peculiarities are not so readily seen as when shown in the second diagram, (Plate No. 50,) where the regular tidal curve is represented as a horizontal line. The times of the San Diego curve are reduced to San Francisco time. The curve at San Diego presents many minor irregularities, from the motion of the float not having been sufficiently checked to prevent the recording of the waves caused by the wind.

Upon a falling tide the crests of these waves will be met earlier, and the hollows later, than upon a horizontal surface, and the intervals from crest to crest, or from hollow to hollow, will be affected by the change of rate of fall. Upon a rising tide the reverse will occur.

There can be no doubt that these extraordinary rises and falls of the water at short intervals were produced by the same cause which determined the extraordinary rise and fall in the harbor of Simoda, in Japan, and at Peel's island.

The San Francisco curve presents three sets of waves of short interval.

The first begins about 4*h*. 12*m*., and ends at 8*h*. 52*m*., the interval being 4*h*. 40*m*. The second begins at about 9*h*. 35*m*., and ends at 13*h*. 45*m*., the interval being 4*h*. 10*m*. The beginning of the third is about 13¾*h*., and its end is not distinctly traceable.

The crest of the first large wave of the three sets occurred at the respective times of 4*h*. 42*m*., 9*h*. 54*m*., and 14*h*. 17*m*., giving intervals of 5*h*. 12*m*. and 4*h*. 23*m*.

The average time of oscillation of one of the first set of waves was 35*m*., one of the second 31*m*., and of one of the third about the same. The average height of the first set of waves was .45 of a foot on a tide which fell two feet, of the second .19 of a foot on a tide which rose three feet, of the third somewhat less than .10 of a foot on a tide which fell some seven feet. The phenomena occurred on a day when the diurnal inequality of the tide was very considerable. The greatest fall of the tide during the occurrence of the first set of waves was .70 of a foot, and the corresponding rise .60 of a foot. In the second the corresponding quantities were .30 of a foot, and in the third .20 of a foot. These waves would not have attracted general attention.

There is a general analogy in the sequence of the waves of the three sets which seems to mark them as belonging to a recurrence of the same series of phenomena. In the Diagram No. 3 A, (Plate No. 50,) the heights of the successive waves of the first set at San Francisco are shown by the dots joined by full lines, and of the second by those joined by the fine dotted line. The full faint lines show the heights of the first series at San Diego, and the broken faint lines the heights of the second.

The heights in hundredths of a foot are marked at the side of the diagram, and those of the successive waves are placed at regular intervals, the waves being numbered from 0 to 7 at the top of the diagram. The height is the mean of the fall from a crest to a hollow, and of the succeeding rise from the same hollow to the next crest. The times of oscillation from one crest to the next succeeding are placed on the same diagram, the times being written at the right hand, and the wave being designated at the lower part of the Diagram No. 3 B, Plate No. 50. The full line represents the times of the first series at San Francisco, and the broken line the times of the second. The full and broken faint lines represent the times of the first and second series at San Diego. The intervals between the times of occurrence of the crests of the successive waves in the first and second series diminish from *5h. 10m.* to *4h. 48m.* by irregular differences.

The effect of the rising or falling tide, upon which these waves occur, is, of course, greater in disturbing the heights than the times.

The series itself looks like the result of several impulses, not of a single one, the heights rapidly increasing to the third wave, then diminishing as if the impulse had ceased; then renewed, then ceasing, leaving the oscillation to extinguish itself.

If we had a good scientific report of the facts as they occurred at Simoda, the subject would lose the conjectural character which must otherwise belong to it. Although we have no account of the place where the earthquake had its origin, the violence of its effects in Japan, and the diminished effects at Peel's island, show that Japan was certainly not far from the seat of action.

Five successive waves of considerable height are spoken of as having occurred at Simoda, while by the gauge we trace eight, of which seven are of considerable height. The highest wave at Simoda was estimated at thirty feet, at Peel's island at fifteen feet. At San Francisco it was .65 foot, and at San Diego in the first series .50 foot.

At *San Diego*, the same three series of waves are distinctly shown. The first begins *1h. 22m.* later than at San Francisco, correction having been made for the difference of longitude, and ends *0h. 52m.* later. The interval is *30m.* less than at San Francisco, the oscillation being rather shorter than at the last named point. The second begins *0h. 54m.* later than at San Francisco, and ends *34m.* later. The third begins about *54m.* later than at San Francisco. The average time of oscillation of the first set of waves is *31m.*, and of the second *29m.*, being respectively *4m.* and *2m.* less than of the corresponding series at San Francisco.

The average height of the first waves was .17 foot lower than at San Francisco, and the second as much higher. This fact, taken with the difference in the times of oscillation, leads me to suppose the difference in the two series due to interference, which is also suggested by the position of San Diego, in reference to the islands separating the Santa Barbara sound from the ocean.

The general analogy in the succession of heights of the mean of the two series, as shown in Diagram No. 3 C, and in the times as shown in D, of the same diagram, is very satisfactory.

The difference in the periods of the tide at which the waves occurred would tend to cause discrepancies.

The first series occurred on a rising tide of four feet, while at San Francisco it was upon a falling tide of two feet. The second began near high water, and was chiefly upon a falling tide of seven feet, while at San Francisco it was upon a rising tide of four feet.

The forms of some of the individual waves in the second series at San Francisco and San Diego accord remarkably, as those marked 1, 3, 4, 5, and 6, when reduced to the horizontal line. The comparison on the curve where the distortion remains, is also very instructive. The waves marked 1, 4, 6, and 7, are not unlike in the first and second sets at San Diego.

The observations at San Diego confirm, then, in general, the inferences derived from those at San Francisco. The register at Astoria throws no new light upon the subject. The bar at the entrance of the Columbia river would explain why the oscillations were lost or greatly reduced at Astoria, even if they arrived off the entrance of the river. The disturbance is marked on the register, but in an irregular and confused manner.

It was also, apparently, preceded by unusual oscillations of the water.

After allowing for the very free action of the float of the San Diego gauge, there appear to have been indications of disturbance previous to the great earthquake shocks, and following them, occurring at intervals for several days after the 23d of December. The San Francisco gauge presents similar indications.

No special effect appears to have been produced upon the time or height of high or low water by the earthquake, which merely caused series of oscillations upon the great tidal wave.

I now proceed to draw from these results some conclusions as to the progress of the ocean wave accompanying the earthquake.

The latitudes and longitudes of the places referred to are as follows:

	Latitude N.	Longitude W.	
	° ′	° ′	*h. m.*
San Diego	32 42	117 13	7 49
San Francisco	37 48	122 26	8 10
Simoda	34 40	221 02	14 44

The distance from San Diego to Simoda, from these data, is 4,911 nautical miles; and from San Francisco to Simoda, 4,526 nautical miles.

According to one account, the disturbance began at Simoda at 9 a. m., or 23d 11*h.* 44*m.* Greenwich mean time, and the first great wave half an hour after. The first disturbance at San Francisco was at 23d 0*h.* 22*m.*, or 12*h.* 38*m.* after that at Simoda, and the first great wave at 23d 0*h.* 52*m.*, giving the same interval.* The distance and time from this account give for the rate of motion of the wave 358 miles per hour, or 6.0 miles per minute.

The second account would give for the time of transmission 12*h.* 15*m.*, and for the rate of motion 370 miles per hour, or 6.2 miles per minute.

The San Diego observations give for the time of transmission of the wave from Simoda to San Diego 14*h.* 0*m.* by the first account, and 13*h.* 45*m.* by the second account, which combined with the distance, give 354 miles per hour for the mean result, or, sensibly, the same result as derived from the beginning at San Francisco. The first great wave would give identically the same result.

From the results obtained, we may determine the mean depth of the Pacific ocean in the path of the earthquake waves. We have found for the rate of motion from 6.0 to 6.2 miles per minute, and for the duration of an oscillation 35 minutes at San Francisco, and 31 at San Diego. This would give for the length of the wave on the San Francisco path 209 miles to 216 miles; and on the San Diego path, 183 miles.

A wave of 212 miles in length would move with a velocity of 6.1 miles per minute in a depth of 1,887 fathoms, (Airy, *Tides and Waves*, Encyc. Metrop., p. 291, Table II;) the second account would give a depth of 2,005 fathoms. The corresponding depth on the San Diego path is 1,843 fathoms.

The disturbance of the 25th of December presents at San Francisco three sets of waves of seven each, and at San Diego one set of seven, agreeing in their general features with those at San Francisco; and then a set of seventeen, in which, at first, intermediate waves seem to be wanting at San Francisco, or which have no analogous oscillations there. The crests of the first set occurred at a mean about 17 minutes earlier at San Diego than at San Francisco; the heights on the average were nearly the same, being .39 foot at San Diego, and .44 foot at San Francisco, and the time of oscillation at the two places the same, namely, 41*m.* The origin of the disturbance was probably nearer to San Diego than to San Francisco.

APPENDIX No. 25.

ON THE ORIGIN, GROWTH, SUBSTRUCTURE, AND CHRONOLOGY OF THE FLORIDA REEF.—BY CAPTAIN E. B. HUNT, CORPS OF ENGINEERS, U. S. A.

NEW HAVEN, CONN., *November* 18, 1862.

SIR: The examination of the Florida reef, keys, and mainland by Professor Agassiz in 1850–'51. (Coast Survey Report, 1851, Appendix No. 10,) marks an era in our knowledge of the singular geological problems there exhibited, and especially of their zoological phases. This exploration, made under Coast Survey

* The time is reckoned for Simoda, *eastward*, and for California, *westward*, from Greenwich.

auspices, was amply justified by the fact that the Florida reef is the great American danger to navigation. One of the best aids in avoiding reef risks is a clear insight into the structure of the reefs and keys, and this can only result from scientific researches, aided by the Coast Survey detailed hydrography, now well advanced. The millions of property wrecked on the reef are in great part sacrificed to a needless ignorance of hydrography, reef structure, currents, winds, and even lights and beacons. Reef pilots are not employed, and shipmasters are so poorly supplied with precise knowledge of the kind needed for insuring safe navigation amid these dangers, that many wrecks result solely from their ignorance. During the five seasons (1857–'62) in which I was charged with the construction of Fort Taylor, at Key West, I had good opportunities for knowing the history of the wrecks, occurring about at the average rate of one a week. I am now of the opinion that the loss of property in wrecks, which would be preventable by such accurate knowledge as can be furnished to navigators when the Coast Survey shall have published the complete reef hydrography, and its full scientific discussions of reef structure, tides, currents, and winds, has regularly exceeded the annual expense of the entire survey. Many shipmasters are incorrigibly ignorant, and several wrecks have, to my knowledge, occurred by masters not knowing new lights which had been for many months conspicuously advertised in all the custom-houses and in commercial papers. Should shipping merchants insist on having none but intelligent captains, and then furnish them with the very best information concerning the reef neighborhood, a large portion of the wrecks would be prevented. I think the study of currents, and especially of *current variations*, in and near the Florida channel, is now peculiarly needed for preventing wrecks in this region. The fluctuations of currents from their supposed normal type, certainly cause numerous disasters. The lack of distinct ideas as to the relations between the reef and the keys, and ignorance of the manifest signs of proximity to the reef, are the real causes of many disasters. The Coast Survey has done so much to disarm the reef of its terrors and to make known its true character, that, aside from my own connexion with the Coast Survey organization, it seems appropriate for me to present to you some views on the origin, growth, substructure, and chronology of the reef, which have resulted from my observations while at Fort Taylor, and which may prove a needful supplement to Prof. Agassiz's report.

The grand curve of our Atlantic coast terminates in the remarkable crescent of keys and reefs which begins some miles north of Cape Florida, and extends in a well-defined curve some two hundred and forty statute miles to Tortugas bank. At Cape Florida its axis is north and south. In moving down the reef this direction revolves with the sun, until at Tortugas it bears about 5° N. of W. This crescent consists of a line of keys and a parallel outer line of reefs which are separated on an average between five and six miles by a navigable channel obstructed by coral heads. The reef terminates about opposite the Marquesas, some fifty miles east of Tortugas bank. Between the line of keys and the mainland of Florida is a body of shoal water, shaped much like a cornucopia, which embraces Key Biscayne bay, Card's sound, Barnes's sound, and the bay of Florida.

The line from Tortugas to Cape Romano, which may be taken as the mouth of this cornucopia, is one hundred and twenty miles long, the deepest water on it being twenty fathoms, and all within or east of it being still shoaler and characterized by singular evenness of bottom. The straits of Florida, between the reef and the Cuban coast, are about a hundred miles wide, and the bottom slopes from the reef down to eight hundred fathoms, just off the submerged cliffs of Cuba. The one hundred fathom curve of the bottom is about seven miles out from Cape Florida, and from thence to Tortugas it gradually separates further from the keys, being there over twenty miles out.

The well-traced curve along which this grand Florida bank thrusts itself out into the deep water of the Gulf, is strikingly significant of some continuous and regular agency in its production. The adjacent flow of the Gulf Stream would, most naturally, be assumed to govern in some way the production of this curve. It, however, runs in the wrong direction to serve this explanatory use, and it is, in fact, rarely found to run close in upon the reef. There is, however, an eddy counter current, intermitting in character and of variable rate; but, on the whole, a positive and prevailing current.* At Cape Florida it is narrow and precarious; but it widens as it sweeps to the westward, occasionally becoming over ten miles wide at Key West, and twenty miles off Tortugas. It sometimes runs over two knots, and is a great help to vessels bound west, when their masters know the reef well enough to venture so near. There is much need of more precise observations to make out the characteristics of this current; but its existence and its intermitting and sometimes powerful set are facts attested by all who know these waters thoroughly.

* See C. S. Rept., 1858, Ap., p. 32; Am. J. Sci., 1859, v. 27, p. 206.

After careful consideration, I am led to ascribe the peculiar shaping and growth of the Florida bank, including the keys, reefs, and substructure, mainly to the sweeps of this eddy counter current. Darwin, Dana, and Agassiz, have so fully stated the zoological and other ordinary elements of reef and key growth, that I need only refer to their works for details.* Special circumstances, however, so far modify the structure of the Florida reef that it is not fully embraced in the principles laid down by these writers. It is not an atoll, a fringing reef, or a barrier reef, in the accepted sense of these designations; but it is a reef, or bank, shooting out independently *by its end* into the deep Gulf waters. Such, at least, is the view to which I have been led by simply considering the existing agencies as actually working.

The reef proper is the main field of coral growth. This growth is not in one compact mass, but in diversified coral heads, or detached masses. The bold slope of the reef, towards the Gulf Stream, to the proper depth of growing coral, which here does not exceed a hundred feet, and the broad top surface of the reef section are teeming with solid corals and shells. The branching corals grow wherever the violence of the sea does not prohibit, and where moving sand does not forbid a secure foundation for coral colonies.

In general, wherever there are solid surfaces free from sand and weed, and which are washed by warm moving salt water, the coral eggs, diffused throughout the reef waters, attach themselves and grow to the limit of their capacity. Thus, the stones of the Fort Taylor breakwater and foundations, palmetto piles, iron bars lost overboard, &c., have become coated with branching and solid corals, whose growth, between the date of immersion and that of diving up, give a measure of coral increase. Throughout the sand-covered bottom, between the reefs and keys, along the sand-faced south beach slope, towards the reef, and over the mud bottom north of the keys, there are no living corals, except on such accidental bases as may occur, and in the coral heads which have grown upon these bases. Thus, coral masses are mainly produced where the action of storms is most violent, and they are constantly giving way before the assaults of the waves and the corrosions of the numerous and active boring shells. A coral mass, once broken loose, undergoes active attrition and disintegration into calcareous sand of varying fineness. This sand and the accompanying detritus of shells and echinoderms which abound intermixed with the living coral, are, by degrees borne on by the waves towards the south beaches of the keys, where some of the sand is thrown upon the slope of the beach ridge. A coral mass, or shell once cast loose *is* killed, and *is* henceforth untiringly triturated by the waves until it escapes their action, or is reduced to impalpable powder. Every wave agitation of sand pulverizes it yet further, and brings it nearer to the consistency of the white mud which so largely prevails on the bank towards its northern side. There is, thus, a constant coral and shell growth, and as constant disintegration in progress. All this action, however, takes place in the limited range of depth of less than a hundred feet, within which only can the reef-building coral grow. To account for the vast underlying mass between this limit of depth and the deep original sea-floor, is a problem hitherto unsolved, and one which I hope to elucidate.

The tidal currents set strongly across the reef, and through the channels, between the keys, the flood running to the north and the ebb to the south side of the key crescent. When storms occur the agitation of the waves extends to the bottom over the shallower portions of the grand bank and stirs up the sand violently. This causes the water to take up and maintain in mechanical suspension such finely comminuted particles as have too little sinking force, rapidly to reach the bottom again. The finer the particles the longer will they remain suspended, and the very coarse grains will hardly be lifted from the bottom. Between the coarsest and finest are grains of all intermediate sizes, and whether they will be suspended, or not, depends on the violence of the storm, and their interval of suspension varies with their size and the violence of the waves. It results that, in all storms of much violence, the water over the Florida bank becomes white with the bottom deposits. In long and severe northers or gales, the water becomes almost milk white across the whole bank. This "white water" is a familiar appearance, and is one of the sure signs of proximity to the reef. As storms subside the white sand mud is gradually thrown down, and the water clears, after a day or two, to its peculiarly delicate transparency.

During the "white water" periods the flood tidal currents set the white water over the north side of the bank into the bay of Florida, where, by reason of the greater depth, the process of deposition goes on, and thus the floor of this bay has become covered with white mud, and has been brought up with a singular

* The Structure and Distribution of Coral Reefs, 1842, by Chas. Darwin, naturalist of the Beagle expedition, (1832–'36.) On Coral Reefs and Islands, by Jas. D. Dana, geologist U. S. ex. ex., (1838–'42.) 1853; and in Am. J. Sci., 1851–'52, vols. 11, 12, 13, 14. Agassiz's Report; C. S. Report, 1851; App. No. 10, and Atlantic Monthly Magazine, May and June, 1862.

evenness to the prevailing depths. The portion of the bank north of the keys is mainly composed of this fine mud, and the north shores of the keys have long shallow mud slopes, some portions of which seem to be solidifying. The ebb tide carries the white water out towards the Gulf Stream, and it is recognized at times many miles outside the reef. Abreast the Tortugas, it is sometimes encountered over thirty miles out. The eddy counter current setting, perhaps, two knots per hour, transports this white water and its suspended detritus to the westward into deepening water, where it has opportunity to settle as it goes, and finally reaches bottom some miles west of its point of formation. Once on the bottom in deep water, below the action of the waves, nothing can remove it. Thus, we have in actual operation a perfect mechanism for triturating the coral and shell growths, and for transporting the comminuted products by wave disturbance, tidal currents, and the eddy currents, to the deep water further west. These agencies being all unquestionably real, and now active, I find no reason to doubt but that they have been the secular causes at work in extending the Florida bank by its western extremity.

A careful examination of the bottoms, as shown on the several Coast Survey charts of the reef, affords signal confirmation of this view. The indications of white mud, white sand, coral, and broken shells, over all the south frontage of the reef, half way to Cuba, to the west around Tortugas and Tortugas bank, and over the entire long slope by which the west end of the Florida bank runs down into depths of a hundred fathoms, and of four hundred and sixty to the southwest, as also the bottoms over the bay of Florida, and westward to the hundred fathom curve, are all consistently indicative that the material of the bottom, thus brought to light, was originally organic, and has been worn down and transported to its present bed by some agencies like those I have described. The entire lack of any bottoms, in the slightest degree tinctured with Mississippi mud, is a perfect refutation of the view presented by Prof. Jos. Le Conte,* that the substructure of the reef, up to the depth where coral growth can begin, is a result of the deposition of Mississippi sediment, carried across the Gulf by the Gulf current. I venture the assertion that these bottoms are inconsistent with any view which does not derive them from the living coral to the east of their present localities. Should it be said that these bottoms only indicate the mere surface character of the sea bed, it may be replied that the great mass of the bank substructure, shooting out to the west into the Gulf, and rising above the Gulf bottom on both sides, as is amply shown by the 10, 20, and 100 fathom curves around the west end of the bank, is unmistakably a special formation subsequent to the general shaping of the Gulf bed. The actual causes now at work in producing coral or shell material, and in grinding and transporting it, must necessarily result in a building up from the bottom along the line of the eddy current to the westward.

Combine with this the fact, that the most effective winds and waves, both of trade and hurricane origin, come in upon the reef from the southeast, and must, therefore, help to transport detritus to the westward and northwest. Moreover, the heavy waves which wear the front face of the reef must work down along the south slope some of the detritus, and must thus aid in forming the actual double slope in which the bottom expands towards the Cuban cliff coast. It is unlikely that the wave actions extend with appreciable effect below, from fifty to a hundred feet, and detritus, once placed below their extreme range, becomes permanently fixed. It is to be observed that the very zone of coral growth is that of wave agitation, and that this must prevent the lodgment of sand and mud on the growing coral, as, after storms, the swell will always last here until the waters are cleared of white mud. This may, perhaps, be quite as effective a cause as increased pressure, in limiting the depth of coral growth to about the same range as that of wave actions.

A careful consideration of such facts as are now ascertained, leads me to the supposition that the growth of the line of keys and the line of reefs is simultaneous by their western extremities. The reef now ends opposite the Marquesas, while the quicksands, Rebecca and Isaac shoals, the Tortugas keys and the Tortugas bank, indicate the extension of the line of keys beyond the line of reefs to the west. It is remarkable that the Tortugas keys are entirely without the solidification so prominent at Key West. Fort Jefferson, resting wholly on sand foundations has settled in all its circuit, and in some portions it has gone down nearly a foot, showing that a deep sand bed has yielded thus much to compression.

In the sheltered waters among these keys, there is an active growth of branching corals, &c., on sand foundations, which are torn up by storms, and tossed on the beaches by the waves to such an extent as to afford the vast mass of concrete materials used in the masonry of Fort Jefferson. There are, however, no extended rock masses, and the fierce vitality of the corals is shown in an active renewal of growth on dead coral sprigs. It is my impression that the mass of materials forming the Tortugas keys and bank has been

* Amer. J Sci., 1857, vol. 23, p. 46.

transported westward by the eddy current, and north and northwest by the south and southeast storms and hurricane waves, from the reef abreast and east of Marquesas. The shaping of the bottom indicates this, and it is apparent that a westward extension of the reef must be slowly taking place. It would thus appear that the keys, at least in their substructure, are, rather, results of the waste from the present line of reefs, than an original and anterior reef growth. Concurring with this process is the growth of coral as now at Tortugas, and in such heads and masses as can find foundations on the sand slopes of the keys.

The solidification of the keys must be a slow and later process, and some thousands of years hence the sand masses of the Tortugas may assume an oolitic structure like that now seen at Key West. The calcareous mud, wherever found, seems to be preparing for solidification, and in a single instance of hard mud from the eastern portion of Key West, I observed what could easily be fancied to be the circles of incipient oolitic segregation. The crystallization of the contained salt soon broke up this appearance, and I never again observed it, though the confirmation of such an observation of oolite ab ovo would have great interest, in consideration of the vast masses of this rock in the earth's crust. That the finely comminuted white sand or mud solidifies into oolite on Key West, is, I think, fully shown by the fossil traces of a peculiar vegetable scum which forms in the lagoons. This scum, as the lagoons dry up, forms a leathery sheet, which is, by drying, split into pieces, which roll up at the edges, sometimes with three or four turns. I have found these rolls fossilized, and looking much like bones; but distinctly showing the spiral curling in the section. Most of the oolitic stone of Key West shows, on weathering its fractures, a series of thin parallel edges, averaging perhaps, a half inch apart, which, being more resisting, rise on the weathered fracture above the softer parts between. These harder layers seem very like fossil scum sheets; but they are found in stones much above the present ponds or lagoons, and it is hard to conceive that they are due to this origin.

Whether a calcareous sand heap, wholly above the water, can solidify into an oolite, is a question hard to answer; but it is only by such agency that I can explain the solid mound of nearly a mile in diameter, which forms the west part of Key West, and is wholly composed of oolite. The summit of this mound is about fifteen feet above high water, and is believed to be the highest point on the whole line of keys. The gale of 1846 raised the water to within seven feet of the apex, and we can readily conceive that, before the reef barrier protected it, a hurricane might have carried up sand to over fifteen feet above ordinary high water.

The oolite, as shown in the wells of Key West, becomes coarser grained and softer in descending. It is so open that the water level of the wells, even in the heart of the key, or half a mile from the sea, fluctuates with the tides, following them at intervals, varying according to position; but averaging, as nearly as I could ascertain, about three hours.

The whole rocky mass of Key West is of this oolite, there being on the weathered surfaces, and occasionally in the mass, a yellowish brown crust, hard enough to receive a polish, and usually less than a quarter of an inch thick. The granite foundations of Fort Taylor, located in water of eleven feet, or less, were laid wholly on rock which was dressed to form the beds by the use of a diving bell. The submarine rock thus examined was much like the shore rock, except that the materials were coarser, rather less compact, and more brecciated. Occasional shell and coral brecciated masses are found on shore, but such traces are quite rare. In removing the beach sand ridge which skirted the whole south shore, I found a limited stratum of about six inches thick and a few rods long, composed wholly of imperfectly comminuted pieces of small branching corals, averaging about an inch long and a third of an inch thick. Otherwise, this whole ridge of about ninety feet wide, and from five to eight feet thick above high water, was composed wholly of sand, much of which was somewhat blackened by vegetable loam from the ridge sand growth.

It is observable that this calcareous sand is scarcely at all blown about by the winds. Once packed, it resists the blasts of northers and hurricanes so completely, that at a few feet from the reverse slope of the beach ridge, we find only marl and rock. It presents a marked contrast in this point, with silicious beach sands, which may, as in Provincetown, Cape Cod, build up hills of a hundred feet high, or be carried for miles in the interior. When dry, and freshly turned up, it blows freely; but it seems never to be moved by winds from the place where the sea deposited it. It is obvious that the sea is washing away the rock along the south side of Key West, while the north mud slope is being augmented. Several hundred feet of the original south beach rock have probably been cut away.

I am indebted to Mr. Chas. Howe, now collector at Key West, for some account of an artesian well, which, in 1839–'40, he sunk to a total depth of one hundred and thirty feet, on Indian key, about eighty miles northeast of Key West. To the depth of fifteen feet the rock was moderately soft and uniform. It there began to be unsound, the drill occasionally going down three or four feet at once. At forty-five feet a gravel bed of about five feet was found, below which the rock became harder, and continued very solid, with a few interruptions of unsoundness, to ninety-one feet, when another gravel bed of several feet was struck, which gave much trouble. Below this the rock became exceedingly hard, and was "tinged with yellow specks." This continued to one hundred and thirty feet, with several interruptions, by "breaking through," the drill once going down five feet at one jump. The water injected to clear the hole brought up pieces the size of pigeon eggs; but, unfortunately, the specimens are now lost. I suppose, from Mr. Howe's verbal account that all this rock was purely calcareous, and that the very hard variety, which was taken to be quartz, was a compact limestone, such as Dana frequently found in the Pacific coral formations. The unsoundness would seem to be due to the interrupted nature of coral beds, whether *in situ*, or formed of coral boulders and sand.

In general, the actual structure of the reef seems to result mainly from three grand activities. 1st. The ceaseless and persistent growth of coral animals and shells, on every appropriate site within their proper range of depth, temperature, and water supply, which growth, by secretion, separates the carbonate of lime from the mass of the ocean and gulf water. 2d. The untiring action of the winds, tides, and currents, (aided by boring shells,) in breaking up, triturating, transporting, and depositing the calcareous products of the zoological process. 3d. Solidification by time, pressure, segregation, and, possibly, by chemical transformation. It is a complex problem to trace the precise operation of these agencies as now at work, and from the present to pass back over the past, until that time when the Florida bank did not exist, and when the shore, from Cape Sable to Fort Dallas, was the open ocean front of south Florida. It seems, however, not too audacious to say, that the agencies now at work present a general type of operation which requires but unlimited time to realize results no less than the formation, not only of the line of keys and reefs, but of that immense substructure which rises from the great original plane of the gulf bed. This plane, along the Cuban coast, was over eight hundred fathoms deep, and it could hardly have been less than three hundred fathoms under the present Tortugas group.

The evidence that South Florida and the base of the bank have recently undergone neither elevation nor depression, to any considerable extent, is quite convincing. There is a remarkable coincidence of general level along the crescent of keys, and no reliable evidence of vertical movement is found on any of them. Prof. Tuomey fancied he saw evidence of elevation through several feet at Key Vaccas.* Believing that he had mistaken boulders for masses *in situ*, I inquired of Assistant Hilgard, whose observations on the keys, during his surveying labors, have been extensive, and he replied, that he has "never seen any coral beds raised *in situ* above the water." He paid some attention to the subject, and remembers those at Key Vaccas, particularly, where he satisfied himself, by using a crowbar, that they were boulders bedded in sand." Prof. Agassiz and Prof. Le Conte report the same impression. During the growth of two hundred and forty miles of keys, there has been, then, no observable change of level. There is a dead fringing reef forming the Punta, or western angle of the entrance to Havana, which seems to have been elevated some six feet, and this is the only case of recent elevation in this vicinity with which I am acquainted.

Prof. Tuome and Prof. Agassiz fully identify the formations at Fort Dallas with the rocks of the keys. The former reports the descent from the everglades, along the Miami river to tide-water, at six to eight feet,† and estimates the height of the ridge, where cut by the Miami, at twenty to thirty feet. Prof. Agassiz estimates the highest shore bluff in this vicinity as not above thirteen feet. The silicious sand which caps the beach ridge around to Cape Sable was probably transported by the waves down the eastern coast. There seems ample reason to suppose that the crescent from Cape Sable, through the Mangrove swamp and Hunting Grounds, to Fort Dallas, and thence north along the coast ridge, is an older reef curve, and that the Everglades and Lake Okeechobee were the interior flats, analogous to Key Biscayne bay, Barnes's sound, and the bay of Florida. The everglades, which cover about 4,000 square miles, have a substratum of coralline limestone of very rough and irregular surface, which is covered by sand, silicious in part, at least, and soft mud of from three to ten feet deep, which covers all but a few points of the limestone, and is overgrown with rank saw-grass. The water overlying this mud is about three feet deep in dry seasons, and rises after rains from two to

* Am. J. Sci., 1851, vol. 11, p. 390.

† Assistant F. H. Gerdes, U. S. Coast Survey, found the surface of the water in the everglades to be 6 feet 2½ inches above low-water mark at Fort Dallas. See Coast Survey Report for 1849, p. 47.

three feet. Lake Okeechobee is but a deeper extension of the Everglades, its depth averaging about twelve feet, and its area being nearly 1,200 square miles. The slight elevation of the Everglade region increases gradually to the north, and the Kissimmee river, which empties in the north margin of Lake Okeechobee, has a southerly course of near a hundred miles, with a current of half a mile to three miles. There is thus a very gentle rise throughout the peninsula, and in the general slope sweeping the north margin of the Gulf and the south Atlantic.

The existence of abundant coral fossils in the tertiary limestone strata of 200 to 300 feet thick, spreading from the Mississippi river around to the Cape Fear river in North Carolina, indicates an ancient coral origin. Prof. Tuomey was led by these evidences to a special examination of the Florida reef, from which he concluded that a continuous process of coral growth, through geologic ages, may have produced this immense coral limestone area. He agrees with Mr. Conrad in calling the Tampa limestones tertiary. In all this space of limestone strata, there is no point whose altitude approaches to equality with the depth of near a mile, found off the Cuban coast. The whole view of this subject leaves a strong impression that no great changes of level have occurred during the formation period, not only of the present crescent of reefs and keys, and the Cape Sable and Fort Dallas crescent, but even in the ancient coral ages, which produced the north peninsula and the coral limestones of the great Gulf and Atlantic slope.

Confirmatory evidence is found in the Bahamas, Salt key, Cuba, and Yucatan reefs, which have attained great expansion, with but slight evidence of disturbance. There are nowhere indications of atoll formation by sinking; but Darwin (Appendix, p. 186) appeals only to elevation, and meets the fact of the singular coincidence of level over many disconnected banks of great area in the West Indies, by supposing that the elevated masses of the banks were uniformly washed away by the sea during their elevation. It is very evident that the remarkable evenness of soundings over these banks is a measure of the depth to which the destroying action of the waves extends in their several localities. The enormous accumulations on the Florida side of the Gulf Stream make it quite rational to suppose that Salt Key bank, for instance, may have resulted from a single nucleal peak, now worn away by the sea, which has afforded a basis for the growth of a fringing reef, and for a wasting action by the waves, whence an outward expansion may have resulted, which, in the course of ages, has accumulated the larger portion of the great truncated cone, now rising from near four hundred fathoms. To what extent the type of action which I have supposed instrumental in producing the Florida bank may be applied in the explanation of other cases of coral reefs, I am not qualified to decide. It can hardly be supposed that such acute and philosophical minds as Darwin's and Dana's would fail to perceive or give proper weight to this familar action of attrition, transportation, and deposition. Dana is very explicit in stating it, and I must, therefore, suppose that a satisfactory explanation of the growth of the Pacific coral islands demands vertical movements unlike any exhibited in the West Indies.

If the views presented are correct, the chronology of the reef becomes stupendous. The most rapid instance of coral growth which I found on the breakwater and foundations of Fort Taylor was a Meandrina of about six inches radius, which was produced within twelve years; or the rate was a half inch per annum. Numerous specimens, derived from stones or piles, whose dates of immersion were known, and whose surfaces were so rapidly coated by vegetation and corrallines that we can safely assume the coral colonies to have been planted soon after immerson, all indicate for the vicinity of Fort Taylor a general rate of growth less than the above. There is no obvious reason why this rate should not be identical with that on the reef proper, as the tidal currents supply ample moving waters, and the temperature is much the same.

Bearing in mind that the living reef belt hardly averages a mile in width, and that this is much interrupted, while the shoal part of the bank averages between fifteen and twenty miles broad, and that this is but a small part of the breadth of the base of this bank on the original bottom, aside from the marl and sand, contributed to the bay of Florida, we are overwhelmed with the immense demand for time. We ought not to suppose less than three hundred fathoms of detritus built upon an average. Moreover, much of this calcareous material is likely to have been more than once used by the coral animals, and some must have been swept into the ocean waters.

Taking the living reef at one-twentieth the breadth of the total bank, the depth of the bank at three hundred fathoms, and the rate of growth at half an inch per annum, we find, aside from other elements of protraction, 864,000 years as the time for building the bank, when considered in cross-section. Considering the growth as being by the west end from Cape Florida to Tortugas bank, a great increase of time is still demanded, so that we can hardly on these data diminish the chronology of the growth of the present Florida bank even to a million years. Appalling as this estimate of time for building appears, it seems impossible honestly to reduce it. If to this be added the time consumed in building the Cape Sable and Fort Dallas crescent, and, again, the inconceivable periods demanded in the growth of the main peninsula, and the limestone strata of the grand slope of the Gulf and South Atlantic, the imagination is appalled, and can only rest on limitless infinities. We can, indeed, readily make an arithmetical approximation to this inconceivable total. The nature of coral reefs limits the growing portion to the outer reef line, and it is a liberal allowance if we suppose a zone of one mile broad, regularly covered with growing surfaces. The solidified masses derived from this zone, wherever deposited, cannot possibly increase in the whole more rapidly than this zone can supply the materials. If we assume these masses at two hundred and fifty feet thick on their northern margin in Alabama, and eighteen hundred feet thick on the present southern boundary, we can safely assume an average thickness of nine hundred feet. The length of the general line of average cross-sections of the growing front cannot be less than two hundred and fifty to three hundred miles, or, at the minimum, a horizontal growth of two hundred and fifty times the growing zone can be assumed. Taking the rate as before, at twenty-four years to the foot, we shall have for the total time $24 \times 250 \times 900$ on the data as stated; or, we find the total period of 5,400,000 years as that required for the growth of the entire coral limestone foundation of Florida. The rate of coral growth is necessarily a rigid one, scarcely subject to fluctuation in any supposable period of time, and the limitation of growth to an outer reef of narrow section is also a necessity of organic habits. If, then, it be a fact that all the limestone mass now considered is of coral origin, the time of coral growth cannot be reduced below the result given above. It is likely to be much greater, as all the elements have been assumed on the side of a minimum chronology, and no allowance is made for growth by the west end, instead of by the front.

The derivation of the substructure of the bank from coral growth makes the seemingly formidable chronology deduced by Prof. Agassiz shrink into insignificance. But is this vastness of time really incredible? Does its shock to our ideas militate against its reality? It is not the method of true philosophy to belittle nature to our own ideal standard; but it is rather our duty to seek facts, without bias or preconception. Looking thus squarely at the facts of the reef, in the aspect I have regarded them, the aggregate of time given seems really and truly insufficient. There are vast possibilities of error in such estimates; but are we not quite as likely to err through our preconceptions of limited chronology as by boldly submitting to the guidance of estimation from actual bases?

Very respectfully, yours, &c.

E. B. HUNT, *Captain of Engineers.*

Prof. A. D. BACHE,
Superintendent Coast Survey, Washington, D. C.

APPENDIX No. 26.

RESULTS OF EXPERIMENTS FOR DETERMINING THE LENGTH OF THE SIX-METRE STANDARD BAR, AND ITS RATE OF EXPANSION BY HEAT.—REPORTED BY ASSISTANT J. E. HILGARD.

The unit of length, to which all distances measured in the Coast Survey are referred, is the French *metre*, an authentic copy of which is preserved in the archives of the Coast Survey office. It is the property of the American Philosophical Society, to whom it was presented by Mr. Hassler, who had received it from TRALLES, a member of the French committee charged with the construction of the standard weights and measures according to the decimal system. This metre is of iron, and was one of the twelve original bars used in the construction of the standard metre by comparison with the *toise*, which had served as unit of length in the measurement of the meridional arcs in France and Peru. It possesses all the authenticity of any original metre extant, bearing not only the stamp of the committee, but also the original mark (·:) by which it was distinguished from the other bars during the operation of standarding. It is always designated as the *committee metre*. A translation by Mr. Hassler of a paper by TRALLES, detailing the process of construction, is to be found in House Doc. No. 299, XXII Congress, 1st session. (See also *Base du Système Métrique*, by DELAMBRE.)

Beside the committee metre, there is in the collection of the Coast Survey another iron metre of special value, having been made by *Lenoir*, the artist who performed the mechanical operations in the preparation of the original metres. It is designated as the *Lenoir metre*, and has been found by accurate comparisons with the committee metre to be shorter than the latter by $0^{m}.0000258$. Both these metres have the same cross-section, being 1.133 inch wide, and 0.270 inch thick; the ends are squared off, and the abutting surfaces are formed by the entire cross-section.

The compensating base apparatus, used since 1845 for the measurement of base lines, which has been described and figured in the Coast Survey Report for 1854, is six metres long, and as it cannot be considered absolutely invariable in length, owing to some of its parts, on which the length depends, being liable in time to a slight wear by contact, it is on every occasion, when used in the field, compared with a standard iron bar of six metres in length, which may be assumed as retaining a uniform length, at the same temperature, so long as its figure and the polish of its ends are preserved unchanged.

In order then to refer the length of the base lines to the committee metre as unit, it is necessary to ascertain with the minutest accuracy, *first*, the difference between six times that unit and the six-metre standard bar, at the temperature of melting snow, (32° Fahr.,) at which the metre has its standard length, and *secondly*, the expansion of the standard bar for every degree of temperature, in order that its true length may be known at the temperature at which it has been compared with the base apparatus.

The standard six-metre bar is 1.393 inch wide, and 0.270 inch thick; the abutting surfaces are squares in the middle of the end sections, formed by cutting away a portion from the width of the bar on each side. It is contained within a wooden box, about eight inches square in cross-section, and is supported upon rollers symmetrically distributed. The ends project slightly, and are covered by brass caps when the bar is not in use.

This standard bar was first cut to length in March, 1847, previous to the measurement of the base line on Dauphine island, Alabama. Preliminary comparisons were made with three times the length of the committee and Lenoir metres, abutted together by means of the micrometer microscopes of the Troughton comparing apparatus, the whole apparatus being in melting ice, by which the standard bar was found to be $0^{m}.0000005$ shorter than that combined length. Putting for the Lenoir metre the value above given, we have as the first approximate result:

$$\text{Standard} = 6^{m} - 0^{m}.0000779.$$

These comparisons were made by the Superintendent, assisted by Mr. Joseph Saxton and Lieutenant A. A. Humphreys, U. S. A. The method employed, in which the terminal lines for optical observations are produced by placing abutting pieces against the ends of the bars, was not thought to admit of the greatest accuracy, and the result was only considered as preliminary.

In order to attain a greater degree of accuracy it was proposed to compare directly the length of six single metres abutted together, with the standard bar, by means of the Saxton pyrometer. This instrument is described in detail, and figured in the Report of the Superintendent of Weights and Measures for 1856.—(Senate Ex. Doc. No. 27, 34th Congress, 3d session, 1857.) It may be essentially described as follows: While one end of the rod to be compared rests against a fixed abutting surface, the other is in contact with a sliding piece, urged against it by a spiral spring; a delicate chain attached to the slide passes around a small drum on the axle of a mirror, mounted in pivots, which reflects into a telescope placed at a distance opposite to it, the graduations of a long scale placed immediately below the telescope. Any difference in the length of the rod causes a motion of the slide, which occasions a turning of the mirror, and a corresponding change of scale reading, in the ratio of the radius of the drum to twice the distance of the scale from the mirror. Thus, if that distance is two hundred inches, and the effective radius of drum and chain one-fifth of an inch, any change in the position of the slide will be reproduced two thousand fold on the scale. The value of the scale divisions are determined by moving the slide by means of a micrometer screw, the value of which has been accurately compared with the standard scale, and noting the corresponding change of scale readings. In the experiments next described the scale was so graduated that one division corresponded to one twenty-five thousandth part of an inch in the length of the rod.

Four additional iron metres were made by Mr. Saxton of the same figure as the committee metre, except that at the ends shoulders were cut, so as to present only a square of the thickness of the bar as abutting surfaces. These four bars, as well as the Lenoir metre, were compared with the committee metre by means of the pyrometer, at temperatures ranging from 31°.8 to 52°.1, by Mr. Saxton in December, 1862. All the metres being of iron, and having very nearly the same expansion, no differences depending upon temperature were apparent in the results. The observations, being combined in such a manner as to eliminate the change of temperature during the times of comparisons, give the following results in scale divisions:

No. 1	= Com. metre	+ 3.6 prob. error ±	0.23
No. 2	=	+ 2.5	0.25
No. 3	=	− 0.6	0.31
No. 4	=	+ 1.6	0.36
Lenoir	=	− 25.4	0.20
Sum	= 5 Com. metres	− 18.3 prob. error ±	0.62

Or the six metres combined are equal to 6 M^c − $0^m.0000186$.

The six metres were now placed in a wooden box similar to that containing the standard bar, supported upon rollers at distances of half metres, and held in contact by spiral springs attached to pins inserted in the top of each bar near its ends. The fixed abutting screw and mirror plate of the pyrometer being, respectively, fixed upon stone piers six metres apart, in the base apparatus shed near the Coast Survey office, two trestles belonging to that apparatus were placed between them as supports for the boxes containing the bars, which were exchanged as rapidly as they could be handled. The observations were only made when the temperature was nearly stationary, and the several observations on each occasion so combined, by alternate means, as to eliminate the effect of the variation of temperature. The pyrometer being a great deal more sensitive than the thermometers employed, about 40 divisions corresponding to one degree of Fahrenheit, no temperature corrections derived from the indications of thermometers can safely be applied. Moreover, the difference of specific heat renders it impracticable to infer with accuracy the temperature of the iron bar from that of the mercurial thermometer.

The order of contact, which was several times changed, the range of temperature, and the results from each arrangement of bars, are given in the following table:

Date.	No. of set.	No. of comp.	Order of arrangement.	Range of temperature.	Standard short.	Probable error.
				° °	*Scale div.*	*Scale div.*
January, 1853	1	27	Com. 1. 2. 3. 4. Len	32. — 49.5	50.3	± .4
March, 1853	2	12	1. Com. 2. 3. Len. 4	36.9 — 42.9	46.4	.7
March, 1853	3	3	1. Com. 2. Len. 3. 4	39.8 — 51.7	41.3	1.3
March, 1853	4	6	1. 2. Com. 3. Len. 4	43.1 — 52.9	55.6	.9
March, 1854	5	18	Com. 2. 4. 1. 3. Len	30.6 — 64.	57.8	.8
			Mean	36.5 — 52.2	50.3	± 2.0

It is apparent from an examination of the above results that the differences are not owing to temperature, but to the changes in the order of arrangement. Taking the mean of the five sets, without regard to the number of observations taken in each, we find the standard 50.3 scale divisions shorter than the six metres, with a probable error of ± 2 scale divisions; and using the values previously stated we have:

Standard = 6 M^c − $0^m.0000697 \pm 0.0000021$.

The experiments were made by Mr. Saxton, and discussed by Mr. Hilgard, under the immediate direction of the Superintendent. The wide range of the results of different combinations, far exceeding the uncertainties of the instruments of comparison, and of the probable irregularity of the abutting surfaces, is to be ascribed to the insufficient means of securing the contacts, (by means of a spring at the top of the bars,) which would admit a slight shifting of the ends consequent upon the jarring to which the boxes are exposed in being lifted to and from the positions in the comparing apparatus.

It was determined, therefore, to make still further comparisons, in which the contact of the six metres was secured by clamps, as shown in fig. 1, plate 49. The clamping screws being of iron, no sensible difference in the strain could arise from changes of temperature. Two new metres, Nos. 5 and 6, with more highly finished square ends, like those of the first four additional ones, were substituted for the committee and Lenoir metres. Their comparison with the committee metre in 1859 and 1860 gives the following result, in scale divisions of the pyrometer, which, since 1856, represent one fifteen-thousandth part of an inch:

No. 5 = M^c + 2.91 div., prob. error ± 0.13

No. 6 = M^c − 3.41 ± 0.14,

whence, by combining with the values of the other four bars, we have for the combined length of the six bars

$$(1 + 2 + 3 + 4 + 5 + 6) = 6\ M^c + 0^m.00000646 \pm 0^m.00000068.$$

In order to expedite the comparisons, Mr. Saxton contrived a *rocking-frame* (fig 2) as support for the boxes containing the bars, which permitted them to be alternately brought into the pyrometer-line with great facility, by being swung or rocked on the supporting points between stops so adjusted as to secure at once the required position.

The experiments, which extended from January 18 to March 28, 1860, were made under the immediate direction of Assistant J. E. Hilgard by W. L. Nicholson, esq., assisted by Mr. Thomas McDonnell, Mr. Saxton making, as heretofore, the changes in the arrangement of bars. The clamp screws were repeatedly loosened and retightened in each order of arrangement. It was intended to make the observations only under the favorable conditions, that the temperature should be near 32°, and nearly stationary, in order that the bars might be presumed to have the same temperature; since the standard bar, having a less cross-section and thickness than the metres, would with a similar exposure change its temperature more rapidly. The thermometers, of which three were in each box, would serve only approximately as guides, as previously explained, and the changes in scale readings were relied on as indications of the changes of temperature. A large number of observations were thus taken that are not used in obtaining the result, otherwise than as furnishing a criterion for those that are to be admitted, and increasing general confidence in the result.

Thus 13 sets of comparisons at increasing temperatures give a mean difference of......	34.75 div.
24 sets of comparisons at decreasing temperatures give a mean difference of......	41.08
Mean..	37.91
12 sets of comparisons at stationary temperatures give a mean difference of......	38.82
The indiscriminate mean of the 49 sets is....................................	38.85

It will be observed that the standard appears longer at increasing and shorter at decreasing temperatures, as was to be expected. In discussing the results the observations were grouped by means of diagrams, exhibiting at once the relative changes in the bars, and the following 24 sets were selected as being unexceptionable as to change of temperature during the experiments. The reference numbers in the table are those used in the general abstract of the observations, which is not inserted here.

Table of comparisons of standard bar with six metres.

No. of set.	Diff.	No. of observations.	Mean of Thermometer.		No. of arrangement.	Mean difference by arrangements.
			Bar.	Metres.		
	div.		°	°		div.
2	39.8	20	36.3	36.3	2	40.05
3	40.3	9	38.2	38.1	2	
16	38.1	6	34.6	34.5	5	38.65
17	39.2	14	31.9	32.0	5	
20	37.8	6	32.5	32.8	6	39.10
22	40.4	6	33.6	33.9	6	
23	40.6	6	37.3	37.6	7	39.30
24	38.2	6	36.7	36.7	7	
25	39.1	6	32.1	32.1	7	
27	34.7	6	32.1	32.0	8	36.00
29	37.3	6	37.1	37.1	8	
32	42.4	6	37.8	38.0	9	42.40
37	35.6	6	39.0	39.1	10	37.67
38	36.6	6	38.8	39.0	10	
39	40.8	6	35.3	35.9	10	
40	37.2	6	35.5	35.6	11	38.05
41	38.9	6	38.4	38.7	11	
43	37.7	6	42.7	42.9	12	37.55
44	37.4	6	36.3	36.5	12	
45	39.3	6	40.7	41.0	12	
46	35.8	6	43.8	43.8	12	
47	39.6	6	35.7	35.8	13	39.90
48	39.8	6	36.0	36.4	13	
49	40.3	6	38.1	38.5	13	
Mean.	38.58		36.7	36.8		Mean..... 38.87

In the preceding table we have:

12 sets, with apparently stationary temperatures, give.......................... 38.82
4 sets, with slightly increasing temperatures, give.......................... 38.27
8 sets, with slightly decreasing temperatures, give.......................... 38.50

In each set the number of comparisons is 6, except in three cases, where it was increased without improving the result. Ten out of thirteen different orders of arrangement or *positions* of the six metres are preserved. The mean temperature of the experiments, which were generally made about eight o'clock in the morning and ten in the evening, is 36°.7, ranging between 32° and 44°.

The indiscriminate mean difference is............ 38.58 ± 0.26
With the probable error of any single result...... ± 1.26
The mean by positions is...................... 38.87 ± 0.37
With the probable error of any single result...... ± 1.17
The weighted mean of positions becomes......... 38.7 ± 0.3

Which has been adopted.

The value of one scale division having been found, by very careful observations, to be $\frac{1}{14950}$ inch $= 0^{m}.000001699$, we have finally:

$$\text{Standard} = \Sigma\ (1.2.3.4.5.6) - 0^{m}.00006575 \pm 0^{m}.00000051$$
$$\Sigma\ (1.2.3.4.5.6) = 6\ M^{c} + 0^{m}.00000646 \pm 0^{m}.00000068$$
$$\text{Standard} = 6\ M^{c} - 0^{m}.00005929 \pm 0^{m}.00000085$$

The last line gives us the relation of the six-metre standard to the committee metre with a degree of precision which apparently leaves nothing to be desired. The probable error ascribed to it is but one thirty-thousandth part of an inch, and we are safe in assuming that it is not actually in error by one ten-thousandth part of an inch. This conclusion is fully borne out by other experiments about to be detailed. That the standard is apparently longer than indicated by former experiments is probably the result of the more effectual manner of making the contact of the six metres, and securing the straightness and rigidity of the combined bar. In all these experiments the standard bar was in its own box, and in every respect precisely under the same conditions as when used in comparisons with the base apparatus.

As it became necessary from time to time to take the standard bar into the field for comparison with the base apparatus, a copy of the same was made in February, 1855, for preservation at the office. This copy, or standard No. 2, is in every respect similar to the original, except that it was subjected to a moderate process of *annealing*, after being hammered and planed, to guard against any permanent change of length from variations of temperature; it has therefore a bluish color, while the original is of the metallic color of iron.

At that time the two bars were both placed in the box of the copy, and clamped together at one end, resting on the same rollers. On the 15th of February, 1855, fifteen comparisons were thus obtained, agreeing well with each other, at temperatures ranging from 34°.5 to 41°.4, which gave standard No. 1 shorter than standard No. 2 by $0^{m}.0000323$.

The observations are sufficiently accordant, but as the bars were not entirely under the same conditions as when used with the base apparatus, it was subsequently thought best to make further comparisons. Standard No. 2 was therefore compared in March, 1858, with the six metres combined, in the same manner as above described, and subsequently with standard No. 1, in April, 1860.

The former comparisons, consisting of eighteen sets, in three different arrangements of the single metres, at a mean temperature of 35°.6, give:

$$\text{Standard No. 2} = \Sigma\ (1.2.3.4.5.6) - 10.4 \text{ div.} \pm 0.4$$

The comparisons of standard No. 2 with No. 1, comprising sixteen sets, each of six comparisons, made at different times, but at the comparatively high mean temperature of 48°.2, give:

$$\text{Standard No. 2} = \text{Standard No. 1} + 26.6 \text{ div.} \pm 0.35,$$

which, combined with the above, gives for the difference between the standard No. 1 and the six metres joined 37.0 scale divisions, while direct comparisons gave us 38.7. The outstanding difference might very properly be distributed among the three values, which would severally be changed by only $\frac{1}{25000}$ part of an inch. Still, as there is a difference of 12° in the temperature of the comparisons, a very slight variation in the expansion of the two bars would account for the difference, and it seems better for the present to adopt the results of the direct comparisons with the six metres, which give:

$$\text{Standard No. 1} = 6\ M^{c} - 0^{m}.00005929 \pm 0^{m}.00000085$$
$$\text{Standard No. 2} = 6\ M^{c} - 0^{m}.00001767 \pm 0^{m}.00000096$$

Expansion of standard bar.—The next problem was to ascertain by direct experiment the rate of expansion of the standard bar from 32° to about 96°, the extreme limits between which it is likely to be used in the measurement of base lines. The conditions to be fulfilled are, *first*, the establishment of two invariable points, by reference to which the changes in length of the bar can be measured, and which must not be affected by the variations of temperature to which the bar is exposed; and *secondly*, the maintenance and exact ascertainment of various temperatures of the bar under trial.

In order to attain the first condition of fixed points of references the experiments were made (by permission of the secretary) in the basement of the Smithsonian Institute, where the temperature is only subject to small and gradual changes. Large dressed slabs of marble, four inches thick, were there laid upon the ground. which was levelled off accurately, without its natural condition being disturbed by packing or ramming. On these marble slabs, about twenty feet apart, the two blocks for the support of the abutting screw and the mirror piece of the pyrometer were placed. They were eight inches high and twelve inches square on the base, laid in a very thin layer of hydraulic cement. The plates of the abutting screw and mirror piece were fastened by screws to plugs of lead in the top of the stone blocks.

In order to control the temperature of the bar, and to measure it by means of thermometers, it was immersed in sperm oil, contained within a wooden box of seven by eight inches in cross-section, with its walls two inches thick, and heated or cooled by means of hot or cold water circulating through iron pipes disposed in the box as shown in fig. 3. The same diagram shows the relative positions of the standard bar and the thermometers, while fig 5 exhibits the general arrangement of the apparatus. The heating pipes pass out at the side of the box, and are connected by pieces of flexible tubes with other pipes, well covered with felt, that pass into an adjoining room, where the water contained in them can be heated by means of a row of gas-burners, or cooled by means of ice, or salt and snow, in a tub, with which they communicate. Connected with the system of pipes is also a hand pump, for promoting a steady circulation of the water. The connexion by flexible tubes prevents any strain on the box from expansion of the pipes outside, and the inside system of pipes is suspended by swinging hooks, so as to move freely under the influence of temperature. All these precautions to insure stability were attended with a very satisfactory result.

As seen in the plate, there were five thermometers inserted in the top of the box, with the stems and scales inclined, so as to be easily read. The bulbs were very near the bar—almost or quite in contact with it. But the fact of both the bar and thermometers being immersed in a large quantity of fluid, (about fifty-six gallons of sperm oil,) the aggregate capacity for heat of which bore a very large proportion to that of the bar, was relied on to secure the same temperature to both.

The contact between the ends of the bar and the pyrometer was effected by means of small steel pistons, one-fifth of an inch in diameter and three inches long, sliding freely in a packing box, as seen in fig 4. The groove near the outside end of the pistons prevents the small leakage of oil from interfering with the contact. The pistons are held against the bar by means of spiral springs. In order to assist in estimating the average temperature of the pistons a thermometer was inserted in each of the packing boxes, in contact with the piston, as shown in the diagram. This estimation is the least satisfactory part of these experiments, and although the uncertainty in the results arising from that cause is very small, yet it was thought well to devise a method by which it could be entirely removed. This consists in repeating the experiments on the pistons alone, in contact with each other, in a short box, by which the actual effect upon their length of the changes of temperature of the oil would be ascertained, and could be deducted from the observed effect upon bar and pistons combined.

The plans for these experiments were devised by Assistant Hilgard, and the observations were made under his immediate direction by Mr. W. L. Nicholson, assisted at times by Messrs. J. R. Gillis and T. McDonnell.

As the whole change of length to be observed amounted to about one-tenth of an inch, which is much beyond the reach of the scale, the abutting screw necessarily formed the essential part of the measure. It had been carefully compared with the standard Troughton scale, (June 23, 1857,) and found one turn equal to 0.01912 inch $\pm$ 0.00004.

The value of the pyrometer scale was repeatedly determined while the experiments were in progress, and one turn of the screw was found to be equal to 308.87 $\pm$ 0.35 scale disvisions, whence 1 div. = 0.0000619 inch.

The thermometers were made by Mr. Tagliabue in the shape shown in fig. 3. The length of one degree Fahrenheit is about one-eighth of an inch. They were thoroughly and repeatedly compared with a standard by Greiner, and one by Würdemann, both of which were tested at the freezing and boiling points. The latter was found to require no correction, and the fact being known that in its construction the uniformity of its calibre had been ascertained by micrometric measurement, it was adopted as the standard of comparison for the table of corrections to the five thermometers in oil. These corrections vary but about a quarter of a degree, and are the same at the extremes of the temperatures used; hence they have only a very slight influence on the resulting rate of expansion.

The course of the experiments was this: After recording the indications of the mirror screw, and the nine thermometers, five in the oil, two attached to pistons, and two on the stone blocks, the oil being at the natural temperature of the apartment, the gas-burners were lighted under the pipe in the adjoining room, and the pump started. By this means the oil could be heated about sixty degrees in ten hours, readings of the pyrometer and thermometers being taken every half hour.

After a high temperature of from 90° to 100° had been reached, and maintained for some time, the apparatus was allowed to cool slowly, and the readings were taken less frequently. When cooled down to the temperature of the room, about 46°, which required thirty-six hours, ice was introduced into the tub, and the cold water caused to circulate in the pipes. It was found, however, that the temperature could not be reduced below 39° by this means. On one night, therefore, March 14, 15, the windows were opened to allow the whole space to cool, by which means the indications of the pyrometer were temporarily disturbed, vitiating the observations from March 13th to 16th. Snow and salt were subsequently used for cooling the water, and a minimum of 34° was thus reached in the temperature of the oil.

Upon the observations being graphically represented, it was seen that in the process of heating the thermometers went ahead of the bar in temperature by about half a degree in the maximum, while in the slow cooling the most perfect correspondence was observed in both, within the limits of the instrumental indications. The results of the cooling only have, therefore, been made use of in deriving the rate of expansion. The use of the ascending series would not change the result, but would make it appear less certain than it really is. The diagram, fig. 6, shows the several series of observations, from which the following results are derived.

Series A, February 22 to February 25, expansion for 1° Fahr....................24.54 scale div.
B, February 27 to March 2, expansion for 1° Fahr........................24.44 scale div.
C, March 16 to March 20, expansion for 1° Fahr..........................24.45 scale div.
D, April 3 to April 6, expansion for 1° Fahr............................24.42 scale div.

In the mean we have for the expansion of the six-metre standard bar for 1° Fahr. 24.46 scale divisions = 0.00003846 metres, with a probable error of about ± 0.00000010 metres from all sources. Hence the resulting co-efficient of expansion for 1° Fahr. is 0.00000641 ± 0.00000002.

In the computation of the foregoing results the following supposition has been made in regard to the temperature of the pistons: The average temperature of the exposed fifth part of each piston has been assumed to be the mean between the attached and external thermometers, and the average of the other four-fifths the mean of the attached and interior thermometers. This supposition may be slightly too low, but any other probable assumption would not sensibly vary the above results. Thus it has been estimated that if we were assign to the pistons temperatures higher by one-half the difference between the adopted ones, and those of the bar, a supposition certainly too high, the resulting change would be within the probable error above assigned. The plan of measuring the expansion of the pistons independently, above marked out, has as yet been only partially executed. It is designed to push it to the same degree of accuracy as the preceding experiments, in connexion with those on the expansion of standard No. 2, which still remain to be made.

In order to show the stability of the apparatus, the mean readings in the scale in the several series have been reduced to the same temperature, with the following result:

Series A	1731.8	△ = 0.4
B	1729.3	2.1
C	1730.9	9.5
D	1733.2	1.8
Mean	1731.4	1.2

showing an average variation of only 1.2 scale divisions, or $\frac{1}{13000}$ part of an inch, during six weeks, which may be conceived as representing an uncertainty of one-twentieth part of a degree of the thermometer in the temperature assigned.

In conclusion it may be stated, that from the experiments related, the length of the standard six-metre bar, at any temperature between 32° and 100°, can be assigned in terms of the committee metre, with an uncertainty of less than one ten-thousandth part of an inch, the following being the values:

Standard bar = 6 M^c — 0^m.00005929, at 32° Fahr.

Co-efficient of expansion = 0.00000641 for each degree of Fahr.

It will be observed that this rate of expansion is slightly less than that usually found from experiments between 32° and 212°, which is generally given as 0.0000067. It is possible that such differences may be found in different pieces of iron, but the less value for the low range of temperature is quite consistent with the fact that the rate of expansion increases with the temperature.

APPENDIX No. 27.

COMPARISON OF THE EFFECT OF ATMOSPHERIC MOISTURE ON THE DIMENSIONS OF DIFFERENT KINDS OF DRAWING PAPER.

In the Coast Survey report for 1861, the result of some experiments were given, showing that a new preparation of paper, called "parchment paper," recommended as a substitute for common drawing paper for maps, on account of its great strength and durability, is not preferable for that purpose, being greatly more affected in dimensions by atmospheric changes.

New samples of parchment paper having been submitted, which were considered an improvement on the former, similar experiments were again made, the details being attended to, as before, by Mr. E. Hergesheimer, of the drawing division.

The papers compared were common antiquarian drawing, thick parchment and thin parchment paper; each kind was cut into strips, lengthwise and transversely, two metres in length.

The greatest changes observed during six months are given in the following table:

LENGTHWISE STRIPS.				TRANSVERSE STRIPS.			
Months. 1862.	Backed antiquarian.	Thick parchment.	Thin parchment.	Months. 1862.	Backed antiquarian.	Thick parchment.	Thin parchment.
	Millimetres.	*Millimetres.*	*Millimetres.*		*Millimetres.*	*Millimetres.*	*Millimetres.*
May	9.6	14.6	19.7	May	8.9	8.7	13.2
June	11.1	15.5	20.9	June	10.3	9.6	15.0
July	6.1	7.9	7.9	July	4.7	4.0	6.5
August	10.9	14.1	15.3	August	9.8	8.7	12.7
September	10.1	13.1	14.0	September	9.5	8.9	11.6
October	6.6	13.1	16.2	October	7.4	8.7	13.5
Means	9.0	13.0	15.7	Means	8.4	8.1	12.1
Ratios	1.00	1.44	1.74	Ratios	0.93	0.90	1.34

It will be seen that the parchment papers change more than the backed drawing paper, under the same atmospheric influences, and unequally, while the drawing paper is acted upon nearly the same in both directions—an important advantage, since the proportions of the map are at least preserved, although the dimensions are subject to change.

APPENDIX No. 28.

Coast Survey parties engaged in military departments, or on duty with blockading squadrons, during the working season ending with June, 1862.

No.	Section.	Locality.	Under immediate command of—	Names of assistants and aids.	Service.
1	III.	Accomac county, Va	General H. H. Lockwood	A. M. Harrison, assistant	Topography & hydrography.
				H. W. Bache, aid	do ... do
2	...do...	Accomac county, Va	General H. H. Lockwood	Charles Hosmer, aid	Topography
				F. A. Lueber, aid	do
3	...do...	Yorktown, Va., and the peninsula above.	General George B. McClellan, (General A. A. Humphreys.)	F. W. Dorr, sub-assistant	Topography
				J. W. Donn, aid	do
4	...do...	York river, Va., and Pamunkey and Mattapony rivers; steamer Corwin.	Admiral L. M. Goldsborough	T. S. Phelps, Lieut. commander U. S. N.	Reconnaissance, and naval duty with boats and armed crews.
				Charles Junken, draughtsman	
				S. B. Minor, master's mate	
				W. D. Du Barry, master's mate	
				W. Buttrick, master's mate	
				E. L. Taylor, master's mate	
				E. L. Brady, first engineer	
				R. B. Swift, second engineer	
5	...do...	Fredericksburg, Va	General Irvin McDowell, (Col. J. N. Macomb.)	C. M. Bache, sub-assistant	Topography
				T. W. Robbins, aid	do
6	...do...	Manassas Junction, Va	General Irvin McDowell	H. L. Whiting, assistant	Topography
				C. M. Bache, sub-assistant	do
7	...do...	Potomac river, Maryland and Virginia; schooner Cobb and schooner Dana.	By request of Navy Department.	Professor Fairman Rogers, act'g assistant	Triangulation
				F. P. Webber, sub-assistant	do
				Charles Ferguson, sub-assistant	do
				Charles Hosmer, aid	do
				H. L. Whiting, assistant	Topography
				A. W. Longfellow, assistant	do
				John Mechan, sub-assistant	do
				R. E. Halter, sub assistant	do
				Charles Hosmer, aid	do
8	IV.	Oregon inlet and Neuse river, N. C; schooner Bancroft.	General A. E. Burnside, (Gen. J. G. Foster.)	Henry Mitchell, assistant	Hydrography
				A. S. Wadsworth, assistant	do
				Edward Cordell, draughtsman	do
				C. P. Dillaway, aid	do
9	...do...	Beaufort harbor, North Carolina; schooner Joseph Henry.	By request of Navy Department.	Albert Boschke, acting assistant	Hydrography
				Charles Heyne, draughtsman	do
				E. H. Courtenay, aid	do
10	V.	Port Royal, S. C., and other harbors of South Carolina, and of Georgia; steamer Bibb, schooner Caswell, schooner Arago.	Admiral S. F. DuPont	C. O. Boutelle, assistant, in gen'l charge.	Hydrography
				E. Willenbucher, draughtsman	do
				Robert Platt, executive officer	do
				C. French, engineer	do
				C. H. Boyd, aid	do
				J. S. Bradford, aid	do
				C. L. Bixby, aid	
11	...do...	Broad and Beaufort rivers, Skull creek, and Calibogue sound, (inland passage,) S. C., and Stono river.	Admiral S. F. DuPont	W. S. Edwards, sub-assistant	Hydrography
12	...do...	Islands above Beaufort, S. C.	Admiral S. F. DuPont	W. H. Dennis, sub-assistant	Topography
13	...do...	Port Royal island, S. C	General I. I. Stevens	Cleveland Rockwell, aid	do
				W. W. Harding, aid	do
14	VI.	Florida reefs and keys	General J. M. Brannan	George Davidson, assistant	Hydrography
				W. B. McMurtrie, draughtsman	do
				A. Strausz, draughtsman	do
				A. R. Fauntleroy, aid	do
				C. T. Iardella, sub-assistant	Topography
				C. Fendall, sub-assistant	do
				L. L. Nicholson, aid	do
				G. A. Fairfield, assistant	Triangulation
				A. T. Mosman, aid	do
15	VIII.	Mississippi river and Mobile bay; steamer Sachem.	Admiral D. G. Farragut, (Com. D. D. Porter.)	F. H. Gerdes, assistant	Triangulation, topography, and hydrography.
				J. G. Oltmanns, sub-assistant	
				J. S. Harris, acting assistant	do
				T. C. Bowie, aid	
16	...do...	St. Louis, Missouri	General H. W. Halleck	John Mechan, sub-assistant	Topography
17	...do...	St. Louis, Missouri	(Col. R. D. Cutts.)	R. M. Bache, assistant	do

APPENDIX No. 29.

Occupation of parties on the Atlantic coast and in military departments, between June and November, 1862.

No.	Section.	Locality.	Under immediate command of—	Assistants and aids.	Service.
1	I.	Passamaquoddy bay, Maine		W. H. Dennis, sub-assistant	Topography
2	...do..	Coast of Maine		F. P. Webber, sub-assistant	Triangulation
3	...do..	Frenchman's bay, Maine		Cleveland Rockwell	Topography
4	...do..	Isle au Haut bay, Maine		G. A. Fairfield, assistant	Triangulation
5	...do..	Penobscot bay, Maine		S. C. McCorkle, sub-assistant	Triangulation
6	...do..	Tennant's harbor, &c., Me.		C. Ferguson, sub-assistant	Topography
7	...do..	Wiscasset bay, &c., Maine		F. H Gerdes, assistant	Hydrography
				C. Fendall, sub-assistant	...do
				T. C. Bowie, aid	...do
8	...do..	Passages between Sheepscot and Kennebec rivers, Me.		C. T. Iardella, sub-assistant	Topography
9	...do..	Casco bay, Me., (upper part)		A. W. Longfellow, assistant	Topography
10	...do..	Casco bay, Maine		Edward Cordell, acting assistant	Hydrography
				L. L. Nicholson, aid	...do
				J. A. Sample, aid	...do
11	...do..	Environs of Portland, Maine	For use of Engineer department	F. W. Dorr, sub-assistant	Topographical reconnaissance
				H. W. Longfellow, aid	
12	...do..	Narragansett bay, R. I.	Navy Department	H. L. Whiting, assistant	Topography & hydrography
13	...do..	Narragansett bay, R. I.	Navy yard commission	A. M. Harrison, assistant	Topography
				H. W. Bache, aid	...do
				F. A Lueber, aid	...do
14	...do..	Narragansett bay, R. I.	Navy yard commission	Henry Mitchell, assistant	Hydrography
				C. P. Dillaway, aid	...do
				P. Frazer, jr., aid	...do
15	II.	Coast of Connecticut		A. D Bache, superintendent	Primary triangulation, latitude, azimuth, and magnetic observations
				G. W. Dean, assistant	
				Edward Goodfellow, assistant	
				R. E. Halter, sub-assistant	
				S. H. Lyman, aid	
				H. M. De Wees, aid	
16	...do..	Connecticut river		W. S Edwards, sub-assistant	Triangulation
				F. H. Dietz, aid	
17	...do..	Long Island, N. Y		H. L Whiting, assistant	Topography
				J. W. Donn, aid	...do
18	...do..	Hudson river, N. Y		Edmund Blunt, assistant	Triangulation
				A. T. Mosman, aid	...do
				A. R. Fauntleroy, aid	...do
19	...do..	Hudson river, N. Y		John Mechan, sub-assistant	Hydrography
				W. W. Harding, aid	...do
				C. S. Hein, aid	...do
20	...do..	Coast of New Jersey		John Farley, assistant	Triangulation
21	...do..	Delaware river	For Navy and War Departments	George Davidson, assistant	Hydrography
22	III.	Williamsport, Maryland	General W. B. Franklin	John Mechan, sub-assistant	Topography
				Charles Hosmer	...do
				W. W. Harding	...do
				F. A. Lueber	...do
23	...do..	Bladensburg, Maryland	Colonel J. N. Macomb	C M. Bache, sub-assistant	Topography
				T. C. Bowie, aid	Topography
24	...do..	Defences of Washington	General J. G. Barnard	J G Oltmanns, sub-assistant	Topography
25	...do..	Fairfax county, Virginia	Colonel J. N. Macomb	T. W. Robbins	Topography
26	VIII.	St. Louis, Missouri	Colonel R. D. Cutts	R. M. Bache, assistant	Topography

APPENDIX No. 30.

REPORT OF ASSISTANT HENRY MITCHELL ON HYDROGRAPHIC SURVEYS AT OREGON INLET AND IN NEUSE RIVER, MILITARY DEPARTMENT OF NORTH CAROLINA.

BOSTON, MASS., *June* 9, 1862.

DEAR SIR: The instructions which I received from you on the 25th of March last directed me to report to Commodore L. M. Goldsborough, U. S. N., and Major General A. E. Burnside, U. S. A., for the execution of certain hydrographic surveys in the military department of North Carolina. I accordingly proceeded to Hampton roads and communicated with the flag-officer, from whom I received an order on Captain Rowan, commanding the naval fleet in that department, for the captured steamer Albemarle, to be used for hydrographic purposes at Oregon inlet.

By the first transport I left for Hatteras inlet, and thence went directly to Newbern, where, without delay, I reported to the commanding general, and presented my order to Captain Rowan.

Greatly to my disappointment, I found that the steamer Albemarle lay at the bottom of the Neuse river, having been run down by a large vessel a few days before my arrival. I was, however, assured that, after several days' delay, I could be furnished with another steamer suitable for my work, but that circumstances prevented her immediate delivery into my hands.

Against all delays I had been especially cautioned by yourself and the flag-officer. I therefore had recourse to other expedients suggested in your instructions. I went on board of the Coast Survey schooner Bancroft, then in charge of Assistant A. S. Wadsworth, and requested the use of his vessel and his own co-operation in our enterprise. Mr. Wadsworth, with his wonted zeal and spirit, at once assented, and united his party with my own.

I found the Bancroft in good order, and as well adapted for my work as any sailing vessel. Her boats, however, were quite unsuited for sounding among breakers, and I was obliged to apply to Brigadier General Foster, military governor of Newbern, for the use of one of the life-boats. The cheerfulness with which the governor supplied this and other wants of my party convinced me that he still retained that lively interest in the Coast Survey which characterized his course while attached to our service years ago.

Thus, happily sped by fortune, we left Newbern for the scene of our work, without delay.

On our way up the sound, we ran in over the Hatteras swash and loaded up the schooner with spar buoys and sinkers, in order that we might possess the means of marking out all the channels and shoals as fast as we surveyed them.

On reaching Oregon inlet, April 14, our first care was to make a hasty examination of the whole ground and write out a sketch of the inlet and swash, setting forth such prominent facts relative to the depths of the channels and the dangers of the bar as should enable the military and naval authorities to decide upon the usefulness of this avenue.

Having sent off several copies of this sketch, we at once applied ourselves to the systematic survey of the outer bar and approaches. By the 27th of the month we had sounded out the bar and lower channels of the inlet, and placed three buoys in proper positions for guiding vessels in from sea. We had also set up ranges on shore, which were unmistakable, and sent to the commanding general full and complete sailing directions for entering the basin from the ocean.

For the swash no sailing directions could possibly be written; the channel being some five miles in length, and very tortuous. This portion of our survey was exceedingly slow and tedious. We could work, accurately, only about the time of slack water, and even at such times the gusts of wind and the frequent grounding of the boat caused us to lose many lines. Among such rapid tidal currents a narrow channel can only be developed by running a multitude of short lines and coming to anchor, for the determination of position, at each change of course.

Stakes had been placed upon the swash by one of the government pilots before our arrival; but their number and positions had to be changed somewhat, as our survey defined the course of the channels. We placed a striped buoy to mark the approach to the swash from the sound side, and erected a conspicuous tripod at the entrance to the slue-way.

In forwarding the chart of Oregon inlet, I must call your attention to the movements of the beaches and shoals, which have taken place since our previous survey. While, upon the one hand, the opening through the beach of Bodie's island has shifted to the southward, you will observe, upon the other, that the channel over the bar has moved in the opposite direction; that it now opens to the *northward*, instead of leading out to the southeast, as formerly. The reason why this channel is now more shallow than formerly is obviously to be found in this unfavorable change of the course.

From considerable experience in the study of waves upon the open coast, I have come to the conclusion that there is everywhere a *prevalent*, if not a *permanent*, angle at which the larger class of swells or rollers strike the general shore-line. I have observed, also, that the current flowing from an inlet is broken up or turned aside by coming in direct collision with the waves of the ocean, so that the stream inclines to escape along the trough of the sea, or in its wake.

In the bend below Cape Hatteras, where the "ground swell," propagated from the northeastward, drives obliquely upon the coast, the outflowing stream from an inlet may pursue almost a direct path, and yet find its way along the trough of the sea, receiving no sudden check from the waves; but preserving for a gradual decline its scouring power, it may sweep its burden of sand far out from the coast, and distribute it uniformly over a great area.*

The conditions at Hatteras inlet are favorable for the maintenance of a good bar, while those at Oregon inlet are quite opposed to this advantage.

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* The popular term "*ground swell*" distinguishes from all others those larger waves, which, *feeling the ground*, have a perceptible *motion of translation*, when in three to five fathoms of water.

At Bodie's island the swell strikes the coast from the northeast. This direction, however, is not so nearly normal to the shore-line, but that a channel, leading out along the south beach, may have a decided advantage over that in any other direction.

Our work in the vicinity of Bodie's island was completed on the 14th of May, and, by the 20th, the chart was brought up, so that tracings were made and presented to Major General Burnside and Commodore Rowan. A copy was also prepared and sent through your hands to Flag-Officer Goldsborough.

In the course of this survey, Mr. Wadsworth set up and determined the numerous signals, and made an interesting sketch of Fort Oregon, a fine earthwork built by the enemy on the south side of the inlet, and of other objects.

The accomplished draughtsman of the party, Mr. Edward Cordell, of the Coast Survey, occupied one of the deserted houses on Bodie's island, where he plotted each day's work done by me in the boats. As the plotting kept up with the field-work, we were able to watch our development of the channels, and the better fill in the details. Several blind channels had to be followed up with soundings till their bulkheads were found and located on our map.

Messrs. T. E. Ames and C. P. Dillaway were principally employed with the sextant; the former accompanied me in the boat, while the latter developed the shore-line.

Mr. Sengteller accompanied the party as tidal observer. His conscientiousness of character gives value to the remarkably neat records which he kept. I should have been better satisfied if I could have furnished him with an assistant, so that the observations could have been kept up night and day; but this was impossible.

Comparative tidal observations for the determination of the *inclined plane of reference* were made by Mr. Dillaway at different points on the swash. I plotted these, and ascertained that the tide wave enters Oregon inlet with a mean range of two feet; that it suffers a gradual *degradation* as it advances towards the sound, so that it becomes insensible upon a gauge at the outer edge of the swash.

I found, from a study of the current epochs, that I could assume, without any considerable error, that the surface of the sound lay at the *mean level of the sea*. I therefore decided to refer my soundings to an inclined plane, extending westward from the bar and rising one foot in five miles. The foot of this plane *mean low water at the inlet*, was computed from the observations made during a semi-lunation; its position was referred by levellings to the bottom or floor of the new light-house cistern, (the most permanent object we could find,) and ascertained to be 2.10 feet below this bench.

The mean level of the sea, which may be so easily and accurately determined from a few days' observations, and which is a plane common to all places upon the coast, would seem to be the most natural plane of reference for a hydrographic survey; but the use of this upon our charts would leave to the inexperienced navigator the task of making the very calculations which we would avoid; for he desires to know the *low water depths* along the channel ways, and possesses but a vague notion of the motion and character of the tide wave.

Before quitting the subject of Oregon inlet, I would mention that we found the Bodie's island light tower in ruins; it was blown up by the enemy. For what purpose this wanton act was committed it is hard to divine. The pilots testify that this light had often misguided coasters, who mistook it for Hatteras.

By special request, I detained the schooner Bancroft and party for about a week, in order to examine the Neuse river middle ground—a bad shoal, five to nine miles below Newbern, upon which several gun-boats and transports had grounded.

Upon this shoal we placed three heavy spar buoys, within sight from each other, marking the upper end, middle, and lower end of the bank, along the southern side.

The least water found by us, in our rapid reconnaissance, was five feet upon the upper lobe, and eighteen and a quarter feet upon the lower knoll. There are several slues which cross the bank, connecting the channels on either side.

At the time of our examination the river was high; the least water along the thread of the southern channel being eleven feet.

We furnished, for the use of the military department, sketches showing the positions of our buoys and the soundings we had made.

Major General Burnside has done me the honor to make me bearer of a letter to yourself, commending our services.

Very respectfully, yours,

HENRY MITCHELL, *Asst. U. S. Coast Survey.*

Prof. A. D. BACHE, LL. D., *Sup'd't U. S. Coast Survey.*

APPENDIX No. 31.

ORDERS, ETC., FROM ADMIRAL S. F. DUPONT, RELATIVE TO THE SERVICE OF COAST SURVEY PARTIES FOR THE SOUTH ATLANTIC BLOCKADING SQUADRON, ON THE COAST OF SOUTH CAROLINA AND GEORGIA.

FLAG-SHIP WABASH, *Port Royal Roads, November* 5, 1861.

SIR: I have to thank you for your efficient assistance and co-operation in bringing the heavy ships of the squadron under my command, and transports, into Port Royal roadstead; and I shall take pains to inform the Superintendent of the Coast Survey that your services have met my cordial commendation.

I have now to request that you will be pleased to make a hydrographic reconnaissance of the channel between the North Breaker and Fishing Rip, placing such buoys on the latter as will make it safe to pass the southeast or northwest points of the shoal, or to cross it with gunboats at low water.

I have the honor to be, sir, your obedient servant,

S. F. DUPONT,
Flag-Officer, Com'g South Atlantic Blockading Squadron.

CHARLES O. BOUTELLE, Esq.,
Assistant U. S. Coast Survey.

FLAG-SHIP WABASH, *Port Royal Harbor, S. C., January* 9, 1862.

SIR: It has occurred to me that we should have a better understanding as to your operations with the Coast Survey force, and I desire to make the following suggestions:

I am expecting the light-ship here in a few days, and I will be obliged to you if you will drop a buoy to-day on the place she is to occupy.

When I requested you to survey Skull creek and Broad river it was my expectation that the results of a rapid reconnaissance, showing the direction of the principal channel and the depths at mean low water, could be furnished in a few days, the completion of the work being left to a more leisurely time. I find, however, I can depend upon the skill of pilots and masters for the safe navigation of these passages; and I therefore will ask you to turn your personal attention to the placing of the buoys in the harbors and in the possession of the naval forces under my command, and to take them up in the following order: Tybee Entrance, St. Helena Sound, Wassaw Sound, South Edisto, Ossabaw Sound, North Edisto.

Of these harbors the first four are, like Port Royal, permanently occupied. Vessels are passing in and out of their channels at all times; and if the latter are buoyed in such a manner that, with simple directions, they can be traversed by a stranger in security, much labor and delay will be saved.

No one knows how to do this better than yourself, and I rely upon your judgment and zeal.

Please deliver to this ship the barge taken in North Edisto.

I am, respectfully, your obedient servant,

S. F. DUPONT,
Flag-Officer, Commanding South Atlantic Blockading Squadron.

C. O. BOUTELLE, Esq.,
Assistant Coast Survey, Port Royal Harbor.

FLAG-SHIP PAWNEE, *Fernandina Harbor, March* 7, 1862.

SIR: On the receipt of this order you will immediately proceed with the Bibb to this place, with a proper supply of buoys, to mark out the channels to Fernandina and to Brunswick.

The utmost despatch is necessary, as I consider this bar a very dangerous one. In my absence you will please report to Commander Drayton.

The buoys taken up here are in good preservation, but without moorings. I think, however, that car wheels, many of which can be had here, will answer the purpose. I see no chains.

Respectfully, your obedient servant,

S. F. DUPONT,
Flag-Officer, Commanding South Atlantic Blockading Squadron.

C. O. BOUTELLE, Esq.,
Assistant Coast Survey, Surveying Steamer Bibb.

FLAG-SHIP WABASH, *Port Royal Harbor, S. C., May* 9, 1862.

SIR: I am informed by the blockading officers off Charleston that one or two buoys placed on the Rattlesnake shoal would assist them materially in covering that port.

I have therefore to request that you will proceed with the United States steamer Bibb, under your command, off the bar of Charleston, and, after communicating with the senior officer, Commander Parrott, proceed to plant, in accordance with his wishes and your intelligent judgment, such buoys as may be needed.

Respectfully, your obedient servant,

S. F. DUPONT,
Flag-Officer, Commanding South Atlantic Blockading Squadron.

C. O. BOUTELLE, Esq., *Ass't U. S. Coast Survey,*
Command ng U. S. St amer Bibb, Port Royal.

FLAG-SHIP WABASH, *Port Royal Harbor, S. C., June* 30, 1862.

SIR: You will proceed with the U. S. steamer Bibb, under your command, to Hampton Roads, stopping on your way at North Edisto, Stono, and Charleston, communicating with the commanding officers at those places, and delivering all mails and stores put under your charge.

It will give me pleasure, in transmitting your various reports to the Secretary of the Navy, to call attention to the valuable services of the vessels of the Coast Survey since they have been attached to this squadron, and particularly to the zeal and earnestness which you have always exhibited, not only in the execution of the duties pertaining to the Coast Survey, but in aiding important war operations on this coast by assisting with your local knowledge the gunboats in crossing the various bars and entering the difficult inlets, regardless whether they were brought under fire or not.

You will please convey to all associated with you my appreciation and commendation of their services, and which I purpose to bring to the notice of the Superintendent of the Coast Survey.

The buoy vessel, S. C. Steele, will be left in charge, for the present, of Commander Drayton, the senior officer in Stono, until I can give further directions.

Respectfully, your obedient servant,

S. F. DUPONT,
Flag-Officer, Comd'g South Atlantic Blockading Squadron.

C. O. BOUTELLE, Esq.,
Assistant Coast Survey, U. S. S. Bibb, Port Royal.

APPENDIX No. 32.

LETTER OF MAJOR GENERAL B. F. BUTLER, ADDRESSED TO ASSISTANT C. O. BOUTELLE, ON THE COMPLETION OF REPAIRS BY HIS PARTY TO THE U. S. STEAMER MISSISSIPPI IN PORT ROYAL SOUND, S. C.

TRANSPORT STEAMER MISSISSIPPI,
Hilton Head Island, S. C., March 10, 1862.

SIR: I cannot allow myself to leave this port without tendering to you my cordial thanks for the great assistance which you have rendered to the service, and to myself, during the past week, in making this vessel fit to pursue her voyage to Ship island in safety.

With the injury which this vessel has received it would have been probably impossible to have gone forward in her; and it would have been equally impossible at this place, within a reasonable time, to have repaired that injury without the constant and cheerfully tendered services of yourself, and the ingenious skill and unremitting labor of your officers, Chief Engineer Charles French and Executive Officer Robert Platt.

To you, therefore, and to these officers, I owe it that I may now hope to reach my command in the gulf in season for active operations in that quarter.

I shall take pleasure in causing a proper representation to be made to the government of your usefulness in this regard.

For the many courtesies experienced by myself at your hands, believe me, sir, your grateful friend and obedient servant,

BENJ. F. BUTLER,
Major General Commanding.

CHAS. O. BOUTELLE, Esq.,
Ass't U. S. Coast Survey, Com'dg U. S. Steamer Bibb.

APPENDIX No. 33.

LETTER OF COMMANDER PERCIVAL DRAYTON, U. S. N., IN REFERENCE TO MAPS AND CHARTS, AND TO THE SERVICES OF THE PARTY OF ASSISTANT C. O. BOUTELLE, ON THE COAST OF SOUTH CAROLINA.

UNITED STATES STEAMER PAWNEE,
Stono River, June 14, 1862.

DEAR SIR: The charts of this river, kindly sent me from your office some little time since, have afforded so much valuable information, which could be obtained nowhere else, and without which I scarcely see how either I or the commanders of the other vessels composing the squadron in these waters could have got on in their very intricate navigation, that I cannot but express the obligation I feel under, not only on this, but other occasions, for the great assistance the Coast Survey charts have been to me in properly understanding the complicated inland navigation of Carolina and Georgia. And I will also beg leave, at the same time, to call attention to the very valuable services of the same nature, rendered to vessels which I have had on detached service, by Captain C. O. Boutelle, of the Vixen and Bibb, during the last eight months. Without him I do not see how we could have got into St. Helena Sound, or North or South Edisto, to say nothing of Stono.

Very truly, your obedient servant,

P. DRAYTON,
Commander, Senior Officer at Stono.

Professor A. D. BACHE,
Superintendent Coast Survey, Washington.

APPENDIX No. 34.

EXTRACTS FROM COMMODORE D. D. PORTER'S LETTER TO PROFESSOR A. D. BACHE, DATED "HARRIET LANE, FORTS JACKSON AND ST. PHILIP, APRIL 29, 1862."

DEAR SIR: Amid the exciting scenes here, and the many duties that are imposed on me, I must steal a few moments to tell you something of the share the Coast Survey has had in our doings, and to thank you for the valuable assistance rendered me by the party you sent out here. * * * The results of our mortar practice here have exceeded anything I ever dreamed of; and for my success I am mainly indebted to the accuracy of positions marked down, under Mr. Gerdes's direction, by Mr. Harris and Mr. Oltmanns. They made a minute and complete survey from the "jump" to the forts, most of the time exposed to fire from shot and shell, and from sharpshooters from the bushes. * * * The position that every vessel was to occupy was marked by a white flag, and we knew to a yard the exact distance of the hole in the mortar from the forts, and you will hear in the end how straight the shells went to their mark. Mr. Oltmanns and Mr. Harris remained constantly on board to put the vessels in position again when they had to haul off for repairs, or on account of the severity of the enemy's fire. * * * I cannot speak too highly of these gentlemen. I assure you that I shall never undertake a bombardment unless I have them at my side. Mr. Gerdes has been indefatigable in superintending the work, laboring late at night in making charts and providing the officers in command of ships with them, marking the positions of obstructions in the channel, and making all familiar with the main way. No accident happened to any ship going through, notwithstanding the gentlemen in the forts thought the obstructions impassable. * * * You must excuse my hurried letter, but I could not omit writing to you to thank your good fellows for what they have done for me, and to thank you for sending them.

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Yours, very truly,

DAVID D. PORTER.

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey.

Letter of Commander D. D. Porter, U. S. N., to Prof. A. D. Bache, Superintendent U. S. Coast Survey.

U. S. STEAMER HARRIET LANE, *Ship Island, May* 16, 1862.

SIR: I forward to you by the Baltic a plan of Fort Jackson, (or the remains of it,) faithfully drawn, under the direction of Mr. Gerdes, by Messrs. Harris and Oltmanns, Assistants of the Coast Survey. It is a striking specimen of the effects of mortar practice, showing what can be done when distances are accurately determined, as they were in this case, by the gentlemen belonging to the Coast Survey. If you can afford the expense it would be worth while to have the plan lithographed and kept as part of the history of this hideous war.

I regret to say that Mr. Oltmanns, of the Sachem, has been severely wounded in the left breast by a rebel rifle ball. I sent the Sachem, in company with three of the mortar steamers, to show them the way up Pearl river, in hopes of finding some of the enemy's gunboats, which have mysteriously disappeared, (now most likely burnt,) and while trying alone to push up the river the Sachem was attacked by a body of riflemen. Mr. Oltmanns fell while directing the movements of the vessel. The battery of the Sachem was soon brought to bear and the rebels driven away, one of them being shot dead on the branch of a tree. Everything has been done to make Mr. Oltmanns comfortable. I intend to send him to the hospital at Southwest Pass, where he can be properly attended to. I regret his loss very much, as he has made himself very prominent throughout the operations here, in performing the various duties he was called upon to do, as indeed all the members of the Coast Survey party have. I have not spared the Sachem, but have treated her like the rest of the vessels, putting her under fire when it was necessary.

On the 8th of this month, off Mobile entrance, the steamer Clifton went ashore on S.E. shoal, under the guns of Fort Morgan, and neither of the larger steamers could get near enough to help her without danger of grounding. I ordered the Sachem to go in and help her by carrying out anchors and lines, and though the shot from the fort were flying over and around the Clifton they went at it cheerfully and intelligently. The Clifton got off just as they got their lines ready and anchors down to heave her off, but Lieut. Com'g Baldwin felt as much indebted to the party on the Sachem as if they had been the means of relieving him from his perilous position.

I look upon the Sachem in the same light as I would upon a topographical party in the army, and if I lose her in such employment she will have well paid for herself.

Mr. Gerdes will be employed, for the present, in looking up the numerous buoys which these people have stowed away or wantonly destroyed, as they have nearly everything else. When found he will put them all down in their proper places. * * * * * * *

Very respectfully, your obedient servant,

DAVID D. PORTER,
Commanding Flotilla.

A. D. BACHE, LL. D.
Superintendent Coast Survey.

APPENDIX No. 35.

REPORT OF ASSISTANT F. H. GERDES, U. S. COAST SURVEY, TO COMMANDER D. D. PORTER, U. S. N., COMMANDING MORTAR FLOTILLA IN THE GULF OF MEXICO

U. S. SURVEYING STEAMER SACHEM,
Off Ship Island, May 16, 1862.

DEAR SIR: Having received your verbal instructions to accompany the gunboats of your flotilla to Lake Pontchartrain and Pearl river, I got under way on the 13th instant, at 5 o'clock a. m., and was followed by the Westfield, Captain Renshaw; Clifton, Captain Baldwin; and Jackson, Captain Woodworth. I led them south of Cat island to St Joseph's light-house, they following close in my wake. We carried, for the least, nine feet, and no stoppages occurred. Near Grande island, your senior officer, Captain Renshaw, requested me to overhaul a vessel to the southward, as I drew the least water. Returning I led the course again, and went through the Rigolets, and over the middle ground, with eight feet, and thence directly to Mandeville and the mouth of the Chefuncta river, on which Madison is situated. I brought two more schooners to, and overhauled another, but all had passes from General Butler. We anchored here in company with the New London, and I believe also the Calhoun. The former intending to go next day into the river and visit Madison, Captain Renshaw concluded to return to Pearl river, and search in Pearlington and Gainesville for vessels, and I took the lead again. On the *middle ground*, near Point aux Herbes, the Jackson ran aground, but the other vessels got over without touching. The senior officer requested me to relieve her if possible, the Sachem not drawing over six and a half feet, but it was found impossible. An arrangement was made with the steamer Whiteman to come alongside next day, lighten the Jackson, and tow her off. I anchored near the light-house of the Rigolets, close to the Westfield, having previously run ten miles further to the eastward and back to communicate with Captain Baldwin, and to bring him Captain Renshaw's directions.

On the 15th instant we started early, and I took the lead into Pearl river. We passed Pearlington, and went up some thirteen miles, where, the river becoming so narrow that the Westfield and Clifton could not make the abrupt turns, both of those vessels came to. Their captains came on board the Sachem, and we went further up. About three miles from Gainesville we were fired upon with musketry, several balls striking the vessel, and one severely wounding my executive officer and assistant, Mr. Oltmanns, of the Coast Survey. The bullet hit him in the left breast, just over the lungs. He was carried down at once, and placed in the cabin, where he was as well attended to as circumstances would permit. We returned the fire, discharging perhaps some fifty or sixty musket shots, and finally grape and canister from the 32-pounder, which scattered the enemy. The difficulty consisted in getting the Sachem turned, as the river had hardly the width of her length.

The first cutter of the Sachem was lost, and Captain Baldwin lost his gig, both being crushed between the woods and the propeller in turning, and my launch was filled, and nearly lost too. The Sachem also lost her flag-staff, but the stars and stripes were hoisted directly on the main gaff. She now carries the marks of ten or twelve rifle or musket balls. The quartermaster at the wheel narrowly escaped, a bullet having passed through his clothes, and several other persons on board had very narrow escapes from injury. When we retured to the Clifton and Westfield, Mr. Oltmanns was transferred to the former vessel, and everything that the great kindness of Captain Baldwin could suggest was done for him. The doctor probed his wound, but did not find the ball. At seven o'clock we anchored near Grassy island, in Lake Borgne.

We are deeply indebted to Captains Renshaw and Baldwin, both of whom ably directed affairs during the attack. The loss of Mr. Oltmanns from the party is very great, as he had learned to manage the Sachem for any service. Even if he recovers, he will be unfit for duty this season, and will have to take the first opportunity to return north. Late at night I visited the Clifton, and was told by the doctor that the wound was very severe; but that Mr. Oltmanns, with care, might recover.

This morning, the 16th May, we got under way, and stood for Cat and Ship islands. Mr. Harris takes the post of executive officer on the Sachem.

Very respectfully,

F. H. GERDES, *Assistant U. S. Coast Survey.*

Capt. D. D. PORTER, U. S. N.,
Commanding U. S. Mortar Flotilla.

APPENDIX No. 36.

Aids to navigation placed at the entrances of southern harbors for the use of the United States blockading squadrons, by parties of the Coast Survey, during the working season of 1861–'62.

Section.	Number of buoys set in localities.	By whom placed.	Date.
III.	Two buoys permanently placed as guides for passing the bar and entering Metomkin inlet, Va.; one of these being carried away and lost by a storm was replaced by another buoy.	Assistant A. M. Harrison	April, 1862.
IV.	Three buoys set to mark the bar and channel through Oregon inlet into Pamplico sound, N. C., and one at the western or inside approach of the inlet. The swash was thoroughly marked by stakes.	Assistant H. Mitchell	April, 1862.
	Three buoys permanently placed on the middle ground of Neuse river, N. C.	do	April, 1862.
V.	Two buoys to mark the north and south ends of Rattlesnake shoal, near the entrance of Charleston harbor, S. C.	Assistant C. O Boutelle	May, 1862.
	Five buoys set at Stono bar and entrance, S. C.	do	May, 1862.
	Four buoys placed on the bar of North Edisto river, S. C.	do	April, 1862.
	Five buoys marking the bar, and one placed in the entrance to St. Helena sound, S. C	do	April, 1862.
	Nine buoys set for the channels into, and six others inside of Port Royal sound, S C.	do	Dec., 1861; Jan., 1862.
	Three buoys to mark the channel from Tybee roads into Calibogue sound, S C.	do	May, 1862.
	Six buoys to lead into and serve for guides to the anchorage at Tybee roads, Ga.	do	February and May, 1862.
	Five buoys set to mark the Wassaw bar, and the channel leading into the sound.	do	February, 1862.
	Three buoys placed on the bar of St. Simon's sound, Ga.	do	March, 1862.
VI.	Five buoys which had been taken away replaced on the bar at Fernandina harbor, Fla.	do	March, 1862.
VIII.	Six buoys permanently set for passing over the bar and through the channel of the Southwest Pass, Mississippi delta.	Assistant F. H. Gerdes	June, 1862.
X.	Buoy recommended for the shoal point found to be encroaching on the channels at the confluence of Karquines and Mare Island straits, Cal.	Commander B. F. Sands, U. S. N., Assistant Coast Survey.	May, 1862.

APPENDIX No. 37.

RESOLUTION PASSED BY THE COMMISSION APPOINTED TO EXAMINE SITES FOR A NAVY YARD.

NAVY YARD, *Philadelphia, October* 23, 1862.

SIR: I have the honor to transmit to you a copy of a resolution passed by the board* on League island navy yard, etc., at their meeting of this day.

Very respectfully, your obedient servant,

S. H. STRINGHAM, *Pres't of the Board.*

Prof A. D. BACHE, *Sup't U. S. Coast Survey.*

Whereas very important services have been rendered this board by the officers attached to the Coast Survey, in furnishing maps, charts, and other valuable information in reference to the various qualities of the localities which have been examined, thereby greatly reducing the labors of the board, and expediting the completion of its work, it is due to those gentlemen that the board should express its high appreciation of the great value of the assistance which has been so cheerfully and promptly rendered: Therefore—

Resolved, That the thanks of this board be tendered to Professor Bache, and through him to the gentlemen connected with the Coast Survey, for the very valuable assistance which they have so kindly, promptly, and cheerfully rendered in furnishing maps, charts, and other hydrographical and topographical information, whereby the labors of this board have been materially reduced, and the accomplishment of the object of its mission greatly facilitated.

* Admiral S. H. Stringham, president; Commodore G. J. Van Brunt; Commodore W. H. Gardner; Captain John Marston, U. S. N.; Professor A. D. Bache, Superintendent U. S. Coast Survey; Civil Engineer W. P. S. Sanger.

APPENDIX No. 38.

List of capes, headlands, islands, harbors, and anchorages on the western coast of the United States, of which either topographical, hydrographic, preliminary, or complete surveys have been made, or maps, charts, or sketches issued.

Names in geographical order.	Character of survey.	Published.
CAPES AND HEADLANDS.		
Point Loma	Complete survey	Sketch 1851.
Point Pedro	do	do 1859.
Point Fermin	do	do 1859.
Point Duma	Topographical survey, 1857	
Point Hueneme	Topographical and hydrographic survey	do 1857.
Buenaventura Mission	do do	do 1857.
Point Conception	Topographical survey	do 1852.
Point Pinos	Complete survey	do 1851.
Point Santa Cruz	Topographical and hydrographic survey	do 1854.
Point Año Nuevo	do do	do 1854.
Pigeon Point	do do 1854-'56	
Point San Pedro	Complete survey, 1853-'54	
Point Lobos	do	On map of San Francisco entrance 1856.
Point Bonita	do	do do 1856.
Ballenas Bluff	do	do do 1856.
Point Reyes	do	Sketch 1855.
Tomales Point	do	Map 1861.
Sand Point	do	do 1861.
Point Adams	do	Sketch 1854.
Cape Disappointment	do	do 1854.
Cape Flattery	Topographical survey	do 1853.
Point Roberts	Hydrographic survey	On reconnaissance of Washington sound, 1862.
ISLANDS.		
Los Coronados islands	Topographical survey	Sketch 1853.
Anacapa island	Complete survey	Map 1856.
Santa Cruz island, east end of	do	do 1856.
South Farallon island	Topographical survey	Sketch 1855.
Alcatraz island	Complete survey	On map of San Francisco entrance 1856.
Yerba Buena island	do	do do 1856.
Angel island	do	do do 1856.
Mare island	do	On map of San Pablo bay 1856.
Sand island	do	On map of Columbia river entrance 1854.
Smith's island	do	Sketch 1855.
Cypress island, part of	Topographical and hydrographic survey	On reconnaissance of Washington sound, 1862.
Lummi island, part of	do do	do do 1862.
Matia island	do do	do do 1862
Lucia island	do do	do do 1862.
Patos island	do do	do do 1862.
Tumbow island	do do	do do 1862.
Saturna island, part of	do do	do do 1862.
Mayne island, part of	do do	do do 1862.
Caliano island, part of	do do	do do 1862.
HARBORS AND ANCHORAGES.		
San Diego harbor	Complete survey	Map 1857.
San Clemente anchorage, southeast end of island.	Hydrographic survey	Sketch 1856.
San Clemente anchorage, northeast end of island.	do	do 1852.
Catalina harbor	do	do 1852.
San Pedro harbor	Topographical and hydrographic survey.	Map 1859.
Smuggler's cove, Santa Cruz island.	Complete survey	Sketch 1856.
Prisoner's harbor, Santa Cruz island.	Hydrographic survey	do 1852.
Cuyler's harbor, island of San Miguel.	do	do 1852.
Santa Barbara anchorage	Complete survey	do 1855.
Coxo harbor	Topographical survey	do 1852.
San Luis Obispo harbor	Hydrographic survey	do 1852.
San Simeon harbor	do	do 1852.
Monterey harbor	Complete survey	Preliminary chart 1857.
Sauquel	do	Sketch 1857.

List of capes, headlands, islands, &c.—Continued.

Names in geographical order.	Character of survey.	Published.
Santa Cruz harbor	Complete survey	Sketch 1856.
Point Año Nuevo harbor	Topographical and hydrographic survey	do 1854.
San Francisco harbor	Complete survey	Map 1856.
Mendocino City harbor	Hydrographic survey	Sketch 1854.
Shelter cove	do	do 1854.
Crescent City harbor	do	do 1854.
Port Orford, or Ewing harbor	Topographical and hydrographic survey	do 1854.
Gray's harbor	do do 1860-'62	
Grenville harbor	Hydrographic survey	do 1854.
Nee-ah harbor	Topographical and hydrographic survey	do 1853.
False Dungeness	Hydrographic survey	do 1856.
New Dungeness	Complete survey	do 1856.
Port Townshend	do	do 1858.
Port Ludlow	do	do 1856.
Mats-Mats, or Boat harbor	do	do 1856.
Port Gamble	do	do 1858.
Apple cove	Topographical survey, 1856	
Murden's cove	do	
Blakeley harbor	Hydrographic survey	do 1856.
Fauntleroy cove	Complete survey, 1857	
Steilacoom harbor	Hydrographic survey	do 1856.
Olympia harbor	do	do 1856.
BAYS.		
San Diego bay	Complete survey	Map 1857.
False bay	Topographical and hydrographic survey	On map of San Diego bay 1857.
Monterey bay	Complete survey	Preliminary chart 1857.
San Francisco bay	do	Map 1856.
San Pablo bay	do	do 1856.
Ballenas bay	do	On map of San Francisco entrance 1856.
Drake's bay	do	Map 1861.
Tomales bay	do	do 1861.
Humboldt bay	do	Sketch 1858.
Trinidad bay	Hydrographic survey	do 1851.
Koos bay	Complete survey	Map 1861.
Shoalwater bay	Hydrographic survey	Sketch 1856.
Duwamish bay	do	do 1854.
Strawberry bay	Topographical & hydrographic sur., 1854	
Bellingham bay	Hydrographic survey	do 1854.
Semiahmoo bay	do	do 1858.
REEFS AND BANKS, OR SHOALS		
Cortez bank	Hydrographic survey	Chart 1856.
Duxbury reef	Complete survey	On map of San Francisco entrance 1856.
Horse-shoe bar	do	do do 1856.
Zuniga shoal and San Diego bar	do	On map of San Diego bay 1857.
Middle sands	do	On map of Columbia river entrance 1854.
Alden's bank	do	On map of Washington sound 1862.
STRAITS AND ENTRANCES.		
San Diego entrance	Complete survey	Map 1857.
Santa Barbara channel, eastern entrance of.	Hydrographic survey	do 1857.
San Francisco entrance	Complete survey	do 1856.
Karquines straits	do	On map of San Pablo bay 1856.
Mare Island straits	do	Map 1857.
Umpquah river entrance	Hydrographic survey	Sketch 1854.
Columbia river entrance	Complete survey	Chart 1854.
Coquille river entrance	Reconnaissance	Sketch 1861.
Admiralty inlet, part of	Topographical survey	On map of Washington sound 1862.
Entrance to Hood's canal	do 1857	
Entrance to Port Gamble	do	Sketch 1858.
Washington sound	Reconnaissance	do 1862.
RIVERS AND CREEKS.		
Santa Clara river	Topographical survey, 1855	
Salinas river	do 1854	
Pajaro river	do 1854	

List of capes, headlands, islands, &c.—Continued.

Names in geographical order.	Character of survey.	Published.
San Antonio creek	Complete survey	Map 1857.
Petaluma creek	do	do 1861.
Napa creek	do	do 1861.
Du Vree's creek	do	On map of San Francisco entrance 1856.
Mission creek	do	do do 1856.
Tolay creek	do	On map of San Pablo bay 1856.
Sonoma creek	do	do do 1856.
Novate creek	do	do do 1856.
CITIES AND TOWNS.		
San Diego	Complete survey	On map of San Diego bay 1857.
Santa Barbara	do	On sketch of Santa Barbara 1853.
City of Monterey	do	On map of Monterey bay 1857.
City of San Francisco	do	Map 1858.
Oakland city	do	On map of San Antonio creek 1857.
Brooklyn	do	do do 1857.
Vallejo	do	On map of San Pablo bay 1856.
Benicia	do	do do 1856
Union city	do 1857	
Alviso	do 1857	
Martinez	do	do do 1856.
Napa city	do	Map 1861.
Petaluma city	do	do 1861.
Newtown	do	On map of San Pedro harbor 1859.
Santa Cruz	do	On sketch of Santa Cruz harbor 1854.
Mouldro city	do	On map of Tomales bay 1861.
Humboldt	do	On sketch of Humboldt bay 1858.
Bucksport	do	do do 1858.
Eureka	do	do do 1858.
Crescent City	do	On sketch of Crescent City harbor 1854.
Trinidad	Sketch	On sketch of Trinidad bay 1851.
Port Townshend	Complete survey	On sketch of Port Townshend 1858.
Steilacoon	Sketch	On sketch of Steilacoon harbor 1856.
Olympia	do	On sketch of Olympia harbor 1856.

APPENDIX No. 39.

DIRECTORY FOR THE PACIFIC COAST OF THE UNITED STATES, REPORTED TO THE SUPERINTENDENT OF THE UNITED STATES COAST SURVEY.—BY GEORGE DAVIDSON, ASSISTANT.

INTRODUCTION.

The directory furnished by Assistant Davidson, and first published in the Coast Survey Report for 1858, is now in its revised form, preceded by a brief sketch of the commencement and progress of the survey of the western coast.

California was ceded to the United States by the treaty which was ratified with Mexico on the 30th of May, 1848. In that same year the march of improvement, having already gained the shores of Oregon, prompted applications to the Treasury Department that the Coast Survey organization, which had been working several years on the Atlantic side, might be made to include also the Pacific coast. In accordance with directions from the department, the Superintendent of the Coast Survey, in the autumn of 1848, organized a surveying party, assigning for the field work, in Oregon, James S. Williams, one of the most experienced of the civil assistants in reconnaissance, and, for the hydrography, Lieut. Com'g W. P. McArthur, U. S. N., of tried service in the survey of the Atlantic sections. Sub-Assistant Jos. S. Ruth was detailed as topographer. For the general uses of the party, the schooner Ewing was despatched from New York on the 10th of January, 1849, under command of Lieut. W. A. Bartlett, U. S. N., and the party followed on the 1st of February in the steamer Falcon, by way of the Isthmus of Darien. The Ewing, after a long and dangerous passage, passed the straits of Magellan, and finally reached San Francisco on the 1st of August, her time from Callao being fifty-one days. The opening of gold deposits near San Francisco had, months before, concentrated all the means of coastwise transport there, leaving Mr. Williams unable to reach the mouth of the Columbia river. He occupied the time, after his arrival in April, by a general reconnaissance of the north shores of San Francisco bay. Lieut. Com'g McArthur joined the party in the Ewing, at the end of August, to find that the retention of any part of her crew, while gold was to be picked up, would be a matter of extreme difficulty. The high rate of wages, moreover, and the lateness of the season, made it expedient to defer special operations till the next year. Notwithstanding the drawbacks alluded to, a general reconnaissance of the coast was made by this party from Monterey northward to the mouth of the Columbia river, and a preliminary survey of the entrance of that river. With full knowledge of the difficulties to be overcome in pushing the desired work further, four of the younger officers, who had been engaged on the Atlantic coast—George Davidson, A. M. Harrison, James S. Lawson, and John Rockwell—pledged the assurance of their exertions, and were sent out in May, 1850. These were followed in October by Assistant R. D. Cutts and by A. F. Rodgers, the result of whose labors has been the elaborate topographical survey of the shores of San Francisco bay, and of the coast northward to Bodega bay. The party first detailed for duty left the Pacific coast in the following autumn, having added the survey of Mare Island strait, and a large amount of general information relating to the coast, its harbors, and river entrances, and to the islands. Lieut. Com'g McArthur and Lieut. Bartlett had given special attention to the lighting and marks needed for safer navigation, and furnished the sailing directions then requisite for passing up the coast and through the straits of Fuca.

Assistant Davidson, of the party, which, in 1850, so fully met my expectations, determined the geographical position of Point Conception, a service of the first consequence at that time for the rapidly increasing transit by sailing vessels along the coast of California. To this succeeded the determination of geographical positions, and of the magnetic variations at prominent points and headlands, and the topographical survey of various localities in California and Oregon, by the untiring energy of Mr. Davidson and the assistants who took up work during the same season. Their names are associated with most of the maps and charts of the western coast, which have since been published, and with descriptions of the field work in the annual reports of the Superintendent.

The survey of the shores of the Santa Barbara channel was further extended by the detail for duty of Captain (now Brigadier General) E. O. C. Ord, U. S. A., and Sub-Assistant W. M. Johnson, in the summer of 1853, and by Assistant W. E. Greenwell, since February, 1855. Assistant G. A. Fairfield, in the same season, replaced Mr. Cutts in the triangulation which he had carried from Monterey to the north of San Francisco, and was in turn succeeded by Assistant Davidson, who had, in the interval, developed the geographical peculiarities of Washington Territory by the triangulation of Admiralty inlet, Puget's sound, and the numerous indentations of both, and by determinations of latitude, longitude, and the magnetic elements, at many points of the shores of the Territory, as he had previously done on the shores of California and Oregon. At his return to the Atlantic coast, in December, 1860, the continuance of the work in Washington Territory devolved on Sub-assistant Lawson.

Commander James Alden, U. S. N., took charge of the hydrographic operations in August, 1851; revised the early reconnaissance of the entire western coast of the United States, and in the course of the nine years following brought the local hydrography up even with the data which had been supplied by the field parties. Working part of the time with two vessels, he was assisted in the command at intervals by Lieuts. Com'g Thos. H. Stevens, J. S. Kennard, R. M. Cuyler, and Arch'd MacRae. As chief of the hydrographic party, the name of Commander Alden is connected with nearly all the charts which are referred to in the directory of the Pacific coast. For the tides, to which special attention has been given from an early period in the history of the survey, as to one of its most important adjuncts, the requisite observations, at points selected by the Superintendent, were first directed by Lieut. W. P. Trowbridge, and, for a short period after, by Lieut. N. F. Alexander; but since July, 1857, by Lieut. G. H. Elliot, severally of the Corps of Engineers. The results worked out in the office for the tides, and for latitude and longitude, the sailing directions furnished by the hydrographic officers for the charts, the distances between points as measured on them, the dangers of the coast, and additional particulars within the personal knowledge or observation of Assistant Davidson, will be found embodied in his directory.

A list of the special surveys made on the western coast is given in Appendix No. 38.

A. D. BACHE, *Sup't U. S. Coast Survey.*

GERMANTOWN, PA., *December* 1, 1862.

DEAR SIR: In my answer to your letter of inquiry of November 10, it was stated that since writing the directory I had accumulated much valuable material.

This having been incorporated, it is proper to mention that the principal sources of information were the reports of the progress of the Coast Survey in Santa Barbara channel and Monterey bay; your discussion of the mass of tidal observations; the establishment of new light-houses and changes in old ones; the work upon the approaches to San Francisco bay; the detailed survey of Crescent City harbor; the examinations of the approaches, entrances, and extent of Koos and Gray's bays; the continuation of the work in the Gulf of Georgia; and two years' additional personal experience. In that time I made special examinations of the seaboard, from Half-moon bay to the Walalla river, embracing the first accurate determination of the position and extent of the middle and north Farallones.

It will, perhaps, be gratifying to you to learn that, beyond the typographical errors in the first publication, it has not been found necessary to expunge a dozen lines, and that the few changes made have resulted from giving details where investigation had solved generalities.

Many portions have been rearranged to bring each item consecutively before the eye.

Very respectfully, yours,

GEORGE DAVIDSON, *Ass't U. S. Coast Survey.*

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey, Washington, D. C.

KENSINGTON, PA., *August* 29, 1858.

DEAR SIR: In offering for your acceptance the following Directory for the Pacific Coast of the United States, it may not be amiss to state the circumstances under which it was undertaken.

For nearly eight years the duties which you assigned to me in California, and in Oregon and Washington Territories, kept me moving continually along the seaboard in every manner of conveyance, and familiarized me with almost every mile of the coast, along which my various trips and explorations have amounted to an aggregate of between fifty and sixty thousand miles. I early felt the want of reliable information in tangible form, instead of trusting to memory, and, upon assuming the charge of the coast surveying brig R. H. Fauntleroy, I determined to embody for publication the information acquired, but several years of failing health prevented the execution of more than regular duties, until the growing desire to leave the Pacific coast forced me to occupy the remaining leisure moments in arranging the matter while yet freshly photographed upon the mind. A small part was published in San Francisco, and although abounding in typographical errors, the avidity with which it was sought was a strong incentive to continue the self-imposed task. The result is now placed at your disposal, and having examined all the courses, distances, and positions, I trust that no essential errors have been overlooked; but whatever have, fall upon my own shoulders.

My duties having been especially geodetic and astronomical, we naturally preceded the hydrography, and, working in comparatively unknown waters, have had constant occasion to use the lead. When seeking for an anchorage, drifting with currents, or on boat duty, I have almost invariably kept it going from my own hand. Several discoveries have rewarded our efforts.

The historical notices of previous discoveries will be found few and short, as hardly coming within the scope of the present undertaking. The descriptions may reconcile some of the discordances of the early navigators.

Very respectfully, yours,

GEORGE DAVIDSON, *Assistant Coast Survey.*

Prof. A. D. BACHE,
Superintendent U. S. Coast Survey, Washington, D. C.

INTRODUCTORY.

Before the recent conquest of California and the discovery and development of its vast mineral wealth, comparatively little was known of the hydrography and geography of its coast, except by the few navigators trading along its seaboard, or the daring otter hunter, familiar with every cove, rock, and headland. All that had been accomplished forcibly showed that a great work had yet to be planned and executed.

It would take us far from our prescribed path to trace the extent, bearing, and importance of the successive discoveries made during a period of more than three hundred years, between 1539, when Francisco de Ulloa first determined Lower California to be a peninsula, and 1853, when the Superintendent of the United States Coast Survey first despatched a party to give definite shape to our shores. If the early adventurers and discoverers made their explorations in small crazy vessels, with wretched and untrustworthy instruments and methods, it is no less true that the first Coast Survey parties made theirs with inadequate funds, and under difficulties and privations that the well-housed Californian of to-day can never fully appreciate.

The task we have proposed to ourselves before leaving this glorious El Dorado, whose Golden Gate has admitted in ten years the commerce of every nation, and given egress to products worth five hundred millions of dollars, will be, to state all that is known at the present time of the hydrography and geography of the Pacific coast of the United States from the southern boundary in 32° 32′ to the northern boundary in 49°, embracing an ocean shore-line of over 3,120 miles, divided as follows: California, including the islands of the Santa Barbara channel, 1,097 miles; Oregon 285 miles; Washington Territory, including the south side of the Strait of Juan de Fuca, Admiralty inlet, Puget's sound, the Archipelago de Haro, &c., 1,738 miles.

The descriptions of ports, bays, anchorages, reefs, capes, islands, &c., will be given generally from personal observation made during an examination of the coast, extending through nearly eight years. Whatever has not come directly under our own criticism will be taken from the published reports and maps of the Coast Survey. The names adopted will be those most reliable. Where any changes have taken place, they will be stated if known.

With these few words of introduction, we may be pardoned in expressing a conviction that the knowledge herein conveyed will be of advantage to our extended commerce, and in assuring the navigator approaching the bold outline of our coast, of the accuracy of the geographical positions. No work of the kind has heretofore been undertaken; and should it possess no other merit than serving as a nucleus for aggregating future discoveries and developments, we shall feel that our labor has not been wholly in vain.

EXPLANATORY REMARKS.

The *longitudes* of nine stations on the coast have been determined by the Coast Survey, by means of moon culminations, occultations, and solar eclipses. The observations of moon culminations at each station generally extended through three lunations. The *latitudes* were determined according to the most approved methods and with the most delicate instruments. These stations and twenty-four intermediate ones have been connected by means of a large number of chronometers, (from fourteen to twenty-one,) transported by steamer, for the determination of the longitudes of the intermediate ones, of which the latitudes were also accurately determined in the same manner as the principal ones. Other points, including light-houses, have been determined by triangulation.

Where any position is given to the nearest minute only, it has been taken from the latest chart of the Coast Survey. The longitude is reckoned west from Greenwich.

The prediction of the tides supersedes the crude approximations of previous explorers.

Tables and examples will be introduced to show the manner of predicting the times and heights of high and low waters at San Francisco and other harbors.

Soundings are given for mean low water.

Bearings are magnetic.

Distances are expressed in geographical (nautical) miles.

Magnetic declinations (variations) were determined with delicate and reliable instruments, and precautions were always taken to avoid the influence of local attraction.

Descriptions of light-houses, fog-bells, buoys, &c., are from the published notices of the Light-house Board.

COAST DIRECTORY, MEXICO.

LOS CORONADOS.

These islands belong to Mexico; lie about seven miles off the coast, and nearly eight miles south of the boundary between Mexico and the United States.

They form a group of high, bold, and abrupt rocks and islets, of which the largest is 15 miles S. 11° E. from Point Loma, about $1\frac{5}{8}$ mile in length by one-third of a mile in breadth, and lying in a NW. and SE. direction. It is a wedge-shaped mass, about 575 feet above the sea, the surface having some earth upon it, but entirely destitute of trees. A few small shrubs exist, and during the rainy season the soil is covered with grass, and a great abundance of gaudily colored wild flowers showing in patches of orange, purple, and yellow, when seen from the water. During the dry season everything is withered and the islet presents a sterile appearance. Cacti and other plants grow among the rocks.

There is an anchorage about one-quarter of a mile to the eastward of the islet, and but one landing place; even there the ascent is difficult for fifty feet, and thence easy to the crest, about half a mile distant.

The geographical position of the highest point, as determined by the Coast Survey, is:

	°	′	″
Latitude	32	23	46 north.
Longitude	117	13	21 west.
	h.	*m.*	*s.*
Or, in time	7	48	53.4.

On the west and northwest sides of the islet, and about half a mile distant, lie two smaller ones, or rather two masses of rocks about 50 feet high, and destitute of vegetation. They are a favorite resort for the enormous sea elephants. Excellent anchorage is said to be found in the vicinity. The smaller of the two prominent islets is about half a mile in length; lies N. 58° W. from the larger, and is distant $2\frac{3}{8}$ miles. It is a huge barren rock, with very sharp summit.

In coming from the south, this group affords a good mark for making San Diego, although before being up with them Point Loma shows distinctly.

Los Coronados were discovered by Juan Rodriguez Cabrillo in 1542, and named by Viscaino in 1602, in honor of Francisco Coronado, governor of the province of Xalisco, under Cortes.

PACIFIC COAST OF THE UNITED STATES.

CALIFORNIA.

The name California is first found in the worthless romance of "Sergus, of Esplandian," the son of Amadis of Gaul, written by Garcia Ordoñez de Montalvo, the translator of the Amadis. It was first printed in 1510, with editions in 1519, 1521, 1525, 1526, (two,) 1575, 1587, and the recent reprint of 1857.

The name appears in numerous passages, of which the following are given.

Sergus, ch. 157. "Know that, on the right hand of the Indies, very near to the Terrestrial Paradise, there is an island called California, which was peopled with black women, without any men among them, because they were accustomed to live after the fashion of Amazons."

"In this island called California, are many Griffins, on account of the great savageness of the country and the immense quantity of the wild game found there."

"Now, in the time that those great men of the Pagans sailed [against Constantinople] with those great fleets of which I have told you, there reigned in this land of California a queen, large of body, very beautiful, in the prime of her years," &c., &c.

The name California next occurs in the memoirs of the conquistador, Bernal Diaz del Castillo, who served with Cortes in the conquest of Mexico. He writes that "Cortes again set sail from Santa Cruz and discovered the coast of California." Here Cortes remained for some time, disheartened at the want of success of his various expeditions. The viceroy, Mendoza, despatched a vessel under the command of Ulloa with letters to Cortes. "Ulloa had a most favorable voyage, and soon arrived in the harbor where Cortes lay at anchor. The letters of his wife and those of his children and of the viceroy had so much effect upon him that he gave the command of his vessel to Ulloa, embarked for Acapulco, and, when he had arrived here, he hastened to Quauhnahuac, where his wife resided. * * * Shortly after, also, the troops arrived which had been left behind in California."

After a few months' repose Cortes sent out a more considerable expedition, under command of Ulloa· "This armament left the harbor de la Natividad in the month of June of one thousand five hundred and thirty, and so many years—I forget the exact year."

The California referred to above is the peninsula of that name, generally known as Lower California, and the date 1535. They are the only times in which Diaz uses the name. (Cap. CC.)

In 1539 Francisco de Ulloa determined Lower California to be a peninsula; this fact appears to have been subsequently forgotten, for it was called Ilas Carolinas, in honor of Charles II of Spain.

The name California was gradually used to designate the region from the Gulf of California to the mythical "Straits of Anian."

The country was called New Albion by Sir Francis Drake in 1579.

In recent times the region north of San Diego was called Alta California.

From the southern boundary, in latitude 32° 32′, longitude 117° 06′, to Point Arguello, in latitude 34° 34′, longitude 120° 38′, the coast runs W.NW. 225 miles; from Point Arguello to Cape Mendocino, in latitude 40° 25′, longitude 124° 22′, NW. 525 miles; from Cape Mendocino to Cape Flattery, in latitude 48° 23′, longitude 124° 44′, N.NW. 480 miles.

The monument marking the western initial point of the boundary between Mexico and the United States is on the table bluff rising from the low land south of San Diego bay. It is an obelisk of white marble, about twenty feet in height, and resting upon a pedestal. It stands near the edge of the bluff, about two hundred yards from the sea-shore, and is plainly visible from the water. Its geographical position, as determined by the Coast Survey, is:

	° ′ ″
Latitude	32 31 58.46 north.
Longitude	117 06 11.12 west.
	h. m. s.
Or, in time	7 48 24.74.

A view of the initial point and surrounding country was published by the Coast Survey on the reconnaissance chart of 1853.

From the boundary the coast is low and flat, running N. by W. for about 7 miles; thence curving gradually westward until it is nearly east and west at the entrance of San Diego bay. The interior of the country is marked by high mountains.

POINT LOMA.

This is the southern part of the western boundary of San Diego bay, and the termination of a remarkable narrow spur of coarse, crumbling sandstone, which rises south of Puerto Falso, or False bay, and west of the town of San Diego, to the height of 300 feet, and after stretching south for about 5½ miles, gradually increasing in height to 422 feet, terminates very abruptly. It is covered with coarse grass, cacti, wild sage, and low bushes.

SAN DIEGO BAY.

Next to that of San Francisco, no harbor on the Pacific coast of the United States approximates in excellence that of the bay of San Diego. It is readily distinguished, easily approached, and a depth of 22 feet can be carried over the bar, which is three-quarters of a mile east of the southern extremity of Point Loma, and between it and the tail of the Zuniga shoal. The bar is about 650 yards across from the outer to the inner five-fathom lines.

Vessels coming from the northwest make the ridge of Point Loma as a long, flat-topped island, when about 25 miles distant. This appearance is occasioned by the bay to the southwest, by the low land to the northeast, and by the Puerto Falso at the north.

A thick field of kelp lies along the western shore of Point Loma, the inner edge being about one mile off-shore, and having a breadth of half a mile. The outer edge marks the line where the depth of water suddenly changes from 20 to 10 fathoms. The field commences off the bar at the entrance to False bay, and stretches southward 2¾ miles south of Point Loma. Approaching the south end of Loma, along the outer edge of the kelp, pass through a partial break in it, and when the point bears NE. by E., distant 1½ mile, keep along the northern edge of the kelp in 4½ fathoms, and about half a mile from the point.

As soon as the point is passed, a long, low beach of shingle is opened, making out from the east side of the point and forming a natural breakwater, formerly called Punta de Guiranas* by the Spaniards, but now designated as Ballast Point.

Round up gradually until Ballast Point is brought in range with the easternmost house of La Playa, (distant one mile from Ballast Point and on the same side of the bay,) and be careful not to open more of the village, as the shoal called Barros de Zuniga† stretches south from the east side of the entrance, parallel to the ridge of Point Loma, and distant only three-quarters of a mile from it. Between Point Loma and this shoal runs the channel, which is less than half a mile wide within the three-fathom lines. With the least swell the breakers show the position and extent of the shoal, and at low tides part of it is bare. It has been said that a rock, having but five or six feet of water upon it, lies in the channel; its position being marked by a patch of kelp, which is, however, torn away in heavy weather. The pilot-boat Fanny reported being upon it in 1851, but the examinations of the Coast Survey have developed no such danger, and the report has been generally discredited.

During the summer keep as close to Point Loma as the draught of the vessel will permit, and lay on the wind up to Ballast Point, off which four fathoms can be carried within a ship's length, with 10 fathoms in mid-channel, and a very strong current on the ebb and flood tides; the former setting over the Zuniga shoal. After passing Ballast Point steer for La Playa, and anchor anywhere in from 4 to 10 fathoms, with good holding-ground. Inside the point, and about 250 yards N. by W. from it, is a shoal having only 12 feet water upon it, in a line from Ballast Point to the westernmost house at La Playa. It is a quarter of a mile long. The shoals on the starboard hand, after entering, are plainly in sight, except at very high water. The channel, however, is buoyed, and cannot be missed. From La Playa to New San Diego, four miles distant, the channel curves to the right and contracts, but about six fathoms water may be carried that far. A mile or two beyond the town the bay becomes shoal and filled with flats, yet a very narrow three-fathom channel runs close along the eastern shore, nearly to the head of the bay.

Coming from the south, run for the extreme end of Point Loma until Ballast Point and La Playa are in range, as before, and follow the foregoing directions.

When inside the harbor vessels are perfectly safe, but during very heavy southerly weather the kelp is said to drive in such masses as to make vessels drag their anchors. We have never known such a case, and doubt if a vessel with good ground tackle and proper attention would suffer from this cause. Certainly there is not reach enough for the wind to raise a swell, and the holding-ground is excellent. In heavy southeast weather the sea breaks over Ballast Point, and in 1851 the pilot-boat Fanny was piled upon it.

POINT LOMA LIGHT-HOUSE.

This primary sea-coast light is less than half a mile from the southern end, and situated upon the highest part of the point, which here attains an elevation of 422 feet above high water. The building consists of a stone dwelling of one and a half story, with a low tower of plastered brick rising from the centre sufficiently high to place the focal plane of the light 450 feet above the sea. The light is a *fixed white light* of the third order of Fresnel, exhibited (since November 15, 1855,) from sunset to sunrise, illuminates the entire horizon, and in clear weather should be visible—

From a height of 10 feet above the sea, at a distance of 28 miles.
From a height of 20 feet above the sea, at a distance of 29 miles.
From a height of 30 feet above the sea, at a distance of 31 miles.

The geographical position of the light, as given by the Coast Survey, is:

	°	′	″	
Latitude	32	40	13.0	north.
Longitude	117	12	22	west.
	h	*m*	*s.*	
Or, in time	7	48	49.5.	

Magnetic variation, 12° 29′ east, in April, 1851, with a yearly increase of 1′.

* Or Punta de los Guijarros.

† Named by Viscaino in 1602. Don Gaspar de Zuniga, Count de Monterey, despatched the expedition.

TIDES AT SAN DIEGO.

General remarks upon the nature of the tides of the Pacific coast will be given further on, under the head of tides at San Francisco. The tables for San Diego will be given at the end of the Directory.

Tables I and II are used for determining the time of high water, and table III will give the times of the other high and the low waters. Tables IV and V give the height of high water, and tables VI and VII the height of the other high and low waters. The explanation of these tables, with an example illustrating their application for San Francisco, will be found on pages .

The corrected establishment or mean interval between the time of the moon's transit and the time of high water at La Playa is IX*h*. XXXVIII*m*. The mean rise and fall of tides is 3.7 feet, of spring tides 5.0 feet, and of neap tides 2.3 feet; the mean duration of the flood is 6*h*. 25*m*.; of the ebb, 6*h*. 0*m*.; and of the stand 0*h*. 30*m*. The average difference between the corrected establishment of the a. m. and p. m. tides of the same day is 1*h*. 20*m*. for high water, and 1*h*. 6*m*. for low water. The differences, when the moon's declination is greatest, are 2*h*. 4*m*. and 1*h*. 36*m*., respectively. The average difference in height of these two tides is 1.5 foot for the high waters and 2.1 feet for the low waters. When the moon's declination is greatest, those differences are 2.2 feet and 3.0 feet, respectively. The average difference of the higher high and lower low waters of the same day is 5.5 feet, and when the moon's declination is greatest, 6.3 feet. The higher high tide in the twenty-four hours occurs about 9*h*. 10*m*. after the moon's upper transit, (southing,) when the moon's declination is north, and about 3*h*. 16*m*. before when south. The lower of the low waters occurs about 7¼ hours after the higher high tide.

The greatest observed difference between two low waters of one day was 4.2 feet, and the greatest difference between the higher high and lower low waters of one day, 8.8 feet.

The existence of a bar at the entrance of this port was discovered by Vancouver in 1793, and in criticising a plan of the harbor, published by Dalrymple in 1782, he remarks: "This plan, in point of correctness, is justly entitled to much praise, but was yet capable, as far as came under my observation, of the following little improvements: the scale representing five nautical miles should only subtend three miles and a half; the shoals of Barros de Zooniga, though well placed, instead of being two distinct shoals ought to have been one entire shoal, stretching something further to the NW. and SE. than is therein represented; and the soundings between Barros de Zooniga and the land of Ponta de la Loma, (which is omitted,) are in no part, from the south extremity of the former directly across to the latter, more than four fathoms at high water, and form a narrow bar from the shore to the shoal, gradually deepening as well on the inside as on the outside of the bar, with a regular increase in mid-channel, from five, close to the shore, to ten fathoms between the two low points that form the entrance to the port."—(Vol. II, page 473.)

As the mean rise and fall of spring tides is five feet, and of neap tides about two and a half, Vancouver's and the recent examinations of the Coast Survey confirm each other, and tend to show that the depth has remained the same for the last sixty-three years.

The primary astronomical station of the Coast Survey is on the round-topped hill, 100 feet high, and a quarter of a mile W.SW. of La Playa.

Its geographical position is:

	°	′	″	
Latitude	32	41	57.6	north.
Longitude	117	13	22	west.
	h	*m*	*s*.	
Or, in time	7	48	53.5.	

The eastern side of the entrance to San Diego bay is low and flat, covered with thick bushes and grass. It is called "The Island," although a peninsula, being very low and narrow towards the head of the bay. On Ballast Point, at the base of the Point Loma ridge, are visible the ruins of the old Spanish fortifications, &c.

From Ballast Point the bay runs about north for a mile and a half; thence curves gradually to the eastward for three miles to New San Diego; thence to the head of the bay, southeast, seven miles. The average width of the bay after passing La Playa is a mile and a half, but at New San Diego, after contracting to a trifle over half a mile, it again expands to about a mile and a half, with low shores and extensive marshes and flats. Many years since the San Diego river changed its course during a freshet, and emptied into San Diego bay instead of Puerto Falso to the northwest. The result was a rapid filling in of the bay opposite the old town of San Diego. An appropriation was made by Congress to turn the channel of the river to its original bed. This was done a few years ago, but the works have not proved of sufficient strength.

The great drawback in San Diego bay is the want of fresh water, which has to be brought from the river. An effort was made in 1851 to obtain a supply at La Playa by sinking an artesian well, but after boring 635 feet the attempt was abandoned. A similar attempt, with like results, was made at New Town, both confirming the previously expressed opinion of geologists. The same amount of money would have brought it in earthen pipes from the river. During the long dry season the river loses itself in the sand, and the inhabitants are compelled to dig in its bed to obtain their supplies. Fresh provisions are readily procured here. Wood is scarce and not good.

The land in the region of San Diego bay is, with the exception of a small portion, well adapted to grazing. There are numerous tracts, of limited extent, which produce well, but they are favorably situated for irrigation, the want of rain being very much felt in every section. Back in the mountainous districts is found abundance of timber of many varieties, such as oak, pine, cedar, fir, ash, sycamore, elm, &c. Gold, silver, lead, copper, &c., are found, but the product is not remunerative. A vein of coal (lignite) has been discovered near San Diego, is reported of excellent quality, and interested parties are erecting machinery to work the lead, but the experiment must prove a failure, because no genuine coal is to be found upon the coast, and in 1851 a report was made against this very deposit.

When fishery assumes a practical shape on this coast the harbor of San Diego will become a position of importance. Already several small companies are engaged in the whaling business. The waters in this vicinity abound with the "California Greys," which are very troublesome to deal with, unless the bomb-lance is used in killing them.

Communication with San Francisco and the northern or windward ports is maintained every week by steamer, and by regular lines of sailing vessels.

San Diego bay was discovered by Juan Rodriguez Cabrillo, a Portuguese in the service of Spain, in September, 1542; called Port San Miguel, and placed by him in latitude 34° 20′ N., showing the imperfection of the instruments and the modes of observing in those days. He found great numbers of Indians here, who received him hospitably, but with cautiousness. It received its present name from Sebastian Vizcaino, who surveyed it in November, 1602.

In his time there existed a forest of tall, straight oak and other trees bordering the NW. side of the bay. This forest was said to be three leagues in length and half a league in breadth, and that to the northwest of it was a good harbor, now known as Puerto Falso.

La Perouse (in 1787) gives a copy of an English map of San Diego, of 1782, (Dalrymple's,) on which no name is assigned to the Zuniga shoal, but the shoal inside Ballast Point and under the eastern shore is called "Shoal of Zuniga." Ballast Point is called "Point Guisarros," and Point Loma, "Hill Point."

At the north end of the ridge of Point Loma is an extensive shoal bay called *Puerto Falso*, or *False Bay*. The bar at its entrance lies N. by W. ½ W., distant 5½ miles from the southern extremity of Point Loma; and having but three feet of water, it can be crossed only in the smoothest weather. The entrance just inside the line of heavy breakers is about a quarter of a mile in width, but rapidly contracts to less than an eighth. The northern point of this bay is about two miles in length, very narrow, and covered with low sand dunes.

A view of False bay and the surrounding country was given on the Coast Survey reconnaissance chart of 1853.

To the north and west of this the shore becomes compact and unbroken, except by the valleys of San Luis Rey and San Juan Capistrano. The waters off this stretch of the coast Vizcaino called the bay of Santa Catalina.

The latest chart of San Diego bay is that accompanying the Report of the Superintendent of the Coast Survey for 1857.

From the southern extremity of Point Loma the coast runs N. by W. for 22 miles; thence to Point Lausen, (of Vancouver, 1793,) forming the east point of San Pedro bay, NW. by W. ½ W. nearly 60 miles.

SAN LUIS REY.

The mission of San Luis Rey is the largest in California, and the number of domesticated Indians formerly in its neighborhood gave it the appearance of a large and thriving settlement.

It was founded June 13, 1798, stands in a rich valley from one to two miles wide, and is about three miles from the ocean, being separated therefrom by a range of hills.

It is nearly in the centre of a section of country unequalled for salubrity and productiveness, but the scarcity of rain is an insuperable drawback.

The mission is now a military post, but very few men are stationed there.

The anchorage is very much restricted and unprotected, and now never visited. Its position on the coast will be seen by reference to the reconnaissance sheet of the Coast Survey published in 1853.

Its approximate geographical position is:

	° ′
Latitude	33 17 north.
Longitude	117 29 west.

SAN JUAN CAPISTRANO.

Now a place of no importance, with an unprotected anchorage, rocky bottom, and bad landing.

This mission, like all the others, is rapidly going to decay.

The approximate geographical position of the anchorage is:

	° ′
Latitude	33 27 north.
Longitude	117 43 west.

The site of the mission is marked on the reconnaissance sheet of 1853.

In latitude 33° 30½′ N., about four miles northwestward along the coast from the western point of Capistrano anchorage, the line of *equal magnetic declination* of 13° east cuts the shore, and passes over the great transverse break of the island of Santa Catalina. This line annually moves southward a mile and a half.

SAN PEDRO BAY.

This bay is well protected in every direction, except against the winter gales from the southeast round to the southwest. During the spring, summer, and autumn, it is an excellent roadstead. From Point Fermin,* which is the southeast point of high land west of the bay, the line of bluff runs exactly north and south for about two miles, being bold, and averaging 60 feet in height.

Vessels coming from the westward through the Santa Barbara channel make San Pedro hill, (1,600 feet in height,) forming the west side of the bay, as an island projected against the mountains to the southward and eastward. Approaching Point Vincente, which is the southwest point of the hill, vessels can keep it close aboard, there being from 50 to 80 fathoms within a mile of the shore; round Point Fermin within half a mile, in from 6 to 10 fathoms, and open the small island called El Moro,† run for that island, and when abreast of the landing, (readily recognized by the houses on the bluff,) about one mile north of Point Fermin, anchor in three fathoms, hard bottom, and half a mile off shore. Vessels must anchor a mile off to get five fathoms.

Coming from the south with northwest winds, beat in boldly until abreast of the landing; keep the lead going and anchor anywhere in its vicinity. Do not approach the low shore, to the north and east of El Moro, closer than one mile, at which limit four fathoms water will be found.

In winter, anchor further out, and more to the southward, in order to be able to slip the cable and go to sea should a heavy southeaster spring up. In 1852 we saw a vessel ride out a very heavy southeast gale of three days' duration. In March, 1863, the steamer Senator was lost in entering San Pedro in a fog.

The waters of the lagoon, inside of the low sandy beach, and a mile or more northward of El Moro, find their principal outlet between that island and the bluff point half a mile west of it. The entrance is very narrow and crooked, and has two buoys, about 200 yards apart, to mark it. In 1859 it is stated‡ that the "bar at the entrance to the creek remains about the same, (as it did in 1852.) At mean low water, throwing out the half tides, only two feet of water can be carried over it." A small tow-boat is now used for taking vessels to New San Pedro, situated about three miles inside the bar.

* Named by Vancouver in 1792, after the Father, Fermin de la Suen, President of the Missions of Alta California. He applied the name to the west point.

† For El Morro. On the Coast Survey reconnaissance chart of 1852 it is called Dead Man's island.

‡ Report of the Superintendent of the Coast Survey for 1859, page 100.

Wood and water are not readily obtained, and charges are high. The beef raised here is remarkably tough.

The geographical position of the Coast Survey astronomical station on the bluff at the landing is:

	°	′	″
Latitude	33	43	19.6 north.
Longitude	118	16	03.0 west.
	h.	*m*	*s.*
Or, in time	7	53	04.2.

Magnetic variation, 13° 30′ east, in November, 1853, with a yearly increase of 1′.

An appropriation has been made for a *light-house on Point Fermin*, and the necessary topographical survey completed. The site recommended to the Light-house Board, by the Superintendent of the Coast Survey, is S. 15° W., and fifteen-sixteenths of a mile distant from the astronomical station.

Tides.—The corrected establishment or mean interval between the time of the moon's transit and the time of high water is IX*h.* XXXIX*m.* The mean rise and fall of tides is 3.7 feet, of spring tides 4.7 feet, and of neap tides 2.2 feet. The mean duration of the flood is 6*h.* 18*m.*, of the ebb 6*h.* 5*m.*, and of the stand 0*h.* 30*m.* The average difference between the corrected establishments of the a. m. and p. m. tides of the same day is 1*h.* 10*m.* for high water, and 1*h.* 4*m.* for low water. The differences, when the moon's declination is greatest, are 1*h.* 55*m.* and 1*h.* 38*m.*, respectively. The average difference in height of these two tides is 1.5 feet for the high waters and 2.0 for the low waters. When the moon's declination is greatest, those differences are 2.3 feet and 3.1 feet, respectively. The average difference of the higher high and lower low waters of the same day is 5.6 feet, and when the moon's declination is greatest 6.6 feet. The higher high tide in the twenty-four hours occurs about 9*h.* 10*m.* after the moon's upper transit (southing) when the moon's declination is north, and about 3*h.* 16*m.* before when south. The lower of the low waters occurs about seven hours after the higher high tide.

The greatest observed difference between the two low waters of one day was 3.9 feet, and the greatest difference between the higher high and lower low waters of one day 8.4 feet.

To find the times and heights of high and low waters, compute them for San Diego, the times and heights being sensibly the same for both places.

The town of Los Angeles is 22 miles north by the road, from San Pedro, and is the centre of an extensive grazing, agricultural, and grape-growing country.

The quantity of grapes, and fruit generally, shipped to San Francisco during the proper season is already enormous, being not less than 2,000,000 pounds. At all seasons one steamer finds a profitable trade. The coasting trade of this place is now greater than the aggregate trade of all the other ports south of San Francisco. In nine months of 1856–'57 the number of vessels entering the port was 82, with an aggregate tonnage of 26,971 tons. Regular communication is maintained with San Francisco and other ports by steamers and sailing vessels.

Over 100,000 gallons of wine, and 5,000 gallons of brandy, were produced in 1854, and the culture of the grape bids fair to outstrip all others. The quantity of wine produced from the vintage of 1857 was 350,000 gallons; of brandies 5,000 gallons. There is no doubt that in 1862 the yield is more than double these quantities.

Cotton, sugar cane, tobacco, flax, and the cereals, yield productive crops, and the olive grows in abundance.

Salt works have been established within a few miles of Los Angeles, but the pond from which the salt water is obtained covers only an area of 600 yards in length by 200 in width. The yearly product is about five tons.

The country at the foot of the back hills is as productive as any in California, but its distance from a large market is a great hindrance to investment and improvement. The vast plains are literally covered with cattle, and many of the rancheros count their yearly increase by thousands. These cattle are driven to the mining districts and San Francisco, but during the not unusual droughts of summer great suffering is experienced, and large numbers of them perish.

The Bay of San Pedro was discovered by Cabrillo in 1542, and was called the Bay of Smoke, (Fumos.)

When Vancouver was seeking for San Pedro bay he found such deep water off Point Vincente that he thought this could not be near the place; but after getting to the south and east he had a full view of the anchorage. He did not, however, enter it.

A view of San Pedro bay and San Pedro hill was given on the Coast Survey sheet of 1853.

In 1861 a preliminary examination was made of the lagoon, situated E. ¼ S., about 15 or 16 miles from San Pedro, and which receives the waters of the Santa Anna river. It was found to be some five miles long, and separated from the ocean by a narrow strip of low sand beach, over which washes the heavy swell from the northwest and southeast storms. The lagoon has a breadth of only a few hundred yards, and a mouth about 50 yards in width, with a narrow bar, upon which it is supposed 10 or 12 feet of water might be found at high tide. On this bar there is a very heavy break at all stages of the tide, rendering it dangerous to cross in boats of any kind. There is said to be no safe anchorage off the entrance, and the low straight beach, with a trend nearly east and west, affords no protection whatever. The San Pedro wind gap lies between San Pedro hill and the Sierra San Juan, to the southeast of the Santa Anna, and the summer winds draw directly on the land, causing the northwest swell to roll upon the beach with great force. In winter the southeast and southwest swell breaks square upon this whole line of coast, and would prevent any vessel passing into or out of the lagoon, or riding at anchor near it.

In summer the Santa Anna is said to frequently dry up before reaching the lagoon.

*From Point Vincente** the coast trends N. by W. ¾ W. for 17 miles; thence W. by S. to Point Dume, in latitude 34° 00′ north, and longitude 118° 41′ west; thence to Point Mugu, W. ½ N. for 17 miles. The last point lies NE. by E. ⅛ E., distant 14 miles from the eastern end of Anacapa. This long curve in the coast is known as the Bahia Ona.

*Point Dume** rises into a dome-like form 202 feet high. The land immediately behind it falls away, so that in making it from the west it rises into view as an island close under the high mountains. Eastward of Dume the mountains spring directly from the water.

A view of Point Dume is given on the Coast Survey sheet of 1853.

From Point Mugu to San Buenaventura, distant 17 miles, the coast has a general trend NW. by W.; but, about midway, it curves southwestward of this course 2½ miles towards Anacapa, thus contracting the eastern entrance to the Santa Barbara channel. Two miles west of Point Mugu is Laguna Point, close under which is very deep water, the 10-fathom line running within 250 yards of the shore. Between Mugu and Buenaventura the coast is low, flat, and sandy, being the opening of the valley of Santa Clara, through which flows the Santa Clara river. This stream is nearly dry during the summer, and terminates in lagoons and marshes, but in the rainy season a volume of water is brought down having sufficient force to break through the narrow sand beach and flow into the ocean. The configuration of the shore, and its relation to Anacapa and Santa Cruz island, are shown upon the preliminary chart of the eastern entrance to the Santa Barbara channel, published by the Coast Survey in 1857.

The eastern entrance to the Santa Barbara channel lies between the eastern end of Anacapa island and Point Hueneme, which is about halfway between Mugu and Buenaventura. From Anacapa, Point Hueneme bears NE. by N. ½ N., distant 9¼ miles. Directly off this point is found a remarkable example of a submarine valley, commencing with a depth of 10 fathoms, 400 yards from the beach, increasing to 50 fathoms in five-eighths of a mile, and to 113 in less than two miles. Its general direction is south, with a width of a mile, and bounded on either side by depths of 12 and 15 fathoms. The best landing is directly on the point. Landing in the bight to the eastward and leeward is impracticable.

The erection of a *primary sea-coast light* at this point was recommended by the Superintendent of the Coast Survey, and has been authorized by Congress.

The approximate geographical position of the site is:

	° ′
Latitude	34 08 north.
Longitude	119 09 west.

The computed magnetic variation, August, 1857, was 13° 38′, with a present yearly increase of 1′.

Vancouver says this was called Point Conversion on old Spanish maps; he placed it in latitude 34° 09′, and retained the name.

There is excellent holding ground off Buenaventura in 10 fathoms, but the landing is not good. The three-fathom line lies about a quarter of a mile off-shore.

The Mission of Buenaventura, situated at the foot of the dividing ridge of the valleys of San Buenaventura and Santa Clara, about a half a mile from the shore, was founded March 31, 1782. Its approximate geographical position is:

* Named by Vancouver, 1793.

	° ′
Latitude	34 15 north.
Longitude	119 15 west.

Fifteen miles westward of Buenaventura, on the coast, there is a rich deposit of sulphur, surface specimens of which have yielded 60 per cent. Around the locality are found ashes and scoria. The ground is hot, and the gas emitted is almost suffocating.

SANTA BARBARA.

From San Buenaventura to Santa Barbara the distance is 23 miles, and the bearing nearly W. by N.

Santa Barbara is an open roadstead for all, except northerly winds, which are unfrequent. On the west side of the long, low, sandy beach is a bold bluff, called *Point Felipe.** The hill rising behind it is called La Vigia.

The landing is on the beach about half a mile east of Point Felipe; the shore is very low and flat as far as the town, three-quarters of a mile distant, but gradually rises to the mission, which is a prominent object about two miles inland.

Vessels coming from the westward first sight La Vigia, and, upon approaching the anchorage, keep outside of the line of kelp, (here nearly half a mile wide:) gradually round the point upon which is situated the *light-house,* two miles southwesterly of the landing, keep along the kelp until abreast of the town and anchor in seven fathoms; or pass through the kelp and anchor on the inside in 3½ fathoms, hard bottom. In anchoring far enough off to get 9 or 10 fathoms the bottom will be found sticky. A hydrographic sketch of the vicinity was published by the Coast Survey in 1855. A view of the town and mountains accompanies the sheet of 1853.

No dangers have been discovered in the kelp off this beach.

With the least swell the surf on the beach is a bad one, not falling square on, but cutting it at a sharp angle.

In winter, vessels must anchor outside of the kelp, as the gales detach and drive it shoreward in such vast quantities that, coming across a vessel's hawse, it helps to bring home her anchors.

In January, 1863, the Pride of the Sea was wrecked on the rocks under the light-house at this place.

LIGHT-HOUSE AT SANTA BARBARA.

The structure consists of a plastered dwelling of one and a half story, with a low grey tower, also plastered, rising through the roof. The illuminating apparatus is of the fourth order of the system of Fresnel, and shows a *fixed white light,* illuminating the seaward half of the horizon. It is situated at an elevation of 180 feet above the sea, two miles southwestwardly from the landing on the beach, and 183 yards from the edge of the bluff. The light, as seen from the sea, will be projected against the hill rising behind it.

In clear weather it can be seen from a height of 10 feet at a distance of 19 miles; from a height of 20 feet at a distance of 20½ miles.

It was first exhibited December 1, 1856, as a red light, but has since been changed.

The geographical position, as given by the Coast Survey, is:

	° ′ ″
Latitude	34 23 35 north.
Longitude	119 42 05 west.
	h. m s
Or, in time	7 58 48.3

Magnetic variation, 13° 30′ east in November, 1853; yearly increase 1′.

The secondary astronomical station of the Coast Survey was on the slight grassy rise just in from the beach, and 60 yards from the west side of the road leading to the town. Its position is:

	° ′ ″
Latitude	34 24 24.7 north.
Longitude	119 40 18.0 west.
	h. m. s.
Or, in time	7 58 41.2.

* Named by Vancouver, 1793; called Point Castillo on the Coast Survey chart of 1853, from a small Mexican battery formerly existing upon it.

Santa Barbara is a town of considerable size, lying in the middle of an agricultural tract, running east and west, at the southern base of the Sierra Concepcion, but of limited breadth. The trade with San Francisco is not extensive; but this being one of the greatest stock-raising districts on the coast, vast droves of cattle pass through and are sent to San Francisco and the mining districts.

The mission, founded December 4, 1786, is one of the largest and best establishments of the kind in California, and in the gardens attached to it the grape and olive were cultivated with success. In the town of Santa Barbara there is a single grapevine which yielded during the year 1858 over two thousand pounds of grapes. A single stem rises from the ground a height of five feet, and its branches, supported by poles, cover a very large area. At the base the trunk measures two feet in circumference.—(California State Register, 1859.)

A large bitumen pit, about eight miles west of Santa Barbara, empties directly into the ocean, and the bitumen, floating on the water, works *against* the summer or northwest winds even beyond Point Concepcion. Very frequently, in calm weather, a great extent of the surface of the channel becomes iridescent from the thin film of bitumen spread over it. The rocks along the shore, even to the westward of Point Concepcion, are covered with it, and when encamped at El Coxo, in 1850, we gathered it to start our fires. The Indians have always used it to pay the seams of their canoes.

Sulphur, in large beds and of superior quality, exists along the seaboard, and manifests itself in all the warm springs.

Wood and provisions in abundance can be easily obtained here. Water is plenty, but not so readily procured.

A very short distance back from the coast line is a range of rugged hills, over 2,000 feet high, forming part of the Sierra Concepcion, (sometimes called the Sierra San Inez,) whose sides are sparsely covered with timber, and through some of whose gullies and gorges pass small streams abounding in the finest trout. From others issue warm springs having a temperature of about 117° Fahrenheit, and highly impregnated with sulphuretted hydrogen. The height of the springs by barometric measurement is about 1,200 feet. They lie behind the village of Montecito, eastward of Santa Barbara.

The coast trail to San Francisco passes along the shore for a distance of 15 or 20 miles to the Gaviota pass; thence inland to the Santa Inez valley, which runs nearly parallel with the coast.

Regular communication by steamers and sailing vessels is maintained with San Francisco and other ports.

In 1542 Cabrillo visited this place and found great numbers of Indians, who came off to his ships in large canoes, and were quite hospitable. Close to shore he found an Indian town with "*casas grandes.*" To it he gave the name Pueblo de los Canóas.

The coast line from Santa Barbara light to Point Concepcion light runs W. by S., distance 37 miles. The rugged hills westward of the Gaviota pass come close to the shore, forcing the traveller to leave the beach for their sea slope, the trail passing over steep ridges and down valleys.

The simoom.—The only instance of the simoom on this coast, mentioned either in its history or traditions, was that occurring at Santa Barbara, on Friday, the 17th of June, 1859. The temperature during the morning was between 75° and 80°, and gradually and regularly increased until about one o'clock p. m., when a blast of hot air from the northwest swept suddenly over the town and struck the inhabitants with terror. It was quickly followed by others. At two o'clock the thermometer exposed to the air rose to 133°, and continued not lower than that point for nearly three hours, whilst the burning wind raised dense clouds of impalpable dust. No human being could withstand the heat. All betook themselves to their dwellings and carefully closed every door and window. The thick *adobe* walls would have required days to have become warmed, and were consequently an admirable protection. Calves, rabbits, birds, &c., were killed; trees were blighted; fruit was blasted and fell to the ground, burned only on one side; and gardens were ruined. At five o'clock the thermometer fell to 122°, and at seven it stood at 77°. A fisherman, in the channel in an open boat, came back with his arms badly blistered.

It is recorded that on the 23d of June there was a remarkable hot day over Stanislaus county. The thermometer stood at 113° in the shade, and the wind actually burned as from a hot oven. Birds dropped dead from the trees.

At the entrance of the valley of El Coxo, near Point Concepcion, whilst engaged in making astronomical observations, during July, August, and September, 1850, we frequently experienced at night hot blasts coming down from the Sierra Concepcion, after two or three days of clear, calm, hot weather; the north winds apparently bringing the heated air from the valleys behind the sierra. The records show many cases where stars suddenly became so very diffused, large, and unsteady by these short hot blasts as to be unfit for observation. Beyond the annoyance and delay occasioned by this circumstance no observations were made to determine the temperature of the heated air. It had, of course, not near so elevated a temperature as that sweeping over Santa Barbara, and was quite fitful.

POINT CONCEPCION.

This characteristic and remarkable headland, about 220 feet in height, lies at the western entrance to the Santa Barbara channel. Once seen, it will never be forgotten. When made from the northward, or from the eastward, it rises as an island, but, upon approach, is found to be a high promontory, stretching boldly into the ocean, and terminating abruptly. The land behind it sinks comparatively low, and at first gradually, but soon rapidly rises to the mountains, which attain an elevation of about 2,500 feet. Between three and four hundred yards south of the face of the cape is a large rock nearly awash, upon which some of the California steamers have struck in very foggy weather. A topographical sketch of the point accompanies the Superintendent's report on the Coast Survey for 1851. Views of it accompany the sheet of 1853.

LIGHT-HOUSE AT POINT CONCEPCION.

The buildings are erected on the extremity of the cape and upon the highest part, which is 220 feet above the sea, and covered with grass and bushes like the land behind. As seen from the southward by day it will be projected against the Sierra de la Concepcion, and appear about one-third of their height from the water. The part of the range behind the light-house seems very level along its summit, and the house is seen about one-third of the length of the level range from the western part of it. The structure consists of a brick dwelling, plastered, of one and a half story, with a low tower, also of brick, and plastered white, rising from the centre. The light was first exhibited February 1, 1856, and shows from sunset to sunrise. It is a primary sea-coast light, consisting of an illuminating apparatus of the first order of the system of Fresnel, and exhibits *a revolving white light, showing a flash every half minute,* throughout the entire sea horizon. It is elevated about 250 feet above the sea, and should be visible, in a favorable state of the atmosphere, from a height of—

10 feet above the sea, at a distance of 21.8 miles.
20 feet above the sea, at a distance of 23.3 miles.
30 feet above the sea, at a distance of 24.4 miles.
60 feet above the sea, at a distance of 27.1 miles.

Its geographical position, as given by the Coast Survey, is:

	° ′ ″
Latitude	34 26 47 north.
Longitude	120 27 00 west.
	h. m. s.
Or, in time	8 01 48.0.

Magnetic variation, 13° 50′ east, in September, 1850; yearly increase, 1′.

Fog-bell at Point Concepcion.—A fog-bell, weighing 3,136 pounds, is placed on the edge of the bluff, seaward of the light-house. The striking machinery occupies a frame building, whitewashed, on a level with the ground, and having the front open to receive the bell, which is sounded during foggy or other thick weather, night or day, every thirteen and a half seconds.

The following bearings and distances are taken from the Coast Survey chart of this locality, published in 1853.

The rock off the west end of the San Miguel island, S. ½ E., distant 22 miles.

The east end of San Miguel island, SE. by S. ¼ S., distant 26 miles.

The southwest end of Santa Cruz island, SE. by E. ½ E., distant 40 miles.

Next to the islands of the Santa Barbara channel, Point Concepcion is the most prominent and interesting feature between San Francisco and the peninsula of Lower California. It has very justly and appropriately been termed the "Cape Horn" and the "Hatteras" of the Pacific, on account of the heavy northwesters that are here met with on coming through the channel, with a great change of climate and meteorological conditions; the transition being remarkably sudden and well defined. An investigation of the temperature of the ocean, northwest and east of the cape, would be highly instructive, as some characteristics would naturally be expected from the abrupt change in the direction of the mountains and coast line. We have frequently seen vessels coming from the eastward with all sail set, and light airs from the north, in a very little time reduced to short canvas upon approaching the cape, and vessels from the northwest coming before a spanking breeze lose it within a few miles after passing the cape into the channel. These last would be fortunate in reaching Santa Barbara in a day. We have known a vessel to be three days working from San Buenaventura to Santa Barbara, whilst a ten-knot breeze was blowing west of Point Concepcion.

During some summer seasons the fog is almost interminable, but more particularly among the islands. For the space of six weeks, with clear days and nights at the cape, the islands have been invisible; rising, however, to an elevation of 1,000 or 1,500 feet, the observer plainly sees the summits of the islands over the sea of fog which envelops them.

When the fogs prevail, they generally roll in from seaward at sunset, and clear away about ten o'clock next morning.

Point Concepcion was discovered by Cabrillo in 1542, and called Cape Galera. He placed it in latitude 36½ N. It was afterwards named Punta de la Limpia Concepcion.

The extent of shore-line from the southern boundary to Point Concepcion is about 250 miles.

EL COXO.

Two miles east of Point Concepcion is the anchorage of El Coxo, off the entrance to the valley of that name. This anchorage is a better one than that of Santa Barbara, and the kelp is not so compact. After passing the point from the westward, at a distance of about three-quarters of a mile, run E. by N., and gradually round the bluff one mile distant from the cape, giving it a berth of half a mile; run on a N.NE. course for three-quarters of a mile, when the valley will open with a sand beach off it. Anchor outside or inside the kelp, according to the choice of depth; five fathoms being obtained within a quarter of a mile of the shore, with hard, sandy bottom. Ten fathoms water will be found half a mile from shore.

A hydrographic sketch of the anchorage was issued from the Coast Survey Office in 1852.

There is a large rancho at El Coxo, and it is one of the very best tracts for grazing. The beef has a finer flavor and more delicacy than any we have met with on the coast. At the head of the valleys and in the mountains is a species of large live oak, very brash when newly cut, but growing hard by seasoning. Willow, for fuel, and water can be obtained here, but neither in abundance. The water is disagreeable to the taste.

The primary astronomical station of the Coast Survey was on the top of the bluff, and between 250 and 300 yards W. ½ S. from the mouth of the creek. Its geographical position is as follows:

	° ′ ″
Latitude	34 26 56.5 north.
Longitude	120 25 39 west.
	h. m. s.
Or, in time	8 01 42.6.

Magnetic variation, 13° 50′ east, in September, 1850; yearly increase, 1′.

In passing this valley, in 1793, Vancouver saw an Indian village, the inhabitants of which made signs for him to land.

ISLANDS OF THE SANTA BARBARA CHANNEL.

The name El Canal de Santa Barbara was given by Vizcaino, in December, 1602, to the narrowest part of the channel lying east and west, and about 24 leagues in length.

Until the Coast Survey first examined in detail the islands lying off the main, between San Diego and Point Concepcion, nothing accurate was known of their number, peculiarities, extent, or position. Upon all maps, of as recent date as 1850, an island called San Juan was laid down, and upon a map of the republic of Mexico, compiled in the United States, and dated 1847, we find no less than twelve large islands, the positions and extent of which are most grotesquely erroneous. The island of San Miguel, the most western of the Santa Barbara group, is placed 70 miles SE. of Point Concepcion, instead of 23 miles SE. by S. ½ S. The same general remarks will apply to the coast line as thereon represented. Three large rivers are made to flow into the sea between Santa Barbara and San Diego bay, which is increased in size to 20 miles by 15, and running north, whilst two others rival it in extent. A Russian chart published in 1848 has a bay and river on the east side of Point Dume. The geographical positions given previous to the Coast Survey operations are remarkably erroneous. We recollect well, when coming upon this coast, of finding in good nautical authority Point Concepcion over six miles distant from the latest determination in latitude; and we have heard of more than one vessel reaching California with only a school atlas for a chart.

In Findlay's Directory for the Pacific Ocean, published late in 1851, we find a description of the already mentioned San Juan island, but it does not give it a very definite location. It may not be uninteresting to state how the error has been perpetuated. The first notice we can find of this island is its discovery by Martinez, in 1789, on his passage from Monterey to San Blas. The next time it turns up is in Vancouver, vol. II, page 474, where the following account is given:

"At the distance of about eight leagues, somewhere about N. 55° W., or N. 60° W. from Point de la Loma, by a very uncertain estimation, is situated an island called St. John's, between which and the coast we passed without seeing it, [although he previously states having seen San Clemente and Santa Catalina,] nor did we observe it while we remained at anchor, excepting on one very clear evening, when it was seen from the Presidio [of San Diego] at a time when I was unprovided with a compass or any other means of ascertaining its direction, and was therefore only able to guess at its situation.

"It appeared to be low and flat; is but seldom seen from the Presidio of San Diego, and was undiscovered until seen by Martinez, a few years before, in one of his excursions along the coast."

As Vancouver has plotted this island on the line from Point Loma to San Clemente, and as it is generally so placed, we have no hesitation in assuming that, during peculiar states of the atmosphere, the top of San Clemente or of Santa Catalina has been mistaken for another and intermediate island.

Having visited and examined San Clemente, Santa Catalina, San Nicolas, Santa Cruz, and San Miguel, we found them offering no inducements for agriculture, and very few, indeed, for raising stock, while there are so many advantages on the main. In a few words, we may characterize their disadvantages as want of water, and want of fuel, with high, bold, and rugged sides, which in many places become precipitous. The surface of San Miguel and Santa Rosa is rolling, and covered with grass and bushes; the mountains of Santa Catalina almost inaccessible, and San Nicolas, and San Clemente, composed of coarse sandstone, presenting a dry, sandy, and sterile aspect.

On the chart of the coast from San Diego to San Francisco, published by the United States Coast Survey in 1853, a remarkable and beautiful exhibition of the parallelism between the islands and the adjacent coast is presented. The four islands, Anacapa, Santa Cruz, Santa Rosa, and San Miguel, with the rocks seven miles W. by N. from the latter, lying broad off the coast between San Buenaventura and Point Concepcion, have their longer axes parallel to the trend of the shore-line, which is the general direction of the Sierra Conception immediately behind it. In Vizcaino's voyage, this parallelism was noted west of Santa Catalina, "where a regular row of islands exist, five or six leagues distant from each other, all populous, and the inhabitants trading with each other and the main, and the islands following each other in the same direction as the main land."

Cortes shoal, the islands of Santa Catalina, San Clemente, San Nicolas, with John Begg's rock, seven miles from its northern extremity, have their longer axes NW. by W., and parallel to each other, whilst the sland of Santa Barbara is on the prolongation of the longer axis of San Clemente. In the third parallel the direction becomes perpendicular to the first described, for from latitude 33° 05′ N. the trend of the coast and hills southward, through the longer axis of Point Loma, will pass through Los Coronados, although the islands lie NW. with respect to each other.

Navigators, in making the *Santa Barbara channel* from the northwest, readily estimate their approach in thick foggy weather by the peculiar odor of the bitumen which, issuing from a large pit on the shore about eight miles west of Santa Barbara and floating upon the water, works *against* the summer winds far beyond Point Concepcion. This set to the westward is found to exist for about four miles off shore, and runs at a maximum velocity of a mile and a half per hour. Further out the current is variable, but even there its greatest velocity is attained when running to the westward. From Point Concepcion it strikes to the southward and westward, being doubtless influenced by a current from the upper coast.

Vancouver is the first who calls attention to the bitumen, in the following language, vol. II, page 449: "The surface of the sea, which was perfectly smooth and tranquil, was covered with a thick slimy substance, which, when separated or disturbed by any little agitation, became very luminous, whilst the light breeze that came principally from the shore brought with it a strong smell of tar, or of some such resinous substance. The next morning the sea had the appearance of dissolved tar floating upon its surface, which covered the ocean in all directions within the limits of our view, and indicated that in the neighborhood it was not subject to much agitation."

The following remarks of Sir Edward Belcher, in October, 1839, are taken from the Voyage of the Sulphur, vol. I, page 320: "Off this part of the coast to the westward [of Santa Barbara] we experienced a very extraordinary sensation, as if the ship was on fire, and after a very close investigation attributed it to a scent from the shore, it being more sensible on deck than below; and the land breeze confirming this, it occurred to me that it might arise from naphtha on the surface."—See remarks, page . Santa Barbara.

Among the islands, as far as San Nicolas, the current runs to the southward, and there remains little doubt that the steamship Winfield Scott was set out of her course, and upon Anacapa, by this current. On the Cortes shoal it frequently runs against the NW. wind at the rate of nearly two miles per hour. At other times it has been found to run in an opposite direction nearly as strong.

A preliminary chart of the eastern entrance to the Santa Barbara channel accompanied the annual report of the Superintendent of the Coast Survey for 1857.

It may not be here amiss to call attention to the abundance of mackerel found in the channel. We have seen the water fairly alive with them, and have caught them by hundreds. Crayfish of a very large size are found in great numbers along the shores.

The rainy season commences in the early part of November, and continues until the middle of March. The quantity of rain that falls does not average over 15 inches, but some seasons are marked by excessive drought. During the winter SE. gales prevail, and sometimes during the summer months southerly weather will bring up heavy rain.

CORTES SHOAL.

Commencing at the southward, the first object that claims our attention is the dangerous bank and rock called the Cortes shoal, bearing SW. ¼ W. from the southeast end of the island of San Clemente, and distant 46 miles. The extent of this bank has been sounded out carefully, and found much greater than the early examinations led us to suppose. Within the limits of the 50-fathom curve the general trend is parallel with the islands of Santa Catalina, San Clemente, and San Nicolas, and it stretches about 17 miles, from latitude 32° 24′ N., longitude 118° 59½′ W., to latitude 32° 32′ N., longitude 119° 17½′ W., but curves slightly to the southwest. It has an average and nearly uniform width of 3½ miles. The nature of the bottom is hard, composed of white sand, broken shells, and fine coral at the southeast portion; and sand, with broken shells, at the northwest. The shoalest and most dangerous part is that known as the *Bishop rock*, lying five miles from the southeast tail of the bank, and having but 2½ fathoms of water upon it. Around this danger the depth increases gradually, and in an extent of 2½ miles in the general direction of the bank reaches but 15 fathoms. The geographical position of these rocks is, approximately:

	° ′	
Latitude	32 25¾	north.
Longitude	119 05	west.

From the northwest end of the island of San Nicolas the rocks bear SE. ½ S., distant 57 miles; and from the southeast end of the island of San Clemente they bear SW. ¼ S., distant 46 miles.

The next shoal spot is one of 10 fathoms, about the middle of the bank, and of limited extent, being only half a mile square within the 15-fathom curve. Its geographical position is, approximately:

	° ′	
Latitude	32 26¾	north.
Longitude	119 10½	west.

From the northwest end of San Nicolas, the spot last mentioned bears SE. by S., distant 54 miles; and from the southeast end of San Clemente it bears SW. ¼ W., distant 50 miles. From the Bishop rock it bears W. ¾ N., distant five miles.

To the northwestward of this latter shoal spot the depth is nearly uniform at 49 fathoms for 7½ miles, and between it and the Bishop rock the depth is uniform at about 43 fathoms.

Upon this bank the current is variable, frequently setting against the strong NW. winds with a velocity of nearly two miles per hour, and producing at all times a heavy swell, and even in moderate weather breaking heavily upon the rocks. In passing over the bank at night we have been sensible of our proximity to it by the increased swell. In the detailed examination of 1856 it was found that the general set of the current was to the southward and eastward, and the greatest velocity a mile and a half per hour; but no statement is made concerning the prevailing wind.

The existence of this bank had been reported several times, and the following positions assigned to it:

Swift's island, latitude 33° 08′; longitude 119° 06′, as seen by Captain Aulick, U. S. N.

Rock, latitude 32° 30′; longitude 119° 06′; no authority.

Bank, latitude 32° 28′; longitude 118° 42′; no authority.

It lies in the direct route now followed by the Panama and San Francisco steamships, and was discovered by Captain Cropper, of the steamship Cortes, in March, 1853. His position was determined by bearings upon San Nicolas and San Clemente, and was very close, being within a mile of the latest and best assigned place. He says that the water around it was in violent commotion, and thrown up suddenly in columns at regular intervals of four or five minutes. At first he thought he saw breakers; and occasionally the water broke as on a reef, but he became confident that the disturbance was owing to submarine volcanic agency. The specimens of the bottom negative this idea. He found his depth of water reduced from 42 fathoms to 9, which convinces us that he was on the shoal spot, about the middle of the bank, and saw the water breaking upon the Bishop rock, the same appearance that he witnessed having been seen many times since by others, and the nature of the rocky bottom and depth of water supporting the assumption. The position of the bank was afterwards more closely determined by the commander of the steamship Pacific; but in the Coast Survey operations the 10-fathom spot was found, and the surveying schooner used in that duty was anchored on it five days.

Attention was subsequently called to a more extended examination of the vicinity by the clipper ship S. S. Bishop, (now Grey Eagle,) of Philadelphia, striking upon the rock, since called by her name, (1855,) and, under unfavorable circumstances, two points of rock were supposed to exist, to which approximate positions were assigned. In 1856 the bank was sounded out to the extent of 130 square miles; and from a consideration of the highly favorable circumstances under which this last survey was made, confidence is expressed that the point of rock above mentioned is the only one existing; but as it is very difficult to find detached single points of rock below the surface in a sea-way, we shall not be surprised if others be eventually found. At all events the prudent navigator will give this bank a good berth. Its existence forcibly suggests the probability that other submarine ridges lie parallel to the coast.

A chart of the Cortes shoal was published by the Coast Survey in 1856.

ISLAND OF SAN CLEMENTE.

This, like all the islands of the Santa Barbara channel, is high and bold, the southern end being the higher, and gradually falling to the northward.

The general trend of the island is NW. by W.; its length 22 miles, with an average breadth of two miles, and 50 miles in circuit.

The southwest point of the island bears W. ½ S. from Point Loma, distant 60 miles. At the northwest end is a small indentation of the shore-line forming an anchorage, having a width of three-quarters of a mile, by half a mile in depth, with soundings decreasing from 12 fathoms, on the line of a large rocky islet at the side to a point E. by S., to four and five fathoms close in shore. Kelp will be found in 10 fathoms, but the bottom is tolerably regular and hard. It is anything but a pleasant or safe anchorage in bad NW. weather, and even in heavy southerly weather the swell must roll in disagreeably. A hydrographic sketch of it was issued from the Coast Survey Office in 1852.

Under the SE. end of the island anchorage may be had in the deepest part of the indentation, but the bottom is rocky and irregular. The SE. point is a vast sandstone pyramid; and when it is brought to bear north, and the shore three-quarters of a mile distant, the anchorage will lie W. by N. ½ N., one and three quarter mile inside the kelp, in 10 to 15 fathoms, and one-third of a mile from the narrow sand beach at the foot of the cliffs. Outside of the kelp the depth ranges from 10 to 30 fathoms.

This anchorage will afford protection in heavy northwest weather. A hydrographic sketch and view of it accompanies the annual Coast Survey report for 1856.

The soundings around the island show a depth of from 36 to 130 fathoms close in shore, except off the northwest point, from which a reef makes out about a mile.

The Coast Survey secondary astronomical station was at the northwest anchorage, on the grassy rise, just inside of the high-water line, and bore S. 17° E. from the north point of the rock islet before mentioned. Its geographical position is:

	° ′ ″
Latitude	33 02 00 north, (approximate.)
Longitude	118 34 00 west.
	h. m. s.
Or, in time	7 54 16.

Neither wood nor water can be had here. The whole island appears unfit for raising stock, on account of the want of water. Very few trees are found, and the aspect is sterile.

This island was discovered by Cabrillo in 1542, and called by him San Salvador, after one of his two vessels. The present name was given by Vizcaino in 1602.

ISLAND OF SANTA CATALINA.

This island rises to a height of about 3,000 feet, and is remarkable for the great transverse break or depression, five miles from the northern end, running partly through it, and forming an anchorage or cove at each side. The land connecting these is very low, say not over 30 feet; but the hills rise up on each side two or three thousand feet, and, when sighted from the north or south, the whole appears like two very high islands. The view on the Coast Survey chart of 1852 shows this very beautifully, and is highly characteristic. The general trend of the island is W. by N. ¾ N.; its length 17½ miles, with an average breadth of four miles to the southern part, and two miles to the northern, while the shore-line amounts to about 42 miles.

The depression in the island bears S.SW. from Point Fermin, and is distant 18½ miles.

The harbor or cove on the southern side, five miles from the northern end, is only about one-third of a mile in width, but its approaches are bold, and, so far as known, free from hidden dangers. To find it, run along the SW. side of the island and make the depression; then stand in for the opening, keeping a little left of mid-channel until a third of a mile inside of the heads. From thence keep in mid-channel until abreast of the long, low point on the right, and anchor in five fathoms, soft bottom. There is a depth of three fathoms inside of the low point, with hard bottom, but not room enough for a vessel to swing. If the wind is blowing from the NW., vessels will lose it at the heads, and perhaps require to be towed in.

The anchorage on the north side of the depression is also small, with a reef in the centre and two large outlying rocks. A steamer could run in on the west side of the rocks, and anchor off the low beach in 10 fathoms, when the reef would lie N. by E. from her, distant an eighth of a mile. Small craft will here find protection from the prevailing wids, but experience difficulty in getting out, as there is always a swell setting in, and the wind blows in flaws and eddies on account of the high hills. Between the two points forming the anchorage the distance is half a mile, and the depth one third.

The soundings around the island show bold water, from 19 to 75 fathoms, close in shore, with no outlying rocks except off the north cove. The shores are rocky, and on the southern side fearfully abrupt, but on the northern shore there are several indentations, where boats may land at almost any season. Deep and precipitous gulches are formed by the ridges of rock running diagonally across the island from NE. to SW., and occasionally a small valley varies the scene. Four or five settlers cultivate these spots, but their inconsiderable extent precludes the realizing of anything beyond a bare sustenance. About midway between the NW. extremity of the island and the great break there is a spring of good water, and at the SE. point good water has been obtained by sinking wells to a depth of fifty feet or more, but in the intermediate places water found at the same depth is brackish. There is a large pond on the low land between the anchorages, but the water is very brackish. Scrub-oak is obtained for firewood, and a growth of thorny bushes covers the whole island, rendering travelling very difficult. The island was partially stocked with cattle and sheep, and at one time vast numbers of wild goats abounded, but they have helped to supply the California market with fresh meat. In 1863 some old lead mines were rediscovered; the ore is described as argentiferous galena.

From the north end of the near large rock at the north cove, the Coast Survey secondary astronomical station, which was on the edge of the bank, bore S. 25° W. Its geographical position is:

	° ′ ″
Latitude	33 26 34.7 north.
Longitude	118 28 45 west.
	h. m. s.
Or, in time	7 53 55.0.

This island was discovered by Cabrillo in 1542, and called by him La Victoria, after one of his two vessels. It received its present name from Vizcaino in December, 1602, when it was thickly inhabited by a people reported to be very ingenious, particularly in pilfering and concealing; some examples of which accomplishments they gave the Spaniards. Padre de la Ascension, who accompanied this expedition, gives very particular descriptions of a kind of temple to the sun, with images and idols, found near the two coves.

Hydrographic sketches of the anchorages have been published by the Coast Survey.

ISLAND OF SANTA BARBARA.

This is one of the only two small islands of the Santa Barbara group. It lies on the line between the north end of San Clemente and the east end of Santa Cruz, and almost exactly half way between them. From the north end of Santa Catalina it bears W. by S., distant 23 miles.

The extent of the island would not exceed two miles of shore-line; its elevation at the highest part is about 500 feet, and the top has an area of about thirty acres covered with soil, but no water is found, and not a vestige of wood. The shores are rocky and abrupt, presenting on the northeast and south sides perpendicular cliffs exposed to the full force of the ocean swell.

Landing is at all times difficult and dangerous. The water around it is deep, and there are no outlying rocks. It is said to be much more enveloped in fogs than the neighboring islands. Its approximate geographical position is:

	° ′
Latitude	33 30 north.
Longitude	119 02 west.

ISLAND OF SAN NICOLAS.

Of the channel islands this is the most distant from the coast, as well as the driest and most sterile. It is about 600 feet high, abrupt, and, like San Clemente, comparatively flat-topped, but falling to the southern end. The sides are bold and precipitous, and composed of coarse sandstone.

Its general direction is W.NW.; its length is eight miles, with an average and nearly uniform width of 3½ miles, whilst the extent of shore-line is about 22 miles.

The north point of the island bears SE. by E. from Point Fermin, distant 67 miles; the line passing one mile south of the island of Santa Barbara.

At the north end of San Nicolas heavy breakers make out two miles and a half, and the soundings towards the Begg rock show irregular and rocky bottom. Breakers also extend from the southern point to the distance of a mile and three-quarters, according to Kellet. This is doubtless the case in heavy weather.

The soundings around the island show depths varying from 10 to 48 fathoms.

Off the southeast point, which is low and sandy, vessels may anchor in 10 fathoms, hard bottom, with a current running steadily to the southward, which makes the landing bad, as the surf cuts the beach at an acute angle.

The Coast Survey secondary astronomical station was on the sandy point just referred to, and its geographical position determined as follows:

	° ′ ″
Latitude	33 14 12.9 north.
Longitude	119 25 00 west.
	h. m. s.
Or, in time	7 57 40.

This island was not seen by Vancouver in 1793.

The *Begg rock* is situated on the prolongation of the longer axis of the island of San Nicolas, bearing NW. by W. ½ W. from its nearest (NW.) point, and distant seven miles. The rock is about 40 feet high, bold, and well defined, and can be easily seen at a distance of ten miles. The soundings between it and the island indicate the existence of a submarine ridge connecting them. Its approximate geographical position is:

	° ′
Latitude	33 22½ north.
Longitude	119 39½ west.

It was named after the ship John Begg, which struck upon a reef near it, September 20, 1824, and was nearly lost. The foul bottom is covered with kelp. The position of the rock relative to the island of San Nicolas is shown on the general chart of reconnaissance published by the Coast Survey in 1852.

ISLAND OF ANACAPA.

This is, in fact, a curiously formed group of three islands, extending in a nearly E.NE. direction, their entire length being five miles. The west end of Anacapa is a peak 930 feet in height, with a base of over two miles by three-quarters of a mile. This is separated from the middle island by a gap ten feet wide, through which boats can pass. The middle island is nearly two miles long by 500 yards wide, whilst the eastern island is little over a mile long by 500 yards wide. The gap separating the middle and eastern islands is over 200 yards wide, but so completely filled with rocks as to be impassable for boats, which can, however, land on the north side of the island.

The west end of Anacapa is $4\frac{1}{2}$ miles from the eastern point of the island of Santa Cruz, and bears E. $\frac{1}{2}$ N. from it. The depth of water between these islands is 30 fathoms, with a very regular bottom composed of grey sand, coral, and shells. The eastern end of the island bears SE. $\frac{3}{4}$ E. from the Santa Barbara light, distant 28 miles, and from Point Hueneme or Conversion, the nearest point of the mainland, SW. by S. $\frac{1}{3}$ S., distant $9\frac{1}{4}$ miles.

Anacapa is in latitude 34° 01′ N., and between longitudes 119° 19′ and 119° 24′ W. Upon it the *site for a light-house* has been recommended by the Superintendent of the United States Coast Survey.

The island is composed of coarse, dark grey sandstone, very rotten and crumbling. The sides are perpendicular, and from 250 to 300 feet high. The main peak is marked on the north side by several deep gulches, with almost vertical sides running from the summit to the bluff. The whole formation is filled with innumerable cavities, giving it the appearance of an enormous blackened honeycomb. At the eastern extremity is found a very beautiful arch in one of the outlying rocks. This is well shown in the view accompanying the Coast Survey chart of the vicinity of the island of Anacapa published in 1856. The soil is loose and thin, producing only a few dwarfed species of cactus and a thick-leaved succulent plant common to the sea-coast in dry sandy localities. Not a drop of water is to be found on the island.

Anacapa is a place of great resort for the seal, sea lion, and formerly of the otter, but the latter have been nearly all killed off.

It was on this island that the steamship Winfield Scott ran ashore during a dense fog at midnight, December 2, 1853, in calm weather. The vessel was steaming at full speed, and ran between and upon the rocks with such force that she remained fast by the bow until heavy weather broke her up. The course of the steamer had been taken from Point Concepcion, but without a knowledge of the currents.

Vancouver, in his narrative, calls this island Enneeapah, and repeatedly mentions it by that name; but upon the chart of his survey and explorations it is engraved Enecapah, which has given rise to every variety of spelling. Old Indians at the present time pronounce it En-nee-ah-pagh′, with a very strong guttural intonation.

A chart of Anacapa and the eastern end of Santa Cruz was published by the Coast Survey in 1856, and a preliminary map showing its relation to the mainland in 1857.

ISLAND OF SANTA CRUZ.

This island is the largest of the channel group, and lies broad off the coast opposite the town of Santa Barbara, at a distance of 20 miles. Its general direction is east and west, with a length of 21 miles and an average width of four miles, while the extent of its shore-line is not less than 53 miles.

On the northern side of the island, and near the middle, the shore makes a moderately deep curve, forming a roadstead called ***Prisoner's harbor***, at the opening of a valley, where plenty of wood and water can be obtained. Anchorage may be had a quarter of a mile off the middle of the beach in 15 fathoms, sandy bottom; but there is no protection from the heavy swell setting in with a northwester. It must, however, afford excellent refuge in southeast weather. A hydrographic sketch of the harbor was published by the Coast Survey in 1852.

The soundings around the island show deep water close to the shore; but there are rocks showing quite plainly one mile from the southwest point. A chart showing the hydrography of the eastern end of the island was published by the Coast Survey in 1856.

The island is bold, and about 1,700 feet in height. Its eastern part is extremely irregular, barren, and destitute of water; and the surface of the northeastern portion is thickly strewn with large angular pieces of stone, broken as if with a hammer. Several species of cactus and some of the coarse grasses flourish. The only wild animal found here is a small gray fox, of which there are great numbers.

Santa Cruz island is composed of coarse, dark gray sandstone, crumbling and rotten, like that of Anacapa.

The Coast Survey secondary astronomical station was on the eastern side of the fresh water. Its geographical position is:

	° ′ ″	
Latitude	34 01 10.2	north.
Longitude	119 40 00	west.
	h. m. s.	
Or, in time	7 58 40	

From the Santa Barbara light we have the following bearings and distances:

East point of Santa Cruz island SE. ⅜ S., distance 24 miles.

Prisoner's harbor S. by E. ½ E., distance 22 miles.

West point of Santa Cruz island S. by W. ½ W., distance 21 miles.

A site for a light-house at the eastern end of the island has been reported upon and recommended by the Superintendent of the Coast Survey to the Light-house Board.

This island was called Juan Rodriguez by Ferrelo, who commanded the ships of Cabrillo after his death, which took place either in Prisoner's harbor, or in Cuyler's harbor (island of San Miguel.) The greater probability rests with the former, as there they could obtain water, and oak wood for repairs, &c., while neither is to be had in the last-mentioned harbor, except water, during the rainy season.

The group comprising Santa Cruz, Santa Rosa, and San Miguel, was discovered and called San Lucas by Cabrillo in 1542.

ISLAND OF SANTA ROSA.

This is the middle island of the group off the coast between Santa Barbara and Point Concepcion. Its general shape is that of a parallelogram, with the direction of the longer axis almost exactly east and west, and fifteen miles in length; and the shorter north and south, giving it a width of ten miles. The extent of shore-line is about 42 miles.

On the northwest side of the island, and midway between the north and west points, a reef extends out for a distance of a mile and a quarter.

There is a good passage between Santa Cruz and Santa Rosa, with a width of five miles, and one between it and San Miguel of four miles. Both passages are frequently used by the California and Panama steamships.

The soundings around the island do not show as deep water as around the others. On the northwest and northeast sides from fifteen to twenty fathoms are found two miles from shore, but on the southeast and southwest sides the water is much deeper.

The outline of the island is bold, but not so high as Santa Cruz. The hills are rolling, and covered with coarse grass and bushes. No harbors exist around its shores, which are steep and broken. The relative position of Santa Rosa in the group of the Santa Barbara islands is shown on the reconnaissance chart of the Coast Survey published in 1852.

The approximate geographical position of the south point of the island is:

	° ′	
Latitude	33 53	north.
Longitude	120 04	west.

For the western point we have:

Latitude	33 58½	north.
Longitude	120 12½	west.

On some early Spanish charts the western two of the Santa Barbara islands are called San Miguel and Santa Rosa, (naming the western first,) and upon others Santa Barbara and San Miguel. The present names and order are those adopted by Vancouver in 1793.

ISLAND OF SAN MIGUEL.

This is the western of the Santa Barbara Channel islands, its longer axis lying E. ½ N., and 7½ miles in length, with an average breadth of 2½ miles. The extent of shore-line is 21 miles. Its western extremity is bold and narrow, gradually increasing in breadth until it attains 3½ miles. As seen from the southwestward, this end of the island appears to be several hundred feet in height, and composed of sand dunes, therein differing from all the other islands. The eastern face is nearly straight for two miles; the southern face is nearly straight along its whole length, with high, abrupt shores; and from 30 to 37 fathoms water are found close in shore. On the NE. side of the island is the small bay called *Cuyler's harbor*, off which lies a rock or islet more than a fourth of a mile long, and several hundred feet high. From this islet to the deepest part of the harbor the distance is a mile and a quarter, and the course SW. Close under the western side of the harbor is anchorage in six fathoms, secure from every wind except the north, which rarely blows here. The eastern part of the bay is full of rocks and reefs, and ought to be avoided. The reef in the middle of the bay bears SW. from the west end of the islet, and is distant half a mile. It is the same distance from the west point of the bay, near the anchorage, and bears E. by S.

SW. by S. ½ S. from the west end of the islet is a rock, and rocky bottom, distant a third of a mile; and on the same line another, half a mile distant. The southern part of the islet is about half a mile from the east shore of the bay. The bay shores are high, steep, and rolling, and covered with coarse grass and bushes. There is no water here in summer, but during the winter water drains down the gully at the beach in the middle and southern part of the harbor.

A hydrographic sketch of Cuyler's harbor was published by the Coast Survey in 1852.

The western point of the island bears S. by E. ¼ E., distant 25 miles, from Point Concepcion, and SE. by S. ½ S., distant 35 miles, from Point Arguello.

A *sea-coast light* has been reported upon for this point of the island, and the subject referred to the Light-house board.

Sheep and some stock have been placed upon San Miguel, but the success of the experiment has been doubtful—certainly unremunerative. A peculiar bobtail fox is found here.

The Coast Survey secondary astronomical station is on the SW. part of Cuyler's harbor, about forty feet up, on the side-hill. Its geographical position is:

	° ′ ″
Latitude	34 03 00 north, (approximate.)
Longitude	120 20 27 west.
	h. m. s.
Or, in time	8 01 21.8.

Tides.—The corrected establishment, or mean interval between the time of the moon's transit and the time of high water, is IX*h.* XXV*m.* The mean rise and fall of tides is 3.7 feet; of spring tides, 5.1 feet; and of neap tides, 2.8 feet. The mean duration of the flood is 6*h.* 13*m.*, and of the ebb 6*h.* 5*m.* The average difference between the corrected establishment of the a. m. and p. m. tides of the same day is 1*h,* 40*m.* for high water, and 1*h.* 9*m.* for low water. The differences, when the moon's declination is greatest, are 2*h.* 54*m.* and 2*h.* 12*m.*, respectively. The average difference in height of these two tides is 1.6 foot for the high waters, and 2.5 feet for the low waters. When the moon's declination is greatest these differences are 2.6 feet and 3.6 feet, respectively. The average difference of the highest high and lowest low waters of the same day is 5.8 feet, and when the moon's declination is greatest, 6.8 feet. The highest high tide in the twenty-four hours occurs about 8*h.* 35*m.* after the moon's upper transit, (southing,) when the moon's declination is north, and about 3*h.* 51*m.* before when south. The lowest of the low waters occurs about 7½ hours after the highest high tide.

To find the times of high and low waters first compute them for San Diego, and, from the numbers thus obtained, subtract 19*m.* for Cuyler's harbor.

San Miguel was discovered by Cabrillo in 1542, and Cuyler's harbor is supposed by some to be the bay in which he wintered. He died January 5, 1543, having directed Bartolome Ferrelo, his pilot, to assume the command of the expedition and continue the exploration as far north as possible. Ferrelo afterwards named the island in whose harbor his commander had wintered, Juan Rodriguez. It is sometimes called San Bernardo.

Cuyler's harbor was named by the U. S. Coast Survey in 1852.

Two rocks, showing themselves well above water, lie NW. by W. from the western extremity of San Miguel, the larger being distant five miles. It bears S. ½ E., distant 22 miles, from Point Concepcion, and S.SE., distant 30 miles, from Point Arguello. Off the inner and smaller rock a reef extends a short distance to the southward and westward. Deep water is found around the rocks, and vessels may pass between them. The total extent of shore-line of the Santa Barbara islands is about 232 miles.

FROM POINT CONCEPCION, NORTHWARD.

The first headland to the northward of Point Concepcion is *Point Arguello*,* distant 12 miles, and bearing NW. by W. ½ W. The shore is bold and compact, curving slightly to the eastward between the two points, and the mountains immediately behind are not less than 3,000 feet in height. Two or three hundred yards off Point Arguello are some detached rocks, upon which the steamship Yankee Blade struck and was lost on the 1st of October, 1854, and 415 persons perished.

From this point the trend of the coast is NW. to Point Reyes, 240 miles distant, passing tangent to Point Sur in latitude 36° 19½′ N., and inside the South Farallon.

Eight miles north of Point Arguello a small stream empties into the ocean. It was considered by Vancouver the largest he had seen south of the Columbia, but it is insignificant and unimportant. He states that on the old Spanish charts it is called the Rio de San Balardo. On a French chart of 1841 it is called the San Geraldo; on a recent Russian chart we find it called the river Benardo; on the Coast Survey charts it is designated *La Purissima*, from the mission La Purissima Concepcion, situated a few miles inland. On the State map of California it is called the San Ines. It rises in longitude 119° 20′, about 15 miles from the coast, and runs parallel therewith behind the Sierra Concepcion.

The first point northward of Point Arguello is *Point Purissima*, off which makes a reef about a fourth of a mile to the S.SW. This is known on the coast as *Point Pedernales*, signifying Point of Flints, but now generally and erroneously printed Pedro Nales. Formerly it was called San Pedro Nolasco. Near this point the steamship Edith was lost in 1849. The State survey of California places Pedernales only two miles to the northward of Arguello.

Between Points Sal and Purissima a small stream called the Guyamas opens.

From Point Arguello N. by W. ⅝ W., and distant 19 miles, is Point Sal,* which is marked by streaks of yellow sand, except at the extreme point. The extremity is formed by high, round, black rocks, off which are several sunken rocks, extending half a mile to the southward and westward. This stretch of the coast is very similar to that behind Concepcion and Arguello, but, after passing Point Sal, the mountains fall back, and the shore is formed of sand-hills. The general bend hence is north, until the shore commences sweeping westward to form the bay of San Luis Obispo, and the shores become high and abrupt.

The line of *equal magnetic variation* of 14° east cuts the coast line in latitude 35° 01′ N., and crosses the meridian of 121° 30′ W. in latitude 33° 55½′ N. It moves annually southward about a mile and a half

SAN LUIS OBISPO.

This bay is an open roadstead, exposed to the southward, and even during heavy northwest weather a bad swell rolls in, rendering it an uncomfortable anchorage. The landing is frequently very bad, and often impracticable, but the best place is in the mouth of the creek, keeping the rocks at its mouth on the starboard hand. Fresh water may be obtained at a small stream opening on the beach half a mile west of the creek. In the coarse sandstone bluff between these two places are found gigantic fossil remains.

Off *Point San Luis*, which forms the SW. part of the bay, are some rocks, and in making the anchorage vessels should give this point a berth of half a mile, passing in six or eight fathoms; run on a N. by E. course, and anchor three-fourths of a mile from shore in six fathoms, sticky bottom; four fathoms can be got about a fourth of a mile from the beach. In winter, anchor far enough out to clear Point San Luis if a southeaster should come up. During southerly weather landing is frequently effected at the watering place, when impracticable at the creek.

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* Named by Vancouver in 1793. A view of it is given on the Coast Survey sheet of 1853.

The distance from the rock off Point San Luis to the mouth of the creek is a mile and a half; from the same rock to a white rock bearing N. 70° E. the distance is two and a quarter miles; and a black rock lies halfway between the white rock and the mouth of the creek.

The Coast Survey secondary astronomical station is on the bluff at the east side of the small fresh-water stream, west of the creek, and its geographical position is:

	° ′ ″
Latitude	35 10 37.5 north.
Longitude	120 43 31 west.
	h. m. s.
Or, in time	8 02 54.1.

The magnetic variation, 14° 17′ east, in February, 1854; yearly increase, 1′.

Tides.—The corrected establishment, or mean interval between the time of the moon's transit and the time of high water, is X*h.* VIII*m.* The mean rise and fall of tides is 3.6 feet; of spring tides, 4.8 feet; and of neap tides, 2.4 feet. The mean duration of the flood is 6*h.* 25*m.*, and of the ebb 5*h.* 58*m.* The average difference between the corrected establishments of the a. m. and p. m. tides of the same day is 1*h.* 24*m.* for high water, and 1*h.* 0*m.* for low water. The differences when the moon's declination is greatest are 2*h.* 0*m.*, and 1*h.* 28*m.*, respectively. The average difference in height of these two tides is 1.5 foot for the high waters, and 2.0 feet for the low waters. When the moon's declination is greatest, those differences are 2.0 feet and 3.1 feet, respectively. The average difference of the higher high and lower low waters of the same day is 5.4 feet, and when the moon's declination is greatest 6.1 feet. The higher high tide in the twenty-four hours occurs about 9*h.* 32*m.* after the moon's upper transit, (southing,) when the moon's declination is north, and about 2*h.* 54*m.* before, when south. The lower of the low waters occurs about seven hours after the higher high tide. The greatest observed difference between the two low waters of one day was 4.0 feet, and the greatest difference between the higher high and lower low waters of one day was 8.3 feet.

To find the times of high and low waters, first compute them for San Diego, and to the times thus obtained add 30*m.* for San Luis Obispo.

The town of San Luis Obispo, which takes its name from the mission of that name, founded September 1, 1772, is not on the bay, but is situated about ten miles in the interior, in the middle of an extensive and excellent grazing country. Communication is maintained with San Francisco and other ports by regular steamers and lines of sailing packets.

The bay was discovered by Cabrillo in 1542, and called by him Todos Santos.

A preliminary chart of the harbor of San Luis Obispo was issued from the Coast Survey Office in 1852.

To the northwest of the Bay of San Luis Obispo rises to a great height the *Monte de Buchon*, which is readily distinguished in coming from the northward or southward.

We have been informed by old otter hunters on this coast that there exists a sunken rock about eight miles S.SW. from Point San Luis, and furthermore that they had found kelp upon it in four fathoms. On the old Spanish charts an island appears laid down in that direction, but distant about eight leagues. One of the Pacific mail steamships laid to in a southeast gale and thick fog off Point Concepcion, and drifting to the northward came unexpectedly upon a sunken rock, upon which the sea was breaking heavily. The commander supposed the vessel to be then off Point Sal, and had so plotted the rock upon his chart; but upon being informed of the alleged existence of a rock off San Luis Obispo, he was satisfied that he had been near it, but unfortunately had no opportunity of determining his position.

This locality demands a thorough examination, as it is in the direct track of the whole California trade from San Francisco.

From Point San Luis the coast trends in a straight line W.NW., for a distance of eight miles, and close along the shore of this stretch are several large rocks. Thence the coast trends abruptly to the north, running to the high conical rock called *El Moro*, distant eight miles—these two shores forming the seaward base of Mount Buchon.

From El Moro the shore-line gradually trends to the westward, thus forming a deep indentation or bay, called *Los Esteros* on the old Spanish charts, but designated as the Estero bay on the Coast Survey chart. It was discovered by Cabrillo in 1542, and here he obtained wood and water. Behind El Moro are several lagoons or streams, and the high land retreats for some distance, leaving the shore low and sandy, while the north shore is rugged, and guarded by rocks. The NW. point of the bay is called *Punta de los Esteros* on the old Spanish charts, and bears NW. ½ N. from the west point of Mount Buchon, distant 13 miles. A line joining these two points shows that the bay is about five miles deep.

A view of El Moro is given on the Coast Survey sheet for 1853.

From Point Arguello, Punta de los Esteros bears NW. by N., distant 53 miles.

From Point Los Esteros to the western point of the anchorage of San Simeon the coast runs nearly straight NW. by W. for a distance of 15 miles. The shores are not so bold as to the southward or northward, and the mountains fall well back, leaving a fine rolling country of no great elevation, and well suited to agriculture. We have seen wild oats growing here over six feet in height—not one or two stalks, but in acres.

BAY OF SAN SIMEON.

This is a small exposed roadstead, but affords tolerably good anchorage during northwest winds. The southwest point of the bay bears NW. by W. from Point Esteros, and is distant 15 miles. The indentation of the shore-line forming the bay trends between N.NW. to N. for half a mile, and then sweeps away to the westward about a mile and a half, gradually taking a southeast direction. The land behind the bay is comparatively low and gently rolling, the high hills retiring well inland.

Vessels coming from the northward may run boldly round the SW. point, within a few hundred yards of the shore in eight or nine fathoms, round up to north and anchor anywhere off the sand beach, in five fathoms, hard bottom, and a little more than a quarter of a mile from shore. The beach is half a mile long, stretching well out, and rendering the landing disagreeable with any swell; but in such cases it is usual to land at the western part of the beach. Eastward of the sand beach the shore-line is bluff and guarded with rocks. Vessels from the southward must make short tacks close in shore, or they will assuredly miss it. The only sure marks for it are the Piedras Blancas, as will be hereafter shown. It was in this bay that the steamship Pioneer put in leaking badly; was driven or dragged upon the beach, and after being abandoned by the underwriters was got off and carried to San Francisco. The bay affords not the slightest refuge in southerly weather. A hydrographic sketch of it was published by the Coast Survey in 1852.

In making this harbor from the northward vessels must sight the *Piedras Blancas,* (White Rocks,) four miles W. ¾ N. of the SW. point of San Simeon. They are two large white sharp-topped rocks, and nothing else like them is found on this part of the coast. The geographical position of the outer and larger rock is, approximately:

	°	′	
Latitude	35	39	north.
Longitude	121	15	west.

From Point San Luis they bear NW. ¾ W., distant 38 miles.

From Point Esteros they bear NW. by W. ½ W., distant 18 miles.

From Point Arguello they bear NW. ½ N., distant 72 miles.

The secondary astronomical station of the Coast Survey at San Simeon is on the rise just off the beach, and bearing N. 5° W. from the SW. point of the bay. Its geographical position is:

	°	′	″	
Latitude	35	38	24.4	north.
Longitude	121	10	22	west.
	h.	*m.*	*s.*	
Or, in time	8	04	41.5.	

This bay is supposed by some to be the "Bay of Sardines" of Cabrillo, where he anchored and landed in 1542.

A view of the Piedras Blancas is given on the Coast Survey sheet of 1853.

From *Piedras Blancas* the coast trends NW. ½ W. for a distance of 57 miles, in an almost perfectly straight line. At a distance of 18 miles from these rocks the above-mentioned bearing cuts a bold bluff and rounded point called Punta Gorda, off which, and for two or three miles along the shore northward, there are many rocks. This point is the *Cape San Martin* of Cabrillo. He placed it in latitude 37° 30′ N.; but applying the correction obtained from his erroneous determination of San Diego, we obtain 35° 50′ N. as the position of San Martin, which is very nearly its proper latitude. As there is one point under Cape Mendocino, more generally known as Punta Gorda, it is recommended that this point retain the name given to it by Cabrillo, especially as all his names have been cast aside.

Continuing on the same bearing, and at a distance of 49 miles from Piedras Blancas, is *Point Sur*, sometimes called Lobos, making out nearly half a mile. As seen from the north or south, at a distance of 10 miles, Point Sur appears as a high, large, round-topped island; but upon approaching it a low neck of land is seen, connecting it with the main. Its approximate geographical position is:

	°	′
Latitude	36	19 north.
Longitude	121	52 west.

Vancouver, in passing down the coast in 1793, thought this "small, high, rocky lump of land, lying nearly half a mile from the shore," was detached, and that it formed an island.

The highest peak of the range bordering the coast lies six miles square in from Point Sur, and attains an elevation of 4,414 feet.

A view of the point is given on the Coast Survey sheet of 1853.

Still continuing on the same bearing, 57 miles from Piedras Blancas and 7½ miles from Point Sur, another slightly projecting point is passed, about a mile to the eastward of the course. Thence the coast trends more to the eastward, running N.NW. for eight miles, to *Point Cypress*, and passing *Point Carmel*, the south point of *Carmel bay*.

From *Point Arguello* to *Point Sur* the bearing is N. 44° W., and the distance 120 miles. From *Point Sur* to *Punta de los Reyes* the bearing is N. 43° W., and distance 118 miles.

The mountains, which had fallen back behind Los Esteros, gradually approach the shore-line north of San Simeon, and about 10 miles north of Piedras Blancas they come down abruptly to the coast, and run parallel with it to Point Carmel, forming the boldest and most compact shore that we have yet passed, and attaining a uniform elevation of nearly 4,000 feet. These mountains were called by Cabrillo the "Sierras Altas," but at present the range is known as the *Sierra de Santa Lucia*. From their abrupt faces we have seen cascades falling from a height of forty or fifty feet directly into the sea.

CARMEL BAY.

Between Point Carmel and Point Cypress, which are about three miles apart, lies the small, rocky and unsafe bay of Carmel. At the southern extremity is a small cove, sufficiently land-locked and protected for small vessels. In the vicinity there is an extensive quarry of granite, and several small coasting vessels are employed for its transportation to San Francisco; but there is so little space that they are compelled to warp in and out by buoys placed at the entrance. Point Cypress, the north point of the bay, is low, and covered with cypress to the water, and is the first wooded point met with in coming from the southward. The upper branches of the trees are spread out by the influence of the strong prevailing winds, and present a flat or umbrella-like appearance.

The Mission del Carmelo is situated but a short distance from the shores of the bay, and can be seen from the water in certain directions. After the abolishment of the Society of Jesus, in Lower California, by the emperor Charles III of Spain, with the transfer of the administration of the missions to the Dominican monks, and of the property to the Franciscan order, the Visatador, Don Josef de Galves, of the latter order, in July, 1768, visited San Diego and Monterey, for the purpose of establishing missions. On the 3d of June, 1770, he founded that of San Carlos de Monterey, now usually called the *Carmel mission*.

The name Rio Carmel was applied to the small stream emptying into Carmel bay, by Vizcaino, in December, 1602.

From *Point Cypress to Point Pinos* the general direction of the shore is N. ¾ E., and the distance four miles.

POINT PINOS

makes out as a low rounding point, bringing the pines, with which it is covered, within a quarter of a mile of the shore, off which the rocks make out a quarter of a mile, and the line of three fathoms nearly half a mile, when the depth suddenly increases to 10 or 15 fathoms, and at a mile reaches 40 or 45 fathoms. The three-fathom line follows the shore within a third or half a mile into Monterey, whilst outside of that line the depth increases as suddenly as off the point. Vessels should always give Point Pinos a good berth, as a very heavy swell almost invariably sets upon it. This point is the northern termination of the long and elevated range called Sierra de Santa Lucia, extending southward and forming the bold rocky coast-line to San Luis Obispo.

A view of Point Pinos is given on the Coast Survey sheet of 1853.

POINT PINOS LIGHT-HOUSE.

This is a secondary sea-coast light, situated upon the northwestern part of Point Pinos, at the face of the growth of pines. The building is a grey granite dwelling one story in height, surmounted by a tower and lantern, which is 35 feet above the ground. The illuminating apparatus is of the third order of Fresnel, and shows a *fixed light of the natural color*, from sunset to sunrise. It illuminates about four-fifths of the horizon, and is elevated 91 feet above the level of the sea. During ordinary clearness of the atmosphere it can be seen from an elevation of—

10 feet, at the distance of 14.5 miles.

20 feet, at the distance of 16.0 miles.

30 feet, at the distance of 17.1 miles.

Its geographical position, as determined by the triangulation of the Coast Survey, is:

	°	′	″	
Latitude	36	37	58.1	north.
Longitude	121	55	00	west.
	h.	*m.*	*s.*	
Or, in time	8	07	40.0.	

The primary astronomical station of the Coast Survey is about half a mile eastward of the light, and has the following geographical position:

	°	′	″	
Latitude	36	37	59.3	north.
Longitude	121	54	25	west.
	h.	*m.*	*s.*	
Or, in time	8	07	37.7.	

Magnetic variation, 14° 58′.3 east, in February, 1851, with a yearly increase of 1′.

A topographical sketch of Point Pinos is given in the annual report of the Coast Survey for 1851.

BAY OF MONTEREY.

Point Pinos forms the southwest point of this bay, and *Punta de la Santa Cruz*, (forming the western shore of the anchorage of Santa Cruz,) the northwest point. A line joining these two points runs N. 27° W., 19⅜ miles, and the greatest width of the bay, near the mouth of the Salinas river, is 9⅜ miles.

From Point Pinos to the anchorage off the town of Monterey, the course is E. by S. ½ S., and the distance three miles. The shore towards the town is rugged, composed of granite, and covered with a heavy growth of fir; but to the eastward of the town is a long, sandy beach, backed by sand dunes of slight elevation. For a distance of 10 miles along this beach the line of three fathoms lies at a distance of 150 yards off shore, the water deepening rapidly beyond that, and the bottom almost everywhere hard.

Vessels coming from the northward, bound to Monterey, follow the coast from *Point Año Nuevo* to Point Santa Cruz, then run well into the bay, but not too far, for fear of losing the wind, and to avoid the set of the heavy swell rolling towards the beach. Leaving Point Santa Cruz and keeping on a SE. by E. course about 15 miles, will bring vessels into 25 fathoms, and nearly two miles from the beach; thence a south course for eight miles will bring them to the anchorage in 10 fathoms, and half a mile from the landing. These precautions are necessary, because Point Pinos, with the whole bay, is almost continually enveloped in a dense fog. Very frequently the coasting steamers have to run for the beach, and then be guided by the rote to the anchorage.

A direct course from Point Año Nuevo to the anchorage is SE. ½ E., and the distance 36½ miles. From Point Pinos to Point Año Nuevo the bearing is N. 47° W., and the distance 34 miles.

By anchoring well in at the western side of the anchorage vessels will avoid much of the swell that comes in with the heavy northwest winds, but never sufficient to make any berth there dangerous. In heavy southerly weather Point Pinos breaks the swell, but the wind draws very strong over the anchorage. The water shoals from 15 to 3 fathoms in a distance of 300 yards, and the lead should be used to avoid running in too far.

When the California mail steamships stopped at Monterey they frequently ran outside of Point Pinos, or in very dangerous proximity to it. This led to their firing a gun when approaching the harbor during foggy or dark weather, and upon the report being heard at the fort a gun was fired in answer, and the exchange kept up until the steamer was safe at her anchorage. We were encamped at Point Pinos when the steamship Carolina was brought in by this means, after she had got nearly as far down as Carmel bay.

The approximate geographical position of the end of the wharf, abreast of the custom-house at Monterey, is:

	° ′ ″
Latitude	36 36 17 north.
Longitude	121 52 27 west.
	h. m. s.
Or, in time	8 07 29.8.

Tides.—The corrected establishment, or mean interval between the time of the moon's transit and the time of high water, is X*h.* XII*m.* The mean rise and fall of tides is 3.4 feet; of spring tides, 4.3 feet; and of neap tides 2.5 feet. The mean duration of the flood is 6*h.* 31*m.*; of the ebb, 6*h.* 2*m.*; and of the stand, 0*h.* 35*m.* The average difference between the corrected establishment of the a. m. and p. m. tides of the same day is 1*h.* 44*m.* for high water, and 1*h.* 2*m.* for low water. The differences, when the moon's declination is greatest, are 2*h.* 40*m.* and 1*h.* 28*m.*, respectively. The average difference in height of these two tides is 1.4 feet for the high waters, and 2.4 feet for the low waters. When the moon's declination is greatest these differences are 2.2 feet and 3.7 feet, respectively. The average difference of the higher high and lower low waters of the same day is 5.3 feet, and when the moon's declination is greatest, 6.3 feet. The higher high tide in the twenty-four hours occurs about 9*h.* 36*m.* after the moon's upper transit, (southing,) when the moon's declination is north, and about 2*h.* 50*m.* before, when south. The lower of the low waters occurs about seven hours after the higher high tide. The greatest observed difference between the low waters of one day was 4.3 feet, and the greatest difference between the higher high and lower low waters of one day was 7.9 feet.

To find the times of high and low waters, first compute the times for San Francisco, and from the numbers thus obtained subtract 1*h.* 44*m.* for Monterey.

The town of Monterey presents a very pretty appearance as seen from the water. Immediately behind it the country rises in plateaus, diversified by hill and valley, and beautifully dotted by oak groves. It was the capital of California while under the rule of Mexico, and for some years after it became a State.

A Portuguese company has been formed here to engage in the whale fishery, and even with inadequate means it succeeded in obtaining over 16,000 gallons of oil (which sold for $12,000) in less than a year. Other companies have since been formed; their cruising ground is the bay of Monterey, and a short distance to sea. Operations are carried on by means of boats furnished with bomb lances during the season, which usually lasts nine months—from March to November.

Regular communication is kept up with all parts of the coast by steamers and numerous sailing vessels. Stages communicate with Santa Cruz and all the towns to San Francisco.

Following the shore from the town of Monterey, northward, it presents a uniform sand beach running nearly north, backed by low dreary sand dunes, producing sparsely the coarsest grasses and bushes, and entirely destitute of fresh water. This waste extends to the *Salinas river*, of which we reach the great bend at about 9½ miles from Monterey, and only one hundred yards from the beach. From Point Pinos it bears N. 30° E., distant 8½ miles. From this bend the river follows the line of the beach, just inside of the low sand dunes, for a distance of 4½ miles, and then disembogues. From Point Pinos it bears N. 18° E., and is distant 12¾ miles. This river has been designated by a variety of names—as Buenaventura, Monterey, and Salinas; but it is now generally known by the latter. It rises in the latitude of the Piedras Blancas; one branch about 20 and the other 33 miles from the coast. These branches meet at San Miguel, and thence the stream runs parallel with the coast and behind the Sierra Santa Lucia. From its mouth, which is only 60 yards wide at low water, to the entrance to the *Rio del Pajaro*, or San Antonio, the distance is 2¼ miles; the shore trending to the N.NW. The entrance of that river bears N. 11° E., 14 miles from Point Pinos.

From here the coast runs NW. nearly straight to Atos creek, a distance of seven or eight miles, and about six miles E. by N. of Santa Cruz, with the shore rocky and abrupt.

North of the Salinas river commence rich meadow and table lands, affording to the settler spots unsurpassed for productiveness, even in the prolific State of California.

A remarkable sub-marine valley, similar to that off Point Hueneme, has been discovered, and to some extent traced out in this bay. The head of the valley is five-eighths of a mile south of the mouth of the Salinas river, and the 20-fathom line is only a quarter of a mile off the beach, the depth increasing to 50 fathoms in the next quarter of a mile. At this distance from shore the 20-fathom lines are three-eighths of a mile apart. The general direction of the valley for the next two miles is SW. ½ W., where we find a depth of 117 fathoms, and the 50-fathom lines lie about five-eighths of a mile apart; thence the valley runs about west, reaching a depth of 170 fathoms in a mile, and 240 fathoms in 3¼ miles, with 42 fathoms, less than a mile to the north of this. The soundings are not numerous enough to trace its outlines in deep water; but the indications are that, for 10 miles of its length, it runs S. 60° W., with no bottom at 315 fathoms. The only available boat landing upon the beach of the bay shores is at the head of this sub-marine valley. There are no indications on the land of this peculiar formation, except that at its head the bay very gradually reaches its greatest casting.

An extensive valley, called the Salinas plains, through which comes the Salinas river, extends inland from the eastern part of Monterey bay, nearly to the mission of San Miguel, situated on a plateau of the San Bruno mountains. This valley is said to be nearly 90 miles in length, and in breadth varying from two to ten. It contains some 200,000 acres of good agricultural lands, and the remainder affords excellent pasturage for horned stock, horses, and sheep.

The bay of Monterey was discovered by Cabrillo in 1542, and called the Bay of Pines. It was surveyed by Sebastian Vizcaino in 1602, and the name was changed to Puerto de Monte-rey, in honor of the Spanish viceroy of Mexico, Don Gaspar de Zuniga, Count de Monte-rey, who despatched the expediton.

It was used by the Spanish galleons on their return from Manilla to Mexico.

A preliminary chart of Monterey bay was published by the Coast Survey in 1857.

The line of *equal magnetic variation* of 15° east cuts the coast line of Monterey bay in latitude 36° 45′ N., about half way between the great bend and mouth of the Salinas river, and crosses the meridian of 123° 0′ W., in latitude 36° 36′ N. This line moves annually southward about a mile and a half.

SANTA CRUZ HARBOR.

This harbor or anchorage is at the northwest part of the bay of Monterey, and is of very limited extent. It is protected from all the winds from the northward, but exposed to the full sweep of southerly gales, and many coasters have been driven ashore during the winter season. It is about three-quarters of a mile in depth northward, by 1½ mile east and west.

Vessels coming from the northward, after leaving Point Año Nuevo, follow the coast-line on a general course E.SE. for about 18 miles. The shore for this distance is abrupt, jagged, and moderately elevated, with a range of high hills, or mountains whose summits in summer are almost continually enveloped in fog. Skirting the shore at a distance of half a mile a depth of 6 to 10 fathoms can be carried, and upon making Point Santa Cruz, the top of which is moderately level for some distance back, four fathoms are obtained within a quarter of a mile of it; round up and run along in five fathoms until abreast of the beach, where good anchorage will be found half a mile from shore.

Vessels from the south in summer keep well into Monterey bay, to escape the full force of the northwesters and the heavy head sea.

During the winter months anchor well out, so as to be able to clear the shore westward of Point Santa Cruz in case a southeaster springs up.

Landing on the beach is generally disagreeable, as it extends out some distance, but boats usually land at the embarcadero, at the foot of the bluff in the NW. part of the harbor.

The beach is over half a mile in length, and between its eastern extremity and the bluff point empties the San Lorenzo river, a small stream running past the town and mission, which is situated a mile inland.

A chart of the harbor and vicinity was published in the Coast Survey report for 1854.

The country about Santa Cruz is exceedingly productive, and now thickly settled. A steamer runs regularly in the trade between this place and San Francisco, and numerous coasters find abundant freight from here and the Pajaro country to San Francisco.

Regular stage communication is maintained with San Francisco and Monterey.

The secondary astronomical station of the Coast Survey was at the top of the bluff at the embarcadero. Its geographical position is:

	° ′ ″	
Latitude	36 57 26.9	north.
Longitude	122 00 10	west.
	h. m. s.	
Or, in time	8 08 00.7.	

An examination for the location of a *harbor light* has been made, and the site recommended to the Light-house Board by the Superintendent of the Coast Survey.

The high mountain, N. 25° E., 12½ miles from Santa Cruz, is named Mount Bache, and attains an elevation of 3,791 feet.

Tides.—The corrected establishment, or mean interval between the time of the moon's transit and the time of high water, is X*h.* XVIII*m.* The mean rise and fall of tides is 4.1 feet; of spring tides, 5 5 feet; and of neap tides, 2.9 feet. The mean duration of the flood is 6*h.* 47*m.*; of the ebb, 5*h.* 45*m.*; and of the stand, 0*h.* 20*m.* The average difference between the corrected establishment of the a. m. and p. m. tides of the same day is 1*h.* 44*m.* for high water, and 1*h.* 2*m.* for low water. The differences, when the moon's declination is greatest, are 2*h.* 40*m.* and 1*h.* 28*m.*, respectively. The average difference in height of these two tides is 1.4 feet for the high waters, and 2.4 feet for the low waters. When the moon's declination is greatest these differences are 2.2 feet and 3.7 feet, respectively. The average difference of the higher high and lower low waters of the same day is 6.0 feet, and when the moon's declination is greatest, 7.0 feet. The higher high tide in the twenty-four hours occurs about 9*h.* 32*m.* after the moon's upper transit, (southing,) when the moon's declination is north, and about 2*h.* 54*m.* before, when south. The lower of the low waters occurs about 7*h.* after the higher high tide.

It was off Point Santa Cruz that Cabrillo is supposed to have anchored on the 17th of November, 1542, upon his return from the northward.

From Point Santa Cruz to *Point Año Nuevo* the distance is 18 miles, and the general direction W. by N. ¾ N., at first curving to the southwestward of that course, and then to the northward, until within three miles of the rock of Point Año Nuevo, when the shore curves well to westward, (for the last mile to the southwest,) forming an anchorage protected somewhat against the heavy swell from the northwest, and having a depth of five fathoms within less than half a mile of the shore, and from 10 to 15 fathoms at the distance of a mile.

At a quarter of a mile from the point lies a black jagged islet, consisting of a sloping ledge of rocks covered with a stratum of yellow clay about four feet thick, and this again covered with a mound of sand about 30 feet high. Upon this a *light-house* is to be built. The point itself is composed of rolling hills of shifting sand, varying from 20 to 100 feet in height, while behind them rises the Santa Cruz range of mountains. The coast trail, which followed the beach from the southward, here strikes up the hills behind the sand dunes.

Steamers coming upon the coast from the southward in thick weather, always endeavor to make the land near Point Año Nuevo, and then follow the coast to the San Francisco bar. On account of its importance in this respect a light-house was recommended by the Superintendent of the Coast Survey.

A map of the anchorage, with a view of the point, was published by the Coast Survey in 1854.

From Point Año Nuevo the coast runs NW. ¾ N. for about 10 miles, to the rocky point called the *Punta de la Bolsa*, but designated Point Miramontes on the Coast Survey reconnaissance sheet, from Mexico to San Francisco, in 1853. The high mountain square in from La Bolsa, bearing N. 53° E., and distant 13 miles, named Black mountain, attains an elevation of 2,809 feet. Two miles north of La Bolsa empties the Piscador, a small stream running through a valley of inconsiderable extent. For the foregoing 12 miles the general formation of the immediate seaboard is that of a table land of three terraces, the lowest gradually sloping from the base of the second to the coast, which is exceedingly rocky and forbidding; the underlying stratum is sandstone.

From Point Año Nuevo to Pillar Point, or Punta de Corral Tierra, forming the south and western point of Half-moon bay, the general direction is NW. by N. ¼ N., and the distance 25 miles. Three and a third miles above the Piscador opens the San Gregorio, another small stream, and 2⅓ miles still further opens the Tunitas. The seaboard between the valley of the Piscador and that of the San Gregorio undergo is a striking change both in the character of its topography and its geology. Instead of the table land we meet with a spur of the coast mountains running into the sea, and having an elevation of 600 feet within a mile of it. The shore-line and the coast generally presents a very broken and rugged appearance, occasioned by the deep gulches cut through to the ocean.

HALF-MOON BAY.

This anchorage is six miles S.SE. from Point San Pedro, and 18 miles S. by E. from the Golden Gate. The southwestern point of the bay is formed by a bluff table land about 160 feet in height, called the Corral de Tierra, 325 yards south of which stretches a number of black rocks, which show as one when seen coming up the coast, but as three or four when approached from the northwest. The largest is nearly as high as the bluff, and locally known as Sail rock, or Pillar rock. The point is known as ***Pillar Point***, and from its southeastern extremity rocky and foul-bottom, marked by kelp, extends SE. ⅛ E., seven-eighths of a mile, dropping suddenly from 14 feet to 5 fathoms. This is the inner reef, and makes the bay available as a summer anchorage. One mile and three-quarters southeast from the same part of the point a narrow ledge of rocky bottom, one-third of a mile long, and marked by kelp, stretches in the same general direction. The passage between this outer and the inner reef is three-quarters of a mile wide, with rocky and uneven bottom, from 3¼ to 10¼ fathoms. These ledges lie parallel with the coast mountains, and with the shore-line from which the outer one is distant 1⅔ mile. From the eastern extremity of the point the shore runs NW. by N. for a quarter of a mile; then NE. for three quarters of a mile, curving to the eastward and southeastward in a long bend, for 2½ miles to the mouth of the Arroyo de los Pillarcitos, down which comes the only road crossing the peninsula of San Francisco, between the Laguna de Mercedes and Santa Cruz The highest part of this road, which crosses a depression of the peninsula, is near the Coast Survey station "Ridge," which is 1,093 feet above the ocean, and but a few feet higher than the road. The outer reef is nearly abreast of the Pillarcitos, from which the coast runs south four miles to ***Miramontes point***, which is S. 48° E., five miles from Pillar Point; thence to the mouth of the Tunitas the distance is four miles SE. The greatest extent of the bay may be said to be between Pillar and Miramontes Points, but the part near the former only is available.

The soundings between the rocky ledges and the shore are quite regular, decreasing from nine fathoms to three fathoms at less than a quarter of a mile from the beach, with sandy bottom. The passage to the anchorage is between the inner and outer reef, with the high, bare-topped mountain bearing a little north of east, and Pillar Point open to the westward. This mountain is steep, with straggling redwoods on its flanks, and the summit bare. It is locally known as Bald Pate; but, on the Spanish grants, as Cumbra de las Auras. When inside the reefs beat up until Pillar Point bears about SW., distant half a mile, and anchor in 4½ fathoms, hard sand. With southerly light winds a heavy swell sets in; but upon the approach of heavy southeast weather it is necessary to go to sea.

The mass of redwoods cresting the mountains of the peninsula cease abruptly abreast of Miramontes, and only stragglers are seen to the northward. They are a good mark for recognizing this part of the coast when coming in from sea.

Around Half-moon bay is a limited extent of agricultural country at the seaward base of the mountains, and small coasters carry the produce to San Francisco.

About one mile along the coast to the northwestward is a small boat harbor, 100 yards wide, formed and protected by outlying rocks, and having 3½ fathoms in it. In the autumn months it is used as a whaling station. About a thousand barrels of humpback oil were obtained in the fall of 1863.

Point San Pedro lies NW. by N. ¼ N., 30 miles from Point Año Nuevo, and S. 12° E. from Point Lobos, at the entrance to the Golden Gate. It is a black, bold, rocky promontory, over 500 feet high, having a high, large, jagged rock at the northern part, and is a prominent and excellent mark for making the entrance to San Francisco. The principal rock is nearly a hundred feet high. Its south face is white, and shows the line of stratification plainly. From the west the dip of the strata shows about 60 degrees to the northward. It is connected with the main by some low rocks. Half a mile to the northeast of the point is the valley of San Pedro, from which the point takes its name.

From Point San Pedro the bell-boat off the bar of San Francisco is distant 12 miles, and from Point Año Nuevo it is 40 miles upon a NW. by N. course.

The range of mountains forming the northeastern shore of Monterey bay, and extending to Santa Cruz and Point Año Nuevo, is called Santa Cruz. Thence northward to the ***Golden Gate***, and forming the peninsula of San Francisco, by bounding the bay on the west, the mountains are known as the San Francisco or San Bruno range.

The extent of shore-line from Point Concepcion to ***Point Boneta*** is about 286 miles.

BAY OF SAN FRANCISCO AND APPROACHES.

This bay affords the finest and most commodious harbor on the Pacific coast of the United States. From its discovery it has commanded the admiration of navigators, and, since the wonderful rise of California, has well sustained its reputation. Its geographical position, its size and depth of water, its noble entrance and bold shores, the Sacramento and tributaries, draining the rich agricultural valleys and auriferous slopes of the Sierra Nevada, the magic city upon its shores, and the salubrity of its climate, have conspired to make it emphatically the port of the Pacific.

The Golden Gate is the entrance to the bay, and presents the character of a great cleft or fissure in the sea-coast range of mountains, thereby connecting the bay of San Francisco with the Pacific ocean. On approaching, it is difficult to imagine that a deep channel lies ahead, so clear is the atmosphere, and so well defined the Contra Costa mountains, behind the bay. Both shores are bold, broken into points, and rocky; but the northern is much the bolder, rising almost perpendicularly from the water, attaining an elevation of about 1,000 feet, but a short distance back, and in seven miles rising to 2,600 feet. On the south side, between the points, are stretches of low beach; the hills are undulating and of moderate elevation, increasing very gradually in altitude to the southward, and reaching a height of 1,250 feet in about six or eight miles. The chart of San Francisco entrance, which accompanies the annual Coast Survey Report for 1856, shows the bold and characteristic topography of the vicinity of the Golden Gate.

Point Boneta.—The north head of the entrance is formed by this point; a narrow, precipitous, rocky cape, nearly 300 feet high, and stretching from the light-house about half a mile to the SE. Behind it the mountains rise rapidly to an elevation of 1,500 feet. During the dry season the deposit of sea birds accumulates in such quantities on the ridge outside of Boneta light-house, as to make the bluff show white, but the first heavy rain carries it off, and then, throughout the rainy season, the point exhibits its natural color and appearance. There are no dangers off the point, the line of three fathoms rarely extending 300 yards from any portion of it. When the clipper ship San Francisco was lost on this head, we are told that she first struck the *bluff* inside the heads; was carried by the currents around the point, and then cast ashore on the outside. The reef, or line of sunken rocks, stretching out three-quarters of a mile upon some maps, has no existence, and only serves to mislead those unacquainted with the locality. From five to six fathoms can be found on every side within a fifth of a mile.

One mile and seven-eighths NW. of the point the steamship Tennessee went ashore whilst endeavoring to find the entrance in a thick fog, (calm weather,) and was lost. The Cortes had got in just before her, and as the fog was shutting down over the entrance.

POINT BONETA LIGHT-HOUSE.

The building is situated nearly half a mile from the extremity of the point, and consists of a brick tower painted white, and surmounted by a lantern painted black. From seaward it is seen projected against the dark, high hills behind it, and in clear weather is a very plain object. The illuminating apparatus is of the second order of the system of Fresnel, was first exhibited April 30, 1855, and shows a *fixed light of the natural color* from sunset to sunrise. It illuminates five-sixths of the horizon, and is elevated about 306 feet above the level of the sea. During ordinary conditions of the atmosphere it can be seen from an elevation of—

10 feet at a distance of 23.6 miles.
20 feet at a distance of 25.1 miles.
30 feet at a distance of 26.3 miles.
50 feet at a distance of 28.1 miles.

Its geographical position, as determined by the triangulation of the Coast Survey, is:

	°	′	″	
Latitude	37	49	10.0	north.
Longitude	122	30	50.3	west.
	h.	m.	s.	
Or, in time	8	10	03.4.	

Magnetic variation 15° 27′ east, in 1852, with a present yearly increase of 1′.

From the light at Point Boneta to that on Fort Point the distance is 2⅜ miles, and bearing E. ¼ N.

Fog-bell at Point Boneta.—The bell, with the machinery, is in a frame building, open in front, and placed on the bluff just in advance of the light-house tower, at an elevation of 270 feet above the level of the sea. The bell weighs 1,500 pounds, and during foggy and thick weather is struck six blows, at intervals of sixteen seconds each, followed by a pause of forty-four seconds.

The fog-gun at Point Boneta has been discontinued since the placing of the *bell-boat* outside the bar, March 18, 1858. It may not, however, be amiss to state here the design of the fog-gun. A twenty-four pounder was placed near the *light-house*, and during fogs or thick weather, either day or night, was fired at the hours and half hours of San Francisco mean time. It enabled vessels, before reaching the bar, to get the bearing of Point Boneta, and, by the loudness of the report, or better, by the soundings, to form an estimate of their distance from it.—(See remarks, page 296, Monterey bay.)

We advocated this plan strongly soon after our arrival upon the coast, and it met with the hearty support and commendation of officers of the navy and commanders of the steamships, clippers, and coasters. Continuing to urge its adoption until the spring of 1855, we had the satisfaction of seeing it tried in August of that year. We have since learned, by British newspapers, that the Board of Trade and Liverpool Corporation have placed a gun of large calibre on Holyhead, to be fired during foggy weather, for the benefit of mail steamers passing up the Irish channel.

Point Lobos.—The south head of the entrance to San Francisco bay is formed by this point, 375 feet high, upon which Congress authorized the erection of a *secondary sea-coast light*, where a light has been regularly shown, and a fog-bell kept in operation by private enterprise. Upon the round-topped hill behind the point is erected a large frame building for a telegraph station, whence the electric wires run to the city of San Francisco. The first telegraphic message transmitted on the Pacific coast was over these wires. Southward of the head the sand dunes are conspicuous and easily recognized features in approaching the entrance. The strong northwest summer winds, drawing in over the land, raise the white sand from the three miles of broad beach, and carrying it inland over the hilltops, bury grass, bushes, and scrub oak. The quantity of sand driven in from this beach is enormous, and its accumulation has greatly modified the topography of the peninsula.

The geographical position of the site selected for the *light-house*, as determined by the triangulation of the Coast Survey, is:

	°	′	″	
Latitude	37	46	56.9	north.
Longitude	122	29	39.5	west.
	h.	*m.*	*s.*	
Or, in time	8	9	58.6.	

This position is 32 feet north and 1,317 feet west of the outer telegraph station.

Off the western face of Point Lobos lie a number of black jagged rocks about 50 feet high, but all within the five-fathom line, and close in shore. They are called the *Seal rocks*, and one of them shows a large arch from particular directions. The outer one bears from Point Boneta SE. by S. ¼ S., and is distant 2⅛ miles. From it the general trend of the shore runs in a line to Fort Point for nearly a mile, to a short jutting high point, off which lie the *Mile rocks*. From this point the shore runs well to the eastward for a mile, gradually trending to the north for a mile and a half to Fort Point. In the deepest part of this bend the shore is low, with small hillocks rising from the general surface and slope of the hills, and fronted by a long sand beach.

Mile rocks.—These two rocks lie off Point Lobos, a short distance within the limit of the entrance of the Golden Gate. They are small, near each other, and have a height of 15 feet above water, with a good depth of water all around and close to them; but the current swirls and eddies about them in such a manner as to render a near approach anything but agreeable or safe with a light wind. The inner and smaller rock is one-third of a mile to the northward of the small jutting point inside of Point Lobos, and very nearly two miles SW. ½ S. from Fort Point. Vessels running in on the line of Fort Point and Alcatraz island pass less than half a mile from the outer and larger rock. The rocks bear almost SE. from Boneta light, and distant 1⅛ mile. They were called "One Mile Rocks" by Beechy, in November, 1826.

Fort Point.—This was formerly a bold, narrow, jutting promontory of hard serpentine rock, 107 feet above high water, and surmounted by a small Mexican fortification called Fort Blanco. The view from the point was one of the finest in the harbor; but the whole headland has been cut down to within a few feet of high water, and increased in area to form a large fortification, which will be mounted with guns of the largest range and calibre. Upon the hillside rising behind it are houses for the accommodation of the commandant, officers, soldiers, and workmen. Eastward of the point is a long substantial wharf, constructed for receiving stores, ordnance, &c. Several large vessels have been lost on Fort Point by venturing too close during light airs and strong irregular currents.

FORT POINT LIGHT-HOUSE.

This is a wooden building, painted white, and situated outside of the fortifications. The illuminating apparatus is of the fifth order of Fresnel, and shows a *fixed light of the natural color* from sunset to sunrise. It is 52 feet above the level of the sea, and, during ordinary states of the atmosphere, can be seen from an elevation of 15 feet at a distance of 12½ miles. The angle of visibility seaward is bounded by the extremity of Point Boneta, bearing W. ¾ S., and Point Lobos, bearing SW. by S. ¼ S.

The geographical position, as determined by the triangulation of the Coast Survey, is:

	° ′ ″
Latitude	37 48 37.4 north.
Longitude	122 27 37.8 west.
	h. m. s.
Or, in time	8 9 50.5.

The light-house first built upon the high point was taken down when the fortification operations commenced. The light in the present one was first exhibited March 21, 1855.

The South Farallon light is visible from a vessel's deck when abreast of Fort Point.

Fog-bell at Fort Point.—The framework supporting the bell is on the eastern side of the light-house, and almost touching it. The crown of the bell is 40½ feet above the surface of the ground, and supported by iron rods, 10 feet above the wooden structure in which it was formerly placed. The bell weighs 1,092 pounds, and during foggy or thick weather is struck by machinery, five blows at intervals of ten seconds, followed by a pause of thirty-four seconds.

BELL-BOAT OUTSIDE OF SAN FRANCISCO BAR.

A bell-boat is placed just outside of the bar, in 15 fathoms at mean low water, on the range of the Fort Point and Alcatraz Island light-houses. It is 30 feet long, painted red, and furnished with a day-mark of 3½ feet by four, elevated eight feet above the water. The bell weighs 500 pounds, is elevated 15 feet above the water, is rung by the action of the sea, and, under ordinary circumstances of wind and sea, should be heard from one to three miles. Mariners are cautioned not to run into or damage this aid to navigation. The fog-gun signal at Point Boneta was discontinued with the placing of this bell-boat, March 18, 1858, as already stated; and the bar buoy on the same range was also removed.

The approximate geographical position of the bell-boat is:

	° ′
Latitude	37 45½ north.
Longitude	122 38½ west.

The bearings and distances of prominent objects from it are as follows:

South Farallon Island light-house, SW. by W. ½ W., 16½ miles.
Punta de Los Reyes, (light-house site,) NW. by W. ⅚ W., 22¼ miles.
Duxbury Point, NW. by N. ½ N., 8½ miles.
Point Boneta light-house, NE. ¼ N., 7¼ miles.
Fort Point light-house, NE. ¾ E., 9¼ miles.
Point Lobos telegraph station, NE. by E ½ E., 7½ miles.
Point San Pedro, SE. ¼ E., 11½ miles.

The course to enter the bay from it is NE. ¾ E., and it will be seen that it lies almost in the line from the S. Farallon light to the proposed Point Lobos light.

From the bell-boat, Fort Point (two miles inside the south head formed by Point Lobos) is on with Alcatraz island, inside of the harbor. Fort Point and Alcatraz island have harbor lights upon them, and are the fair way line for crossing the bar.

The bell-boat was upset about April 1, 1859, as seen from Table mountain. It was subsequently replaced, and again carried away. When we came out in November, 1860, it was not on the bar.

SAN FRANCISCO BAR.

The bar off the entrance to the bay of San Francisco has a depth of five fathoms at the lowest tides. Its general form is that of a horse-shoe, commencing four miles southward, stretching out gradually to six miles abreast of Point Lobos; and when nearly up to the parallel of Point Boneta, running in shore towards that point and forming the "four-fathom bank," from a distance of four miles down to one. The average breadth of the bar within the limits of the six-fathom curve is about one mile. It falls off outside to 10 fathoms in half a mile, and deepens gradually inside. Not less than five fathoms exist over the bar when Point Boneta light bears between NE. by E. ½ E., and N. by W. ⅓ W.

No vessel should anchor upon the bar if she can possibly avoid it; frequently a heavy swell sets in without wind, and if the current is running strong ebb, it allows little chance of escaping from an uncomfortable berth.

The flood tide makes on the bar about 61 minutes earlier than at San Francisco.

It has been given as a rule for steamers approaching in thick weather to run for the bar as nearly as they can estimate, keeping the lead going until they strike five fathoms, and run on until the depth is increased, when the armed lead should bring up gray sand with red specks, and they may conclude themselves within the bar. Recently it has been intimated that these peculiarities of bottom exist also outside of the bar.

A line of large buoys, properly marked, outside the bar in 10 fathoms is the next best expedient after a large fog-gun. From them the position of the bell-boat could be known; and numbered buoys from it across the bar would enable steamers in thick weather to feel their way in, and be independent of guessing about the velocity and direction of the current.

The fog sometimes stands like a wall outside of a line from Fort Point across the entrance, while the bay inside is beautifully clear. After the greatest heat of the day is passed this fog creeps in and envelopes land and water.

Buoy on the four-fathom bank.—A first class can buoy, with red and black horizontal stripes, is placed in four fathoms at mean low water near the western and seaward end of the "four-fathom bank," lying off Point Boneta. The following bearings and distances will give its position:

It is on the prolongation of the line from Fort Point light to the extreme point of Boneta.

Point Boneta light bears E. 13° N., distant 3½ miles.

Outer telegraph station on Point Lobos bears E. 13° S., distant 5¼ miles.

The highest part of the western ridge of Table mountain bears N. 13° W.

There is a spot having but 3¾ fathoms upon it outside this buoy, bearing S. 34° W. and distant seven-eighths of a mile.

The shores of the Golden Gate.—On the north side of the Golden Gate the shores are very precipitous, with an occasional short stretch of sand beach at the base of the bluffs, affording a boat landing. *Point Diablo* is the first point inside Boneta, and bears NE. by E. ⅜ E., distant 1⅓ mile from it; between these the shore is indented about three-quarters of a mile, affording a boat landing during smooth weather for the light-house people. In the vicinity of Diablo the faces of the cliffs show of a reddish purple color. The rock is very hard and flinty, "traversed by seams of quartz, and has a banded or belted structure, so that it resembles varieties of jasper. * * * * * It exhibits its stratified character most distinctly. It is also found at the cinnabar mine of New Almaden."

The red specks found on the bar are doubtless derived from the disintegration of these reddish cliffs.

From Diablo the shore is jagged and irregular to *Lime Point Bluff*, 495 feet high, distant one mile, and bearing NE. ¾ E. Off this point are several high rocks, but they are so close to the bluff as to be distinguishable only from certain directions. From Lime Point Bluff to Fort Point the distance is barely a mile, and the bearing S. by E. ¾ E. This is the narrowest part of the Golden Gate. Thence the bay begins to open well to the northeast.

On the south side, eastward from Fort Point, the shore is low, flat, and marshy to *Point San José*, distant 2¼ miles, and bearing E. by N. This point is moderately high, with a few houses clustering upon it, and is locally known as Black point. Off this reach was the "outer anchorage" of former navigators, and the Presidio of San Francisco is seen a short distance behind it.

"It is a curious and interesting fact that the sand beach between Fort Point and Point San Josef has been thrown up by the surf upon an extensive alluvial deposit, which has the character of a peat bog or swamp. When the tide is very low the edge of this peat formation may be seen. Large masses of the peat are also broken out during storms, and thrown up on the sand of the beach. This sand and all the loose round boulders, from three to eight inches, or more, in diameter, rest upon a foundation of the peat; and the continuation of the peat is found in the swamp or flat meadow land which lies inside the belt of sand, and between it and the base of the sandstone hills. It is very difficult to account for the formation of this swamp under conditions like those at present existing."

"A strong current is constantly setting back and forth through the channel, and the action of the surf constantly undermines and encroaches upon the beach, so that the present action is destructive, and the swamp could not possibly have been formed while the Golden Gate was open as we now find it." These remarks are taken from a geological report of the coast of California, by W. P. Blake, esq.—(See Coast Survey Report for 1855, page 389.)

From Point San José to North Point, at the base of *Telegraph hill*, the distance is one mile, and the bearing E. ¾ N. All this space forms part of the city of San Francisco, and is covered with houses. The shore-line is denominated the *North beach*, and from about the middle of the lowest part projects a long wharf over the flats to three fathoms water. This has naturally caused a great deposit around it, and now only 4½ feet of water can be obtained at the northwest part of the wharf at mean low water.

Telegraph hill rises to a height of 301 feet above the mean level of the bay, and is covered with houses to its summit wherever building room can be obtained. The present plan of the city grades contemplates the entire removal of this hill.

The geographical position of the triangulation station of the Coast Survey, upon its summit, is:

	°	′	″	
Latitude	37	48	00.1	north.
Longitude	122	23	19.4	west.
	h.	m.	s.	
Or, in time	8	9	33.3.	

Upon this hill was formerly erected a telegraph or semaphore, by which intelligence of the arrival of vessels off the Golden Gate was made known to the city—hence the name of the hill.

ALCATRAZ ISLAND AND LIGHT.

This is the first island that is opened in entering the Golden Gate, and upon it is erected a light-house. The island is nearly 600 yards long, in a W.NW. direction, by about 260 in width, and rises to an elevation of 135 feet above high water. The summit is flat, falling away gently on all sides for some distance, and then at the sides dropping perpendicularly. Upon the top exists a thin layer of earth, but the island is composed of a fine-grained and "very compact sandstone of a dark bluish green color. It is regularly stratified in beds of varying thickness, and often separated by thin layers of argillaceous shale. It appears to contain a large amount of protoxide of iron, which changes to the hydrous sesquioxide on exposure." Deep water marks exist all round the island, and, with the exception of one or two places, the sides are so steep that a landing is effected with difficulty. Extensive fortifications are now in course of construction upon it. At the SE. side a small pier has been built to receive stores, ordnance, and materials. Off the NW. part, foul bottom makes out about 300 or 400 yards.

Alcatraz Island light-house is built on the summit of the island, and bears NW. from Telegraph hill, distant 1⅜ mile; from Fort Point NE. ¾ E., distance 2⅚ miles.

The light is a *fixed harbor light of the natural color*, and of the third order of Fresnel, illuminating the entire horizon, and exhibited from sunset to sunrise. It is 160 feet above the level of the sea, and should be seen from the sea, under ordinary states of the atmosphere, at a distance of 14 miles, or outside the bell-boat off the bar.

Its geographical position, as determined by the Coast Survey, is:

	°	′	″	
Latitude	37	49	26.6	north.
Longitude	122	24	18.8	west.
	h.	m.	s.	
Or, in time	8	9	37.3.	

Fog-bell on Alcatraz island.—The framework supporting the bell is built on the southeastern extremity of the island, close to the water's edge, and is elevated about 30 feet above the water. The bell weighs 1,092 pounds, and, during foggy or thick weather, is struck by machinery four blows at intervals of eight seconds, followed by a pause of fifteen seconds.

Alcatraz is the Spanish name of the island; Beechy erroneously calls it Alcatrasses; the local name is Bird island.

No hidden dangers have been discovered in the entrance outside of the line from Fort Point to Lime Point Bluff, but there are several inside.

Presidio shoal, having 3½ fathoms upon it, lies 1¼ mile inside of Fort Point, and bears NE. by E. ¾ E. from it, or three-quarters of a point eastward of the line between the lights on Fort Point and Alcatraz island. The shoal is about 700 yards long within the four-fathom curve, and over half a mile long within the five-fathom curve. It is very narrow, shows sandy bottom, and has deep water all around it. Its general direction is on the above mentioned bearing.

From the shoalest part the Presidio flag-staff bears S. ½ E., and we have ventured to distinguish the shoal by that name.

Anita rock shows above water at low tides, and is situated 1⅙ mile inside of Fort Point, and bears E. by N. from it. It is only 300 yards from the low beach, and has deep water close around it.

"A spar buoy, painted red, with even numbers, has been placed in three-fathoms water, about half a cable's length due west from the shoalest part of Anita rock. Vessels should not approach this buoy within a cable's length, as a strong current sets across the rock." It was named after the United States quartermaster's barque Anita that struck upon it.

Bird or Arch rock is a small pyramidal rock, about 45 feet in diameter, 30 feet high, and bearing W. ¾ S., distant seven-eighths of a mile from the light-house on Alcatraz island. When seen in the direction from or towards the Presidio shoal, it presents a perforation at low tides.

Shag rock is a low white-topped rock, about half a mile nearly N.NE. from Bird rock. From Alcatraz light it bears W. by N., distant one mile. For about 300 yards towards Alcatraz island the bottom is foul and irregular, but outside that limit 10 fathoms are found. The rock shows about four feet above the highest tides, being then not more than 8 or 10 feet in extent.

Wreck.—The wreck of the "Flying Dragon," sunk early in 1862, inside the Golden Gate, has been found in the track of vessels passing close to or between Bird and Shag rocks. There is plenty of water around this obstruction.

From it the following bearings are given to determine its position:

Shag rock, N. 14° E., distant 670 yards.

Bird rock, S. 88° E., distant 336 yards.

Bird rock is on with the highest point of Yerba Buena island from the wreck.

Blossom rock is a ledge having five feet water upon it at the lowest tides, and, within the three-fathom curve, is about 300 by 200 yards in extent, with deep water outside these limits. A spar buoy, painted with red and black horizontal stripes, has been placed in four fathoms water, about half a cable's length due south from the shoalest part of the ledge. Vessels should not approach this buoy from any direction nearer than a cable's length. In the winter of 1863–'64 it was torn from its moorings during a heavy norther.

This ledge bears E. by S. from Alcatraz light, and 1⅛ mile distant, being almost on the line joining the south points of Alcatraz and Yerba Buena islands. From the summit of Telegraph hill it bears N. 6° W., distant one mile.

It was discovered and named by Beechy, after his ship, in November, 1826.

Yerba Buena island is the large high island opened to the east and south of Alcatraz after entering the Golden Gate. The western point of this island is 1¾ mile from Telegraph hill, and the bearing NE. by E. Its peak is 343 feet high; the sides steep and irregular, and rising to a ridge running nearly east and west. On the western or San Francisco side the water is very deep close in shore, but from the NW. point a three-fathom bank extends 1¼ mile NW. by N., spreading to the eastward for half a mile, and thence running to the NE. point. The wreck of the ship Crown Princess lies in five fathoms on the western edge of this bank, and a day-mark, painted red, has been attached to her, consisting of a plank seven inches by three, 30 feet long, showing 15 feet above high water, with a board five feet long, nailed across just below the top. The following bearings and distances give its position:

Alcatraz Island light-house, W. by S., 2¼ miles.

Telegraph hill, SW. by S., 1⅗ mile.

West end of Yerba Buena island, SE. by S. ⅜ S., ¾ mile.

East end of Yerba Buena island, E. by S. ¼ S., one mile.

In early times this island is said to have been densely covered with wood, and was known to navigators and whalers as Wood island. Now it has but a few scrubby trees. In 1839 a large number of goats was placed upon it, and it received the still popular name of Goat island. On a recent map of California (1858) it is called Ghote island.

Angel island.—When passing through the narrowest part of the Golden Gate this large island bears about N.NE., and is seen as an island for a very short time when in the narrowest part of the Golden Gate. It has an irregular and bold shore-line of about five miles, and an area of one square mile. It rises to a height of 771 feet, is covered with grass and bushes, and cut in every direction by deep gulleys. As seen from the southeastward it appears part of the northern peninsula, but is divided from that on its NW. face by Raccoon straits, three-quarters of a mile in width, having a depth of water ranging from 10 to 30 fathoms, and a very strong current. A narrow high jutting point makes out from the SE. portion of the island, bearing N. $\frac{3}{4}$ W. from Alcatraz Island light, and distant $1\frac{5}{8}$ mile. From this head the general trend of the southern face for over a mile is W. by S. toward Saucelito Point.

Punta de los Cavallos is half a mile N.NW. from Lime Point bluff. The shore-line between them falls slightly back, and a very small valley makes down from the high hills behind.

Point Saucelito.—From Point Cavallos the general trend of the shore is NW. by N. for $1\frac{1}{2}$ mile to Point Saucelito, with nearly a straight shore-line. One mile from Point Cavallos is the anchorage of Saucelito, where men-of-war and whalers formerly anchored. It lies abreast of a few houses forming the town of Saucelito, whence much of the water used in San Francisco was formerly taken in steam water-boats. North of this anchorage is a large bay, with but a few feet of water. From Saucelito Point to the western point of Angel island the distance is $1\frac{3}{4}$ mile, and the bearing NE. by E $\frac{1}{2}$ E.

To Peninsula Point, forming the southwestern part of Raccoon straight, the distance is one mile, and bearing NE. $\frac{2}{3}$ E.

The following list of geographical positions in San Francisco bay is taken from the published reports of the United States Coast Survey:

"*Outer telegraph station,*" on the summit of the hill behind Point Lobos.

	°	′	″	
Latitude	37	46	50.2	north.
Longitude	122	29	23.3	west.
	h.	*m.*	*s.*	
Or, in time	8	09	57.5.	

"*Presidio,*" near the Presidio of San Francisco. Primary astronomical station.

	°	′	″	
Latitude	37	47	29.8	north.
Longitude	122	26	15.0	west.
	h.	*m.*	*s.*	
Or, in time	8	09	45.0.	

Magnetic variation, 15° 27′ east in February, 1852; yearly increase, 1′.

Telegraph hill, near the San Francisco observatory. Primary astronomical station.

	°	′	″	
Latitude	37	47	52.8	north.
Longitude	122	23	10	west.
	h.	*m.*	*s.*	
Or, in time	8	09	32.5.	

The highest part of the hill is 301 feet above the mean level of the bay.

Rincon, summit of the slight hill NE. of South Park. Secondary astronomical station.

	°	′	″	
Latitude	37	47	00.6	north.
Longitude	122	22	32	west.
	h.	*m*	*s*	
Or, in time	8	09	30.1.	

SAILING DIRECTIONS FOR APPROACHING AND ENTERING SAN FRANCISCO BAY.

In approaching the coast every opportunity should be seized for determining the vessel's position, as fogs and thick weather prevail near the land. Vessels coming from the *southward* make the coast about Point Año Nuevo, (lat. 37° 07′ N.,) and follow it at a distance of four or five miles up to the bar. Steamers keep close under the land for fear of losing it in foggy weather. Coming from the *westward* they first sight the South Farallon island, (latitude 37° 42′ N.,) having the light-house upon it, and keep upon either side of it; but it is preferable to go to the southward, especially in thick weather and at night, as the vicinity of the island has not yet been surveyed in detail. From the South Farrallon light-house the Point Boneta light bears NE. by E., 23⅔ miles; and the bell-boat outside the bar bears NE. by E. ½ E., 16½ miles. Coming from the northwestward they make Punta de los Reyes, 597 feet high, in latitude 38° 00′ N., longitude 123° 00′ W., and pass within two or three miles of it, 15 fathoms being found within a quarter of a mile from it, but vessels are apt to lose the wind by getting too close under it. From the western extremity of this point the Point Boneta light bears E. ¾ S., distant 25¾ miles, the line passing over the tail of Duxbury reef, at a distance of 17¼ miles from Los Reyes. To the bell-boat off the bar the bearing is SE. by E. ⅚ E., and distance 22¼ miles.

The bell-boat, 1½ mile outside of the bar, is placed on the prolongation of the range from Alcatraz island to Fort Point, giving a course NE. ¾ E. for vessels entering the Golden Gate, and designated by Belcher the "fair way line," and he calls the island and fort the "fair way marks." But with a heavy swell on the bar this range should be used merely as a line of reference, because on the bar it passes over a small five-fathom spot, while half a fathom more can be obtained for a distance of two miles both north and south of it. In clear weather and with a favorable wind a vessel can cross the bar in not less than five fathoms from the line, having the north end of Alcatraz island just open by Point Boneta, (NE. by E. ¾ E.,) round to the shore south of Point Lobos, (N. by W. ⅓ W.) Northward of the former line the four-fathom bank (having 3¾ fathoms on it) commences one mile west of Boneta, and stretches out over three miles, with a breadth of one mile. Upon this bank the clipper Golden Fleece struck in 1857, and came into port with seven or eight feet of water in her hold. She was the second of her name that was unfortunate in entering the harbor, the first having been totally lost on Fort Point.

Between the eastern extremity of the "four-fathom bank" and the shore, the distance is seven-eighths of a mile, and within this space can be found the deepest water for entering the harbor, but it would be dangerous for a sailing vessel to attempt it with a flood tide and light winds. While it is breaking on the bank only a heavy swell is found through this 8½-fathom channel, and small sailboats have passed in safety when they dared not try the bar. We entered by it in the brig Wyandot, in June, 1854, and the steamship Columbia frequently used it in leaving the harbor for the upper coast when the heavy weather on the bar would otherwise have delayed her in port. Close in under the cliffs, two or three miles above Boneta, we anchored in eight fathoms, with muddy bottom.

During clear, moderate weather any vessel can cross the bar, within the limits we have mentioned, without running until she has got on the "fair way line," whereby she might lose her slant of wind. Should the wind fail, or be light, and the current adverse, anchor outside the bar in 15 fathoms, mud and fine sand; or, after crossing the bar, in 6 to 10 fathoms, fine grey sand, with red specks in some places. Run in mid-channel between the heads; avoid too close proximity to the northern shore, not only in entering, but in leaving; the high, bold bluffs causing calms and baffling airs, even with a southeaster blowing out. On the last of January, 1864, during a southeaster, three vessels were at one time becalmed under the northern shore, and baffled with variable airs and strong current eddies for several hours. One of them, the barkentine Jenny Ford, was carried on Point Diablo and totally wrecked. Between Fort Point and the opposite shore, take special care not to approach Fort Point too close, because the currents set around it irregularly and with great rapidity, and the bottom is uneven and rocky. A depth of 69 fathoms is given in the centre of the channel. In the Golden Gate we have measured an ebb current running about six miles per hour. As a general rule, the winds increase within the heads, drawing in very strongly abreast of Fort Point. When off this point steer for Alcatraz light-house until the north point of Telegraph hill bears E. by S., then steer to give it a berth of a quarter of a mile, running through among the shipping.

In making the port at night it is customary to run for the bell-boat, and cross the bar with Fort Point light on with Alcatraz island light, or better, the latter a little open to the northward. But this practice frequently involves much delay and annoyance when the wind will not permit a vessel to attain this position without a tack. With Boneta light bearing from N. by W. to NE. by E. a vessel may boldly run on within those limits, and, unless there be a heavy swell, safely cross the four-fathom bank. Give Boneta a berth of a mile, and when within the heads, and Boneta abeam, gradually open Alcatraz light north of Fort Point, until abeam of the latter; then run for Alcatraz until the lights of the shipping show the vessel's position. Hauling up for them, anchor off the north beach in 10 fathoms, or off the northeast front of the city in 10 fathoms, soft mud.

In coming upon the coast in thick foggy weather, sailing vessels should not run into less than 50 fathoms because the water around the South Farallon, and off Point San Pedro and Punta de los Reyes, is very bold. It is believed, however, that a 30-fathom bank exists at a considerable distance to the westward of the last. Southwest of the line passing through the Farallones and Noonday rock, the 100-fathom curve is only four miles distant, and the 50-fathom curve only two miles, with a very irregular bottom. If the Farallones be made, a course can be easily laid for the bar, but it would be unadvisable to run into less than 10 fathoms, soft mud, if the bell-boat be not heard, as the set and strength of the currents off the bay are yet undetermined. Belcher says that, being caught in a fog, he anchored in 15 fathoms, to the southward of the bar, and determined "that southerly of the fair way line the ebb tide set N.NE., flood S.SW." We suppose he means from the N.NE., and from the S.SW. During the season of freshets in the Sacramento and tributaries the discolored water outside the bar will frequently point out the position of the entrance.

Steamers in thick weather were accustomed to run close along the coast, and endeavored to make the land north of Point San Pedro, running in until they got about 15 fathoms, and then laying a course for the bar, shoaling upon it to about five fathoms, and then gradually deepening, while the fog-gun gave the direction of Boneta light. Before the establishment of the fog-gun the steamship "Tennessee" was wrecked two miles north of Boneta, when seeking for the entrance in a dense fog; the steamship S. S. Lewis, just north of Duxbury reef; and the U. S. revenue brig Lawrence, between points Lobos and San Pedro. Steamers and clippers are afraid to approach the bar in thick weather. We have entered in a dense fog without hearing the bell, and the general opinion is that it is ineffective.

As it has been frequently stated that Beechy did not intend to adopt the range, Fort Point and Alcatraz island as a fair way over the bar to the entrance, we here quote his directions, as published under authority of the Lords of the Admiralty. "In crossing the bar it is well to give the northern shore a good berth, and bring the small white island, Alcatrasses, in one with the fort or south bluff, if it can be conveniently done, as they may then insure six fathoms; but if ships get to the northward so as to bring the south bluff in one with the island of Yerba Buena, they will find but 4¼; * * * * to the northward of this bearing the water is more shallow."

"Approaching the entrance, the island of Alcatrasses may be opened with the fort, and the best directions are to keep mid-channel, or the *weather side*."

In his narrative he says: "The best part for crossing is with the island of Alcatrasses in one with the fort."—(Vol. 1, page 345.) When approaching the harbor he steered directly into it, and in crossing the bar the depth of water gradually diminished to five fathoms; "this would have been of no consequence had it not been for a swell which rolled so heavily over the bank that it continually broke; and, though our depth of water was never less than 4½ fathoms, the ship on two or three occasions disturbed the sand with her keel. The tide was, unfortunately, against us, and the swell propelled the ship just sufficiently fast for her to steer without gaining any ground, so that we remained in this position several hours."—(Vol. 1, page 345.)

The U. S. sloop-of-war Vincennes, during the cruise of the Exploring Expedition, anchored on the bar in a calm, and, when the flood tide made it brought up a swell that broke over her.

In beating out, vessels start on the last quarter of the flood, make the first tack to the northward of the Blossom rock, and weather it on the second; thence they keep between Alcatraz and the south shore, avoiding Bird rock, one mile west of the south end of the island, and giving a good berth to Fort Point, past which the ebb current will carry them rapidly, (with a strong tendency towards the south shore,) and a couple more tacks carry them clear of the heads. If the vessel be bound to the northward, and the weather shut in thick, with the wind to the northwest, she makes a tack off shore to the southward of the Farallones; if the weather be clear short tacks are made off shore until she works up to Los Reyes, because the sea to the leeward of that headland is much smoother and the current less; then stands off until a course can be made for her port.

The winds.—It has been advised to work close along shore to northern ports during the summer northwest winds, and take the chances of land breezes to make latitude, but the attempt will double the length of any voyage. Baffling light airs and calms frequently exist along the coast, while vessels several hundred miles off have strong NW. winds. Moreover, along the coast we know that the current frequently sets two miles per hour from the northward, except very close under the shores. In our experience we never yet have met a wind off the land north of San Francisco, and very rarely, indeed, south of it, except in the region of the Santa Barbara channel. As a general rule, it may be safely stated that the summer winds follow the line of the coast, nearly, and gradually draw towards and over the land In winter, with winds from the southward, this is not so marked.

From April to October, inclusive, the prevailing wind is from the northwest, changing to west in valleys opening upon the coast, but in no case so strongly as through the Golden Gate. During the summer the wind sets in strong about 10 a. m., increasing until nearly sunset, when it begins to die away. During its height it almost regularly brings in a dense fog, which, working its way over the peninsula, meets that already advanced through the Golden Gate, and envelopes San Francisco and the bay by sunset. As a rule, the breeze does not dispel the fog. If a fog exists outside, the wind is sure to bring it in, but the heated earth dissipates it for a time.

From November to March the wind is frequently from the southeast, blowing heavily, working round to the southwest, with a large and broken swell from the SW., weather thick, rainy, and squally; the wind not unfrequently ending at NW., with an ugly cross sea. During heavy southeasters the sea breaks upon the San Francisco bar, clean across the entrance, presenting a fearful sight. The sound can be heard at the anchorage in front of the city.

During some winters a hard "norther" will spring up and blow steadily and strongly from one to five days, with a clear blue sky, and cold bracing weather. Winds rarely blow from points between north, round by the east, to southeast.

The further north we advance, the heavier blow the gales in the winter. The northwest winds are not predicted by the barometer, but, from the southeast, almost invariably; the mercury falling one inch from its usual height of about thirty inches. When it begins to rise, the wind may be looked upon as soon to shift round by the west, and to decrease. Only in one instance during our experience has this failed, and that was off the Strait of Juan de Fuca.

On the tops of the mountains bordering the coast, light variable and easterly airs are frequently experienced whilst the northwest winds are blowing freshly along the seaboard. Upon Sulphur Peak, in latitude 38° 46′, and 26 miles from the coast, we have had fresh breezes from the E.NE., whilst the usual northwest winds were prevailing off shore. On Ross mountain, only three miles from the sea, and rising 2,197 feet from the right bank of the Slavianska river, we found variable airs when strong summer winds were blowing below.

TIDES AT SAN FRANCISCO.

As a general rule, there are upon the Pacific coast of the United States one large and one small tide during each day, the heights of two successive high waters—occurring one, a. m., and the other, p. m. of the same twenty-four hours—and the intervals from the next preceding transit of the moon are very different, so much so that at certain periods a rock which has 3½ feet upon it at low tide may be awash on the next succeeding low water.

These inequalities depend upon the moon's declination. They disappear near the time of the moon's declination being nothing, and are greatest about the time of its being greatest. The inequalities for low water are not the same as for high, though they disappear and have the greatest value at nearly the same times.

When the moon's declination is north, the higher of the two high tides of the twenty-four hours occurs at San Francisco about eleven and a half hours after the moon's transit; and when the declination is south, the lower of the two high tides occurs at about that interval. The lower of the two low waters of the day is the one which follows next the higher high water.

The corrected establishment, or mean interval between the moon's transit and the time of high water at San Francisco, is XII*h.* VI*m.* The mean rise and fall of tides is 3.6 feet; of spring tides, 4.3 feet; and of neap tides, 2.8 feet. The mean duration of the flood is 6*h.* 39*m.*; of the ebb, 5*h.* 51*m.*; and of the stand, 34*m.* The average difference between the corrected establishment of the a. m. and p. m. tides of the same day is 1*h.* 28*m.* for high water, and 0*h.* 38*m.* for low water. The differences when the moon's declination is greatest are 2*h.* 30*m.* and 0*h.* 48*m.* The average difference in height of these two tides is 1.1 foot for the high waters, and 2.2 feet for the low waters. When the moon's declination is greatest those differences are 1.5 foot and 3.7 feet, respectively. The average difference of the higher high and lower low waters of the same day is 5.2 feet, and when the moon's declination is greatest, 6.1 feet. The higher high tide in the twenty-four hours occurs about 11*h.* 22*m.* after the moon's upper transit, (southing,) when the moon's declination is north, and about 1*h.* 2*m.* before, when south. The lower of the low waters, about 7*h.* after the higher high tide. The greatest observed difference between the two low waters of one day was 5.3 feet, and the greatest difference between the higher high and lower low waters of one day was 8.5 feet.

The following tables will give the times and heights of high and low waters at San Francisco. Similar tables will be found at the end of the directory for San Diego, Astoria, and Port Townshend.

Tables I and II give the number to be added to the time of moon's transit to find the time of high water. It is one of double entry, the time of transit being placed in the first column, and the number of days from the day at which the moon had the greatest declination being arranged at the top of the table. Entering the first column with the time of transit, and following the line horizontally until we come under the column containing the days from the greatest declination, we find the number to be added to the time of transit to give the time of high water. If the moon's declination is south, Table I is to be used; if north, Table II.

TABLES FOR SAN FRANCISCO.

TABLE I.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*
0 0	11 43	11 59	12 15	12 33	12 50	13 03	13 17	13 20	13 19	13 14	13 07	12 57	12 45	12 32	12 18
0 30	11 37	11 53	12 09	12 27	12 44	12 57	13 11	13 14	13 13	13 08	13 01	12 51	12 39	12 26	12 12
1 0	11 31	11 47	12 03	12 21	12 38	12 51	13 05	13 08	13 07	13 02	12 55	12 45	12 33	12 20	12 06
1 30	11 25	11 41	11 57	12 15	12 32	12 45	12 59	13 02	13 01	12 56	12 49	12 39	12 27	12 14	12 00
2 0	11 19	11 35	11 51	12 09	12 26	12 39	12 53	12 56	12 55	12 50	12 43	12 33	12 21	12 08	11 54
2 30	11 14	11 30	11 46	12 04	12 21	12 34	12 48	12 51	12 50	12 45	12 38	12 28	12 16	12 03	11 49
3 0	11 11	11 27	11 43	12 01	12 18	12 31	12 45	12 48	12 47	12 42	12 35	12 25	12 13	12 00	11 46
3 30	11 11	11 27	11 43	12 01	12 18	12 31	12·45	12 48	12 47	12 42	12 35	12 25	12 13	12 00	11 46
4 0	11 16	11 32	11 48	12 06	12 23	12 36	12 50	12 53	12 52	12 47	12 40	12 30	12 18	12 05	11 51
4 30	11 24	11 40	11 56	12 14	12 31	12 41	12 58	13 01	13 00	12 55	12 48	12 38	12 26	12 13	11 59
5 0	11 33	11 49	12 05	12 23	12 40	12 53	13 07	13 10	13 09	13 04	12 57	12 47	12 35	12 22	12 08
5 30	11 41	11 57	12 13	12 31	12 48	13 01	13 15	13 18	13 17	13 12	13 05	12 55	12 43	12 30	12 16
6 0	11 49	12 05	12 21	12 39	12 56	13 09	13 23	13 26	13 25	13 20	13 13	13 03	12 51	12 38	12 24
6 30	11 54	12 10	12 26	12 44	13 01	13 14	13 28	13 31	13 30	13 25	13 18	13 08	12 56	12 43	12 29
7 0	12 01	12 17	12 33	12 51	13 08	13 21	13 35	13 38	13 37	13 32	13 25	13 15	13 03	12 50	12 33
7 30	12 07	12 23	12 39	12 57	13 14	13 27	13 41	13 44	13 43	13 38	13 31	13 21	13 09	12 56	12 42
8 0	12 12	12 28	12 44	13 02	13 19	13 32	13 46	13 49	13 48	13 43	13 36	13 26	13 14	13 01	12 47
8 30	12 15	12 31	12 47	13 05	13 22	13 35	13 49	13 52	13 51	13 46	13 39	13 29	13 17	13 04	12 50
9 0	12 14	12 30	12 46	13 04	13 21	13 34	13 48	13 57	13 50	13 45	13 38	13 28	13 16	13 03	12 49
9 30	12 12	12 28	12 44	13 02	13 19	13 32	13 46	13 49	13 48	13 43	13 36	13 26	13 14	13 01	12 47
10 0	12 08	12 24	12 40	12 58	13 15	13 28	13 42	13 45	13 44	13 39	13 32	13 22	13 10	12 57	12 43
10 30	12 02	12 18	12 34	12 52	13 09	13 22	13 36	13 39	13 38	13 33	13 26	13 16	13 04	12 51	12 37
11 0	11 55	12 11	12 27	12 45	13 02	13 15	13 29	13 32	13 31	13 26	13 19	13 09	12 57	12 44	12 30
11 30	11 47	12 03	12 19	12 37	12 54	13 07	13 21	13 24	13 23	13 18	13 11	13 01	12 49	12 36	12 22

TABLE II.

Time of moon's transit.	North declination.—Days from moon's greatest declination.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	12 27	12 11	11 55	11 37	11 20	11 07	10 53	10 50	10 51	10 56	11 03	11 13	11 25	11 38	11 52
0 30	12 21	12 05	11 49	11 31	11 14	11 01	10 47	10 44	10 45	10 50	10 57	11 07	11 19	11 32	11 46
1 0	12 15	11 59	11 43	11 25	11 08	10 55	10 41	10 38	10 39	10 44	10 51	11 01	11 13	11 26	11 40
1 30	12 09	11 53	11 37	11 19	11 02	10 49	10 35	10 32	10 33	10 38	10 45	10 55	11 07	11 20	11 34
2 0	12 03	11 47	11 31	11 13	10 56	10 43	10 29	10 26	10 27	10 32	10 39	10 49	11 01	11 14	11 28
2 30	11 58	11 42	11 26	11 08	10 51	10 38	10 24	10 21	10 22	10 27	10 34	10 44	10 56	11 09	11 23
3 0	11 55	11 39	11 23	11 05	10 48	10 35	10 21	10 18	10 19	10 24	10 31	10 41	10 53	11 06	11 20
3 30	11 55	11 39	11 23	11 05	10 48	10 35	10 21	10 18	10 19	10 24	10 31	10 41	10 53	11 06	11 20
4 0	12 00	11 44	11 28	11 10	10 53	10 40	10 26	10 23	10 24	10 29	10 36	10 46	10 58	11 11	11 25
4 30	12 08	11 52	11 36	11 18	11 01	10 48	10 34	10 31	10 32	10 37	10 44	10 54	11 06	11 19	11 33
5 0	12 17	12 01	11 45	11 27	11 10	10 57	10 43	10 40	10 41	10 46	10 53	11 03	11 15	11 28	11 42
5 30	12 25	12 09	11 53	11 35	11 18	11 05	10 51	10 48	10 49	10 54	11 01	11 11	11 23	11 36	11 50
6 0	12 33	12 17	12 01	11 43	11 26	11 13	10 59	10 56	10 57	11 02	11 09	11 19	11 31	11 44	11 58
6 30	12 38	12 22	12 06	11 48	11 31	11 18	11 04	11 01	11 02	11 07	11 14	11 24	11 36	11 49	12 03
7 0	12 45	12 29	12 13	11 55	11 38	11 25	11 11	11 08	11 09	11 14	11 21	11 31	11 43	11 56	12 10
7 30	12 51	12 35	12 19	12 01	11 44	11 31	11 17	11 14	11 15	11 20	11 27	11 37	11 49	12 02	12 16
8 0	12 56	12 40	12 24	12 06	11 49	11 36	11 22	11 19	11 20	11 25	11 32	11 42	11 54	12 07	12 21
8 30	12 59	12 43	12 27	12 09	11 52	11 39	11 25	11 22	11 23	11 28	11 35	11 45	11 57	12 10	12 24
9 0	12 58	12 42	12 26	12 08	11 51	11 38	11 24	11 21	11 22	11 27	11 34	11 44	11 56	12 09	12 23
9 30	12 56	12 40	12 24	12 06	11 49	11 36	11 22	11 19	11 20	11 25	11 32	11 42	11 54	12 07	12 21
10 0	12 52	12 36	12 20	12 02	11 45	11 32	11 18	11 15	11 16	11 21	11 28	11 38	11 50	12 03	12 17
10 30	12 46	12 30	12 14	11 56	11 39	11 26	11 12	11 09	11 10	11 15	11 22	11 32	11 44	11 57	12 11
11 0	12 39	12 23	12 07	11 49	11 32	11 19	11 05	11 02	11 03	11 08	11 15	11 25	11 37	11 50	12 04
11 30	12 31	12 15	11 59	11 41	11 24	11 11	10 57	10 54	10 55	11 00	11 07	11 17	11 29	11 42	11 56

Example.—Required the time of high water at North Beach, San Francisco, on the 7th of February, 1853.

1st. The time of the moon's transit at Greenwich, from the British Nautical Almanac, is 11*h.* 41*m.*; the longitude of San Francisco, 8*h.* 10*m.*, requiring a correction of 16*m.* to the time of transit at San Francisco, which is thus found to be 11*h.* 57*m.*

2d. The moon's declination is south, and at the time of transit about two days after the greatest. Entering Table I, we find 12*h.* (or 0*h.*) of transit, the nearest number to 11*h.* 57*m.*, which the table gives; and following the line horizontally until we come to two days after the greatest declination we find 13*h.* 14*m.*

To 11*h.* 57*m.* time of transit of moon, February 7, San Francisco,
Add 13 14 from column 0*h.* transit, and two days after greatest declination.

Sum 25 11, or 1*h.* 11*m.*, February 8, is the time of high water corresponding to the transit which we took of February 7. If we desire the tide of February 7, we must go back to the moon's transit of the 6th. The example was purposely assumed to show this case.

To 11*h.* 01*m.*, time of transit, February 6, 1853,
Add 13 31, number for 11*h.* transit, and one day from greatest declination.

Sum 24 32, time of high water 0*h.* 32*m.*, a. m., February 7.

The approximate times of the successive low and high waters of the day will be found by adding the numbers in Table III to the time of the first high water already determined by Tables I and II.

TABLE III.

The days from the greatest declination are written in the first and last columns of the table. The second, third, and fourth columns refer to south declination, and the fifth, sixth, and seventh to north. The second column gives the number which is to be added according to the declination to the time of high water obtained by means of Tables I and II, to give the next low water, which is a small low water. The third contains the numbers to be added to the same to give the second or large high water. The fourth, the numbers to be added to the same to give the second or large low water. The succeeding columns give the numbers to be used in the same way for north declinations, to obtain the large low water, the small high water, and the small low water.

Days from moon's greatest declination.		South declination.			North declination.			Days from moon's greatest declination.	
		Low water. (Small.)	High water. (Large.)	Low water. (Large.)	Low water. (Large.)	High water. (Small.)	Low water. (Small.)		
		h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*		
Before.	7	5 58	13 14	18 58	5 41	11 46	17 41	7	Before.
	6	5 36	12 42	18 48	6 06	12 18	17 54	6	
	5	5 14	12 10	18 33	6 28	12 50	18 04	5	
	4	4 55	11 34	18 21	6 47	13 26	18 21	4	
	3	4 37	11 00	18 05	7 05	14 00	18 37	3	
	2	4 24	10 34	17 52	7 18	14 26	18 50	2	
	1	4 12	10 06	17 36	7 30	14 54	19 06	1	
	0	4 12	10 00	17 30	7 30	15 00	19 12	0	
After.	1	4 17	10 02	17 27	7 25	14 58	19 15	1	After.
	2	4 27	10 12	17 27	7 15	14 48	19 15	2	
	3	4 41	10 26	17 27	7 01	14 34	19 15	3	
	4	4 56	10 46	17 32	6 46	14 14	19 10	4	
	5	5 14	11 10	17 38	6 28	13 50	19 04	5	
	6	5 36	11 36	17 42	6 06	13 24	19 00	6	
	7	5 57	12 04	17 49	5 45	12 56	18 53	7	

TABLES IV AND V.

The height of high water is obtained by the use of Tables IV and V, entering them in the same manner as Tables I and II, with the time of transit and days from greatest declination as argument. Table IV is for south declination, and Table V for north.

TABLE IV.

Time of moon's transit.	South declination.—Days from moon's greatest declination.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
0	4.8	4.7	4.5	4.3	4.3	4.2	4 3	4.3	4.4	4.5	4.7	4.8	5.0	5.3	5 5
1	4.7	4.6	4.4	4.2	4.2	4.1	4.2	4.2	4.3	4.4	4.6	4.7	4.9	5.2	5.4
2	4.6	4.5	4.3	4.1	4.1	4.0	4.1	4.1	4.2	4.3	4.5	4.6	4.8	5.1	5.3
3	4.5	4.4	4.2	4.0	4.0	3.9	4.0	4.0	4.1	4.2	4.4	4.5	4.7	5.0	5.2
4	4.3	4.2	4.0	3.8	3.8	3.7	3.8	3.8	3.9	4.0	4.2	4.3	4.5	4.8	5.0
5	4.1	4.0	3.8	3.6	3.6	3.5	3.6	3.6	3.7	3.8	4.0	4.1	4.3	4.6	4.8
6	4.1	4.0	3.8	3.6	3.6	3.5	3.6	3.6	3.7	3.8	4.0	4.1	4 3	4.6	4.8
7	4.2	4.1	3.9	3.7	3.7	3.6	3.7	3.7	3.8	3.9	4.1	4.2	4.4	4.7	4.9
8	4.4	4.3	4.1	3.9	3.9	3.8	3.9	3.9	4.0	4.1	4.3	4.4	4 6	4.9	5.1
9	4.5	4.4	4.2	4.0	4 0	3.9	4.0	4.0	4.1	4.2	4.4	4.5	4.7	5.0	5.2
10	4.7	4.6	4.4	4.2	4.2	4.1	4.2	4.2	4.3	4.4	4.6	4.7	4.9	5.2	5.4
11	4 8	4.7	4.5	4.3	4.3	4.2	4.3	4.3	4.4	4.5	4.7	4.8	5.0	5.3	5.5

Table V.

Time of moon's transit.	North declination.—Days from moon's greatest declination.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	Feet	Feet.	Feet.	Feet.	Feet	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
0	5.4	5.5	5.7	5.9	5.9	6.0	5.9	5.9	5.8	5.7	5.5	5.4	5.2	4.9	4.7
1	5.3	5.4	5.6	5.8	5.8	5.9	5.8	5.8	5.7	5.6	5.4	5.3	5.1	4.8	4.6
2	5.2	5.3	5.5	5.7	5.7	5.8	5.7	5.7	5.6	5.5	5.3	5.2	5.0	4.7	4.5
3	5.1	5.2	5.4	5.6	5.6	5.7	5.6	5.6	5.5	5.4	5.2	5.1	4.9	4.6	4.4
4	4.9	5.0	5.2	5.4	5.4	5.5	5.4	5.4	5.3	5.2	5.0	4.9	4.7	4.4	4.2
5	4.7	4.8	5.0	5.2	5.2	5.3	5.2	5.2	5.1	5.0	4.8	4.7	4.5	4.2	4.0
6	4.7	4.8	5.0	5.2	5.2	5.3	5.2	5.2	5.1	5.0	4.8	4.7	4.5	4.2	4.0
7	4.8	4.9	5.1	5.3	5.3	5.4	5.3	5.3	5.2	5.1	4.9	4.8	4.6	4.3	4.1
8	5.0	5.1	5.3	5.5	5.5	5.6	5.5	5.5	5.4	5.3	5.1	5.0	4.8	4.5	4.3
9	5.1	5.2	5.4	5.6	5.6	5.7	5.6	5.6	5.5	5.4	5.2	5.1	4.9	4.6	4.4
10	5.3	5.4	5.6	5.8	5.8	5.9	5.8	5.8	5.7	5.6	5.4	5.3	5.1	4.8	4.6
11	5.4	5.5	5.7	5.9	5.9	6.0	5.9	5.9	5.8	5.7	5.5	5.4	5.2	4.9	4.7

Example.—To obtain the height of the tide on February 7, 1853, the declination being south, we enter Table III, with 0*h.* of transit, and two days after greatest declination, and find that the tide will be 4.5 feet above the mean of the lower low waters, or that 4.5 feet are to be added to the soundings of a chart reduced to the mean of the lower low waters of each day. If the soundings of the chart were given for mean low water, then 1.2 foot ought to be subtracted from the Tables III and IV; thus, in this example, it would be 3.3 feet.

The rise and fall of the same successive tides may be obtained by inspection from Tables VI and VII, in which the first column, at the side, contains the time of transit, and the successive columns the numbers corresponding to that time, and to the number of days from greatest declination.

TABLES VI AND VII.

The arangement of these tables is similar to that already given. In Table VI the numbers for the small ebb tide are given, and then those for the rise from small low water to the larger high water. In Table VII the numbers for the large ebb tide are given, and then those for the rise from the large low water to the small high water.

Table VI.

Hours of moon's transit.	Small ebb tide, or from small high water to small low water.															From small low water to large high water.															Hours of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.															
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.
0	4.7	4.0	3.4	2.9	2.4	2.0	1.8	1.7	1.7	1.9	2.2	2.6	3.1	3.7	4.4	5.2	4.9	4.6	4.5	4.0	3.7	3.4	3.2	3.1	3.0	3.1	3.1	3.3	3.4	3.5	0
1	4.5	3.8	3.2	2.7	2.2	1.8	1.6	1.5	1.5	1.7	2.0	2.4	2.9	3.5	4.2	5.0	4.7	4.4	4.3	3.8	3.5	3.2	3.0	2.9	2.8	2.9	2.9	3.1	3.2	3.3	1
2	4.3	3.6	3.0	2.5	2.0	1.6	1.4	1.3	1.3	1.5	1.8	2.2	2.7	3.3	4.0	4.8	4.5	4.2	4.1	3.6	3.3	3.0	2.8	2.7	2.6	2.7	2.7	2.9	3.0	3.1	2
3	4.0	3.3	2.7	2.2	1.7	1.3	1.1	1.0	1.0	1.2	1.5	1.9	2.4	3.0	3.7	4.5	4.2	3.9	3.8	3.3	3.0	2.7	2.5	2.4	2.3	2.4	2.4	2.6	2.7	2.8	3
4	3.6	2.9	2.3	1.8	1.3	0.9	0.7	0.6	0.6	0.8	1.1	1.5	0.0	2.6	3.3	4.1	3.8	3.5	3.4	2.9	2.6	2.3	2.1	2.0	1.9	2.0	2.0	2.2	2.3	2.4	4
5	3.2	2.5	1.9	1.4	0.9	0.5	0.3	0.2	0.2	0.4	0.7	1.1	1.6	2.2	2.9	3.7	3.4	3.1	3.0	2.5	2.2	1.9	1.7	1.6	1.5	1.6	1.6	1.8	1.9	2.0	5
6	3.2	2.5	1.9	1.4	0.9	0.5	0.3	0.2	0.2	0.4	0.7	1.1	1.6	2.2	2.9	3.7	3.4	3.1	3.0	2.5	2.2	1.9	1.7	1.6	1.5	1.6	1.6	1.8	1.9	2.0	6
7	3.4	2.7	2.1	1.6	1.1	0.7	0.5	0.4	0.4	0.6	0.9	1.3	1.8	2.4	3.1	3.9	3.6	3.3	3.2	2.7	2.4	2.1	1.9	1.8	1.7	1.8	1.8	2.0	2.1	2.2	7
8	3.8	3.1	2.5	2.0	1.5	1.1	0.9	0.8	0.8	1.0	1.3	1.7	2.2	2.8	3.5	4.3	4.0	3.7	3.6	3.1	2.8	2.5	2.3	2.2	2.1	2.2	2.2	2.4	2.5	2.6	8
9	4.1	3.4	2.8	2.3	1.8	1.4	1.2	1.1	1.1	1.3	1.6	2.0	2.5	3.1	3.8	4.6	4.3	4.0	3.9	3.4	3.1	2.8	2.6	2.5	2.4	2.5	2.5	2.7	2.8	2.9	9
10	4.5	3.8	3.2	2.7	2.2	1.8	1.6	1.5	1.5	1.7	2.0	2.4	2.9	3.5	4.2	5.0	4.7	4.4	4.3	3.8	3.5	3.2	3.0	2.9	2.8	2.9	2.9	3.1	3.2	3.3	10
11	4.7	4.0	3.4	2.9	2.4	2.0	1.8	1.7	1.7	1.9	2.2	2.6	3.1	3.7	4.4	5.2	4.9	4.6	4.5	4.0	3.7	3.4	3.2	3.1	3.0	3.1	3.1	3.3	3.4	3.5	11

TABLE VII.

Time of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER															FROM LARGE LOW WATER TO SMALL HIGH WATER.															Time of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.															
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	H.
0	3.9	4.6	5.2	5.7	6.2	6.6	6.8	6.9	6.9	6.7	6.4	6.0	5.5	4.9	4.2	3.4	3.7	4.0	4.1	4.6	4.9	5.2	5.4	5.5	5.6	5.6	5.5	5.3	5.2	5.2	0
1	3.7	4.4	5.0	5.5	6.0	6.4	6.6	6.7	6.7	6.5	6.2	5.8	5.3	4.7	4.0	3.2	3.5	3.8	3.9	4.4	4.7	5.0	5.2	5.3	5.4	5.3	5.3	5.1	5.0	5.0	1
2	3.5	4.2	4.8	5.3	5.8	6.2	6.4	6.5	6.5	6.3	6.0	5.6	5.1	4.5	3.8	3.0	3.3	3.6	3.7	4.2	4.5	4.8	5.0	5.1	5.2	5.1	5.1	4.9	4.8	4.8	2
3	3.2	3.9	4.5	5.0	5.5	5.9	6.1	6.2	6.2	6.0	5.7	5.3	4.8	4.2	3.5	2.7	3.0	3.3	3.4	3.9	4.2	4.5	4.7	4.8	4.9	4.8	4.8	4.6	4.5	4.5	3
4	2.8	3.5	4.1	4.6	5.1	5.5	5.7	5.8	5.8	5.6	5.3	4.9	4.4	3.8	3.1	2.3	2.6	2.9	3.0	3.5	3.8	4.1	4.3	4.4	4.5	4.4	4.4	4.2	4.1	4.1	4
5	2.4	3.1	3.7	4.2	4.7	5.1	5.3	5.4	5.4	5.2	4.9	4.5	4.0	3.4	2.7	1.9	2.2	2.5	2.6	3.1	3.4	3.7	3.9	4.0	4.1	4.0	4.0	3.8	3.7	3.7	5
6	2.4	3.1	3.7	4.2	4.7	5.1	5.3	5.4	5.4	5.2	4.9	4.5	4.0	3.4	2.7	1.9	2.2	2.5	2.6	3.1	3.4	3.7	3.9	4.0	4.1	4.0	4.0	3.8	3.7	3.7	6
7	2.6	3.3	3.9	4.4	4.9	5.3	5.5	5.6	5.6	5.4	5.1	4.7	4.2	3.6	2.9	2.1	2.4	2.7	2.8	3.3	3.6	3.9	4.1	4.2	4.3	4.2	4.2	4.0	3.9	3.9	7
8	3.0	3.7	4.3	4.8	5.3	5.7	5.9	6.0	6.0	5.8	5.5	5.1	4.6	4.0	3.3	2.5	2.8	3.1	3.2	3.7	4.0	4.3	4.5	4.6	4.7	4.6	4.6	4.4	4.3	4.3	8
9	3.3	4.0	4.6	5.1	5.6	6.0	6.2	6.3	6.3	6.1	5.8	5.4	4.9	4.3	3.6	2.8	3.1	3.4	3.5	4.0	4.3	4.6	4.8	4.9	5.0	4.9	4.9	4.7	4.6	4.6	9
10	3.7	4.4	5.0	5.5	6.0	6.4	6.6	6.7	6.7	6.5	6.2	5.8	5.3	4.7	4.0	3.2	3.5	3.8	3.9	4.4	4.7	5.0	5.2	5.3	5.4	5.3	5.3	5.1	5.0	5.0	10
11	3.9	4.6	5.2	5.7	6.2	6.6	6.8	6.9	6.9	6.7	6.4	6.0	5.5	4.9	4.2	3.4	3.7	4.0	4.1	4.6	4.9	5.2	5.4	5.5	5.6	5.5	5.5	5.3	5.2	5.2	11

Example.—Thus, in the preceding example the high water of February 7 was found to be 3.3 feet above mean low water. The declination being south, this high water is the small one. To obtain the fall of the next low water, or small low water, we enter Table VI, with *0h.* of moon's transit, and two days after greatest declination, in the first part of the table, and find 1.9 foot, which will be the difference in height of this high and low water. Entering with the same transit and day in the second part, we find 3.3 feet, which is the rise of the large high water above the small low water; the difference between 1.9 foot and 3.0 feet, or 1.1 foot, is the difference of height of the two successive high waters. It is easy to see how, in this way, the soundings of a chart can be reduced to what they would be approximately at all the successive high and low waters.

THE SEASONS.—There are but two seasons on the Pacific coast, usually denominated the dry and rainy seasons; the former corresponding to the Atlantic summer, the latter to the winter; but much error exists in regard to them, especially as to the amount of rain falling during the rainy season. The following totals of rain that fell at San Francisco during each wet season, from 1850 to 1862, will show that the yearly amount is not great:

During the wet season of	1850–'51	there fell	7.0	inches.	
" " "	1851–'52	"	19.0	"	
" " "	1852–'53	"	32.7	"	
" " "	1853–'54	"	21.9	"	
" " "	1854–'55	"	24.3	"	
" " "	1855–'56	"	20.7	"	
" " "	1856–'57	"	20.2	"	
" " "	1857–'58	"	21.7	"	
" " "	1858–'59	"	22.0	"	
" " "	1859–'60	"	22.0	"	
" " "	1860–'61	"	19.4	"	
" " "	1861–'62	"	48.5	"	to the middle of April.
Average of twelve wet seasons....			23.3		

The wet season of 1861–'62 was remarkable for the disastrous effects of the great rains in December and January. In the latter half of December, 6.3 inches fell; in the first half of January, 15.9 inches; and in the latter half of January, 8.5 inches. At Sonora, Tuolumne county, no less than 72 inches were registered between November 11, 1861, and January 14, 1862. Millions of dollars' worth of property were destroyed in the Sacramento valley.

The following table will show how the foregoing yearly amounts were distributed each month, from November, 1850, to the middle of April, 1862:

Mean	monthly	rain for	January,	4.90	inches.
"	"	"	February,	3.69	"
"	"	"	March,	3.51	"
"	"	"	April,	2.02	"
"	"	"	May,	.85	"
"	"	"	June,	.02	"
"	"	"	July,	.02	"
"	"	"	August,	.02	"
"	"	"	September,	.02	"
"	"	"	October,	.77	"
"	"	"	November,	2.53	"
"	"	"	December,	4.90	"
Giving a yearly average of.....				23.25	

An examination of the extended tables from which the above results are derived, show that as a rule the greatest depth of water falls in December, and that during the latter half of December, and the first half of January, one-fourth of the average falls.

There is a very notable abatement from the middle of January to the middle of February. In 1851 we noticed this particularly when stationed at Point Pinos, because the above period was much prolonged. In 1852, while observing near the Presidio of San Francisco, we found this period to extend from the early part of January to near the end of February. In 1858–'60, and '61, and the exceptional part of 1862, we found this cessation marked.

During the latter part of March heavy rains occur, and about the middle of April. The southerly winds generally bring the rain. During the seasons we passed about San Francisco, we never heard thunder or saw lightning, and never but once saw snow fall, and then only at an elevation of 400 feet; the line being distinctly marked, and the elevation being well determined by a knowledge of the height of the hills. On the mountains of the seaboard snow frequently falls, but with trifling depth.

The fogs that prevail upon the coast during the dry season have an elevation of 1,300 to 1,700 feet; generally the former, and only upon one occasion have we determined the latter. Through this dense cloud the mountain tops pierce as islands.

The following statement will give a general idea of the temperature of the seaboard. The interior is much warmer, but on account of the dryness of the atmosphere the effect is not so enervating to the system as a lower temperature on the Atlantic.

Mean temperature at sunrise and noon for seven years, from 1851 *to* 1857, *computed from the California State Register for* 1859.

	Sunrise.	Moon.
	Deg. Fahr.	*Deg. Fah.*
January	44.2	57.6
February	46.8	60.0
March	47.8	63.0
April	49.6	65.7
May	50.0	64.5
June	51.8	68.2
July	52.6	67.5
August	53.6	67.9
September	53.8	69.8
October	52.7	68.4
November	49.4	62.0
December	44.9	55.8
Average	49.8	64.2

The lowest temperature experienced at San Francisco in the above six years was 25° Fah., in January, 1854. In 1852, '53, '56, the temperature was always above freezing, and falling no lower than 28° in 1850; 40° in 1853; 29° in 1855; 31° in 1857.

The highest temperature was 98°, in September, 1852, and that may be considered remarkably high, 93° and 90° having been reached but once.

The mean temperature of spring is 54°, of summer 57°, of autumn 56°, and of winter 50°, showing a difference of only seven degrees between the average of winter and summer. There is a range of nine degrees in the mean temperature of the months; and the mean of the whole year is about 54°.

The mean temperature at Sacramento, latitude 38° 33′ north, and longitude 121° 20′, and 75 miles from the ocean, for five years observations, is 60° 5 .

Clipper passages.—The number of clippers arriving at San Francisco from New York during the 10 years, 1850 to 1859, was 663, and the average length of the passage was 135.7 days. In the same years 373 arrived from Boston, and the average passage was 136 days.

In 1850 six clippers arrived from New York averaging only 115 days; the Sea Witch being reported at 97 days, but her actual passage was 101. The average passage of all American vessels that arrived from Atlantic ports was 187 days.

In 1851 only two clippers made the passage in less than 100 days—the Surprise in 96, and the Flying Cloud in 90, both from New York.

In 1852 the Flying Fish made it in 98 days from Boston, and the Sword Fish in 93 from New York.

In 1853 it was made by the Contest in 97 days, Flying Fish in 92, John Gilpin in 93, and the Oriental reported 100; all from New York.

In 1854 the passage was made by the David Brown in 98 days, the Flying Cloud in 89, the Hurricane in 99, the Witchcraft in 97, from New York; and by the Romance of the Seas in 96 days from Boston.

In 1855 no vessel made it in 100 days, although the Herald of the Morning and Neptune's Car reported in 100 from New York, and the Westward Ho in 100 from Boston.

In 1856 the Antelope made it in 97 days, and the Sweepstakes in 94 from New York.

In 1857 the Flying Dragon arrived in 98 days, and the Great Republic in 92 from New York. The Danish clipper Cimbar made the trip from Liverpool in 106 days, the quickest on record.

In 1858 the ship Twilight made the passage in 100 days, and the Andrew Jackson in 99 days from New York.

In 1859 no vessel made the passage in 100 days. The Andrew Jackson made the shortest trip, in 102 days from New York.

In 1860 the ship Sierra Nevada made the passage from Boston in 97¼ days, and the Andrew Jackson from New York in 90¼ days.

The shortest passage made from New York to San Francisco by steamship, *via* the Isthmus of Panama, was by the Moses Taylor on the eastern side, and the Golden Age on the western; their actual running time 19 days 23 hours; total time from dock to wharf 21 days, 2 hours, 13 minutes, arriving at San Francisco February 26, 1858.

The clipper Northern Light, of Boston, is reported to have made the run from San Francisco to New York, in ballast, in 75¼ days, and the Trade Wind, with cargo, in 84 days. The average time of passage is about 100 days.

The average length of passages from other prominent ports is given for the years 1857, '58, and '59.

From China 32 vessels arrived in 1857, averaging 59 days, the quickest trip from Shanghai being 34 days, by the tern Spray, and from Hong Kong in 35 days, by the schooner Giulietta.

In 1858 28 vessels arrived, averaging 53 days, and in 1859 28 vessels, averaging 54½ days.

From Honolulu 19 vessels arrived in 1851, averaging 19½ days, the shortest trip being made by the barque Yankee, in 13 days.

In 1858 25 vessels arrived, averaging 15 days, the shortest trip being made by the barque Yankee, in 11 days. In 1859 20 vessels arrived, averaging 20 days, the shortest passage being by the barque Onward, in 10 days.

For a period of five years ending August 1, 1859, a record was kept of 427 passages between San Francisco and Honolulu. The average time of 224 passages from San Francisco to Honolulu was 16⅞ days, four being made in 9½ days each. The average time of 203 passages from Honolulu to San Francisco was 20 days, three being made in 11 days each.

From Valparaiso 17 vessels arrived in 1857, averaging 53 days, the shortest passage being made by the Danish ship Velox, in 37 days. In 1858 16 vessels arrived, averaging 73 days.

From Australia 13 vessels arrived in 1857, averaging 81½ days, the shortest passage by the topsail schooner Vaquero, in 57 days. In 1858 14 vessels arrived, averaging 80 days, the shortest passage being made by the Vaquero, in 54 days. In 1859 27 vessels arrived, averaging 76 days.

Statistics.—Previous to the discovery of gold in California, San Francisco bay furnished few inducements for traders or whalers to visit. Cattle were cheap, but about the only provisions to be obtained, and these were valuable solely for their hide and tallow; "fine fat bullocks, weighing from 400 to 500 pounds, hide included, were purchased at $5 each, and sheep at $2."—(Belcher, Vol. 1, page 135.) "All the forts were in ruins, and not even a single gun mounted" at the time of his visit in 1837, and Wilkes's description of the few miserable *adobe* buildings at Yerba Buena, the site of San Francisco, fully proves how fast the country was driving to wreck. In 1848 the resources, the population, and geography of the State were almost unknown; but since then she has commanded the attention of the world. She stands alone as an example of all past time of a country emerging so suddenly from obscurity, and at one gigantic stride assuming the importance and complicated relations of a large empire. In less than fifteen years she has acquired a population of over half a million, and has developed the wonderful resources comprised within her limited boundaries. On the site of half a dozen adobe buildings has risen a city of 90,000 inhabitants, in whose streets is seen the dress and heard the tongue of every nation. The last census represents the taxable property of San Francisco at $36,967,499, and that of the entire State at $148,198,540. Over 600 ships, under every known flag, have been anchored at one time in the harbor of San Francisco. The commercial enterprise developed has given birth to a new era of naval architecture; the old-fashioned full, clumsy-bowed ships, that carried the early adventurers round Cape Horn, and made their passages in something less than a year, have played out their part, and have been succeeded by the famed clippers. In 1860 not one of the old deserted hulks disfigured the harbor.

In the first three quarters of 1849 no less than 509 large vessels entered the bay; at the end of August of that year there were 62,000 tons of shipping at anchor, exclusive of vessels running on the Sacramento, San Joachim, the adjacent bays, and in the coasting trade. On the 24th of September over 11,000 tons of shipping entered the Golden Gate, and at the end of September there were 94,500 tons in the harbor. For a city one year old, and 17,500 miles from the nearest eastern ports, this may well be viewed as marvellous.

Tonnage of San Francisco.—At the end of the fiscal year, June 30, 1855, there were registered, enrolled, and licensed, at the custom-house of San Francisco, owned wholly or in part by citizens of California, 702 steam and sailing vessels engaged in trade upon the Pacific, distributed under the following heads:

Registered tonnage.

3 steamships	1,058 tons.	
36 ships	14,428 tons.	
59 barques	15,999 tons.	
50 brigs	8,592 tons.	
49 schooners	5,887 tons.	
Total		45,964

Enrolled tonnage.

45 steamships	11,223 tons.	
1 ship	386 tons.	
17 barques	3,759 tons.	
28 brigs	4,667 tons.	
127 schooners	8,774 tons.	
59 sloops	2,137 tons.	
Total		30,946

In addition to the above, there were licensed at that time, as coasters, 228 schooners and sloops below 20 tons each, with an aggregate tonnage of	2, 399
Making a total of permanent registered, enrolled, and licensed tonnage of 702 vessels of	79, 309

We have no means now at hand for ascertaining the increase up to 1857, but the following tables, exhibiting the tonnage entering and clearing the port of San Francisco, may not be without interest:

Tonnage of the port of San Francisco.

Years.	ARRIVALS.		DEPARTURES.	
	American vessels from American & foreign ports.	Foreign vessels from foreign ports.	American vessels to American & foreign ports.	Foreign vessels to foreign ports.
	Tons.	*Tons.*	*Tons.*	*Tons.*
1849	108, 644	*65, 729		
1850	255, 428	*131, 628		
1851	292, 940	*125, 965		
1852	268, 737	132, 094	344, 760	131, 111
1853	404, 220	124, 874	501, 229	137, 110
1854	336, 058	76, 127	426, 775	83, 871
1855	325, 102	55, 148	369, 213	48, 322
1856	305, 519	40, 378	347, 451	41, 809
1857	382, 958	44, 608	291, 879	45, 143

*Books of custom-house destroyed by fire.

A great number of vessels that arrived in 1849, '50, '51, began to clear in 1852, when seamen could be obtained.

The following shows in more detail the shipping operations of the year 1857:

Table showing the shipping entered and cleared at the port of San Francisco for the year 1857.

	Entered.	Tons.
Number of American vessels from American ports	1, 328	291, 561
Number of American vessels from foreign ports	130	91, 397
Number of foreign vessels from foreign ports	125	44, 608
	1, 583	427, 566
	Cleared.	Tons.
Number of American vessels for American ports	516	108, 538
Number of American vessels for foreign ports	203	183, 341
Number of foreign vessels for foreign ports	129	45, 608
	848	337, 022

The difference noticeable between the vessels entered from and cleared for American ports is owing to the fact that these vessels are not required to clear at the custom-house, and therefore many departures are not noticed.

For the year 1860 the reported tonnage of vessels entered was 538,081, and cleared, 393,355.

Table showing the total tonnage entered from eastern States and from foreign ports, with the amount of freights paid upon the cargoes.

Years.	Tons.	Freight.
1853	407, 235	$11, 752, 084
1854	254, 714	5, 311, 612
1855	247, 682	3, 999, 755
1856	236, 389	4, 592, 104
1857	197, 814	2, 842, 671
1858	313, 158	3, 836, 197
1859	374, 338	4, 763, 131
1860	336, 658	4, 110, 050

The steamship tonnage entered from Panama and San Juan del Sur, and the coasting tonnage entered, were as follows:

Years.	Steamship.	Coasting.
	Tons.	*Tons.*
1853	83, 432	67, 213
1854	85, 735	59, 230
1855	77, 280	146, 495
1856	65, 477	138, 149
1857	47, 716	182, 036
1858	....	136, 781
1859	....	209, 002
1860	....	201, 423

During the years 1856, 1857, the movements of the filibusters retarded, and finally put a stop to all travel across the isthmus of Nicaragua, and the steamships were hauled off. In 1862 the line was again opened.

Table of the value of imports, free and otherwise, into the district of San Francisco.

1854	$5,899,620
1855	7,144,075
1856	9,155,507
1857	9,528,291
1858	8,984,688

Table showing the value of imports of certain articles, such as flour, grain, salt meats, &c., now produced in California.

1853	$14,021,940
1854	5,161,586
1855	2,444,626
1856	1,248,343
1857	1,631,467

Table showing the receipts of customs of the port of San Francisco, and the expenditures.

Year.	Receipts.	Expenditures.
1848, 1849	$1,581,640	
1850	1,908,220	$303,033
1851	2,316,675	1,009,436
1852	2,008,410	655,694
1853	2,589,406	684,114
1854	1,563,103	646,288
1855	1,804,904	438,684
1856	1,713,408	441,678
1857	1,504,137	607,090
1858		425,886

Value of the exports of leading articles of California produce from San Francisco.

1854	$1,496,761
1855	2,753,147
1856	2,279,942
1857	2,319,266
1858	2,526,791
1859	2,129,330
1860	4,948,921

Of these amounts the following are the principal items :

Year.	Wheat, oats, barley.	Flour.	Hides.	Wool.	Quicksilver.
1853					$611,000
1854	$49,689	$523,035	$107,500	$14,000	648,317
1855	378,351	925,728	338,310	36,000	975,621
1856	92,500	588,080	443,517	80,000	833,185
1857	445,665	90,050	681,788	165,000	954,100
1858	404,226	179,630	549,032	199,969	870,500
1859	736,484	164,281	454,092	356,737	*126,262
1860	2,239,939	590,763	600,750	397,192	*338,330
1861					†952,518

* In these years the New Almaden mines were stopped by legal embarrassments.
† Up to the end of October.

Table showing the passengers arrived by steamship and sailing vessels at the port of San Francisco.

Year.	Arrived.	Departed.
1849	91,405	
1850	36,462	
1851	27,182	
1852	66,988	22,946
1853	33,233	30,001
1854	47,531	23,508
1855	29,198	22,898
1856	28,119	22,747
1857	24,759	16,906
1860	27,586	12,857

The following table will exhibit the tonnage movement of the principal cities of the United States for the year 1856:

City.	Entered.	Cleared.	Total.
New York	1,681,659	1,520,623	3,202,282
Boston	682,165	647,404	1,329,569
New Orleans	663,067	773,162	1,436,229
San Francisco	345,897	389,260	735,157
Philadelphia	173,179	129,739	302,918

It would be doing injustice to the State not to give a few facts relating to her principal mineral wealth.

The average amount of gold taken from the country during the nine years 1850–'59 has been fully $55,000,000 per annum; the average value of the exported cotton crop of the United States for the same period was $105,908,327, and of the breadstuffs and provisions $46,022,165.

The following table exhibits the amount of gold shipped, per manifest, from San Francisco, from 1849 to 1863, inclusive:

1849	$4,921,250
1850	27,676,346
1851	42,582,695
1852	46,586,134
1853	57,331,024
1854	51,328,653
1855	43,080,211
1856	48,887,543
1857	48,976,207
1858	47,528,786
1859	47,664,999
1860	42,302,346
1861	40,639,090
1862	42,380,809
1863	41,569,876
	633,455,876

The gold and silver coinage of the branch mint of San Francisco, from its organization to June 30, 1862, has been as follows:

Year.	Gold.	Silver.	Total.
1854	$9,731,574	....	$9,731,574
1855	20,957,677	$164,075	21,121,752
1856	28,315,538	200,609	28,516,147
1857	12,490,000	50,000	12,540,000
1858	19,276,096	147,503	19,423,599
1859	13,906,272	327,970	14,234,242
1860	11,889,000	572,912	12,461,912
1861	12,421,000	269,485	12,690,485
Total	128,987,157	1,732,554	130,719,711

The following figures will exhibit the marked influence which the gold product of California has had upon the coinage of the United States. For the 57 years previous to 1850 the total gold, silver, and copper coinage was $162,161,731; of this $85,349,197 was gold. From January 1, 1850, to June 30, 1861, the gold coinage was $583,698,592; the silver, $53,146,814; the copper, $1,395,740; or a total of $638,241,146 in eleven and a half years. The entire deposit of domestic gold, since the organization of the mint, has been $523,529,409, of which California produced $501,290,998.

California placer gold has a dark color from its light coating of oxide of iron; but, when fused, its light color indicates a large per-centage of silver. The average fineness of California gold, as determined by some thousand assays at the United States mint, Philadelphia, is 885 thousandths, or 88½ per cent. pure gold, and 115 thousandths, or 11½ per cent. of silver. The quantity of platinoid metals found in the gold is small, about 1½ pound of iridosmin having been obtained from about 25 tons of the gold ($\frac{3}{1000000}$), but the greater part had, of course, passed into the coin, the coarse grains only being left.

The recent developments of the silver mines of Nevada Territory, on the eastern boundary of California, lead to the conclusion that not less than $12,000,0000 of silver will be produced from them in 1862.

Agriculture.—The amount of land in California adapted to the purposes of agriculture is estimated at 41,622,400 acres, exclusive of the swamp and overflowed lands, estimated at 5,000,000; which, when reclaimed, will produce every variety of crop. On the Sacramento the experiment is being made to cultivate rice with Chinese labor. The amount of grazing land is estimated at 30,000,000 acres. The amount of land under cultivation in 1856 was 578,963 acres; and of that enclosed for the purposes of agriculture, about 120,000. The amount in wheat was 176,869 acres, and the product 3,979,032 bushels; in barley 154,674 acres, and the product 4,639,678 bushels; in oats 37,602 acres, and the product 1,263,359 bushels. Part of this season was characterized by a severe drought.

In 1858 the amount of land under cultivation was 756,734 acres. The amount in wheat was 186,464 acres, yielding 3,568,669 bushels. Napa county was the heaviest wheat-growing district; 16,000 acres yielded an average of 31⅛ bushels to the acre.

The president of the State Agricultural Society, in his address of 1856, before that body, says: "It it is now a well-ascertained fact, established by several years' experience, that California stands without a rival in respect to her capacity for producing wheat and other small grains. She produces it in larger quantities to the acre, of better quality, with more certainty, and with less labor, than any other country in the known world."

In 1858 the number of acres under cultivation for barley was 237,692, producing 5,382,718 bushels, exceeding the aggregate of the crops of the United States in 1850.

Dr. Trask, in the "Geology of the State," says: "Toward the foot-hills of the mountains on the west of the San Joachim valley is a low table of the valley, apparently destitute of water, either for the support of vegetation or animal life; in some parts this land has a slight gravelly appearance, but this is not general. On one rancho, situated on this plateau, there have been two full crops of barley harvested from the same piece of ground, and when I visited this place, in October, the third crop was being then harrowed in, the whole having occurred within the term of 273 [consecutive] days."—(Page 54.)

The following extract from the report of the visiting committee for 1856 will best illustrate the extra ordinary capacity of the soil for the culture of this important grain: "Near Alviso, Santa Clara county, there is a field of barley, fifty acres in extent, which has averaged the present season forty-three bushels to the acre This is the fifth crop from a single sowing; it has received no special care, and may be regarded as a memorable example of a succession of volunteer crops."

In 1858 the number of acres under cultivation for oats was 44,616, and the produce 1,322,221 bushels. Crops of this grain have frequently averaged 75 bushels to the acre, and one crop from 32 acres, in Alameda county, averaged 134 bushels in 1856. In Del Norte county, during the year of 1858, two crops of oats yielded an average of 125 and 157 bushels, respectively, and a crop of barley 100 bushels to the acre.

The cultivation of the grape, and its manufacture into wines and brandies, is rapidly assuming a degree of importance, and increasing to such an extent that these products must soon become one of the most reliable and lucrative branches of the resources of the State. The experience of the last few years has proved conclusively that this country produces this fruit in the greatest variety and abundance, and in a few years will surpass the most extensive wine-producing countries of the world. The number of vines in cultivation in 1856 was 1,532,224, and the average yield over fifteen pounds of fruit. The number of all kinds of fruit trees that year was 1,296,783, and the fruit far superior to any on the Atlantic or Gulf seaboard.

In 1857 the number of vines was 3,954,548, and the average yield 14 pounds. The number of all kinds of fruit trees was 1,963,349. The partial returns for 1858 indicated an increase of seventy-five per cent. over 1857.

The two great staples, cotton and flax, will render the country independent of other places for her manufactures, whilst the production of silk bids fair to go hand in hand with both. The true wealth of the country has but commenced its development, and in a short period she will successfully compete with the Atlantic States and Europe for the markets of the Pacific.

Regular mail communication is maintained by steamships with the Atlantic and the Gulf States twice* a month, crossing the Isthmus of Panama by 47½ miles of railroad; the transit from steamer to steamer occupying four hours. For the year ending June 30, 1856, the number of letters conveyed by this route was 2,365,902, and newspapers 3,463,817; the number of letters and newspapers exchanged between the United States and Great Britain, in British mails by the Collins, Cunard, Bremen, and Havre lines, for the same time, was 3,909,128 (letters,) and 3,196,014 (newspapers.) The comparison speaks well for the modern El Dorado.

The entrance to San Francisco bay is supposed to have been first seen by Bartolome Ferrelo, pilot and successor to Juan Rodriguez Cabrillo, who, running down the coast with a gale strong from the north, on the 3d of March, 1543, descried what he supposed to be the mouth of a great river, having every appearance of draining a large extent of country; and steering SE. and E.SE. he soon after sighted Point Pinos, and on the 5th the port in the Island of Juan Rodriguez, where Cabrillo is supposed to have died. If this account is correct, he was the first European that beheld the Golden Gate.

Sir Francis Drake visited California, which he named New Albion, in 1579, and we are of opinion that in this bay he overhauled and repaired his vessel; "it having pleased God to send him into a fair and good bay, with a good wind to enter the same." Curiously enough, we find the statement that "there is no part of the earth here to be taken up wherein there is not some probable show of gold and silver." In this harbor he remained over a month "trimming" his ships and taking possession of the country.

A land discovery of the bay was made in 1769 by Gaspar de Portola, who left San Diego to establish a Jesuit colony at Monterey; but by travelling along the eastern slope of the Coast mountains he passed Monterey, and towards the close of October came unexpectedly upon the shores of a great bay, which they supposed to be the Port St. Francisco of the old navigators. Having no supplies, the party returned to San Diego.

Vancouver visited the bay in 1792 and 1793, and gives a good general map of the entrance. The presidio of San Francisco was then occupied by Spanish troops.

The first accurate hydrographic survey was made by Capt. Fred. W. Beechy, in the Blossom, in November, 1826, he carrying his work to the Strait of Karquines.

In October, 1837, Capt. Sir Edward Belcher ascended the Sacramento with the boats of the Sulphur, and starting from the "Fork" carried the survey down the river to connect with Beechy's survey. The "Fork" he calls Point Victoria, and places in latitude 38° 46′ 47″, and 0° 47′ 31″.5 east of the observatory on Yerba Buena. This point is formed by the confluence of the Rio de las Plumas, or Feather river, with the Sacramento, about 20 miles above Sacramento city. The river, but a short distance above his starting point, was fordable, and thence to its mouth traversed in its meanderings 150 miles. The head of steamboat navigation is at Red Bluffs, in latitude 40° 10′.

The Coast Survey charts of 1857 furnish all that can be desired in regard to the lower part of the bay of San Francisco, the upper bays, and the waters approaching the mouth of the Sacramento.

DUXBURY POINT AND REEF.

From Point Boneta to Duxbury Point, forming the west side of Ballenas bay, the course is W. by N. ¼ N., and the distance 9¼ miles. The point, sometimes called Ballenas, is a table land about 100 feet high, which stretches along the coast for a mile or more, and gradually rises to a narrow, nearly treeless ridge, 1,389 feet high at its greatest elevation, and running in a straight line 25¼ miles NW. ¾ W. to Tomales Point. The old Californians expressively call it the Cuchilla Grande. Parallel to this ridge on the east, and starting from the west end of the great cross ridge of Table mountain, runs another to the northwestward, and the depression between them, abreast of Duxbury Point, forms the Ballenas bay, as it does the Tomales bay further

* Every ten days since 1862.

up the coast. This depression forms a long narrow valley, well watered and timbered, and in many places cultivated. Two streams running into each bay, have their sources nearer the bay from which each runs.

Duxbury reef makes out $1\frac{1}{4}$ mile SE. $\frac{1}{4}$ S. from the southern extremity of the point, and stretching towards Point Boneta, forms a safe anchorage in northerly weather. From the tail of the reef to the rocky point E.NE. from it, the distance is three miles, and from this line to the greatest bend of the bay the distance is $1\frac{3}{4}$ mile. In this bay the three-fathom line makes off three-quarters of a mile from the southeast face of Duxbury Point, but approaching the low sand beach east of the narrow entrance to the lagoon. From four to eight fathoms of water, with a regular bottom of sand and mud, are formed in the bay, and six fathoms quite close to the reef. From Duxbury Point to the bluff, at the entrance to the lagoon, the distance is $1\frac{1}{4}$ mile NE. by N.

In June, 1860, the British barque Camilla, from San Francisco to Melbourne, drifted in a dead calm near Duxbury reef, and let go her anchors in six fathoms. When she swung to the swell and current her stern struck, and she thumped for four hours.

Quite close to Duxbury Point the steamship S. S. Lewis went ashore, April 9, 1853, in a thick fog and calm, while running at her ordinary speed. She was backed off and ran ashore again within a few hundred yards to the northward, and was totally lost in the breakers.

The lagoon north of the bay is at the foot of the mountains, and, except small crooked channels, is bare at low tides, and filled with small islets. The south side of this lagoon is bounded by a long, narrow sand spit, stretching so nearly across it as to leave an entrance of but 100 yards wide at the southwest part of it. Only a few small vessels run between this place and San Francisco.

The shore north of Boneta is bold and high, presenting a marked and peculiar undulating surface at right angles to the sea front. This characteristic is well delineated on the Coast Survey map of the approaches and entrance to San Francisco bay, published in 1857.

North of Duxbury the hard rocky shore continues bold and high, but gradually merges into cliffs, consisting chiefly of yellowish clay and sand resting upon granite, and, as the surface is regularly undulating, with the direction of the alternate ridges and valleys at right angles to the shore, the wearing action of the surf forms a continuous series of round-topped, bright, vertical bluffs, averaging nearly 100 feet high, and presenting a very noticeable feature from the sea. Its resemblance to portions of the coast of England was one of the reasons which induced Drake to apply the name New Albion to the country in June, 1579.

The mountains in the back ground rise over 2,000 feet, and the "Table mountain" of Beechy attains an elevation of 2,604 feet, stretches nearly two miles inland at right angles to the coast, and forms a prominent mark from seaward and from the bay of San Francisco. A few large trees are seen along the top of the main ridge running parallel with the coast and behind the valley, connecting Ballenas and Tomales bays.

Table mountain is a very sharp ridge, showing flat-topped only in two directions. From South Farallon light-house it bears NE. $\frac{1}{2}$ N., distant 24 miles; the geographical position of the eastern peak is:

	° ′ ″
• Latitude	37 55 36.7 north.
Longitude	122 33 38.7 west.
	h. m. s.
Or, in time	8 10 14.6.

It was called Mount Palermo by the United States Exploring Expedition, but is known only by the name here used.

By the old Californians it is called Tamal Pais, because this part of the country was inhabited by the Tamal Indians, who, in 1816, were within the jurisdiction of the mission of San Francisco. The Tamal, Numpal, and Suysum tribes tatooed themselves and spoke the same language; the first lived in the northwest, and the last two in the north.

SIR FRANCIS DRAKE'S BAY.

From the tail of Duxbury reef to the west end of Los Reyes the course is W. $\frac{3}{4}$ N., and distance $17\frac{1}{3}$ miles. To the east end the course is W. by N., distance $14\frac{5}{8}$ miles. From Duxbury the shore is bold and compact, running nearly NW. by W. for about 10 miles, then curving regularly to the westward, changing to a low shore, until it reaches its greatest latitude at the Estero de Limantour, which bears N. by E. $\frac{1}{2}$ E. from the east end of Los Reyes, distant three miles; thence the line curves to the southward and southwest, one mile west of the point, leaving a long, high, narrow point stretching to the east, and off which the breakers extend half a mile. This curving shore-line forms Sir Francis Drake's bay, which affords a large and admirable anchorage in heavy northwest weather; and by anchoring close in under the north side of the point, in four or five fathoms, hard bottom, good but contracted anchorage is obtained in southeast gales, as the swell rolling in from the SW. is broken by the reef.

The secondary astronomical station of the Coast Survey was, on the north side of the first small gulley, five-eighths of a mile from the eastern end of the head, and about 40 feet above the water. Its geographical position is:

	°	′	″
Latitude	37	59	35.0 north.
Longitude	122	57	36.1 west.
	h.	*m.*	*s.*
Or, in time	8	11	50.4.

The computed magnetic variation in July, 1860, was 15° 58′ east, and its present yearly increase 1′.

Several esteros or lagoons open into the north side of the bay, but their entrances are very narrow and shoal. The largest is the *Estero de Limantour*, which stretches to the northward over three miles, and one of its numerous arms approaches within a mile of the ocean beach, five miles north of Point Reyes head. The entrance to this lagoon has eight feet of water, and is generally marked by breakers on either hand. Coasters can enter with the prevailing northwest wind. It is called Drake's Estero on the Coast Survey chart of Sir Francis Drake's bay, published in 1860. It was named after Limantour, notorious for his attempted great land claim fraud in California. He was a Frenchman, but a citizen of Mexico, and asserted that in trading upon this coast in 1841 he lost the Mexican vessel Ayachuco at the entrance to this estero.

Drake's bay is the Port Francisco of the Spaniards, of about 1595. It was certainly known before the time of Vizcaino, who, having separated from his tender, sought her in Port Francisco, and, according to Venega's account, "to see if anything was to be found of the San Augustine, which, in the year 1595, had, by order of his majesty and the viceroy, been sent from the Philippines by the governor to survey the coast of California, under the direction of Sebastian Rodriguez Cermeñon, a pilot of known abilities, but was driven ashore in this harbor by the violence of the wind; and among others on board the San Augustine was the pilot Francisco Volanos, who was also chief pilot of the squadron." This pilot recognized the bay as being that where he was wrecked.

POINT REYES.

This is the most prominent and remarkable headland north of Point Concepcion. It is distinctly visible from the entrance to San Francisco bay, and the summit of the ridge presents an irregular jagged outline, with the highest part about one-fourth of its length from the western extremity. Its southern face is a precipitous wall of hard sienitic granite, rising boldly from the ocean, attaining an elevation of 597 feet in 300 yards, and stretching nearly in a straight line E. by N. and W. by S. for three miles. This direction is peculiar on the coast, and would not be expected from a consideration of the trend of the coast mountains and of the Farallones, which are in line NW. and SE. On the north side the cape falls away regularly to a low undulating neck of land, cut up by esteros making in from Drake's bay. When made from the southward it is raised as a long, high island; but on approaching it from the westward it is projected upon the mountains running north from Table mountain, and its characteristics are not so readily recognized. Its base is very broken and rocky, and bordered by crags and hundreds of rocks, but may be boldly approached, and eight fathoms, hard bottom, obtained within less than a quarter of a mile. Off the eastern extremity a reef makes out half a mile in continuation of the point. Upon this reef it breaks heavily in bad southerly weather, but nine fathoms can be had close to the breakers. Off the western head a depth of 12 fathoms is found quite near to the rocks.

Vessels bound to San Francisco from the northward always make Los Reyes, and, when up to it, sight two mountains on the southern peninsula of San Francisco as islands. One of these is Blue mountain, 1,100 feet high, and the other, Abbey hill, 1,250 feet.

In 1859, while occupying the Coast Survey station on Point Reyes hill, 1,389 feet in altitude, and 8⅗ miles NE. ½ N. from Point Reyes head, we observed a barque, during a perfect calm, having no steerage way, and turning round several times, drift to the northward past Point Reyes head, at the rate of one mile per hour. She was two miles to the westward of the head. On this and subsequent occasions we noticed the discolored water of the Sacramento from San Francisco bay close in shore, and extending to the northward of the head several miles. Different degrees of discoloration, as of successive ebb tides, were plainly marked.

The light-house of Punta de los Reyes will be placed about a quarter of a mile from the western point. A height of 20 feet above the site selected will command the horizon from east round, seaward, to the north. The ocean face is precipitous, and the light will be at an elevation of about 500 feet above the water.

The geographical position of the site selected is:

Latitude	37	59	39.4	north.
Longitude	123	00	13.3	west.
	h.	*m.*	*s.*	
Or, in time	8	12	00.9.	

The magnetic variation computed for July, 1860, was 15° 58′ east, with a present yearly increase of 1′.

This headland was discovered by Cabrillo in 1542, and placed by him about the latitude of 40°; but by applying the correction 1° 50′, obtained from his erroneous latitudes of San Diego, Point Concepcion, (Cape Galera,) and Punta Gorda, (San Martin,) the latitude of 40° becomes 38° 10′, which is within ten miles of the latitude of Los Reyes. We believe he called it Cabo Mendozino, in honor of the viceroy of Mexico, who despatched him; but this name was applied to every cape first made by the Spanish galleons on the passage from the Philippines to La Natividad, New Spain. In this region Cabrillo found the mountains covered with snow. There can be little doubt that he also saw the Farallones.

The present name was given by Viscaino, who anchored under the head in January, 1603, whilst searching for the wreck of the San Augustine.

SOUTH FARALLON.

The southern and principal one of the six rocky islets known as the Farallones de los Frayles, lies off the Golden Gate at a distance of 23½ miles; the whole group is disposed in a nearly staight line running NW. from the southern one. This is the largest and highest, extending nearly a mile east and west, attaining an elevation of about 340 feet above the sea, and presenting to the eye a mass of broken, jagged rocks, upon which no vegetation exists, except a few stunted weeds. The rocks are sharp, angular masses, which, becoming detached by the operations of natural causes, roll down upon the more level parts of the islet and cover it with irregular boulders. Notwithstanding that it is the outcrop of an immense dyke of granite, the condition of the superficial portion is such that it could be separated into small fragments by a pick or crowbar. A more desolate and barren place can hardly be imagined. From the hills about the Golden Gate the South Farallon is plainly visible, rising in regular pyramidal form.

Vessels from the westward, running for the Golden Gate, should keep to the southward of the South Farallon, especially in thick weather and at night. To the westward of it a depth of 50 fathoms is obtained at a distance of three miles, shoaling to 20 fathoms in two miles; whereas, inside of it, the bottom is very regular at 30 fathoms for ten miles, and then decreases regularly to the bell-boat. On the SE. side of the island there is said to be good holding-ground in 15 fathoms.

The San Francisco pilot-boats cruise off the island.

An extended and detailed examination around the island has not yet been published.

Tides.—The corrected establishment, or mean interval between the time of the moon's transit and the time of high water, is X*h.* XXXVII*m.*, and the difference between the greatest and least intervals 1*h.* 16*m.* The mean rise and fall of tides is 3.6 feet; of spring tides, 4.4 feet; and of neap tides, 2.8 feet. The mean duration of the flood is 6*h.* 18*m.*, and of the ebb 6*h.* 09*m.*

To find the times of high and low waters, first compute them for San Francisco, and from the numbers thus obtained subtract 1*h.* 29*m.* for the South Farallon.

The ship Lucas was wrecked on this islet in a fog, November 9, 1858, and 23 lives were lost.

SOUTH FARALLON LIGHT.

The tower stands on the highest peak of the principal island. It is built of brick, 17 feet in height, and is surmounted by a lantern and illuminating apparatus of the first order of the system of Fresnel. It is a *revolving white light, showing a prolonged flash of* 10 *seconds every minute* throughout the horizon. The time of the flash varies on different nights. In 1859 we found the average time 13 seconds. It is levated about 360 feet above the mean level of the sea, and should be visible, in a favorable state of the atmosphere, from a height of—

10 feet, at a distance of 25.4 miles.
20....do......do..... 26.9 "
30....do......do..... 28.1 "
60....do......do..... 30.7 "

At near distances, under favorable circumstances, the light will not wholly disappear between the intervals of greatest brightness. It is plainly visible from Sulphur Peak, distant 64.4 miles, and 3,471 feet above the sea.

The geographical position of the light-house, as given by the Coast Survey, is:

	°	′	″
Latitude	37	41	48.8 north.
Longitude	122	59	05.2 west.
	h.	m.	s.
Or, in time	8	11	56.3.

Magnetic variation 15° 40′ east, in 1857, with a yearly increase of 1′.

The bearings and distances of prominent objects from it are:

North Farallon, N. 64° W., 6⅗ miles.
Western head of Los Reyes, N. by W. ⅜ W., 17¾ miles.
Point Boneta light-house, NE. by E., 23½ miles.
Bell-boat off San Francisco bar, NE. by E. ½ E., 16½ miles.
Point San Pedro, E., 23½ miles.
From abreast Fort Point the light is just visible above the horizon.

Fog-whistle on the South Farallon.—In January, 1859, a fog-whistle, of six inches in diameter, was placed on the south side of the eastern part of the island, about 275 feet from the water. It is erected over a natural hole, in the roof of a subterranean passage, connected with and open to the ocean, and is blown by the rush of air through the passage, caused by the sea breaking into its mouth. The sound should be heard in the vicinity at all times, (its loudness depending upon the height of the tide and the waves,) except about an hour and a half before and after low water, when the sea does not enter the mouth of the passage. It is said to have been heard at a distance of seven or eight miles.

THE MIDDLE FARALLON

is a single rock, between 50 and 60 yards in diameter, and rising 20 or 30 feet above the water. It lies N. 56° W., distant 2¼ miles from the light-house on the South Farallon. Its geographical position is, latitude 37° 43′ 31.6″ north, and longitude, 123° 00′ 54.9″ west.

THE NORTH FARALLONES

lie nearly in line with each other and the Middle and South Farallones, and consist of a group of four islets, having a pyramidal appearance as their name denotes, and comprised within a space of little more than half a mile square. The northern three are quite high and bold, the highest peak of the middle one attaining an elevation of 166 feet, whilst the southern one of the group is a mere rock of about 35 yards in diameter, and hardly 20 feet above water. Viewed from the southwest or northeast, breakers extend across from the largest islet to the next one southeast, and during a heavy ground swell we have watched it from Point Reyes hill breaking on an isolated sunken rock lying apparently between the northern and largest islet. From certain directions a small pyramidal detached peak shows close to the north side of the northern islet.

The geographical positions and extent of the islet are as follows:

	Latitude. ° ′ ″	Longitude. ° ′ ″	Extent. Yards.
Northern islet	37 46 10.9 north	123 05 25.1 west	160
Middle islet	37 45 52.9 north	123 04 59.8 west	185
Southern islet	37 45 42.9 north	123 04 53.6 west	125
Rock off last	37 45 44.8 north	123 04 41.0 west	35

The northern islet, therefore, bears N. 64° W., distant 6⅗ miles from the light-house on the South Farallon. From the light-house site of Punta de los Reyes it bears south, distant 14 miles.

To the southward and eastward from the North Farallones, at a distance of two miles, we are informed that a sunken rock exists, having four fathoms water upon it, with kelp around it, except when torn away by storms. In good weather the fishermen fish around it, but in bad weather the sea breaks upon it. We called attention to this several years ago, and since then have met with a Russian volume of charts, published at New Archangel, in 1848, wherein a rock in this vicinity is marked "overflowed." The Noonday rock, with 4½ fathoms of water upon it, lies W. by N., distant three miles from the North Farrollones, with intervening rocky bottom in 35 fathoms. Between them and Los Reyes the depth increases to 50 fathoms about midway.

The Farallones de los Frayles were discovered by Ferrelo in February, 1543, and he is stated to have seen six islands in this vicinity, one large and five very small, which Cabrillo had passed on the previous voyage. He states that for five days it was impossible to effect a landing upon them on account of the southwest winds and heavy sea.

Sir Francis Drake is the first that specially mentions them, in 1579, as lying off the harbor or bay where he refitted his ships.

In some recent maps they are omitted.

NOONDAY ROCK.

This danger lies nearly on the prolongation of the line from the South Farallon, through the North Farallones. It is of very limited extent, and is, doubtless, a sharp isolated point of a small ledge, having from 20 to 30 fathoms immediately around it. It is plainly visible when directly over it, and has 3½ fathoms of water upon it at mean low water; but at the extreme low water of spring tides there will be hardly more than four fathoms. In very heavy weather and low water the sea breaks upon it, but this indication seldom exists, and must not be depended upon for ascertaining its position.

From it the following bearings will show its relation to other well-marked and determined points.

Punta de los Reyes, western head, N. 13° 25′ E., distant $13\frac{8}{10}$ miles.

North Farallon, S. 79° 30′ E., distant $3\frac{1}{10}$ miles.

South Farallon light-house, S. 69° 45′ E., distant $9\frac{7}{10}$ miles.

Point Boneta light-house, N. 71° 32′ E., distant $30\frac{3}{10}$ miles.

Boneta light will not be visible from a ship's deck, but may be seen from aloft, under very favorable atmospheric circumstances.

The approximate geographical position of this rock is:

	°	′	
Latitude	37	47½	north.
Longitude	123	09	west.

In the description of the South Farallon, and in the directions for approaching San Francisco, we have heretofore advised vessels approaching the Golden Gate at night and in thick weather to keep to the southward of the South Farallon light. This advice has now more significance, and should be followed. With Punta de los Reyes and the Farallones in sight, vessels bound in and running between them should keep the western head of Los Reyes open on a N.NE. course, coming nothing to the eastward, until the North and South Farallones are in range, then bear away for the Golden Gate. In that position the rock will bear SE., distant 2½ miles. Coming from the northwestward at night, vessels should not bring the South Farallon light to bear anything east of SE. by E., which will clear the rock by two miles, and the North Farallones by one mile.

Southwest of the line passing through the Farallones and Noonday rock, the 100-fathom curve is only four miles distant, and the 50-fathom curve only two miles, with very irregular bottom.

Notice of the ledge was first made known in April, 1860, it having been discovered on the 13th of March. The weather was calm, and the pilot boat, drifting with the current, was fishing off the North Farallones in 40 fathoms water. Suddenly the line slackened, and the depth rapidly decreased to ten, and finally to nine fathoms, when it increased again to the first depth. No other examination was made, as the boarding boat was fishing some miles distant. The North Farallones bore E. by S. at an estimated distance of five miles; the single range taken was unavailable for plotting.

On the 2d of January, 1863, the clipper ship Noonday, drawing 21 feet of water, struck twice upon the isolated rock forming the apex of the ledge; passed over it, and within an hour sunk in 40 fathoms of water. At the time of her striking the weather was clear, sea smooth, but with a very heavy swell from the northwest, and the wind from the northwest carrying her towards the Golden Gate, about 9 or 10 knots an hour, with everything set. The tide was three hours past the higher high water of the day, and 3.1 feet above the plane of reference, which is the mean of the lower low waters. The height of the higher high water of that day was slightly greater than the average of the higher high waters. She reported the rock eight miles from the North Farallones, which bore E. by S. ½ S.

On the 29th of January the position of this danger was first accurately determined by the Coast Survey, and notice thereof immediately published.

NEW SHOAL OFF SAN FRANCISCO ENTRANCE.

It is reported, January, 1863, that a shoal has been discovered about 80 miles southwest from the Southeast Farallon. It is said to have but from five to seven fathoms of water upon it, and lies directly in the track of vessels bound into San Francisco. Its approximate geographical position from the above data is:

Latitude	37° $06'$ north.
Longitude	124 22 west.

SHOAL IN THE PACIFIC, OFF THE CALIFORNIA COAST.

In latitude 37° 25′ north, and longitude 137° 30′ west, rocks are reported having but from three to five fathoms of water upon them. This information was obtained in 1855, and failing to ascertain anything more concerning it, is now published to call attention and invite further examination.

POINT TOMALES AND TOMALES BAY.

Northward of Punta de los Reyes we find a long reach of broad white sand beach, backed by sand dunes, and extending in a N. ½ E. direction about 12 miles, curving to the northwest, and changing to a high precipitous coast running to Point Tomales, which bears N. by W. 15 miles from Los Reyes. Three-quarters of a mile before reaching the point, a rocky islet 80 feet in height is seen close in shore. Eight miles above Point Reyes is the opening to an estero, the north point of which is low and sandy. The wider arm runs one mile towards the head of the western branch of the Estero de Limantour, and little more than that distance from it. The other arm runs nearly a mile and a half to the northwestward. The ridge forming Tomales Point and the western shore of Tomales bay is the northern extremity of that starting from Duxbury Point. About 4¼ miles from the point the ridge is 673 feet high, with slightly lower ground a few miles south. It is where the sand dunes strike this ridge that the coast changes its character; thence to the point it is bold and rocky, with breakers about one-third of a mile off the point, and on the prolongation of the ridge, which averages less than three-quarters of a mile in breadth for the last four miles.

The bay of Tomales extends from Tomales Point SE. ¾ E. for 12½ miles, with an everage width of seven-eighths of a mile. The entrance is narrow, and obstructed by a bar having a depth of 10 feet, between sandy lumps of seven feet. The bar lies nearly half a mile east of the extreme point, and 400 yards from the bluffs. It is exposed to the full force of the northwest swell, and with the least swell from seaward it breaks across the whole entrance. For two or three miles this bay is contracted, but has a narrow, deep channel close under the western shore. Four miles within the point lies a small island near the middle of the bay; beyond it the depth of water becomes more regular. Its shores are becoming thickly settled, and trade in agricultural products has increased so much that a small steamer has been put upon the route to San Francisco.

In 1852 the ship Oxford, after getting on the rocks outside of Tomales ridge, was deserted, floated off, drifted into the bay over the bar with the flood tide, grounded on the flats, and at the following high water floated off again; but no one being aboard, she again drifted on the flats and lay inside of Sand Point for some years.

In February, 1857, the waters of the bay changed to a deep purple color, and the fish died in such great numbers that the beaches and water were covered with them.

This bay was known as Port Juan Francisco by the Spaniards when Vancouver visited the coast in 1792.

In old Mexican grants it is called Tamales, and sometimes Tomales. The old Californians invariably pronounce it like the former.

Belcher erroneously designates it as a part of Bodega bay.

The Russians have a chart of it.

De Mofras calls it the Estero Americano, which is another body of water emptying into Bodega bay. He calls Point Tomales Point Bodega.

The topography of its entrance was executed by the Coast Survey in 1853. A map of the whole bay was published in 1861.

BODEGA HEAD.

This point lies N.NW. 18 miles from Los Reyes, and forms the northern point of Bodega bay, considering Tomales Point the southern. The head is two or three hundred feet high, with a slightly rounding summit, and continues of nearly the same height for a mile or two northward, where it changes to a broad sand beach with low country near, but high hills in the back ground. The face of the land about here begins to change from its uniform want of trees to hills partially covered. It has been frequently held out as a warning not to mistake Bodega Head for Punta de los Reyes, but there exists no reasonable ground for raising a question on this subject, although navigators, who have lost or jeopardized vessels, offer as an excuse the great similarity of the coast and headlands to those near the Golden Gate. We have never been able to detect it. The highest part of the head is about 265 feet above the ocean. From an examination of this section we believe that it is the continuation of the Tomales ridge.

The geographical position of the Coast Survey station on the head is:

	° ′ ″
Latitude	38 18 20.0 north.
Longitude	123 02 47.2 west.
	h. m. s.
Or, in time	8 12 11.1.

This station is one mile from the southern extremity of the point.

The magnetic variation observed near the mouth of the Estero Americano, in July, 1860, was 16° 19′.1 east. The present yearly increase is 1′.

The Russians called this head Cape Romanzoff.

BODEGA BAY.

From Tomales Point to Bodega Head the course is NW. ¾ W., and the distance 4¾ miles. The average width of the bay to the eastward of the above line is 1⅜ mile, with the shore running nearly a parallel course. It is bordered by numerous rocks, is abrupt, and reaches a height of 594 feet less than a mile inland. The anchorage lies between the head and the mouth of the Estero Americano, (called Avatcha by the Russians,) which lies E. 16° N., 2½ miles from the head. One mile west of the estero a low, narrow sand spit 1½ mile long, and covered with bushes, stretches towards the head, within one hundred yards of it, where a passage exists for the waters of the extensive lagoon north of the sand spit, having small and intricate channels, but almost destitute of water at low tides. The *anchorage* is half a mile outside of this passage, and about N. ⅓ E. of the rocky islet, in five or six fathoms, hard bottom of coarse sand and small patches of clay. It is protected by the head and the low rocky islet and reef, about three-quarters of a mile off the southeast face, from the full force of the northwest swell, which generally rolls in disagreeably in the open part of the bay if the weather is heavy. The reef is densely covered with kelp, and the breakers usually indicate its position. Between the islet and the head there is a narrow 4½-fathom passage opening directly upon the anchorage. In coming from the northwest in summer this channel is available; but in beating out it is too contracted to be safe. During the winter season it is necessary to anchor well out, to be ready to slip and run, as the sea-room is very contracted and the swell heavy. Some vessels have ridden out heavy southeasters, but several have been lost. In beating out, the only danger is the reef off the head.

On account of the general depression of the coast hills behind Bodega bay, to about 500 or 600 feet elevation, and the valley in which the Estero Americano lies being perpendicular to the coast line, the summer winds draw in towards the Petaluma valley with great force. The trunks of the oak trees rise straight for about 10 feet, then bend almost at right angles, without a branch for 10 or 15 feet, and terminate in a clump of branches all dragged out by the force of the wind. Fogs are found drawing in sooner and more frequently than upon any other part of the coast.

The country in the vicinity of the bay is very productive, both in the valleys and upon the hills. The produce is placed in lighters at the "port" or embarcadero, about one mile within the lagoon, and carried by the current to the anchorage.

A fine tract of agricultural country stretches behind the coast hills, extending from Russian River valley to Petaluma creek, by which channel the produce of this region finds its way to San Francisco.

The secondary astronomical station of the Coast Survey was upon the western end of the sand spit; its geographical position is:

Latitude	38° 18′ 20″.6 north.
Longitude	123 02 17.4 west.
	h. m. s.
Or, in time	8 12 09.2.

Tides.—The corrected establishment, or mean interval between the time of the moon's transit and the time of high water, is XI*h.* XVII*m.*, and the difference between the greatest and least intervals is 1*h.* 54*m.* The mean rise and fall of tides is 3.6 feet; of spring tides, 4.7 feet; and of neap tides, 2.7 feet. The mean duration of the flood is 6*h.* 19*m.*, and of the ebb 5*h.* 59*m.*

To find the times of high and low waters, first compute them for San Francisco, and from the numbers thus obtained subtract 49 minutes for Bodega bay.

Bodega bay was discovered by Heceta and Bodega in 1775, and placed in latitude 38° 18′ north. It was partially examined by Mr. Puget, under Vancouver's direction, in 1792.

In 1812, by permission of the Spanish governor of California, it was occupied by the Russian American Company, who afterwards refused to give it up, and retained possession until 1841. They erected two large wooden houses under the bluff, at the entrance to the lagoon; but these buildings were in ruins at the time of our visit in 1853. A recent Russian work (1848) says: "The bay of Bodega (Tuliatœlivo) was fully described in 1819, by Captain Hagemeister. It is similar to the port of Trinidad, in being convenient only during the summer, when the northwest winds blow along the coast; at any other season it is dangerous. Both its indentations within the NW. and SE. headlands are shallow and contracted, and therefore it is necessary to anchor in the open roadstead."

In 1839, under Belcher's orders, Kellett commenced the survey of Bodega, in the schooner Starling, and was soon after joined by the Sulphur.

The line of equal magnetic variation of 16° east crosses the coast line of Bodega bay in latitude 38° 15′, and in latitude 38° 06′ crosses the 124th degree of longitude. This is for January, 1859. The line moves southward about a mile and a half annually.

Fort Ross.—The rocky, contracted, and unsafe anchorage off this place is NW. ¾ N. from Los Reyes, distance 32 miles, and 15 miles from Bodega Head. The large white buildings of the Russians on the rising ground, and about 100 feet above the sea, are the only marks for making it, and the shore is so steep and guarded by rocks and reefs as to render approach dangerous.

No trade is now carried on here.

The approximate geograpical position is:

Latitude	38° 30′ north.
Longitude	122 13 west.

On some charts it is erroneously placed in Bodega bay, with a large river running from the northward into the bay. Belcher states it to be 30 miles north of Bodega.

The shore between Bodega Head and Fort Ross curves slightly to the eastward of the line joining the two places. Sand dunes commence 1½ mile from the southern point of the head, and extend 2½ miles to the mouth of a small stream called Salmon creek; these dunes are bordered by a broad sand beach. Nine and a half miles from the head the *Slavianska* of the Russians empties into the sea, breaking through the coast hills that here reach an elevation of 2,200 feet. During the summer months a dry bar forms completely across the mouth of the river, so that the travel along the coast passes over it. It requires heavy rains to break through it, and forms again after a few weeks of dry weather. During the summer the bed is dry above Healdsburg, 30 miles from the mouth, and can be forded in several places in that distance. Before breaking through the coast hills it comes from the northward through a broad, fertile valley. The arroyos and streams opening into the Russian river near the coast are filled with a very dense growth of heavy redwood; and in 1860 a tram road was being graded along the coast to the lagoon inside of Bodega Head to carry the lumber from the mill on the river.

From Ross mountain, 2,198 feet in height, we have frequently watched the discolored water of the river working along close inshore to the northward, and never to the south. The fishermen experience the same eddy current.

This stream is usually known as "Russian river." De Mofras calls it the San Sebastian.

Northward of this river again commence the high coast hills, covered with timber, which gradually approaches the coast, and reaches it about half way to Fort Ross. The Russian vessels used this as a distinctive mark for making that anchorage. Where the timber commences to skirt the coast a bold spur of the mountains comes directly upon the sea. At Fort Ross there is a small extent of open, cultivated ground, moderately low, but backed by the high wooded country. The coast and coast hills to the northward are mostly covered with dense forests of immense redwood, pine, and a thick undergrowth. At one of the Coast Survey mountain stations over 40 trees were cut down that measured from 5½ feet in diameter (spruce) to 8½ feet (redwood).

Two miles above Fort Ross is a small contracted anchorage, called Timber cove, where a great deal of lumber is sawed, and carried by coasters to San Francisco.

Eight miles above Ross is another contracted anchorage, under Salt Point, where coasters load lumber.

From Fort Ross to Punta de Arena the coast is almost straight, running NW. by W. ¼ W. for 37 miles. It is compact and abrupt the whole distance, covered with trees to the water's edge, and backed by an unbroken ridge of hills about 2,000 feet high, and wooded to their summits.

Haven's anchorage.—About 24 miles northwestward along the coast from Fort Ross is a contracted anchorage under high precipitous rocky islets, with a short stretch of beach on the main, affording a boat landing. There is a protection, when anchored close in, against heavy northwest weather; but it would be very difficult to recognize the locality unless the position of a vessel approaching it were accurately determined.

On the top of the bluff, at the north side of a small gulley, a secondary astronomical station of the Coast Survey was established in 1853. Its geographical position is:

Latitude	° ′ ″ 38 47 58.0 north.
Longitude	123 34 00.8 west.
Or, in time	*h. m. s.* 8 14 16.0.

Northward of this anchorage high bold rocks line the coast for four or five miles. They are generally known as "Fishing Rocks."

A few miles south of this anchorage is the mouth of the Walalla river, open in the rainy season, but having a dry bar in summer. It rises south of Fort Ross, behind the first range of coast hills. One of the Coast Survey stations on the north side of the river, and three or four miles from the coast, has an elevation of 2,192 feet, and this may be taken as the general height of this coast range.

POINT ARENA.

This is the first prominent headland north of Los Reyes, from which it bears NW. ¼ W., distant 67 miles. Approached either from the northward or southward it presents a long level plateau, stretching out about two miles west of the highlands, and terminating in a perpendicular bluff that averages about 200 feet in height, except the extreme northwest part, which is comparatively low, partially covered with sand, and destitute of trees for some distance inland. When seen from the southward, with the sun shining upon the face of the bluff, it shows remarkably white for the length of two miles. In fact no point upon the coast presents such a bright appearance, or such uniform vertical bluffs, composed of hard rocks, twisted and distorted into many plications. Bold water is found close off the point, outside the kelp, which, stretching strongly to the southward, shows the set and comparative strength of the current. In October, 1857, we judged it to be running at the rate of not less than two miles an hour. In July, 1853, the computed distances between the astronomical stations, compared with the indications of Massey's patent log, showed a current of from one to two miles, running along the coast to the southward.

About two miles southward of the point a small contracted valley opens upon the shore, and off it is an anchorage for small vessels, moderately well protected from the northwest swell, but open to the southwest. Several schooners have gone ashore here. A large bed of kelp lies off the anchorage.

About a mile and a half N. by W. from the point are several rocks showing just above water, and upon which the least swell breaks. These were noticed by Vancouver in October, 1793. When one mile broad off Arena a high, sharp pinnacle rock shows well out from the shore on the horizon to the southward, with some rocky islets inside, and breakers well out beyond the pinnacle rock, yet northward of it; but their distances from shore are probably not so much as a mile.

The approximate geographical position of Punta de Arena is:

Latitude	38° 57′ north.
Longitude	123 45 west.

A recommendation has been made for a *light-house* upon this point, because it is much needed by the mail and coasting steamers and sailing vessels.

The appearance of this and other parts of the coast induced Sir Francis Drake to call the land New Albion, whilst the same appearance and sandy line to the northward of it doubtless led the Spaniards to designate it La Punta de Arena. It suggests an inquiry concerning the numerous Cape Blancos that are found in their voyages and maps.

A view of Punta de Arena is given on the Coast Survey sheet of 1853.

Ten miles above Point Arena is a small stream called the Nevarro, upon which is a lumber mill. Articles floating from this river are found on the coast to the northward of it.

Albion river.—From Point Arena the first point to the northwestward is 24 miles distant, and bearing NW. by N. ⅜ N. After passing Arena the coast trends to the eastward of north, and for six miles presents a low shore-line with sand beach, changing suddenly to a straight, high bluff shore with a few trees, and backed within half a mile by hills of 2,000 feet, covered to their summits with wood. Sixteen and a half miles from Arena is the mouth of the Albion river, a very small stream, with the barest apology for a harbor at its mouth. A saw-mill upon this stream induces coasters to obtain freights here, but a great many of those trading have been lost. In 1853 the Coast Surveying steamer Active passed in, but broke her anchor on the rocky bottom.

Mendocino bay.—Twenty and a half miles from Arena, and four above Albion river, is a contracted indentation called Mendocino bay, available for a few vessels in summer, but dangerous in winter. The northern and southern points are about three-quarters of a mile apart, and the eastern shore retreats nearly half a mile. At the southern head are several small rocks, and one large islet surrounded by rocks, off which are heavy breakers. Midway between the heads is a small reef upon which the sea breaks heavily, with very little swell. Deep water is found close around this reef. Off the northern head is very bold water close to it. Into the northeast part of the bay enters the river *Noyon*, or Rio Grande, between two and three hundred yards wide, with a good channel on the southern side, a broad sand flat on the northern, and a bar at the mouth with but a few feet of water, and upon which it always breaks. The eastern shore is bold and rocky. In the southeastern part is a sand beach, with a reef extending from its centre.

The bay forms so slight an indentation in the coast-line that it is difficult to find without acquaintance with its minutest peculiarities, as there are no prominent marks by which to determine it. The north head is a table bluff about 60 feet high, and destitute of trees to the northward and some distance inshore. The south bluff is likewise destitute of trees, but more irregular in outline than the other. Vessels bound for it in summer work a little to windward; then run boldly in towards the north point, upon which the houses become recognized, keep as close as possible along the shore, gradually decreasing the distance to 100 yards just off the south end of the point in 6 fathoms, run on about 150 yards past the point, head up handsomely, and anchor in 5 or 6 fathoms hard bottom. It is a bad berth in summer, and in winter a vessel must anchor far enough out to be able to slip her cable and go to sea upon the first appearance of a southeaster. Several vessels have been driven ashore here.

An extensive saw-mill is located on the north side of the river, some distance up; formerly (1853) it was on the north head, and a stationary engine was placed near the mouth of the river to draw loaded cars up the inclined plane, whence they were drawn to the mill. The lumber was slid down chutes into large scows, and carried to the anchorage.

The place is now sometimes called Meiggsville; formerly it was Mendocino City.

The secondary astronomical station of the Coast Survey is on the north head, and its geographical position—

	° ′ ″
Latitude	39 18 06.1 north.
Longitude	123 47 25.6 west.
	h. m. s.
Or, in time	8 15 09.7.

The computed magnetic variation, 16° 35′ E., July, 1857; increasing about 1′ yearly.

A view of the vicinity of Mendocino bay is given in the Coast Survey reconnaissance sheet of 1853.

From the point just north of Mendocino bay, (the first one made from Arena,) the shore runs nearly straight for 28 miles N. by W. ½ W., being low and bounded by rocks for 12 miles, when the back hills reach the water and present an almost vertical front 2,000 feet in height.

From the deepest part of the bight the general trend of the coast to Cape Mendocino is NW. ¾ W., and distance 45 miles, and for the whole of this distance it is particularly bold and forbidding, the range of hills running parallel to the shore and rising directly from it. It has been found impossible to travel along this stretch of seaboard; and the trail turns well into the interior valleys.

For January, 1859, the line of equal magnetic variation of 17° east crosses the coast-line in latitude 39° 58′, and in latitude 39° 48′ crosses the 125° of longitude. This line moves southward about a mile and a half annually.

SHELTER COVE.

From the compact shore above described a plateau, destitute of wood, and being from 60 to 300 feet in height, makes square out just above latitude 40° N. for a distance of half a mile, affording an anchorage from northwest winds, and may, perhaps, be regarded as a harbor of refuge for small coasters which have experienced heavy weather off Cape Mendocino, and are short of wood and water, both of which may be obtained here from one or two gulches opening upon the sea.

From Point Arena it bears NW. by N. ⅓ N., distant 65 miles. The whole sea-face of the bluff is bounded by thousands of rocks above and below water, and vessels coming from the north for shelter must give it a wide berth, rounding it within one-third of a mile, and anchoring in 5 fathoms, hard bottom, about one-third of a mile from shore. In this position fresh water comes down a ravine bearing about north, and an Indian village existed in 1853 at the bottom of the wooded ravine, a little further to the eastward. There is always a swell here, and boat landing may not be very easy.

The secondary astronomical station of the Coast Survey was on the southeast part of the bluff, about 60 feet above the sea. Its geographical position is:

	° ′ ″
Latitude	40 01 13.7 north.
Longitude	124 03 02.9 west.
	h. m. s.
Or, in time	8 16 12.2.

The computed magnetic variation, 17° 02′ east, in July, 1857; increasing about 1′ yearly.

Upon old Spanish charts a point in this vicinity is designated Point Delgado, doubtless referring to it.

La Perouse, 1787, calls it Punta del Gada.

A hydrographic sketch of Shelter cove accompanied the Coast Survey Report for 1854.

PUNTA GORDA

Is 17 miles NW. by W. ½ W. from Shelter cove, and, as its name implies, is a large, bold, rounding point. Half a mile off it lies a large rocky islet, with rocks close inshore, north of the point. From Punta de Arena it bears NW. ¾ N., distant 81 miles, and the line passing tangent to Punta Gorda runs one mile outside of Cape Mendocino.

La Perouse calls Cape Fortunas Punta Gorda.

CAPE MENDOCINO

Is 93 miles NW. ¾ N. from Punta de Arena. Here the range of coast hills from the southward appears to meet a range coming from the eastward, forming a mountainous headland of about 3,000 feet high, which is the western limit of the northwest trend of this section of the coast.

The approximate geographical position of the cape is:

Latitude	° ′ 40 25 north.
Longitude	124 22 west.

A *primary sea-coast* light is especially needed at this cape, because it is the point where the coast takes its great change of direction from northwest to nearly north.

About three miles broad off the cape lies a reef, just under water, known as *Blunt's rocks*, or reef, upon which the sea generally breaks. This reef was noticed by Vancouver as being about one league off shore.—(Vol. 1, page 198.) Half way between it and the cape, and a little to the southward, is a sunken rock which has been discovered within the last two or three years, but not yet accurately located. It is called *Fauntleroy's rock*. Steamers have passed dangerously near it, and in 1857 it was distinctly seen almost under the wheel of the steamship Commodore. Vessels can, perhaps, pass over it in smooth weather, but with a heavy sea the water must break.

Such was our description of this rock in 1858.

In January, 1860, the steamship Northerner struck upon it. The weather was slightly hazy; long, large ground-swell from the northwest, no wind, and low tide. She was bound up the coast, and going over 10 knots per hour. As her bow sunk in the trough of the sea a very slight jar was felt forward, exciting no alarm among the uninitiated. The pumps were immediately sounded, and the ship found to be making water very fast. She headed for Humboldt, but was beached north of Cape Fortunas, and went to pieces in a heavy southwest blow that sprang up.

To the southward, and immediately off the pitch of the cape, lie numerous rocks and rocky islets, the latter being large and high, with a peculiar pyramidal or sugar-loaf appearance. None of them seem to be more than half a mile from the shore, which is almost perpendicular and destitute of a beach.

The face of the cape is very steep, rocky, and worn. Above this the general appearance is rolling, and the surface covered with timber. The pyramidal islets off it are very readily distinguished in approaching from the north or south.

A view of the cape is given on the Coast Survey reconnaissance sheet of 1853.

From Cape Mendocino the following are the bearings and distances to headlands to the northward:

Trinidad Head, north, 39 miles.

Redding's rock, N. ¾ W., 56 miles.

Crescent City light-house, N. by W., 79½ miles.

Cape Orford, or Blanco, N. by W. ⅞ W., 145 miles.

The extent of shore-line from Point Boneta to Cape Mendocino is about 224 miles.

It is generally stated that Juan Rodriguez Cabrillo named this cape in honor of Don Antonio de Mendoza, the viceroy of Mexico; but the highest latitude he reached was Punta de los Reyes, to which he in reality applied that name. It is quite probable that under the lee of the rocks off this cape Ferrelo, the pilot and successor of Cabrillo, anchored on the last of February, 1543, and named it Cabo de Fortunas, (Cape of Perils,) although he places his position in latitude 43°. The next day he may have been off Trinidad Head experiencing heavy northerly weather, and his observations might have placed him in latitude 44°, but with his vessels, adverse currents, and a dead beat to windward, he could not have made a degree of latitude in a day. Here he turned back, passed the Golden Gate on March 3, and reached the island of Santa Cruz on the 5th. It is utterly impossible that with his small crazy vessels he could make 800 miles (the distance from latitude 44° to Santa Cruz) in four days.

Seven miles south of Mendocino a small stream called the Mattole empties. Upon the sides of the hills in lower Mattole, and not above a mile from the Pacific, coal oil springs were discovered in 1861. Along the course of this stream are numerous bottom lands under cultivation.

CAPE FORTUNAS, OR FALSE MENDOCINO

Lies northward of Cape Mendocino, distant five or six miles, and is another bold spur of mountainous headland, similar and almost as high as that cape. Between the two the shore recedes slightly, is depressed, and forms a beach receiving a small stream called Bear or McDonald's creek, coming down through a narrow valley or gulch. Off this cape lie several rocky islets presenting the same peculiarities as those off Mendocino. There is no beach at the base of the almost perpendicular sea face.

The vicinity of these headlands certainly deserves a detailed hydrographic and topographical survey. It is reported that the soundings have been obtained well to the westward of the cape; should such prove correct, the fact will be of importance to vessels, especially steamers, bound north or south, when near the coast and enveloped in fog, as it would enable them to judge of their position and change their course.

After passing it the shore changes to a straight, low, sandy beach, with valleys running some distance inland.

We have ventured to call this headland Cape Fortunas, to avoid the repetition of Mendocino, and to commemorate Ferrelo's discoveries.

La Perouse calls this cape Punta Gorda. He reports seeing a large volcano, in latitude 40° 48′, burning very brightly. By reference to this chart it would appear to have been near this locality and close to the shore. It was, doubtless, the burning of wood upon the summit or face of the mountains; possibly on the high peak 10 miles inland, and now called Mount Pierce.

Eel river is a small stream with a bar at its mouth, and distant 14 miles from Cape Mendocino. It is very contracted and crooked, receiving the waters of a great many sloughs near its mouth, and draining a most fertile valley, which is rapidly filling up with settlers.

An extensive business in salmon fisheries is carried on near the mouth.

The first vessel that entered it was a schooner, in the spring of 1850, when searching for Humboldt bay. She thumped over the bar, which is said to have nine feet of water upon it at high tide. The Indian name for the river is Weé-ot. It rises by two heads in about latitude 39° 30′, about 30 miles from the coast, and runs nearly parallel with it. One head of a small branch called the South fork is only five miles from the coast, a short distance south of Shelter cove.

HUMBOLDT BAY.

The entrance to this bay lies 21 miles from Sugar Loaf islet, off Cape Mendocino; and the bar, N. by E., 22½ miles from Blunt's rocks. The bar is 1¼ mile from the entrance between the sand points, or two miles from the southwest and highest point of Red Bluff, which is the second bluff above Eel river. Like all the bar rivers on this coast, it undergoes irregular changes, depending much upon the prevalence, direction, and strength of the wind. Early in 1851 it bore NW., distant two miles from Red Bluff, and about half a mile from the beach of the north spit. Three and a half fathoms were found upon it, with a width of 250 yards between the three-fathom curves, retaining nearly the same width, and running on a southeast course towards the bluff, but approaching closer to the north than to the south spit. When between the two, the depth of water was increased to 11 fathoms, suddenly shoaling to four fathoms inside. Vessels kept the north spit within 150 to 250 yards on the port hand for two or three miles after entering. In the fall of 1852 the bar was reported to have moved to the northward about its entire width, and the ranges for going in, as laid down by the survey of the previous year, were entirely useless. In the winter of 1853–4 the bar changed much, and often suddenly. In the spring of 1854 it was more than its previous width to the southward of its position in 1851, and the depth of water had decreased, until in June of that year, when we crossed, it was over half a mile in extent, with only 16 feet of water at high tide. A bare spot then showed at the lowest tides, W.NW. of the end of the south spit. We saw in that year a strange brig thump over the north sands, while on the course prescribed by the sailing directions of 1851. In 1857 less than 13 feet at high tide could be found upon it, and its extent was very much increased. Eventually a deep and narrow channel will be cut through. About 1852 a steam-tug was placed upon the bay, and has rendered the most efficient service in determining the changes of the bar. When vessels are seen approaching the bar a flag is hoisted on Red Bluff, and the tug goes out to take them in. If it is breaking so heavily on the bar that she cannot get through it, and it is yet practicable for the vessel to run in, she takes up a position and hoists her flag as a signal for the vessel to steer for her. She is invaluable in towing out the deeply laden lumber vessels, as the summer winds blow directly in the channel. In June, 1851, upon our first entering this bay, we found a brig, deeply laden with spars, waiting for an opportunity to get out. She had made several attempts to beat through the then narrow channel, but always failed, and had in this manner occupied 31 days. We have laid 14 days off the entrance, and passed in when the water was breaking on the bar. A preliminary chart of the entrance to Humboldt bay was issued from the Coast Survey Office in 1851. It was subsequently resurveyed, and the chart of 1858 shows that the bar was 1¾ mile from the highest part of Red Bluff, which bore E. by S. ½ S. It then had a depth of 3¾ fathoms, and a width of 600 yards between the three-fathom lines. North and south breakers marked as usual the boundaries of the channel, which ran straight and close to the south spit.

In April, 1859, we received the following information in regard to it, from one who was with us there in 1851 and 1854: "The bar is now a mile south of where it was in 1854, three-quarters of a mile north of where it was last winter, and has five fathoms upon it. All the north point of the entrance is washed away, including the small lagoon on the inner side."

The best advice we can offer in regard to entering the bay is to wait for the tug.

In 1861 the steamship Columbia was detained in the bay six days by unusually heavy weather; at the same time a lumber-laden barque was unable to cross the bar for 25 days. The first reported case of any vessel being struck by lightning on this coast happened at Humboldt, February 25, 1861.

From experiments made in 1854, we found the ebb current to run 3 miles per hour, with a maximum velocity between 4 and 5 miles.

HUMBOLDT BAY LIGHT-HOUSE.

This building is erected on the north spit, three-quarters of a mile north of the entrance, and about midway between the bay and sea shores. It consists of a keeper's dwelling, of one and a half story, with a tower rising 21 feet above the roof from the centre; both being plastered and whitewashed, and surmounted by an iron lantern painted red. The light is a *fixed white light* of the fourth order of the system of Fresnel, and illuminates the entire horizon. It is elevated 53 feet above high water spring tides, and should be seen in clear weather from a height of—

10 feet at a distance of 12 miles.

20 feet at a distance of 13½ miles.

30 feet at a distance of 14½ miles.

Its geographical position, as determined by the Coast Survey, is:

Latitude	40° 46′ 03″.6 north.
Longitude	124 12 21 west.
Or, in time	8h. 16m. 49s.4.

Magnetic variation, 17° 06′ east, in July, 1853, increasing about 1′ yearly.

The light, which is a secondary sea-coast, was first exhibited December 20, 1856, and shows from sunset to sunrise.

A light on Red Bluff, which is nearly 100 feet high, would always serve as a leading range, as the flag-staff and ensign placed there are now thus used by the pilots. It would be distinguishable readily at sea, when the present one might be obscured by the mist hanging over the surf on the beach. During the day the white buildings would be a capital mark against the green hills and trees in the background. This view, now and formerly expressed, has been repeatedly and earnestly urged upon our attention by many captains, merchants, and the pilots of Humboldt bay.

A view of Red Bluff and the back hills is given on the Coast Survey sheet of 1853.

Tides.—The corrected establishment, or mean interval between the time of the moon's transit and the time of high water, is XII*h.* 11*m.*, and the difference between the greatest and least intervals is 1*h.* 11*m.* The mean rise and fall of tides is 4.4 feet; of spring tides, 5.5 feet; and of neap tides, 3.5 feet. The mean duration of the flood is 6*h.* 19*m.*; and of the ebb, 6*h.* 00*m.*

The greatest observed difference between the two low waters of one day was 4.1 feet; and the greatest difference between the higher high and lower low waters of one day was 9.0 feet.

To find the times of high and low waters, first compute the times for Astoria, and from the numbers so obtained subtract 40 minutes for Humboldt bay.

The bay is situated immediately behind the low sand spits and dunes, and extends 9 miles north and 4 miles south of the entrance; being contracted to less than half a mile in width between the south spit and Red Bluff, it then expands to nearly three miles, and runs a mile and a half to the eastward of Table Bluff. The single channel running into this part of the bay divides into two crooked ones, which contain from one to three fathoms of water; all the rest shows a bare mud flat at low tides. Abreast of the entrance it is nearly a mile in width, with extensive sands bare at low tides, lying midway between the opposite shores, and running nearly parallel with them. To the northward its average width is half a mile for a distance of 3½ miles. It then expands into a large shallow sheet of water, having two or three crooked channels through it, but the greater part being bare at low tides, showing extensive mud flats, bordered by a grassy flat nearly a mile in width. In the channel way close to the north spit, not less than three fathoms may be carried, increasing for three miles to 6½ fathoms. One mile north of the entrance, and on the eastern side, enters a small stream called Elk river. Two miles north of the entrance, and on the east side, is situated the town of *Bucksport*, off which a depth of 3½ fathoms is found within 150 yards of the shore. Vessels are got alongside the saw-mill wharf here at high tide to load, at low tides they rest upon the muddy bottom. The military station of Fort Humboldt is on a reservation on the bluff about 100 feet high, and immediately behind the town. On the same side, and 4 miles north of the entrance, is the town of *Eureka*, off which is a portion of the channel, having nearly 3 fathoms in it, but no channel reaching it having more than 1½ fathom. The town was laid out before this latter fact was discovered. Vessels lie at the wharves, resting on the mud at low tide. Abreast of Eureka lie several low marshy islands cut up by sloughs and ponds. The largest, called Indian island, is about a mile long (NE.) by half a mile in width. It is marked by two hillocks, surmounted by clumps of trees, near which were (1854) several wretched Indian huts. The smaller islands lie between this and the eastern shore and parallel with it. *Arcata*, formerly Uniontown, is situated on the northeast shore of the bay, and can only be reached by boats at high tide. It is the starting point for the Trinity and Klamath mines. From it an extensive wharf stretches far out over the mud flat, which vessels can reach at high tides.

The southern spit from the entrance to Table Bluff does not average one-quarter of a mile in width; is formed of low sand dunes and grassy hillocks, and bordered on the bay side by marsh. At the southern extremity rises *Table Bluff*, which the name well describes, to a height of about 200 feet, its western point nearly reaching the sea beach, and forming a good landmark for making the bay. Five miles east of it the hills commence rising. Abreast of the north end of the south spit rises *Red Bluff*, presenting to the entrance a perpendicular face, composed of sand and gravel colored by the decomposition of iron ore near its surface, which is 96 feet above high water, and destitute of tree or brush. The bay front of the bluff is about one-third of a mile long, gradually declining to the low, flat land to the north, and also falling away to the south and east. On this bluff the pilots have a flag-staff to range with known points of trees beyond, by which they cross the bar and keep the run of its changes. At the base of the highest part of this bluff we discovered, in 1854, a tooth and part of the tusk of the *elephas primigenius*. The low land on the eastern shore above Red Bluff averages half a mile in width, and runs as far as Eureka, gradually changing to marsh, and bounded by plateaus and hills covered with wood. The north spit averages half a mile in width, and its southern extremity is composed of sand dunes and grassy hillocks disposed in a marked manner parallel with the direction of the northwest winds. Two miles from the entrance trees cover the hillocks and run northward one mile, when a space of a mile occurs without them. After that they continue along the shore.

We have already mentioned the situations of three of the towns on Humboldt bay. *Humboldt*, the fourth town, is located on the south side of Red Bluff. It had eight or ten houses in 1854, and was going backward; in 1860 it had two houses. Bucksport has a goodly number of houses and one saw-mill, formed by hauling the steamer Commodore Preble on the beach, and using her engines for motive power. Eureka has eight saw-mills and a grist-mill, and presents a thriving appearance; one of the saw-mills is formed by the steamboat Santa Clara. Arcata has one saw-mill. In 1854 we obtained a statement of the commerce of the bay for a period of eleven months, ending May 31 of that year, from which it appeared that 143 vessels, ranging from 71 to 540 tons, with an aggregate of 22,060 tons, had brought to the bay 3,089 tons of merchandise, and 562 passengers, and taken away 18,932,000 feet of lumber. Since that time other mills have been added, with increased power, and at a low estimate we may safely say that all can turn out an average of 120,000 feet per day. Many of the vessels trading to this bay were ill adapted to contend against the summer winds. The average time of the above vessels from San Francisco was a trifle under 12 days. Some beat up in six days; others required over 20; all, however, are in very light ballast trim. With vessels adapted to the trade, the average time up should not exceed eight days, and the passage to leeward would average about four. The average tonnage had regularly increased, and there had been a decrease in the average length of the passage to the windward.

It has been erroneously asserted that this bay was discovered from sea in April, 1850, and by land in

1849; but the following account from a recent Russian work, (1848,) with an accompanying chart, settles that question:

"About 8½ miles from the port of Trinidad is situated the entrance to the Bay of Indians, called entrance of Rezanof. By the colonial documents of the Russian-American Company, it appears that it was discovered by citizens of the United States. In 1806 there was in it, (on an American vessel,) under command of Vintep, [Ven tep,] a beaver party of Aleutians, under the direction of Slabotchikoff, which was met by the Indians inimically. This bay is not fully described, but it is known that it is very large; somewhat resembles the bay of San Francisco, only the entrance to it for vessels of large class is not convenient, and with strong southwest winds it is even impossible with any vessel. The depth at the entrance is two sajhen, (14 feet,) and then it breaks on the bar."

The present name was given to the bay in 1850, by those rediscovering it from sea.

The Indian name of the bay is Qual-a-waloo.

Mad river is said to empty into the sea about a mile north of Humboldt bay. It averages about 100 yards in width, with a bar at its entrance that prevents egress; but the vast amount of timber in the valley must eventually find a passage through a canal to the northwest point of Humboldt bay. A deep slough from the latter is said to approach quite close to Mad river, thus favoring the execution of such a project.

This river is the Rio de los Tortolas of Heceta and Bodega, 1775.

TRINIDAD HEAD AND BAY.

Trinidad Head lies N. ½ W., 17½ miles from the bar of Humboldt bay, and north 39 miles from Cape Mendocino. The low sand beach off Humboldt continues past Mad river to within a couple of miles of Trinidad bay, when it changes to a bluff, guarded by innumerable rocks. For the entire distance of the low beach a depth of from 10 to 15 fathoms may be found one mile from the shore.

The bay or roadstead of Trinidad is very contracted; but having deep water, and all dangers visible, forms a moderately good summer anchorage. The "head," forming the western shore of the roadstead, and a prominent mark when seen from close in, is about 375 feet high, covered with a low, thick undergrowth of scrub bushes, has very steep sides, and eight fathoms close to its southern base. Off the western face, for nearly half a mile out, lie several high, rocky islets, with one one-half a mile south of it, but having nine fathoms close to it. From the south face eastward to the three-fathom curve the distance is one mile, and the depth of the bight to the northward of this line is about half a mile, with half a dozen rocks lying outside the three-fathom line, but well above water. In the northern part of the bay there is a sand beach extending about half a mile; thence eastward the shore is very rocky, the bluff being about 300 feet high, and covered with a heavy growth of timber. The town, formerly a place of some promise, fronts on the northwest part of the roadstead, and the boat landing is on the north side of a round knoll making out about 100 yards from the low neck running to the "head." A wharf is now built here, at which vessels lie to load lumber. A very considerable quantity of seaweed lies off the shore.

In working into the anchorage beat in boldly past the outermost rock until the rock just off the eastern side of the head is in range with the knoll (having a few trees upon it) between the town and the head, with the south face of the head bearing W. by N., and anchor in seven fathoms, hard bottom, within one-third of a mile of the rock and head, having the neck visible to the westward of the knoll, and a sugar-loaf rock beyond the neck showing over it. A swell will generally be found setting in. In winter it is a dangerous anchorage, and if a vessel is unluckily caught, her chances of riding out a southeaster are very few. Several Spanish vessels were wrecked here when it was visited by them, and a number of vessels have been lost within the last eight years. In February, 1851, the barque Arcadia was totally lost in a southeast gale, her ground tackle being insufficient to hold her.

A hydrographic sketch of the bay and view of Trinidad Head accompanied the Coast Survey Report for 1851. A view accompanies the reconnaissance sheet of 1853.

The secondary astronomical station of the Coast Survey was on the neck near the town. Its geographical position is:

Latitude	41° 03′ 20″.0 north.
Longitude	124 08 08 west.
	h. m. s.
Or, in time	8 16 32.5.

The town during the winter is nearly deserted, but a brisk trade is carried on in summer. The connexion with San Francisco by steamers is yet uncertain. The land in this vicinity is very rich, and well adapted to agriculture. The redwood trees grow around it, and attain an enormous size. The stump of one which we measured was about 20 feet in diameter, and a dozen trees standing in the vicinity averaged over 10 feet. One is affirmed to be standing on the bank of a small stream at the southeast part of the bay, that measures over 90 feet in circumference. The bark of these trees has a thickness of from eight to fourteen inches; they grow perfectly straight, retaining their thickness to a great height, begin to branch at 50 or 100 feet, and frequently attain 250 feet in height. The forests of this timber, when free from undergrowth, present an imposing sight.

"Port Trinidad" was discovered June 10, 1775, by Heceta and Bodega, and placed in latitude 41° 07′ N. Near it they place a stream which they call the Rio de los Tortolas, or Pigeon river; this is now called Mad river.

It was visited in May, 1793, by Vancouver, who says, (vol. II, page 245:) "In an excursion made by Mr. Menzies to the hill composing the projecting headland that forms the northwest side of the bay, he found, agreeably with Señor Maurelli's description, the [wooden] cross which the Spaniards had erected on their taking possession of the port; and though it was in a certain state of decay, it admitted of his copying the following inscription: '*Carolus III, Dei G. Hyspaniarum Rex.*'"

Vancouver placed it in latitude 41° 04′ N.—(Vol. I, page 200.)

In some American maps antecedent to the Coast Survey determinations on the Pacific the indentation of the coast between Mendocino and Trinidad was called "Bay of Trinidad."

The Indian name of the bay is Shó-ran.

The shore running NW. by N. from Trinidad Head for five miles is remarkably broken and rocky, which induced Vancouver to call its northern extremity *Rocky Point.* He placed it in 41° 08′. About one mile off it lie several rocks that are sometimes known as the "Turtles."

In January, 1603, Vizcaino's vessels separated during heavy weather, and the smaller sailed, under Antonio Flores, the pilot, to the northward in search of Vizcaino; and when in latitude 41°, with a gale from the SW., he ran before it until he found shelter behind a great rock, where he anchored.

From Rocky Point the shore takes a gentle sweep eastward, making its greatest indentation at the north end of the once famous *Gold Bluff,* in latitude 41° 27′ N., and longitude 124° 03′ W., and then trending westward to Cresent City. Gold Bluff has an extent of 10 miles, and is very bold and high.

Between Rocky Point and Gihon's Bluff, which is the first one to the northward, there is a stretch of low sand beach, immediately behind which is an extensive lagoon several miles in length, and from a quarter to one mile in width. It lies parallel with the beach, and at some seasons is not connected with the ocean, but at others an opening exists at the northern extremity.

The Indian name of this lagoon is Æ-shœ-shó-ran.

Redding's rock lies five miles broad off Gold Bluff, in latitude 41° 21′, and longitude 124° 10′. It is a single large rocky islet about 200 feet high, and reported to have deep water all around it, with no outlying dangers; but its vicinity has not been surveyed. Vancouver places it in latitude 41° 25′ on his chart, and four miles off shore; but in the narrative states the distance at half a league, and that it is half a mile in circuit. His track lies inside of it. We have been informed that a reef, commencing at the shore two miles above the rock, stretches out towards it. The rock received its present name in 1849 or 1850.

KLAMATH RIVER.

The mouth of this river is in latitude 41° 33′ N., longitude 124° 05′ W. It is, perhaps, 200 yards wide, having a long sand spit on the south side running northwest, and parallel to the high hills that form the north shore. South of the entrance for a mile and a half are outlying rocks, and at the north side of the entrance lie several others. It is reported to have 2½ fathoms upon the bar. Upon passing it in 1853, within less than a mile, the sea was breaking across it, and no appearance of a safe channel was presented. Small schooners enter it; but we have been assured that the mouth was completely closed in the winters of 1851 and 1860, and that the bar changes with every change of heavy weather.

McArthur reported in 1850: "The river has 17 feet on the bar at mean low water. It is not difficult of entrance with a good breeze, but very difficult to get out of, the current running so strong that sailing vessels must come out *stern foremost to be steered.*" He did not, however, enter the river. In 1860 the tug from Humboldt bay endeavored to enter, but could not find sufficient water, although it was very smooth; when the swell came in on the second day, she had to throw her remaining freight overboard and put to sea.

Three or four miles northward of the Klamath is a small sharp indentation at the mouth of a gulch, off which lie one large and several small rocks; but from a distance of a mile and a half we were unable to determine whether any stream opened here. It has, however, received the name of False Klamath, because it has misled small coasters seeking for the Klamath, although there is no sand point on either side, as exists at the latter. The State map of California has a creek called Ahmen opening here. The coast continues bold for several miles, when the hills begin to recede and the shores present many pleasant slopes, unincumbered with forests and now under cultivation. The shore is low and regularly sweeps to the westward for a couple of miles, forming the roadstead, which will be next described.

CRESCENT CITY BAY.

This, the most dangerous of the roadsteads usually resorted to on the coast, has acquired much importance on account of the town (Crescent City) being the depot for the supplies of miners working the gold diggings on the Klamath, Trinity, and Salmon rivers. It is filled with sunken rocks and reefs, and has a goodly number showing above water. No vessel should think of gaining an anchorage here without a pilot, or perfect knowledge of the hidden dangers. No sunken rocks are now known to exist outside of the line of visible ones, except one awash, SW. ¾ W., and a little more than half a mile distant from the light-house. A depth of 10 fathoms exists all around it, and seven or eight fathoms outside of the visible rocks. The usual anchorage is on a line between the light-house and the north side of the large islet three-quarters of a mile east of it, in 3¼ fathoms, hard bottom. To reach this position run for the small, round rock bearing S. 55° E., seven-eighths of a mile from the light-house; pass it on the east side, giving it a berth of 100 yards; steer N. by W. ¼ W. for three-eighths of a mile, passing 100 yards on the east of Fauntleroy rock, which is covered at three-quarters flood. If this rock be covered, its position is generally marked by a breaker. It is necessary to keep it close aboard, because there is a sharp bayonet rock having only two feet of water upon it, and 200 yards to the eastward. Head up for the town and anchor in 3¼ fathoms. To enter or leave it at night, as is done by the mail and coasting steamers, requires a perfect local knowledge of the dangers and peculiarities of the landmarks. Coasting steamers, in fine wether, usually anchor close inshore to discharge freight, which is received in lighters.

A wharf has been built out from Battery Point, and landing is now easily effected in good weather. In southeasters the breakers wash over it.

This bay was first surveyed in 1853, and again in 1859, from which our directions are in part drawn up, but principally from our examination in 1857. The following report (1859) will show clearly the dangerous character of the roadstead, and the knowledge required to enter it: "During the progress of the resurvey of Crescent City harbor, we found several new, dangerous rocks; but as they are not in the channels followed by steamers, and do not interfere with the anchorage in use, it does not seem necessary to notice them further in advance of the publication of the chart, as every one trading here knows that vessels drawing over nine feet should be very cautious in venturing out of the beaten track. The rocks at that place are of a peculiar character, standing isolated like bayonets, with their points just below the surface, and ready to pierce any unlucky craft that may encounter them. After we finished the survey, and a fair way had been selected for a sailing line, we discovered a very sharp rock almost directly in the passage, with its point only three feet from the surface, and deep water all around it. This is mentioned to show that, although the greatest care was taken in the survey, the character of the points of rocks is such that it cannot be surprising if new ones be found for several seasons to come."

In summer there is always some swell here, but in winter it rolls in fearfully, and vessels must choose a position to be ready to run to sea at the approach of a southeaster.

Communication is maintained with San Francisco and other ports by mail and coasting steamers, which generally carry as many passengers and as much freight for this place as they carry to the Columbia river.

The town lies NW. from the anchorage, immediately on the low shore; old drift-logs, in some instances, forming the foundation for wooden houses. In August, 1853, there were about 135 houses of all descriptions. In 1860 the population was 553, and the number of houses 176.

The lands adjacent are being cultivated; a grist-mill has been built which turns out 75 barrels of flour per day, and a good trail leads to the "diggings" on the Klamath and Illinois rivers.

The SW. point of the bay is elevated about 25 feet and continues so to the westward. The light-house is erected on the rocky islet about 300 yards from the point, and connected with it at low tides by a broken mass of rocks, over which a single foot-bridge is constructed.

Tides.—The (approximate) corrected establishment, or mean interval between the time of the moon's transit and high water, is XI*h.* XLIV*m.*, and the mean rise and fall of tides, 4.7 feet.

A hydrographic sketch of Crescent City harbor appeared in the Coast Survey Report for 1854, and a map of the harbor and adjacent coast in 1859. A view of Crescent City and its relation to Point St. George is given on the Coast Survey sheet of 1853.

CRESCENT CITY LIGHT-HOUSE.

The building consists of a keeper's dwelling of stone, the natural color (grey,) and one and a half stories high, with a low tower of brick, plastered and whitewashed, rising from the centre and surmounted by an iron lantern, painted red. It is situated at the southwest part of the roadstead on the seaward extremity of the island point, which is here about 45 feet above high water.

The light is a *fixed white light varied by flashes*, of the fourth order of Fresnel. The interval of flash is 1*m.* 30*s.* It illuminates 315° of the horizon, was first exhibited December 10, 1856, and shows from sunset to sunrise. It is 80 feet above high sea level, and should be seen in a favorable state of the atmosphere—

From a height of 10 feet at a distance of 14 miles.
20 feet at a distance of 15½ miles.
30 feet at a distance of 16½ miles.

The geographical position of the light, as determined by the Coast Survey, is:

Latitude	41° 44′ 34″.2 north.
Longitude	124 11 22 west.
Or, in time	8h. 16m. 45s.5

Magnetic variation, 17° 52′ east, July, 1851, with a yearly increase of 1′.

From Cape Mendocino it bears N. by W. 79½ miles.

The secondary astronomical station of the Coast Survey was on the point on the land side of the light-house, near a few Indian huts existing in 1853.

Its geographical position is:

Latitude	41° 44′ 44″.0 north.
Longitude	124 11 14 west.
Or, in time	8h. 16m. 44s.9.

POINT SAINT GEORGE.

This point lies two miles W. by N. from Crescent City light. It is from 50 to 100 feet high, with table-land some distance back. It is bounded by hundreds of rocks, some of which rise perpendicularly 200 feet from the water. Three or four of the largest present a remarkably white appearance, which serves to distinguish this point. The extensive reef in its vicinity may have led to confusion among the old discoverers, by their confounding it with Cape Orford.

The point may possibly be the Cape San Sebastian of Vizcaino, who, after the separation of his vessels, continued his explorations northward, and, on January 20, 1603, when in latitude 42° N., reached a high white bluff, which he named in honor of the saint of that day. On the day preceding, Antonio Flores, his pilot, in the smaller vessel, supposed himself in latitude 43° N., where the land formed a cape or point, which he called Cape Blanco, and from that point the land ran NW. Near the point he discovered a large and rapid river, which he endeavored to enter, but could not from the force of the current. We are inclined to believe that both names refer to the same cape.

Vizcaino, in January, 1603, gave the name Cabo Blanco de San Sebastian to a cape which he places near latitude 42°.

The present name was given to the cape by Vancouver in 1792. He placed it in latitude 41° 46½′ N.

DRAGON ROCKS.

This name is applied to the rocks and reef extending W.NW. from Point St. George for a distance of six miles. The locality has never been surveyed in detail, but a wide passage exists inside of the reef, and is invariably used by the mail and coasting steamers, when entering or leaving Crescent City bay. There are 10 or 12 outlying rocks, and many sunken ones, with the passage running between them and those close to shore. This passage is about a mile in width, has 10 fathoms in it, and the general course through is nearly NW. and SE., but not straight. Among the multitude of rocks on the land side of the passage are three very large and prominent ones about 200 feet high. It has been already stated that several of the largest rocky islets have a well-marked white appearance, occasioned in part by the deposits of sea birds.

This name was first given by Vancouver in 1792. The general name now used is Crescent City reef.

For January, 1859, *the line of equal magnetic variation* of 18° east crosses the coast line north of Point St. George, in 41° 50′, and in latitude 41° 40′ crosses the 125° of longitude. This line moves southward about a mile and a half annually.

PELICAN BAY.

From Point St. George the coast runs straight for 12 miles N. ½ W.; thence W.NW. for nine miles, forming a deep indentation, called by La Perouse, 1787, Pelican bay, and by Vancouver St. George's bay. On the Coast Survey reconnaissance of it in 1850 it is named Pelican bay. For eight miles from Point St. George the shore is low for some distance back, and fronted by a sand beach to the mouth of a small stream called *Smith's river*. The entrance to this river we looked for in vain from the deck of the steamer, although scarcely two miles off shore, but were able to form a good estimate as to where it should open by the peculiarities of the northern bank, which was a low perpendicular bluff.

Its approximate geographical position is:

Latitude	41° 54′ north.
Longitude	124 11 west.

The "Smith's river" of recent maps and descriptions is a myth. Half way between Crescent City and the mouth of Smith's river there is a small sheet of water called Lake Talawa. North of this small stream the coast acquires an elevation of about one or two hundred feet for a short distance inland, and is bounded by high mountains.

COAST OF OREGON.

The etymology of the name Oregon has not been satisfactorily explained. It is first mentioned by Jonathan Carver in the relation of his trading expedition to the head waters of the Mississippi, between June, 1766, and October, 1768. He did not penetrate beyond the 95° of west longitude, and mentions the name but three times, in the following manner: The "River Oregon, or the River of the West, that falls into the Pacific ocean at the Straits of Annian;" the "Oregon, or the River of the West." He states that Robert Whitworth, in 1774, designed to pursue the same route traversed by himself, "till, having discovered the source of the Oregon, or River of the West, on the other side of the summit of the lands that divide the waters which run into the Gulf of Mexico from those that fall into the Pacific ocean, he would have sailed down that river to the place where it is said to empty itself in the Straits of Annian." This is the extent of his information on the subject, and was derived from Indians and traders.

It will be remembered that Martin d'Aguilar reported to have found, in 1603, a large river emptying into the Pacific in latitude 43°, and which was called the "River of the West."

The theory that the Pen d'Oreilles tribe, inhabiting part of the region between the Columbia river and the Rocky mountains, was originally designated Orejon by the Spaniards, and hence gave the name to the river, is unsatisfactory.

About three miles by the shore to the northward from the deepest part of Pelican bay, the boundary line of California and Oregon, of 42° N. latitude, strikes the coast near a noticeable high pyramidal mound, rising abruptly from the plateau, which is destitute of timber.

CHET-KO RIVER.

Five miles from the deepest part of Pelican bay, and in latitude 42° 01′ N., longitude 124° 15′ W., (both approximate,) empties a stream which is from 50 to 60 yards wide at its mouth, with banks about 100 feet high, and bounded half a mile in shore by very high hills. It appears deep and sluggish, and in August, 1853, was completely closed at the mouth by a heavy gravel beach. The anchorage off it is open and exposed from west to south, with several reefs in and around it. No survey or reconnaissance has been made. We found Indian huts in great numbers upon both banks, but most of the Indians were engaged higher up the stream in taking salmon.

On the Coast Survey charts of 1853 this stream was marked Illinois river, that being the name applied to it by miners prospecting from Crescent City, whereas the Illinois is the south branch of the Rogue's river. Similar errors have frequently been made on the coast. Some give the Indian name of this stream Chit-ko.

From Point St. George to an arched rock about 40 feet high, in latitude 42° 11′, the course is NW. by N. 27 miles. The coast between the Chetko and the point within a mile of the arch is high, bold, compact, and bordered by vast numbers of rocks, with very deep water close in shore. From this the shore runs nearly NW. by N. ½ N. for 40 miles to Cape Orford, making a long gentle curve of four miles to the eastward, and being in general high, abrupt, and rocky.

A view of the arched rock is given on the Coast Survey sheet of 1853.

ROGUE'S RIVER.

Within the long stretch just referred to is found the entrance of Rogue's river, in latitude 42° 25′ N., and longitude 124° 22′ W., (both approximate,) having a long, low, sandy point on the south side, and a high, steep hill, with two large rocks off its base at the north side. It comes from the interior between high mountains, and it is next to impossible to travel along its course. Just within the entrance and on the north side were large Indian villages in 1853. When passing it in moderate northwest weather the sea was breaking heavily across the bar, and this is reported to be generally the case. It has not been examined or surveyed, and the depth of water on the bar is variously reported from 10 to 18 feet; the former, doubtless, nearer the truth. McArthur reports ten feet on the bar, but that the channel is too narrow for sailing vessels to turn in. In the spring of 1850 the New York pilot-boat W. G. Hagstaff entered the river, and we believe was attacked by the Indians, deserted, plundered, and burnt. The next vessel that entered was the schooner Sam Roberts, in July of the same year, which got out safely. We know of no other vessels ever having made the attempt.

Near the entrance commences the detached deposits of auriferous sand and gravel, which are found northward along the coast to the Coquille river.

The name of the river was suggested by the dishonest propensities of the natives in its vicinity. On the maps it is called Toutounis, and the Too-too-tut-na or Klamet. These names, we judge, have arisen from misapprehension, because the Indians hereabouts, when asked a question which they do not understand, answered toó-ta, toó-ta; toó-ta signifying negation, and rendered more emphatic by repetition. Or the name may be derived from what is called the Too-too-tan village, some distance up the river. That existing (1853) on the north head of the mouth of the river is Tar-shoots. Several campaigns have been made against the Rogue river Indians, and they have been found a warlike and troublesome race; but the manner in which they were treated by some of the early settlers was well calculated to rouse them to a war of retaliation.

ROGUE'S RIVER REEF.

The rocky islets composing this reef are not so large as the Dragon rocks, and run more nearly parallel with the coast line. The southern group of rocks lies W. ½ N., about four miles from the north head of the entrance to Rogue's river, and stretches northward three miles, where a gap occurs between them, and another cluster lying a mile and a half off shore. Off this inner group lie several dangerous sunken rocks, which must be sharply watched from aloft when the sea is not heavy enough to break upon them. As seen from the southward, the inside rock of the outer group shows a perpendicular face eastward, and sloping back to the west. The channel through this reef is perhaps a mile wide, but more dangerous than any other on the coast. No hydrographic survey has been made of it, and it is never used by the coasting steamers. In 1853 the Coast Surveying steamer passed through it. A view of the reef is given on the Coast Survey sheet of 1853.

Abreast of the northern part of this reef is a five-mile stretch of low sand beach, backed by high, rugged, wooded hills, when the shore changes to an abrupt and precipitous face to Port Orford. Many rocks closely border the shore, and five miles south of Port Orford a high rocky islet lies nearly a mile off the base of the hill, about 1,000 feet high.

PORT ORFORD.

This is by far the best summer roadstead on the coast between Los Reyes and the Strait of Juan de Fuca. From the extremity of the SW. point eastward to the main shore the distance is two miles, and from this line the greatest bend of the shore northward the distance is one mile. The soundings within this space range from 16 fathoms close to Tichenor's rock, forming the SW. point of the bay, to three fathoms within one-quarter of a mile of the beach on the northeast side; with five fathoms at the base of the rocky points on the northwest side towards Tichenor's rock. One mile off the shores of the bay the average depth is about 14 fathoms, regularly decreasing inshore.

The point forming the western part of the bay presents a very rugged, precipitous outline, and attains an elevation of 350 feet. Its surface is covered with excellent soil and with a sparse growth of fir. From this point the shore becomes depressed to about 60 feet at the northern or middle part of the shore of the bay, where the town is located. The hills behind are covered with a thick growth of fir and cedar.

The anchorage is usually made with the eastern end of the town bearing north, being just open to the east of a high rock on the beach, in six fathoms water, hard bottom, having a sharp, high point bearing NW. by W. one-quarter of a mile distant, the beach in front of the town distant a quarter of a mile, and three rocks just in the three-fathom line E. by N., distant half a mile. Steamers anchor a little to the eastward of this position, and closer to the town, in four fathoms. Coasters from the south in summer beat up close inshore, stretching inside of the outlying islets to avoid the heavy swell outside. Coming from the northward they keep just outside of a high rock one-third of a mile off the western head, and round Tichenor's rock within half a mile. In winter, anchor far enough out to be ready to put to sea when a southeaster comes up. During a protracted gale in December, 1851, a terrible sea rolled in, that no vessel could have ridden out The old steamer Sea Gull was driven northward, and lost two weeks in regaining her position, and the mail steamer Columbia hardly held her own for many hours off the Orford reef.

The usual landing is between the rock called Battle rock, north of the anchorage, and the point of rock close on its west side. A road is cut from here up to the town, which consists of but a few houses. Sometimes a landing is made on the rocky beach a quarter of a mile westward of Battle rock, in the bight, where a sloping grassy bluff comes to the water; but this landing is over a rocky bottom. A road is cut up the slope to the site of the military post of Port Orford, which is now abandoned.

From "Battle rock" the shore eastward is skirted by sand beach for $1\frac{3}{4}$ mile to a rough, rocky point called Coal Point. About midway in this distance empties a small creek, whose banks are composed of a deposit of auriferous sand and gravel, the same as found in front of the town abreast of Battle rock, and which has yielded as high as $30 to $40 per diem to each miner. Battle rock was so named, because the first adventurers made a stand against the Indians upon this rock in June, 1851. Coal Point was so named from the reported existence of coal in this vicinity.

Several attempts have been made to open a road from this place to the mines, about 60 or 70 miles eastward, but thus far without success. Several parties have gone through, but could find no direct available route for pack-animals. Upon the opening of such a road it would become a large depot of supply for the interior. In the neighborhood of Port Orford are found immense quantities of the largest and finest white cedar on the coast, and for some years a saw-mill has been in operation, affording a small supply for the San Francisco market of this lumber, unapproachable in quality by any on the Atlantic coast.

The high mountain about 12 miles east of Port Orford is called Pilot Knob.

The primary astronomical station of the Coast Survey, established here in 1851, is on the top of the ridge just west of the town, at a height of 262 feet above the sea, and within a few yards of the western edge of the bluff. Its geographical position is:

	°	′	″	
Latitude	42	44	21.7	north.
Longitude	124	28	47	west.
	h.	*m.*	*s.*	
Or, in time	8	17	55.2	

Magnetic variation, 18° 29′ east, in November, 1851, with a yearly increase of about 1′.

From this station Tichenor's rock bears S. by W., three-quarters of a mile distant.

The secondary astronomical station (1853) is in front of the town, north of the Battle rock, and within 50 yards of the edge of the bluff. Its geographical position is:

	° ′ ″
Latitude	42 44 28.2 north.
Longitude	124 28 13 west.
	h. m. s.
Or, in time	8 17 52.8.

Tides.—The corrected establishment, or mean interval between the time of the moon's transit and the time of high water, is XI*h.* XXVI*m.* The mean rise and fall of tides is 5.1 feet, of spring tides, 6.8 feet, and of neap tides, 3.7 feet. The mean duration of the flood is 6*h.* 19*m.*, of the ebb, 6*h.* 7*m.*, and of the stand, 0*h.* 39*m.* The average difference between the corrected establishment of the a. m. and p. m. tides of the same day is 1*h.* 22*m.* for high water, and 0*h.* 40*m.* for low water. The differences when the moon's declination is greatest are 2*h.* 12*m.*, and 1*h.* 28*m.*, respectively. The average differences in height of those two tides is 1.4 foot for the high waters, and 2.6 feet for the low waters. When the moon's declination is greatest those differences are 2.3 feet and 3.9 feet, respectively. The average difference of the higher high and lower low waters of the same day is 7.1 feet, and when the moon's declination is greatest, 8.2 feet. The higher high water in the twenty-four hours occurs about 10*h.* 45*m.* after the moon's upper transit, (southing,) when the moon's declination is north, and about 1*h.* 14*m.* before, when south. The lower of the low waters occurs about seven hours after the higher high water. The greatest observed difference between two low waters of one day was 5.5 feet; and the greatest difference between the higher high and lower low waters of one day was 11.0 feet.

To find the times of high and low waters, first compute the times for Astoria, and from the numbers thus obtained subtract 1*h.* 16*m.* for Port Orford.

This bay was called Ewing harbor in 1850 by McArthur, but is now known by no other name than Port Orford, from its proximity to Cape Orford. A sketch of it was published by the Coast Survey Office in 1854.

From the western extremity of Port Orford Cape Orford, or Blanco, bears N W. ½ N., distant 6 miles, the shore line between them curving eastward about a mile. Immediately north of Port Orford it is composed of a very broad loose sand beach, backed by a long uniform sand ridge of 100 feet height, covered with grass, fern, sallal bushes, and a few firs; while behind this the ground falls and forms lagoons and marshes. This ridge extends nearly to the mouth of a stream called *Elk river*, 3½ miles from Tichenor's rock. This narrow stream, fordable at its mouth at low tides, comes for miles through broad marshes covered with fir and white cedar, and an almost impenetrable undergrowth. The south side at the mouth is low, sandy, and flat; the north side, a slope rising from the marsh inshore and terminating on the beach in a perpendicular bluff, averaging 100 feet high, covered with timber to its very edge for a couple of miles, when the timber retreats some distance inland. The face of this bluff exhibits vast numbers of fossil shells in the sandstone. At its base a sand beach exists which may be travelled at low water.

At the mouth of Elk river, a bottle, nearly buried in the sand, was picked up on the 18th of May, 1860, with a memorandum, stating that it had been thrown from the steamship Brother Jonathan in latitude 42° 00′, longitude 124° 50′, on the 23d of March, 1860, the wind at the time strong from the south. It had travelled nearly north about 50 miles.

CAPE ORFORD, OR BLANCO.

In making this cape from the northward or southward it presents a great similarity to Point Concepcion, appearing first as an island, because the neck connecting it with the main is comparatively low, flat, and destitute of trees, with which the cape is heavily covered to the edge of the cliff. It is, perhaps, over 200 feet high, but the trees upon it make it appear at least 100 feet more. The sides are very steep, and worn away by the action of the sea, showing a dull whitish appearence usually, but bright when the sun is shining upon them. At the base are many black rocks and ledges stretching out to form the inner part of Orford reef. In the bend, southeast of the cape, rises a large, high, single rock, about 100 yards from the beach.

The approximate geographical position of the cape is:

	° ′
Latitude	42 50 north.
Longitude	124 30 west.

Being thus the most western part of the main land until we reach latitude 47° 50′.

From it Cape Mendocino bears S. by E. 7/8 E., distant 145 miles; Cape Disappointment light, at the north head of the entrance to the Columbia, N. by W. 1/3 W., distant 207 miles; and Tatoosh island light, off Cape Flattery, N. NW., 332 miles. From the line joining Blanco and Cape Disappointment the coast does not, in any place, leave it more than 12 miles.

A light of the first order is required upon this cape, or upon one of the rocky islets of the outlying reef.

Upon old Spanish maps a cape near this latitude has been called Blanco, from the assertion that Antonio Flores discovered and so named it in 1603. He says that from this cape the coast trends northwest, and near it he found a large river, which he tried to enter, but could not on account of the strong current running out.

At that time the magnetic declination must have been about zero, and perhaps several degrees west. Assuming it as zero, the coast thence northward for nearly 100 miles trended N. by E. 1/2 E.

The name Orford was given by Vancouver in 1792, and placed by him in latitude 42° 52′. On the western coast this name is now almost invariably used.

A view of Cape Orford is given on the Coast Survey sheet of 1853.

ORFORD REEF.

About 4 miles off the coast, between Port and Cape Orford, lies a group of rocky islets and sunken rocks. There are seven large high ones within an area of one square mile, with small ones that are just awash, and others upon which the sea only breaks in very heavy weather.

The southeastern rock is called the "Fin rock," and has a perpendicular face to the southwest, with a sloping surface to the northeast. Near it are several low black rocks. The Fin rock lies W. 3/4 N., distant 4 1/3 miles from the western point of Port Orford, and the general direction of the six others is N.NW. from Fin rock. West from Port Orford, and distant 4 1/2 miles, is a small black rock, and near it a smaller one, upon which the sea breaks only occasionally. W. by N. 1/2 N., distant 4 3/4 miles from Port Orford, lies the largest of the seven islets, rising up with high and nearly perpendicular sides. On the same course, and a mile and a quarter further out, is a small rock, and half way between them a rock awash. This is the northern limit of the group.

Stretching S.SW. for a mile and a third from Cape Orford are numerous rocky islets and sunken rocks, with large fields of kelp; but ceasing at that distance, a passage is left one and half mile wide between them and the northern islets of the other group. The course through the middle of the passage, clearing the rock called Klooqueh, off the western point of Port Orford, is NW. by W., with ten fathoms rocky bottom on the shoalest part of that line.

This passage is in constant use by mail and coasting steamers, but the hydrography of the reef has not yet been executed, and only a preliminary examination of the position of the outer rocks. Although the general trend of the southern group is N.NW., it is very probable that they are a continuation of the reef making out from the cape.

When coming down this coast, in 1787, La Perouse says his latitude at noon was 42° 58′ 56″, and that two hours afterwards he was abreast of nine small islands or rocks lying about a league off Cape Blanco, which bore NE. by E. He called them the Necker islands; evidently the group forming the Orford reef.

One mile north of Cape Orford empties a small stream having a great number of rocks off its mouth. In 1851 it was usually called Sikhs river, the Chinook "jargon" name for friend. On some maps we find a stream near this locality called Sequalchin river. The village upon the Sikhs is called Te-chéh-quut.

Ten miles north of Cape Orford La Perouse places a cape called Toledo, but no headland exists between Orford and the south head of the Coquille, although a small stream called Flora's creek empties upon the coast about half way between them.

From Point Boneta to Cape Orford the extent of shore-line is 388 miles, Boneta to Mendocino being 223 miles.

General features.—From Cape Mendocino the hills upon the seaboard range from 2,000 to 3,000 feet high, running parallel with the coast at a distance of from 3 to 5 miles, receding somewhat at the Eel river valley and Point St. George, and at other points coming abruptly to the ocean. The whole face of the country is covered with dense forests, and offers almost insurmountable obstacles to the opening of roads intended to strike the trail leading along the valleys of the Sacramento and Wallamut.

Northward of Cape Orford the appearance and nature of the coast assumes a marked change. Long reaches of low white sand beach occur, with sand dunes, broken by bold rocky headlands, and backed by high irregular ridges of mountains. On the sea-face and southern sides of many of these prominent points no timber grows, and they present a bright, lively green of fern, grass, and bushes. The general altitude of the mountains appears the same as to the southward.

COQUILLE RIVER

From Cape Orford to the mouth of the Coquille, in latitude 43° 07′, the coast runs exactly north for 17 miles, with a slight curve of a mile and a half eastward, and a short distance north of Orford consists of a low sand beach, immediately behind which are long shallow lagoons receiving the water from the mountains, but having no visible outlet to the sea. Along this shore the soundings range from 7 to 15 fathoms at a distance of a mile.

The south point of the entrance to this river is a high bluff headland, whilst the north point is a long, low, narrow spit of sand, overlapping, as it were, the southern head, so that the channel runs parallel with and close under it, (1851.) A short distance off it lie several rocks, but not of sufficient size to lessen the western swell which breaks continually across the bar.

In the winter of 1851 the boats of the propeller Sea Gull effected a landing near the rocks, but it was attended with danger; subsequently boats were carried by land from Port Orford. The widest part of the mouth is less than 200 yards, after which the river spreads out into a large sheet of shallow water, about two miles long by three quarters of a mile broad, and bounded by low ground. Into the northeast part of this lagoon enters the river, which has been followed a distance of about 30 miles in a northeasterly direction, and having a depth throughout of not less than 15 feet, and an average width of 40 yards. It drains a very fertile region, densely covered with many varieties of wood. Numerous Indian encampments were found along its banks from the mouth, and quite extensive fish weirs were discovered and destroyed. About 15 miles from its mouth there is a portage of 1½ mile to Koos river.

The hydrographic reconnaissance of this river in 1859 by the Coast Survey shows only 3 feet of water on the bar, and it is reported inaccessible for vessels of ordinary draught. The north point is a long stretch of dreary sand dunes, and has a single bold rock at its southern extremity. The channel makes out straight from the southern head, and north of the rocks (1859.)

The approximate geographical position of its entrance is:

	° ′
Latitude	43 07 north.
Longitude	124 24 west.

Tides.—The (approximate) corrected establishment is XI*h.* XXX*m.*, and the mean rise and fall of tides 5.0 feet.

A reconnaissance of the entrance and part of the river was published by the Coast Survey in 1861.

When off the entrance in 1854 we saw about a dozen houses which had been built by the miners engaged in washing the auriferous sand and gravel at the back of the beach. In approaching this coast we encountered a very heavy swell, with the water changing to a dark brown color, and after passing through it tacked off shore, hove to, and sounded near its outer limit, but found no bottom with 84 fathoms of line.

The alleged depredations of the Indians in this section led to a campaign against them in 1851.

Some recent maps have a river here called the Soquils, and one within a short distance called the Cotamyts, but no such stream exists in this vicinity.

CAPE GREGORY.

Between the Coquille river and this headland we find another low sand beach for ten miles to the southern part of Gregory, which rises up very precipitously; the hill attaining perhaps 2,000 feet elevation two miles back, runs in a straight line northward for three or four miles, and bounded by many rocks, slopes to the northward to a sharp perpendicular point, about 60 feet high, and peculiarly cut and worn by the action of the sea. Thence it takes a sharp turn to the E.NE. for two miles, to the entrance to Koos bay. The cape, as seen from the southward, shows a couple of rocks a short distance from its western point. Along the low shore soundings in 10 fathoms are found one mile off. We have been informed that vessels anchoring close under the north face of the cape may ride out heavy southeast gales. If so, it is very important, no other place between Sir Francis Drake's and Neé-ah bay, except, perhaps, under Destruction island, affording that protection. If a southeaster should haul to the SW., and then NW., as they usually do, the chances of getting out would be very few.

The approximate geographical position of the NW. point of the cape is:

	° ′
Latitude	43 20½ north.
Longitude	124 22¼ west.

And it bears north 30 miles from Cape Orford.

It was named by Captain Cook, who placed it by bearings in latitude 43° 30′, and is described by him as follows: "This point is rendered remarkable by the land of it rising immediately from the sea to a tolerable height, and that on each side of it is very low." Vancouver placed it in 43° 23′.

It is sometimes called by the recent appellation of Arago, which has been adopted on the Coast Survey charts. It is known by both on the western coast.

A view of it is given on the Coast Survey sheet of 1853.

KOOS BAY.

Nearly 2 miles E.NE. of the northern extremity of Cape Gregory is the wide and well-marked entrance to Koos bay. The south point, named Koos Head, is high and bold, being the base of the hills forming the cape, whilst the north point is low and sandy, with shifting sand dunes that reach 100 feet in height. In 1861 a narrow channel cut across the north point, forming a tolerably large island, which was washed away before the close of the season. Such changes are constantly taking place, and involve changes in the bar and channel. The points lie nearly north and south of each other, and about three-quarters of a mile apart. The bar (1861) lies N. 62° W. one mile from Koos Head; N. 35° E. 1¾ mile from Cape Gregory, and its width between the 12 feet lines on the north and south sides is only 150 yards, with a maximum depth of 13 feet. Thence the channel, increasing in width, runs straight to the north tangent of the head, with 10 fathoms of water at that point. In 1853 and 1854 a depth of only 9 to 9½ feet could be found on the bar. During the working season of 1861 the bar moved to the northward, thus indicating great changes in this as in all other river bars on the coast. Vessels enter and leave on the flood tide because the bar is smoother; with the ebb there is a heavy break, unless the sea be remarkably smooth. The currents run very strongly, as might be supposed, from the extent of the bay and the size of the channel.

We have seen the sea breaking completely across the entrance in moderate northwest weather, and know that the mail steamer has tried to enter, but upon seeing the danger would not take the risk. In 1861 the party examining it could get but one day's work on the bar during several months. In October, 1862, the surveying brig Fauntleroy could not enter.

Traffic is drawn hither by the mining of lignite, which is carried to the San Francisco market. It has been found unfit for steamship consumption, but is used for small stationary engines and domestic purposes. The geology of the country does not give promise of coal. A tug-boat is employed at the entrance for the towing of vessels over the bar. The saw-mills on the bay turn out about 15,000 feet of lumber daily.

Tides.—The corrected establishment or mean interval between the time of the moon's transit and the time of high water is XI*h.* XXVI*m.* The mean rise and fall of tides is 5.1 feet, of spring tides 6.8 feet, and of neap tides 3.7 feet. The mean duration of the flood is 6*h.* 19*m.*, of the ebb 6*h.* 07*m.*, and of the stand 0*h.* 39*m.*

The approximate geographical position of Koos Head is:

	° ′ ″
Latitude	43 21 04 north.
Longitude	124 18 west.

The computed magnetic variation for December, 1861, is 18° 52′ east, with a yearly increase of 1′.

The bay is very irregular in outline, and its general shape is somewhat like the letter U, with the convexity to the north. One small branch stretches southward behind Koos Head; it is called the south slough, and has but two or three feet of water in it. North of the entrance the bay proper begins, and has a good depth of water. Abreast of the north point the width is 600 yards, and the depth from three to seven fathoms; thence northward it increases in width to nearly a mile, and runs very straight on a N. by E. ½ E. course. The channel runs on the eastern side of this part, the western half being filled with sand flats and shallows. A sunken rock, called the Fearless rock, is on the eastern side of the channel, abreast of the upper part of the rocky shore. The whole length of the bay is believed to be about 25 miles, the head of it being a little further south than the entrance. Koos river empties into the head of the bay, and will give passage to boats for twenty miles from its mouth, where a small slough that empties into the Coquille river is so near as to leave a portage of only a mile and a half between the two waters, and about 15 miles from the mouth of the Coquille.

Excepting the peninsula, which forms the western shore of the bay north of the entrance, the entire country is an immense forest of various kinds of pine. No land for cultivation is found without clearing, and even on Koos river the bottom lands, which afford excellent soil, have to be cleared of the thick growth of laurel, maple, and myrtle. The coal mines are beyond the great bend, near the head of the bay, and on the western side.

The name Koos is that approaching nearest the Indian pronunciation of the word. On some maps we find a small stream called Cahoos, emptying just south of Cape Gregory. The Coast Survey chart of the bay was published in 1861.

The word Koos signifies, in the Too-too-tan language, a lake, lagoon, or landlocked bay. Duflôt de Mofras very amusingly translates it R. des Vaches.

In January, 1859, the line of *equal magnetic variation* of 19° east crosses the coast-line in latitude 43° 39′, and in latitude 43° 29′ crosses the 125° of longitude. This line moves annually southward about $1\frac{1}{2}$ mile.

UMPQUAH RIVER.

North of Koos bay to the Umpquah river is another straight, low sand beach, with sand dunes, backed by a high ridge of hills densely timbered. The shore runs nearly north, presenting a very white appearance when the sun shines upon it, and having from 10 to 15 fathoms of water one mile off the beach. The southern point of the entrance to the river is a marked spur of the mountains from the southeast, and is bordered by sand dunes. The north side of the entrance is a long range of white shifting sand hills, running with the coast for two miles, and suddenly changing to high, rocky hills covered with wood. The river is the largest stream entering the Pacific between the Sacramento and Columbia rivers. It is 51 miles N. $\frac{1}{2}$ W. from Cape Orford, and 21 miles north of Cape Gregory. The lower reach of the river is long and narrow, running nearly north for 6 miles; bordered on the south side by a rocky, wooded shore; on the north, for two miles, by loose sand hills, changing after the first mile to sand sparsely covered with coarse grass, bushes, and fir, and in four miles to steep, high, rocky banks covered with large trees. An immense flat, mostly bare at low water, stretches south from the north point to within 300 yards of the south side of the entrance, through which narrow space runs the channel, having (1853) a bar with only 13 feet upon it, and less than 100 yards wide. From the bar the point of bluff, just inside the entrance, bears NE. by E., and is distant $1\frac{1}{4}$ mile. About 1851 or 1852 two range marks were placed on the south shore for running in by, and they are frequently referred to as data by which to trace the changes of the bar; but the captain who erected them has assured us that the bar was not on their range, but to the southward of it.

Buoys for crossing the bar.—In January, 1858, it was announced that the bar had been marked by buoys. Two third class nun-buoys, painted white, with white and black perpendicular stripes, are placed in line with the light-house, which bears from them E. by N. $\frac{1}{4}$ N. The inner buoy is just within the bar, and in $3\frac{1}{2}$ fathoms at mean low water, and can be passed on either hand, but only close to it. The outer buoy is just outside the bar, in 10 fathoms at the same stage of the tide, and can also be passed on either hand. Keeping the two buoys in range with the light-house, 14 feet may be carried over the bar at mean low water.

The above directions show that the bar of the river has moved about 400 yards to the northward of its position, as determined by the hydrographic survey of 1853, and has, moreover, deepened. In light weather it can be readily determined by the breakers on each side, but with a heavy swell the sea is terrific. In October, 1852, the Coast Surveying steamer Active lay off the bar two days trying to get in, but found it impracticable. Several steamers have thumped heavily on the bar, one nearly carrying away her stern-post, and in 1858 the mail steamship Columbia in coming out had her decks swept fore and aft by the huge combers rolling in like high walls. In January, 1861, when going in, this same steamer suffered still more terribly. Several vessels have been lost at its entrance, and within a very recent period no pilots belonged to the river, because the trade was too small to pay.

During the early part of November, 1858, the bar at the entrance to the Umpquah changed greatly, and the depth of water upon it was so much decreased that the steamship Columbia, which thumped over it, could not leave the river for several weeks. Upon sounding at the entrance it was found that the channel across the bar had moved about half a mile northward of its former position.

UMPQUAH RIVER LIGHT-HOUSE.

The light-house is erected on the south side of the entrance, close to the beach, which is of shifting sand. The structure consists of a keeper's dwelling of stone, with a whitewashed tower of brick rising above it, and surmounted by an iron lantern painted red, the entire height being 92 feet, and the height of the light 100 feet above the mean sea level. The light is a *fixed white light* of the third order of the system of Fresnel. It was first exhibited October 10, 1857, and shows every night from sunset to sunrise. In an ordinary state of the atmosphere it should be seen—

From a height of 10 feet at a distance of 15 miles.
20 feet at a distance of 16½ miles.
30 feet at a distance of 17¾ miles.

In the day time the tower will show projected against the dark green fir on the hills behind it, and with the sand dunes to the north be a capital mark for making the river.

The geographical position of the light, as determined by the Coast Survey, is:

	° ′ ″
Latitude	43 40 18.5 north.
Longitude	124 11 00.3 west.
	h. m. s.
Or, in time	8 16 44.2

Computed magnetic variation 18° 55′ east, in July, 1851, with a yearly increase of 1′.

From the bar the light bears E. by N. ¼ N., distant about a mile, (1858.) After crossing the bar the channel, when approaching the light-house, runs close to the south shore, and increases in depth from 3½ fathoms to 13 off the point of bluff. Abreast of the meeting of the sand beach and bluff on the south side, lies a rock, visible at extreme low tide, upon the three-fathom line. It is not laid down on any chart, nor has its position been accurately determined. It has deep water around it. From the point of bluff vessels steer across the river to strike the east side of the north point about one-third of a mile from its extremity, then haul across E.NE. to the other shore, close along which the channel runs. This course takes them clear of a flat and rocks in mid-river, and bearing E.NE. from the south end of the north point, and north five-eighths of a mile from the point of bluff on the south side. The small indentation of the shore-line on the right, after making the first stretch from the point of bluff, is called Winchester bay, having no water, and being but an extensive mud flat. Three miles inside the light-house the river continues half a mile wide, then expands to a mile, and is filled with numerous extensive sand and mud flats. Five miles from the light-house it bends sharply to the eastward.

A preliminary chart of the entrance to Umpquah river was issued from the Coast Survey office in 1854.

The secondary astronomical station of the Coast Survey was on the west side of the river, on the edge of the first grove of fir, and one mile from the end of the north point. Its geographical position is:

	° ′ ″
Latitude	43 41 45.3 north.
Longitude	124 09 57.0 west.
	h. m. s.
Or, in time	8 16 39.8.

This river is said to drain an extremely fertile region, abounding in prairie land well adapted to agriculture and grazing. Ross Cox mentions a pine tree discovered in the Umpquah valley measuring 216 feet to its lowest branches, and being 57 feet in circumference.

The Indian name for the river below the rapids is Kah-la-wat-set, and to the upper part they apply the name Umpt′quah.

The first vessel we know of entering it was the schooner Sam Roberts, August 4, 1850, after coming out of Rogue's river.

This river is sometimes supposed to be the river discovered by Flores in 1603, and afterwards referred to as the "River of the West." Carver, in his narrative, refers three times to the "Oregon, or River of the West."

From the Umpquah the coast runs in a remarkably straight line N. by W. ½ W. to the south point of the entrance to the Columbia river, in no case varying more than three miles eastward of the line joining these two places.

Heceta Bank.—NW. by N., distant 66 miles from Cape Orford, is the southern end of a bank extending parallel with the coast for 30 miles, and about the same distance from it The least depth yet discovered upon it is 43 fathoms, and the nature of the bottom very variable, there being blue mud, coarse blue sand, coral, pebbles, gravel, mud, and shells. Coasting vessels have often reported passing over localities having a heavy swell upon them, and one frequently so reported near the Umpquah led to the examination which discovered this bank. When Heceta was upon this coast, and in this vicinity, he said: "On Sunday I found great differences [of depth;] at seven leagues I got bottom at 80 fathoms; and nearer the coast I sometimes found no bottom." Should a thorough examination of his discoveries here satisfactorily show that he did really cross this or any yet undiscovered adjacent bank, it would be a tribute to his explorations on this coast to apply his name to it.

CAPE PERPETUA.

After leaving the Umpquah two or three miles, a bold rocky coast, with high steep hills covered with timber, runs straight for about eight miles, changing to low sandy beach with sand dunes, backed by a high ridge of hills. This continues for 15 miles, when the hills stretch out to the shore and crowd upon it for 13 miles, to end abruptly in steep bluffs forming Cape Perpetua, which is 39 miles N. by W. ½ W. from Umpquah light, with an approximate geographical position of latitude 44° 19′, longitude 124° 06′. The face of the cape is nearly five miles long, with very slight projection from the straight trend of the shore. It is very high, and has a regular although steep descent to the shore, bringing the trees to its very edge.

From the Umpquah to Perpetua, at a distance of a mile from the shore, soundings are laid down from 8 to 14 fathoms.

This cape was named by Cook in 1778, and by bearings placed in latitude 44° 06′. Vancouver, in 1792, gave its position in latitude 44° 12′.

In recent maps we find a small stream opening south of Cape Perpetua, called the Sciisteum river. We could not detect it in 1853 from the distance of a mile, but believe there is a stream with the name of Scius-clau, (pronounced Sai-yusé-claw,) emptying about 25 miles above the Umpquah.

To the northward of Perpetua the coast range of hills is cut by numerous valleys, through which flow many small streams to the ocean.

Yaquinnah river.—Nine miles north of Perpetua is the mouth of a stream believed to be the Yaquinnah. It is said to expand into a bay, three miles long by 1½ wide running nearly east, and very much contracted at the middle, where a small islet exists. The south head to the entrance is formed by a spur of the hills from Perpetua. The north point has likewise a bold head with a low sand spit stretching south half a mile. The entrance is in latitude 44° 27′ north, (approximate.)

Recent maps place the Alciyco river about this latitude. No name is given in the last Coast Survey reconnaissance, and it was not seen at all by McArthur in 1850.

The names of the streams hence to the northward are very conflicting, and will continue so until a land exploration is made along the seaboard for determining their peculiarities and the latitudes of their mouths.

Celetse river.—North of Perpetua the shore continues straight, high, and bold for five miles, when a cluster of rocks occur, and the bluff changes to low sand beach, running nearly to the mouth of a small stream, about five miles south of Cape Foulweather, called the Alseya on the Coast Survey reconnaissance of 1850, and the Celetse on the original sheets of 1853. This name is the proper one. The north head, which is bold, has a rock close under it. Thence the shore is low and sandy to Foulweather. The country in the interior is very broken and mountainous, and covered with wood.

CAPE FOULWEATHER

From Perpetua to this cape the soundings range from 7 to 12 fathoms about a mile from shore. The cape is in latitude 44° 45′ north, and longitude 124° 04′ west, and forms a high, bold headland, half a mile in width, jutting out about half a mile from the low beach, and backed by high mountains. It is covered with wood, and has several small rocks on its southwest face, with one rocky islet a mile from it. To the northward of the cape are three rocky islets standing a short distance from the low beach, and readily distinguished by being projected against it. In August, 1853, the astronomical party of the coast survey was very desirous of effecting a landing on or near this cape, but the sea was rolling in too heavily to warrant the attempt. There was no appearance of a landing being at all feasible, except in remarkably quiet weather.

This cape was named by Cook on the day he made the coast, March 6, 1778, but the point of the headland, so called on the Coast Survey reconnaissance of 1853, is not that referred to by him. At noon he was in latitude 44° 33′, and the land extended from NE. ½ N. to SE. by S., about eight leagues distant. In this situation he had 73 fathoms over a muddy bottom, and 90 fathoms a league further off shore. The land he describes of moderate height, diversified by hills and valleys, and principally covered with wood. No striking object presented itself, except a high hill with a flat summit, which bore east from him at noon. This may have been what he subsequently called Cape Perpetua. At the northern extreme the land formed a point, which he named Cape Foulweather, from the exceeding bad weather he met with soon after. The expression "northern extreme" has led some geographers to place the cape as high as latitude 45½°; but he judged the Foulweather he named to be in 44° 55′. Being here driven off the coast by continued bad weather, he had no opportunity to verify his position, and did not sight the land again until in latitude 47° 05′, thus passing by the entrance to the Columbia. Vancouver places it in latitude 44° 49′. Both of these determinations evidently refer to the northern part of the high land.

Nekas river.—Soon after passing Foulweather the shore becomes abrupt and moderately high, with an increased depth of water immediately off it. Four miles south of the Nekas, which is in latitude 44° 56′, it changes to low sand dunes stretching into a narrow point, forming the south point of the stream, while the north point is a low bluff. The entrance is very narrow and shoal, and inside the river is reported to spread out into a bay of about a mile in extent, and to receive the waters of a stream draining a valley coming from the eastward.

The name is that used on the Coast Survey charts of 1850 and 1853. Previous maps have a small stream emptying near this, called the Cowes river. De Mofras calls it the Yacoun.

From the Nekas to Cape Lookout the distance is 24 miles, and course N. by W. ½ W., with a shore-line broken by several small streams, amongst which are the *Nechesne* (reconnaissance, 1853,) in latitude 45° 02′, with rocks in the entrance; the *Nestuggah* (reconnaissance, 1853,) in latitude 45° 06′, called Yaquinna in reconnaissance of 1850, and having a large rock off its mouth; the *Nawuggah* (reconnaissance, 1853,) in latitude 45° 14′, and on the south side of whose entrance is a single rocky islet, hereafter referred to.

De Mofras has C. Lucuat in this latitude, and a small stream, R. Kaouai, south of it.

CAPE LOOKOUT.

The soundings from Foulweather to this cape show from 13 to 31 fathoms of water at a distance of a mile from the shore, increasing from 18 fathoms north of latitude 45° N.

This cape is situated in latitude 45° 20′, longitude 124° 00′. It projects somewhat sharply into the sea for half a mile, and as seen from the south the top is tolerably flat and regular, and at the highest part we judge it to attain an elevation of 3,000 feet. The face directly toward the ocean is perpendicular, high, and toward the south destitute of trees. About eight miles southward of it is a large single rock off the Nawuggah, estimated to be 250 feet high, and standing well out from the low sand beach behind it. No rocks lie off this cape, but one appears very close inshore, about a mile to the northward of it.

This name is that used on the Coast Survey charts of 1850 and 1853, and is intended to apply to the cape mentioned and fully described in July, 1778, by Meares, whose description has been corroborated by Vancouver, and incidentally by ourselves.

For January, 1859, the line of equal magnetic variation of 20° east crosses the coast-line in latitude 45° 23′, and in latitude 45° 13′ crosses the 125° of longitude. This line annually moves about one mile southward.

CAPE MEARES.

Two or three miles after leaving Cape Lookout the land falls to a low sand beach, behind which is a long lagoon, called the Nat-a-hats, stretching northward, and having an opening under the south head of the well-marked point to the northward, which is the termination of a spur or ridge running from the southeastward, presenting an abrupt front to the ocean for about two miles, and being part of the western boundary of Tillamook bay. In coming down this coast in the fall of 1857, we made a few notes upon some objects, and find the following memorandum made whilst near this point: "Three high rocks (one arch) off point south of False Tillamook; one more on the north side." Not being then aware of any doubt as to the name of the cape, no other particulars were noted. Four rocks are laid down off the southwest face on the Coast Survey reconnaissance of 1850, and one on the north. Three large rocks and one small one are laid down off the southwest face in the original sheets of the reconnaissance of 1853, the most distant being one mile from shore, with several small ones between them and the shore, and two or three others off the northwest face.

In 1775 Heceta placed La Mesa, the Table, in latitude 45° 28′—a flat-topped mountain, seen at a great distance.

In July, 1788, Meares, in the Felice, after passing False Tillamook, says: "The distant southerly headland we called Cape Lookout. This cape is very high and bluff, and terminates abruptly in the sea. At about the distance of two miles from it there rose three large rocks, which are very remarkable for the great resemblance they bear each other. The middle one has an archway, perforated, as it were, in its centre, through which we plainly discovered the distant sea. They more particularly attracted our notice as we had not observed between King George's sound and this place any rocks so conspicuously situated near the land; their distance from each other might be one-quarter of a mile, and we gave them the name of the 'Three Brothers.' By eight in the evening we were within three or four leagues of Cape Lookout, which we judged to lie in latitude 45° 30′ north, longitude 235° 50′ east."

In 1792 Vancouver described it as a small projecting point, yet remarkable for the four rocks which lie off it, one of which is perforated as described by Meares. He places it in latitude 45° 32′.

This cape is very frequently, but erroneously, stated to be the "Clarke's Point of View," as described by Clarke in the winter of 1805–'6.—(See remarks upon Tillamook Head.)

In the Coast Survey reconnaissance of 1853 the northern part of this cape is placed in latitude 45° 30′, longitude 123° 58′, and stretching southward two miles to the cluster of rocks above described.

We applied the name to this cape in 1857.

TILLAMOOK BAY.

On the Coast Survey reconnaissance of 1853 the entrance to this bay is placed in latitude 45° 34′, four miles north of Cape Meares. The southern point is low, and the termination of a spur from the crest of the cape, whilst the north head is high and bluff. The entrance is very narrow, and reported to have very little water upon the bar; inside it expands into a long wide bay, stretching to the S.SE. behind Cape Meares. No survey has yet been made of it, and some doubts are expressed about the enlarging of the river to form a bay. Two miles northward of the northern head stands a couple of large rocks; thence the coast runs nearly straight to False Tillamook, receiving a considerable stream, called the *Nehalem*, in latitude 45° 41′. Clarke, when about five miles south of Tillamook Head, says that "the principal town of the Killamucks is situated 20 miles lower (south) at the entrance to a creek called Nielee, expanding into a bay, which he named Killamucks bay. Upon this bay were several Killamuck towns. Killamuck river is at the head of the bay, 100 yards wide, and very rapid; but having no perpendicular fall, is a great avenue for trade There are two small villages of Killamucks settled above its mouth, and the whole trading portion of the tribe ascend it till by a short portage they carry their canoes to the Columbia valley, and descend the Multnomah to Wappatoo island." This information he obtained from Indians and traders. On this short expedition he made all his distances from Cape Disappointment and Point Adams too great, and reducing the forementioned 20 miles by the proper proportion, it would give us 13 miles as about the position of the Nehalem. His name seems to agree with this, but the description applies to what is generally known as Tillamook bay.

The shore about the Nehalem is low and sandy, with sand dunes backed by high wooded hills, and cut up by many valleys. It was here that Meares stood in for an anchorage, (July, 1788,) until he found bottom in 10 fathoms, but hauled out again and named the place Quicksand bay, and the adjoining headland north, Cape Grenville.

CAPE FALCON, OR FALSE TILLAMOOK.

The northern part of this headland lies in latitude 45° 47′, longitude 127° 58′. Upon passing close by it in 1857, we judged it to be not less than 3,000 feet high, with the sea-face coming precipitously to the ocean, and off it lie two prominent rocky islets. As seen from the southward the top is irregular whilst the hills inshore fall away. Like some other points in this latitude, the southern face of the cape is destitute of trees, but covered with a thick growth of grass, bushes, and fern. Two miles south of it is a stretch of sand beach and sand dunes.

From Cape Lookout to this headland a depth of 20 fathoms may generally be found a mile from shore; but, as upon the whole coast, a heavy regular swell always rolls in from the west.

In 1775 Heceta placed a headland in latitude 45° 43′, to which he gave the appellation Cape Falcon. According to his description it had a rocky islet lying off it. This name would be far better than applying the term "false" to capes, bays, &c., the names of which were at first uncertain.

In 1788 Meares called this cape Grenville.

The Indian name for the head is Ne-a-kah-nie.

TILLAMOOK HEAD.

This prominent cape, in latitude 45° 58′, is 12 miles N.NW. from Cape Falcon, and 19 miles SE. by S. ½ S. from Cape Disappointment. The coast from Cape Falcon curves two miles eastward; is bold and rugged, guarded by many high rocky islets and reefs, and in several places bordered by a low sand beach at the base of the cliffs. Two miles south of the head, Clarke (1805–'6) locates a creek 80 yards wide at its mouth, which he calls Ecola, or Whale creek. From the south bar of the Columbia river the summit of Tillamook appears flat for some distance back, and has an estimated height of 2,500 feet. Off the face of the cape, which is very steep, lie several rocky islets; one of them is high and rugged, and stands out about a mile from the southwest face. Around it the water is believed to be deep, as we have seen a steamer come almost upon it in a thick fog; but inside of it lie several high rocks. From the bar two rocks can be distinctly seen, the inner being the larger, and its apparent distance from the head about half the apparent height of the cape. Whether the smaller is the one off Cape Falcon, we did not determine. As seen from the southward the large rock has a perpendicular face to the westward, and slopes to the east. It is the resort of thousands of seals.

This cape is a good landmark for making the mouth of the Columbia river, no such high headland occurring on the coast northward of it for over 70 miles, and before being up with it the moderately high land of Cape Disappointment is seen and made as two islands.

The face of the cape is much broken, and formed principally of yellow clay, presenting a bright appearance in the sunlight. Clarke says that 1,200 feet above the ocean occurs a stratum of white earth, then (1805–'6) used by the Indians as paint; and that the hill-sides slip away in masses of 50 to 100 acres at a time.

Upon the top of the cape Clarke says he found good, sound, solid trees growing to a height of 210 feet, and acquiring a diameter from 8 to 12 feet.

From Tillamook head southward many miles was the country of the Killamuck Indians, then estimated to number 1,000 people, and having 50 houses.

In latitude 45° 55′ La Perouse speaks of a cape, formed by a round-topped mountain, as the Cape Redondo of the Spaniards. It bore E. 5° S. from his position.

De Mofras calls it the Cap N. S. de la Lux.

This is the head which is properly called "Clarke's Point of View."

Some recent maps call this Cape Lookout.

The coast from Point Orford to Tillamook Head is well diversified by high hills and valleys, presenting a country well watered by numerous small streams emptying into the ocean. It is densely covered with various woods, and for a few miles inland looks favorably from the deck of a vessel. Some distance in the interior ranges of mountains occur, the general direction of which appears to be parallel with the coast-line, which attained its greatest elevation and compactness between Cape Falcon and Tillamook Head, after which a sudden and marked change takes place, and a stretch of low sandy coast commences and runs for nearly 100 miles northward, only broken by Cape Disappointment.

COLUMBIA RIVER.

POINT ADAMS.

Two miles northward of Tillamook Head commences a peculiar line of low sandy ridges, running parallel to the beach towards Point Adams, and appearing like huge sand waves covered with grass and fern. Between some of them run small creeks, whilst the country behind is low, swampy, and covered with wood and an almost impenetrable undergrowth. About three miles north of the head Clarke says a beautiful stream empties with a strong rapid current. It is 85 yards wide, and has three feet at its shallowest crossing.

Point Adams is low and sandy, covered with bushes and trees to the line of sand beach and low dunes; and although it is reported to have washed away over half a mile since 1841, we find comparatively small changes since the survey of Broughton in 1792.

The geographical position of the triangulation station of the Coast Survey on the point is:

	° ′ ″
Latitude	46 12 30.4 north.
Longitude	123 56 55.8 west.
	h. m. s.
Or, in time	8 15 47.7.

This station is on the inside of the point, and almost half a mile from it.

No light-house exists here, but the necessity for one has been so repeatedly urged that we cannot refrain from calling attention to a few facts bearing upon the question. Off this point, SW. by S. 3¼ miles, lies (1852) the bar of the south channel, through which the far greater portion of the trade has passed; and all vessels use this point as a standard point for their ranges. During the early part of the evening dense fogs, formed over the waters of Gray's and Shoalwater bays, are brought southward by the summer winds, and roll over Disappointment, which they completely shut in before reaching across the river, so that a vessel might make a light on Point Adams when the other cape was invisible; but by seeing both lights a vessel could hold any required position at night near either bar, and run in and take a pilot upon the first opportunity; for it would be assuming too great a risk to enter the river at night, or without a pilot.

This point was called Cape Frondoso by Heceta, who discovered, but did not enter this river in August, 1775; and named Adams' Point by Captain Gray, in 1792. The Indian name of the point is Klaat-sop. It is now called Point Adams.

The beach around Point Adams and to the southward some distance is usually called Clatsop beach. Upon it, many years ago, before the whites occupied the country, a Chinese or Japanese junk, with many hands and a cargo of beeswax, was cast ashore and went to pieces; but the crew were saved. In support of this Indian tradition, there are occasionally, after great storms, pieces of this wax thrown ashore, coated with sand and bleached nearly white. Formerly a great deal was found, but now it is rarely met with. Belcher mentions having a specimen. Many people on the Columbia possess them, and we have seen several pieces. In a late work* this wreck has been confounded with another that took place near Cape Flattery.

COAST AND SHORES OF WASHINGTON TERRITORY AND OPPOSITE SHORE OF VANCOUVER ISLAND.

CAPE DISAPPOINTMENT.

The north side of the Columbia river forms part of Washington Territory; it was the southern boundary of the "New Georgia" of Vancouver, 1792.

This cape is the only headland from Tillamook to latitude 47° 20′ that breaks the low line of shore. It presents a geological formation not before met with on the seaboard, being composed of horizontal columnar basalt, rising to an elevation of 287 feet, disposed in a succession of huge round hills, broken on the sea front by short strips of sand beach, and covering an irregular area of about three miles by one. The sea-faces of all the hills and irregularly projecting knobs rise perpendicularly for many feet, then slope slightly inshore to narrow ridges; are destitute of trees, but covered with grass, fern, and bushes, and have an excellent though thin soil. Inland of their crests the trees commence, and their tops reaching above the summits of the hills increase their apparent height. The inshore slope of the hills is more gentle, so that paths can be easily carried to their tops. In 1851 we opened an ox-team road to the summit of the cape. When the evening fogs from the northern bays do not cover the cape, we have sometimes experienced a dense fog rolling down the river about sunrise, enveloping everything below the top of the cape upon which we have stood, when it looked like an island less than a hundred yards in extent, and surrounded by the river fog, that must be felt to be appreciated. The evening fogs are so regular that we were 35 days on this cape before obtaining a single night's observations.

As seen from the southward, when off Tillamook Head, Cape Disappointment is made as two round-topped islands; approached from the northwest it rises in a similar manner; from the west and southwest it appears

* Perry's Japan.

projected upon the mountains inland, but the slightest haziness in the atmosphere brings it out in sharp relief. This cape being basaltic, and showing an almost iron front to the river and sea, it is impossible that, "in the memory of many, Cape Disappointment has been worn away some hundred feet by the sea and strong currents that run by it."

On the first landing beach on the inside of the cape we found a deposit of auriferous and ferruginous "black sand," the flakes of gold being very small and scarce. This ferruginous deposit—the "black sand" of the California gold digger—caused a local disturbance in the magnetic variation, amounting to 26′.2, being that quantity less than the declination found upon the summit of the cape. Here we also found the remains of the ovens used by the shipwrecked crew of the United States sloop-of-war Peacock, lost on the north shoals of the north channel in 1841.

CAPE DISAPPOINTMENT LIGHT-HOUSE.

The light-house is not upon the top of the cape, but upon a spur a little to the west of the southeast point, and about 95 feet below the highest part. The tower is whitewashed, placed 192 feet above the level of the sea, and being 40 feet in height and projected against a dark green background, shows well in daylight.

The light is a *fixed white light*, of the first order of Fresnel; was first exhibited October 15, 1856, and shows from sunset to sunrise. Under a favorable state of the atmosphere it should be seen—

From a height of 10 feet at a distance of	21	miles.
20	"	"	22½ "
30	"	"	23¾ "
60	"	"	26⅓ "

Its geographical position, as determined by the Coast Survey, is:

	°	′	″	
Latitude	46	16	32.7	north.
Longitude	124	02	13	west.
	h.	*m.*	*s.*	
Or, in time	8	16	08.9	

Magnetic variation, 20° 45′ east, in July, 1851, with a yearly increase of 1′.

Counting round seaward from the south, it commands the horizon for about 135 degrees; that is, from S.SE. to W.NW.; so that vessels coming from the northward cannot see the light until nearly in the latitude of the river. Placed on the top of the cape, it could have been easily made to show over the northwest part of it, and would also have commanded the entire river and Baker's bay.

From Cape Disappointment we have the following bearings and distances of objects to the northward:

Point Grenville	NW. by N. ½ N.,	62	miles.
Destruction island	NW. by N.,	84	"
Flattery rocks	NW. ⅚ N.,	118	"

The last line passes tangent to the coast in latitude 47° 58′, where there are two well-marked rocks, which will be hereafter described.

FOG-BELL AT CAPE DISAPPONTMENT.

A fog-bell of 1,600 pounds has been placed on the bluff in advance of the light-tower, and will be sounded during foggy or other thick weather, night and day. The distinctive mode of striking we have not yet found published. The machinery is on a level with the ground, in a frame building, whitewashed, and with the front open to receive the bell.

The primary astronomical station of the Coast Survey is on the highest part of the southern extremity of the cape. Its geographical position is:

	°	′	″	
Latitude	46	16	35.2	north.
Longitude	124	02	00.8	west.
	h	*m.*	*s.*	
Or, in time	8	16	08.1.	

From Cape Blanco to Cape Disappointment the extent of ocean shore-line is not less than 285 miles.

In August, 1775, this cape was placed by Heceta in latitude 46° 17′, and called Cape San Roque.

In July, 1788, it was called Cape Disappointment by Meares, and placed in latitude 46° 10′ "by an indifferent observation." It was called Cape Hancock by Gray, in 1792, and the entrance placed in latitude 46° 17′; he, however, changed this name to Disappointment, upon hearing that Meares had so named it.

In 1792 it was placed in latitude 46° 19′ by Vancouver.

On the Pacific coast it is and has been known by no other name than Cape Disappointment.

The Indian name for the cape is Káh-eese.

THE ENTRANCE TO THE COLUMBIA RIVER.

The entrance to this, the great river of the Pacific coast, is five miles wide between the nearest parts of Cape Disappointment and Point Adams, bearing S. 58½° E., and N. 58½° W. from each other; but the passage is badly obstructed by shifting shoals that lie two or three miles outside of the line joining the points. The numerous surveys that have been made of this river prove so conclusively the great changes which the channels through the shoals undergo, that we shall not attempt to give any directions concerning the present north and south channels. The best advice we can offer is, when up with the bar, *wait for a pilot.* The mail and coasting steamers enter the south channel, (October, 1857,) parallel and close to the beach south of Point Adams; but, with a heavy swell from the westward, they roll very much after rounding the point. In heavy weather some of them prefer entering the north channel, although it gives a detour of some miles, but that bar has, and always has had, more water upon it than that at the south channel, and does not change its position as much, from the unwearing nature of the cape. Sailing vessels cannot beat into the south channel against the summer winds blowing from the northwest, but almost invariably come out through it. The heavily laden vessels of the Hudson Bay Company have always used the north channel.

During heavy weather, and especially in winter, the sea breaks with terrific fury from northwest of Cape Disappointment well to the southward of Point Adams; and we remember the mail steamer trying for 60 hours to find the smallest show of an opening to get in. Sailing vessels have laid off the entrance six weeks, waiting for a fair opportunity to enter, and many lie inside for weeks trying to get out. The mail steamer, meanwhile, exerting all her power, would drive through the combers, having her deck swept fore and aft by every sea. Few places present a scene of more wildness than this bar during a southeast gale, contrasting strongly with many times during the summer, when not a breaker is seen to mark the outline of the shoalest spot. From the summit of Cape Disappointment we have often watched the bar in varied states of wind and weather, and crossed it when calm and breaking. What is most needed here is a powerful propeller tug, which the amount of trade would assuredly warrant, when we know that the much smaller trade of Humboldt bay supports handsomely a tug for that bar. In bad weather the pilot-boats cannot venture out, but a steamer might; and the mail steamers, to avoid delay, now regularly carry a bar pilot with them.

During the season of freshets, about June, the pilots say that the river brings down such a vast body of water that they can frequently take up for use fresh water upon the bar.

When off the entrance in fine, clear weather, the beautiful snow peak of Mount St. Helens* shows over the lowest part of the land inside, and apparently in the middle of the river valley. It is very regular in outline, and presents a pyramidal appearance, having a base equal to either side. It is over 75 miles eastward from the entrance to the river, and attains an estimated elevation of 13,500 feet. It is volcanic, and occasionally discharges volumes of smoke.

On the 23d of November, 1842, during an eruption, the ashes from it fell over the Dalles of the Columbia like a light fall of snow. On the 13th of November, 1843, St. Helens and Rainier were both in action. Humboldt erroneously states that this volcano is always smoking from the summit crater.—(See remarks on page .)

On October 22, 1792, Vancouver reported having seen several water-spouts off the entrance to the river, and that some of them passed quite near his ships.

The current.—In October, 1851, whilst lying at anchor in the south channel off Sandy island, we measured the strength of the ebb current, and found it to be nearly 5½ miles per hour.

Tides.—At Astoria the corrected establishment, or mean interval between the time of the moon's transit and the time of high water, is XII*h.* XLII*m.* The mean rise and fall of tides is 6.1 feet, of spring tides, 7.4 feet, and of neap tides, 4.6 feet. The mean duration of the flood is 6*h.* 03*m.*, of the ebb, 6*h.* 28*m.*, and of the stand, 0*h.* 33*m.* The average difference between the corrected establishments of the a. m. and p. m. tides of the same day is 1*h.* 02*m.* for high water, and 0*h.* 52*m.* for low water. The differences when the moon's declination is greatest are 1*h.* 38*m.* and 1*h.* 15*m.*, respectively. The average difference in height of those

* Named by Vancouver in 1792.

two tides is 1.4 foot for the high waters, and 2.3 feet for the low waters. When the moon's declination is greatest those differences are 1.9 foot and 3.7 feet, respectively. The average difference of the higher high and lower low waters of the same day is 7.9 feet, and when the moon's declination is greatest, 8.9 feet. The higher high tide in the twenty-four hours occurs about 12*h.* 11*m.* after the moon's upper transit, (southing,) when the moon's declination is north, and about 0*h.* 15*m.* before, when south. The lower of the low waters occurs, about 7½ hours after the higher high water. The greatest observed difference between the two low waters of one day was 5.1 feet, and the greatest difference between the higher high and lower low waters of one day was 11.5 feet.

For the method of computing the times and heights of high and low waters for any date, see the example of San Francisco on pages 311–315, and use the tables given for Astoria at the end of the directory.

The tide makes 40 minutes earlier at Cape Disappointment than at Astoria.

THE DISCOVERY OF THE RIVER AND THE CHANGES IN THE CHANNEL.

The discoverer of this river was Bruno Heceta, commanding the Spanish ship Santiago. On the 15th of August, 1775, he was off the entrance of a great river or inlet, which he called Enseñada de Asuncion, (Assumption inlet;) but in the charts afterwards published in Mexico it was denominated Enseñada de Heceta, and the Rio de San Roque.

In July, 1788, Meares sought an anchorage under Cape San Roque, and finding the breakers barring his progress, applied the name Deception bay to the mouth of the river; and doubtless to vent his pique upon the Spaniards for the ill treatment he had received at their hands, wrote: "We can now safely assert that there is no such stream as that of Saint Roc existing, as laid down in the Spanish charts; to those of Maurello we made continual references, but without receiving any information or assistance from them."

In April, 1792, Vancouver sought for this river, but finding a great line of breakers before him, very wisely did not attempt to pass through them. On the 29th of that month he spoke the Columbia, of Boston, commanded by Captain Gray, who informed him that he had laid off the mouth of a river in latitude 46° 10′, where the outset or reflux was so strong that for nine days he was prevented from entering; whereas Vancouver, having passed this position on the 27th, wrote on that day "that if any inlet or river should be found, it must be a very intricate one, and inaccessible to vessels of our burden, owing to the reefs and broken water."

On the 11th of May, 1792, about noon, Captain Gray's log states, that "being a little to the windward of the entrance into the harbor, bore away and run in E.NE. between the breakers, having from 5 to 7 fathoms water. When we came over the bar we found this to be a large river of fresh water, up which we steered." Without knowing of any reliable chart by him, we are of opinion that then there was but one channel, and that over the position now occupied by Sandy island. He evidently came upon the entrance after very favorable weather, because he not only passed over the bar between the breakers with all sail set, but had only made 6 leagues between daylight and noon. He remained eight or nine days in the river, made a rough sketch as far as Tongue Point or Gray's bay, and named the river after his ship, calling it the "Columbia's river."

In October 1792, Vancouver tried to enter the river with the Discovery, but failing on account of the bad state of the bar, he ordered Lieut. Broughton, in the armed tender Chatham, to enter, which he did three days afterwards, and then commenced a survey of the river, carrying it forward in boats to Point Vancouver, in latitude 45° 27′, and returning to his vessel in ten days. He considered the widest part of the river for 25 miles as an inlet. This is the first reliable survey we have of the river. Gray's eye sketch, which extended to about Gray's bay, showed 36 miles from Cape Disappointment, whereas it is only 16, following the course of the northern channel by the most recent surveys. After crossing the bar the Chatham anchored in 4 fathoms, 1¾ mile E. by S. ¾ S. from the eastern part of Cape Disappointment. Within a cable's length of the ship the sea broke very heavily on the western end of a shoal called the Spit Bank, the southern edge of which stretched about E. by N. in a direct line to *Chinook Point,** behind which rises *Scarborough hill,*†

* Its present name, but called Village Point by Broughton, because he here found a large deserted village. He says the natives called it Chenoke.

† Named after an employé of the Hudson Bay Company, who lived here and acted as pilot on the river at and since the time of the United States Exploring Expedition. The Indian name is No-se-misp.

destitute of trees and covered with fern. Well up in *Baker's bay*,* north of the cape, he gives soundings in 3, 5, and 7 fathoms within less than a mile from the shore. From Cape Disappointment the southern edge of an outside shoal extended about 1½ mile SW. by S., stretched W.SW. nearly 2 miles, then trended N.NW. parallel to the outer beach. A great shoal occupied the whole middle part of the river east of Point Adams. Its northern edge ran parallel with and half a mile from the shore between Gray's Point and Ellis' Point,† there being from 7 to 14 fathoms in the channel between it and the shore. From Ellis' Point it then stretched in nearly a straight line to within a mile of Point Adams, where the tail of it had but 2 fathoms; thence curved to the SE. about a mile, and stretched in a long curve to *Tongue Point*,‡ keeping about three-quarters of a mile from the shore abreast of Point George, 5 miles from Point Adams; and in the channel between it and the shore he gives from 3 to 7 fathoms. Starting half a mile inside of Point Adams, and stretching over to the tail of the above shoal, was a bar having but 3 fathoms upon it.

From Point Adams the northern edge of the breakers stretched seaward, first, W. ½ N. about 3¾ miles; next, SW. by W. ½ W. about 5 miles; then took a rounding course to the southward, extending along the coast at a distance of nearly 8 miles. From this point of view (Adams) the north and south breakers were so shut in with each other as to present an entire line of heavy broken water across the channel, which was about 1½ mile wide at the narrowest part, and having not less in any place than 4 fathoms. The outer line of 5 fathoms off the bar bore SW. by W. 5¼ miles from Cape Disappointment.

This channel permitted the heavy western swell to roll in over the bar, and break upon the shoal stretching between Point Adams and Point Ellis. The directions given by Broughton for entering are, to bring Tongue Point, which looks like an island near the southern shore of the river, to bear about E. by N. and then steer for it, crossing the bar in 4 and 5 fathoms.

In stating the distances above, we should mention that Broughton gives the course from Disappointment to Adams as SE. by E. and the distance about 4 miles, whereas it is really 5 miles. Making this change in his base, and all other positions in proportion, we find that Tongue Point comes within half a mile of the determination by the triangulation of the coast survey, proving Broughton's work right, but the base wrong.

From the foregoing description we deduce the following facts: That but one channel existed at the entrance to the Columbia river in 1792; its general direction across the bar was E. by N. ¾ N., passing 1½ mile south of Cape Disappointment; it was 6 miles long from the outer five-fathom line to a line joining Point Adams and the cape; it was 1½ mile wide, and had not less than 4 fathoms in it; that the Spit Bank stretched nearly straight from about a mile east of the cape to Chinook Point. In the space bounded by the three lines joining Cape Disappointment, Chinook Point, and Point Adams, 5 fathoms water was the least found. The deepest channel after getting in was close under the north side of the river eastward of Chinook Point, and that, between the river side of Point Adams and the shoal stretching from Gray's Point towards it, a narrow channel existed with 3 fathoms in it.

Broughton says: "The discovery of this river, we were given to understand, is claimed by the Spaniards, who call it Entrado de Ceta, after the commander of the vessel, who is said to be its first discoverer, but who never entered it; he places it in 46°."

After completing the survey he could not get out for several days, and the Jenny had been unable to cross the bar during the entire time he was up the river.

In 1813, when the English sloop-of-war Raccoon arrived in the Columbia she found the shoals off the entrance had considerably changed in extent and position from the time of Broughton.

British Admiralty Survey in 1839.—In 1839 the entrance was surveyed by Sir Edward Belcher, in the Sulphur, and remarkable changes had taken place. Between Cape Disappointment and Point Adams a large middle bank had formed, and near its eastern extremity a sandy island, with a bank 1½ mile in extent, visible at low water and full of snags and trees. Its northwestern point bore E.SE. 2¾ miles from Cape Disappointment, stretching on this course 1½ mile further, so that its eastern extremity, off which was deep water, bore N. ½ W., 1¼ mile from Point Adams. This island and the bank naturally divided the waters of the river, the greater volume running to the northward of the bank, through *Belcher's* channel, with 7 fathoms

* Named by Broughton after Mr. James Baker, commanding the schooner Jenny, of Bristol, which he found at anchor here upon entering.

† So named on Belcher's survey of 1839; subsequent surveys call it Point Ellice.

‡ So named by Broughton.

in it, and being a mile wide within the limits of the 3-fathom lines until it aproached the cape, where it was contracted to less than half a mile on a line E.SE. from the cape, but having increased its depth to 16 fathoms. This channel had cut away the western end of Spit Bank, as laid down by Broughton. From the cape, which it washed, this channel ran south for 2¼ miles, with an average depth of seven fathoms, and being a mile wide within the three-fathom lines; then it ran SW. ½ W. for 2¼ miles to the bar, expanding in width and decreasing in depth, but in no place giving less than 4½ fathoms upon the bar, which bore S.SW. from the cape, distant 4 miles, and from Point Adams W. ¾ S., distant 6 miles. In the northern angle, where the channel made the east turn, he has laid down a spot bare at low water, with seven fathoms close under it. From the cape it bears S. by W. 2¼ miles.

The main channel eastward of Sandy island was under Chinook and Ellis Points, having deep water off them, but becoming shoaler and intricate beyond them.

Between this channel and the south shores lay the great shoal existing in 1792, not very much changed in features, with a narrow channel running from Point Adams to Tongue Point, having from 4½ to 9 fathoms.

The west end of this shoal stretched out to the line joining Chinook Point with Point Adams, about a mile from the latter, whilst between the tail of Sandy island and this shoal was a channel half a mile wide, and having from 3½ to 4½ fathoms. Between Sandy island and Point Adams ran Queen's channel*, contracting to half a mile wide within the three-fathom lines, one mile from Point Adams, gradually expanding and running in a general direction W. by S. for 3¼ miles, when it divided into two—one running into the north channel through a narrow four-fathom cut, and the other continuing south, forming a *south channel* one-third of a mile wide, and having 3¼ and 3½ fathoms upon it. From Cape Disappointment it bore S. ½ E., distant four miles, and from Point Adams W. by S. ½ S., four miles. Between the two bars, about two miles apart, lay an irregular shoal of small extent, having 2½ fathoms upon it. The joining of the North and Queen's channels enabled a vessel to have a four-fathom channel south of Sandy island, with a leading wind in summer time, while the north was a beating channel.

A spot, bare at low water, existed 1¼ mile from Point Adams, its northern extremity close to Queen's channel, and bearing west from Point Adams. It stretched south half a mile, and was nearly a quarter of a mile in width.

It may not be out of place here to note that the channel on the south side of the river, east of Tongue Point, now known as the *Woody Island channel*, and claimed as a recent discovery, is clearly indicated by the soundings of Belcher.

By a comparison with the partial survey of 1792 very remarkable changes will be seen to have taken place. The first is the formation of the great *Middle Bank**, covering an extent of four square miles within the three-fathom lines, and part formed into an island occupying the track which Broughton, and doubtless Gray and Baker, sailed over with five fathoms; the formation of two channels; the bank on the SW. face of Cape Disappointment stretching 1½ mile southward of its old limit, and almost crossing the only channel of 1792; the existence of the Middle Bank, within half a mile of the cape, and having but one fathom upon its northwest point, where the Sulphur grounded, when Broughton states that he anchored 1¼ mile E. by S. ¾ S. from the inner part of the cape, there being deep water between him and the cape, whilst the Spit Bank, which was within a cable's length of his anchorage, and stretching to Chinook Point, had been cut away by the broad Belcher channel; the cutting away of three miles of the western part of the shoal off Point Adams, and the opening of the channel along the Clatsop beach and south shore, past Point St. George and Tongue Point.

Belcher calls the bank S.SW. of the cape the Spit Bank; and where Broughton's Spit Bank joins Chinook Point, he designates it Chehalis Spit.

In his narrative he remarks "that the shoals in the entrance to this river have most materially changed their features within the last two years."—(Vol. 1, p. 288.)

Survey of the United States Exploring Expedition, 1841.—In this survey we find but one opening to the ocean, with the inside north and south channels combining and passing through it. The soundings are not numerous enough upon and outside the bar to enable its proper form, extent, and depth of water being traced. Not less, however, than four fathoms are shown upon it, and as much as 4½ fathoms are found on one particular line crossing it. Within the five-fathom curve the bar was two-thirds of a mile across, and stretched seaward in the form of a horseshoe from the north to the south breakers.

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* Named by Belcher in 1839.

From Cape Disappointment the shoalest part of the bar bore SW. by S. ½ S., distant four miles; from the norhernmost trees on Point Adams it bore W. by S., distant 6½ miles; this line passing tangent to the north end of the south breaker. Towards the contracted channel inside the bar the north shoal stretches S. ½ W., 2½ miles from the cape, and the great south shoal stretches nearly W.SW., five miles from Point Adams. At a distance of two miles inside the bar these shoals contracted the channel to a width of one mile, and increased the depth to nine fathoms.

From the bar the course in for the north channel was E.NE. for 2¾ miles, when Cape Disappointment bore N. by W.; then N. ½ W., 3¼ miles, to the inside of the cape, off which the channel was less than half a mile wide, with five fathoms close under the bluff, and 17 fathoms in the deepest part. After passing the cape one-third of a mile the channel was wide, regular, and deep for four miles, running nearly E. by S. ½ S. towards Young's Point, and passing between the bare parts of the middle bank forming Sandy island, and the Chinook shoal. At the eastern end of Sandy island the north and south channels came together for three-quarters of a mile, with a depth of 4¼ fathoms, and the middle bearing north 1¼ mile from Point Adams. The great middle shoal then separated them, and the north channel ran close under the shores at Chinook Point and Point Ellis, contracting and shoaling to three fathoms where the Tongue Point channel entered

From the bar the course for the south channel was E. by N. ½ N. for 6¼ miles, running within three-quarters of a mile of Point Adams with five fathoms; thence along the Clatsop beach E. by S., 3½ miles in a good channel, half a mile wide, and having from six to eight fathoms of water; and finally NE. by E. 2½ miles, passing Young's Point, and running close under the southern shore near Astoria.

The middle bank* was nearly triangular, with one point abreast of Cape Disappointment; the second, 1⅓ mile N. by W. from Point Adams, and four miles E. by S. ¾ S. from the cape; and the third at the confluence of the channels inside the bar, and 2¼ miles SE. by S. ½ S. from the cape. Each side was, therefore, about three miles in length. Sandy island was then composed of two parts; the eastern end of the larger and southern one bearing N.NW. 1¼ mile from Point Adams.

The western tail of the great middle shoal,† lying eastward of Point Adams, bore from that point about N.NE., a little over a mile distant, and in range to Chinook Point; from Cape Disappointment it bore E. by S. ¼ S., distant 4¾ miles.

The map of the survey of the United States Exploring Expedition shows the distance from Cape Disappointment to Point Adams as being only 4½ miles, with the bearing SE. by E. ⅛ E. The distance should be almost five miles, according to the triangulation by the U. S. Coast Survey.

The channel on the south side of the river and east of Tongue Point, mentioned as being clearly indicated by the admiralty survey of 1839, was developed by the U. S. Exploring Expedition in 1841. It was named the Boston channel, and strikes the north shore channel 7½ miles above Tongue Point, and about one mile above the Pillar rock.

The changes that had taken place since Belcher's survey, two years previous, were: that the south sands had stretched westward over the entrance of Queen's or the south channel; and that channel had joined with the north and emptied over one bar, which was almost identical in position and extent with the survey of 1839.

The north channel was, therefore, little changed; it had several lumps with only four fathoms upon them; its general direction was the same; it had at least a fathom more than the south channel, and retained the same shape and direction after passing inside the cape.

The contour and position of the middle bank was nearly the same, but its eastern point had moved nearly half a mile to the NW., giving deep water where Belcher placed the eastern part of Sandy island, whilst the western islet occupied nearly the same position as formerly.

The western extremity of the great middle shoal, east of Point Adams, was hardly changed.

The course in over the bar, and through Queen's or the south channel, was straight for over six miles to abreast of Point Adams, and then ran in the same direction as in 1839.

The United States sloop-of-war Peacock was lost on the north shoals, 1½ mile S. by W. from Cape Disappointment.

* Called Middle sand bank by the U. S. Exp. Exp., 1841.

† Called the Upper sand bank by the U. S Exp. Exp., 1841.

SURVEY OF 1850.

This, the first examination by the Coast Survey, was undertaken under peculiar difficulties which were successfully overcome.

In this survey we find the formation of a new south entrance, but evidently of so recent date that the bar at the entrance cannot be said to have over 16 feet upon it, although two very narrow passages on either side of the middle ground of the bar give three fathoms. From Point Adams this bar bore SW., distant 3¾ miles, being S.SE. 5¼ miles from Cape Disappointment light-house. Inside the entrance, within the three-fathom curve, the width of the channel was half a mile, increasing to over a mile, and the depth of water regularly increasing to 14 fathoms off Clatsop spit, 1½ mile from Point Adams, on a line to Cape Disappointment. The direction of the channel was straight, N. by E. ½ E. to Sandy island, rounding Clatsop spit, and running close to and parallel with the beach east of Point Adams, with a depth of from four to eight fathoms. From the outside of the bar the south edge of the south shoal stretched toward the shore, the bottom changing from hard sand to soft mud in approaching the beach.

The extent of the north bar had so much increased that it is difficult to describe, for it had an area of over two square miles, with from 4 to 5½ fathoms upon it, and the bottom varying from hard sand to soft mud. The middle of it lay south 3¾ miles from the highest part of the cape. Within the three-fathom line the entrance was 1½ mile wide, and in ordinary weather was marked by a line of breakers on either side. The course was nearly straight to the inner point of the cape, with the depth of water increasing to 11 fathoms abreast of it, where the channel was a little over a third of a mile wide, with the Sulphur spit on the east side. Passing the cape, and turning eastward and then E.SE., the three-fathom channel was crooked, and in one place only 400 yards wide.

The north and south bars bore from each other SE. and NW., distant 3½ miles apart, with the seaward face of the middle bank making a direct line on that course. This bank had changed its contour, and was very irregular.

W.SW. of Sulphur spit a three-fathom channel had nearly cut through the north sands. Should a channel open here it would doubtless remain a reliable one. From Cape Disappointment it bore SW. ½ W., 1½ mile distant.

Sandy island bore E. by S. ¾ S., three miles from the cape, and NW. ¼ N., two miles from Point Adams.

The western tail of the great middle bank bore NE. by N. ½ N., a mile from Point Adams.

At the time of this survey the channels were buoyed out, but subsequent gales displaced the buoys.

We note the following changes since the survey of 1850, a little over two years:

That the new south channel had been developed, and the bar moved three-quarters of a mile eastward, with half a fathom more water and the entrance wider.

That the north channel had contracted to half its width at the bar, with its northern line upon the line of 1850; the depth of water not quite so great, but still having a fathom more than the south bar, the channel not as straight, and the formation of a swash channel SW. of the cape across the north sands.

That the Spit bank of 1792 was being redeveloped.

That the middle bank had increased in size, and Sandy island moved over a quarter of a mile W.NW., giving eight fathoms of water where the beacon of 1850 stood, and the bifurcation of the bank, bare at low water, west of it. Compared with the surveys of 1839 and 1841, we find that one part of Sandy island has retained the same position, but that a mile, stretching E. by S. ½ S., has been completely cut away, and is now crossed by the south channel.

That the Clatsop spit has changed its shape, trending more to the westward.

And that the western tail of the great middle bank, east of Point Adams, occupies the position of 1839 and 1841.

No survey has been made subsequent to that of 1852, but we can state, from personal observation, that in October, 1857, the south bar was within less than a mile of the beach south of Point Adams, and that the channel ran nearly parallel with, and not distant more than three-quarters of a mile from the shore. It was unavailable with a very heavy sea on, as a vessel had to run it in the trough of the sea, and for sailing with a NW. wind it was a dead beat. We entered the north channel in May, 1857, and found it wide and straight. It was reported to have one fathom more water on the bar than the south. Those of the old buoys that remained were of no use, on account of having been carried from their proper stations.

Conclusions.—From all these examinations, aided by plotting the outlines upon the same sheet and to the same scale, from corroborative evidence, and from personal observation, we find that the south point of the north sands stretching out from Cape Disappointment has remained nearly the same since 1839, bearing S. ¾ W. from the light house, distant 2½ miles; has not varied its position half a mile; has never reached the southern shoal of 1792; and that the bar has never had less than four fathoms upon it, thereby indicating that this entrance and channel is the less changeable, and has a fathom more water than the other, and that, with well-appointed buoys off its entrance, and range beacons on Sandy island and Chinook Point or Scarborough Hill, it will always prove the safer and better for the interests of the country.

The position of the south entrance is continually changing, and the same causes that closed it between 1839 and 1841 will again close it.

The great middle bank, stretching from Point Ellis nearly to Point Adams, remains almost the same since its first determination.

The formation of Sandy island precludes the probability of the channel returning to the capacity which existed at the period of Broughton's survey in 1792.

In 1859 we published the following remarks in relation to river and bay deposits, and especially those forming Sandy island: "A large drift tree whose roots embrace a mass of hard clay or stones sufficient to give the whole mass a slightly greater specific gravity than water may very readily be carried outward by the strong effluent current of the Columbia, and especially in the season of freshets; but when the current slacked the root of the tree would remain upon the bottom, sink into the sands, and continue stationary whilst the remaining movement of the current would be able to shift the loose sand and deposit it around the roots, where it would remain during slack-water. After a slack of half an hour, during which time the waves would give motion to the mass to work it deeper in the sands, the flood current making feebly at first, would then add more sand to the already incipient deposit; should this flood be a small one, or other favorable circumstances conspire, the tree or trees might, during the one slack-water, be firmly enough fixed to resist the action of the flood."

During the heavy freshets, late in 1861, immense trees floated down the river in a nearly perpendicular position, their roots holding amongst them large quantities of earth and stone torn away when the bluff banks were undermined by the rush of the currents. Such causes may have led to the formation of Sandy island.

Hydrographic reconnaissances and views of the entrance to the Columbia river were issued from the Coast Survey Office in 1850 and 1851.

POINTS INSIDE OF COLUMBIA RIVER ENTRANCE.

Sandy island, (1851.)—It is about one-third of a mile long, E.NE. and W.SW., by 250 yards in width, and consists of loose sand raised a few feet above the river, and covered with drift logs, trees, &c. To the westward of it extend two sand bars nearly a mile in length, and bare at low water. The surveys of 1839, '41, '50, and '52 show that this part of the middle bank has occupied one position, and will doubtless retain it. In 1792 the main channel of the river passed over this position, and a line of soundings in five fathoms ran across it. Considering the immense amount of huge trees coming yearly down the river, we can readily imagine the manner of its formation. A large beacon, erected upon it, distinguishable outside the bar, and ranging with another on Scarborough Hill, would serve to denote the position of the north channel.

From Cape Disappointment light-house it bears E. by S. ½ S., distant 3⅙ miles.

It received its present name from Belcher in 1839. On the Coast Survey charts it is called Sand island.

Chinook Point, on the northern side of the river, lies N. by E. 2¾ miles from Point Adams, and E. ¼ N. 4¾ miles from Cape Disappointment. It is a long, low sand strip at the base of the high wooded hills behind it. One of the hills, called Scarborough, is readily recognized by a great part of its southern slope being destitute of trees and covered with fern; no other hill near this vicinity possesses this peculiar feature.

A number of fishing and Indian huts are situated upon the Chinook beach, the people being engaged in catching and curing salmon, with which the waters abound. The mode of catching them is by means of nets; those of Indian construction being made of twine spun from the fibres of the spruce roots, and sometimes from a peculiar grass obtained from northern coast Indians. The mode of curing is very rude and inefficient, and thousands of barrels that have been shipped have proved worthless. There is no reason why this should not become a large and profitable branch of business. The fish are the largest on the coast, often exceeding 80 pounds weight. We have purchased them weighing between 50 and 60, caught upon the beach at the sea base of Cape Disappointment. They commence to run about the end of May, and become remarkably plentiful by the third week in June. The Indians suppose that the salmon, coming directly from the ocean, linger about the entrance several weeks before starting up the river, because they require time to become accustomed to the fresh water; attributing to a wrong cause this normal habit of the salmon.

Chinook Point was the special location of the once powerful tribe of Chinook Indians, and here the celebrated one-eyed chief, Concomly, held sway. The tribe has dwindled to less than a hundred persons—men, women, and children—and they are poor, miserable, drunken, diseased wretches.

The point was called Village Point by Broughton in 1792.

In 1839 it was called Chenoke Point by Belcher. The Indian name is Nóse-to-ilse.

Point Ellis, on the northern side of the river, is $2\frac{3}{4}$ miles, nearly east of Chinook Point; the sand beach between the two being in some places nearly a mile wide, running at the base of the hills, and surrounding a large lagoon near Chinook. From Point Adams it bears NE., distant $4\frac{1}{3}$ miles.

Behind Point Ellis rise two hills, the southern of which is used as a range with Point Adams for denoting the entrance to the south channel, but, of course, the relative positions vary with every change of the bar.

It was named Ellis Point by Belcher in 1839, and Point Ellice by the United States Exploring Expedition in 1841, and this spelling is found upon all recent maps.

The Indian name is No-wehtl-kai-ilse.

Point George, on the southern side of the river, is the first point made after passing eastward of Clatsop beach. Immediately behind it the land is high and densely wooded; and around its southern face opens Young's river.

It was called "Point George" by Broughton in 1792; "George Point" by Belcher in 1839; "Young's Point" by the United States Exploring Expedition in 1841; "Smith's Point" by the Coast Survey, in the triangulation of 1852; but it is, we believe, generally known as *Young's Point*.

Astor Point, on the southern side of the river, lies E. $\frac{3}{4}$ N., distant $5\frac{1}{3}$ miles from Point Adams. It is low at the river bank, but has moderately high wooded land behind it. The southern channel passes close to it. The name is derived from a Coast Survey triangulation and secondary astronomical station upon it, but it is in reality a part of Point George.

The geographical position of the station, which is about a quarter of a mile westward of the bay, in front of the town, is:

	°	′	″	
Latitude	46	11	27.6	north.
Longitude	123	49	32	west.
	h.	*m*	*s*	
Or, in time	8	15	18.1.	

Tongue Point, on the southern side of the river, bears E.NE. $8\frac{3}{4}$ miles from Point Adams, and NE. $\frac{1}{2}$ E. $3\frac{1}{2}$ miles from Astor Point. It is a high, bold bluff covered with trees, and connected with the main by a moderately low, narrow strip of land. As first made, off the entrance, it appears like a low wooded island. Close to it runs the Woody Island channel, which is plainly foreshadowed in Belcher's survey of the river. The Indian name of Tongue Point is Soo-kum-its-é-ak.

Between the last two points lie the rival villages of Upper and Lower Astoria. The lower is the western, and on the location established by the Pacific Fur Company in 1811, and to which was given the name of Astoria. A large saw-mill is in operation here, and a military post was established, but abandoned a few years since. The place contains less than fifty houses, and at one time, as a landing place, had an unenviable reputation on account of the character of the "beach-combers."

The name of the place was changed to Fort George in 1813, on being taken by the sloop-of-war Raccoon. The original name was restored in 1818.

At Upper Astoria is located the custom-house, off which is the rendezvous of the United States revenue cutter. A large saw-mill is built here, and a government military road is being opened to Salem, on the Willamette river. Between the village and Tongue Point lies the wreck of the Silvie de Grace, around which a shoal has formed.

Cape Broughton is on the north side of the river, N.NW. $3\frac{1}{4}$ miles from Tongue Point, and NE. $\frac{1}{4}$ E. $5\frac{3}{4}$ miles from Ellis Point.

It was named by Belcher in 1839, but was called Gray's Point by the United States Exploring Expedition. This last designation was also applied by the Coast Survey in 1852.

The head between Ellis Point and Cape Broughton was named Chatham Head in 1839.

Gray's bay lies to the NE. of Cape Broughton, and was named, in 1792, in honor of Captain Gray.

Young's bay lies between the eastern part of the Clatsop beach (called Tansey Point) and Point George. Into it empty *Young's river*, discovered, examined, and named by Broughton; Lewis and Clarke's river, examined by them in 1805; and one or two small streams or sloughs.

Baker's bay lies between Cape Disappointment and Chinook Point. It runs $2\frac{1}{2}$ miles to the northward of the cape, and receives the waters of the small streams which head toward Shoalwater bay, and connect with them by a small portage. The western and largest stream is the Wal-la-khut; the eastern, half-way between the cape and Chinook Point, is the Wap-pa-loo-che.

Two or three houses on the shore of the bay, and a saw-mill, are all that remain of the settlement once designated as "Pacific City." The bay was named in honor of Captain Baker, whom Broughton found anchored here in the schooner Jenny, of Bristol, when he entered.

The Columbia river was called the "Oregon" from the mere mention of that name by Carver in 1766. Much doubt exists as to the origin of the name.

In 1775 it was called "Assumption Inlet" by Heceta, but afterwards the Rio de San Roque, from his naming the northern cape San Roque; and also the Enseñada de Heceta.

In 1789 Meares called it "Deception bay."

In 1792 it was named the "Columbia river" by Gray.

Clarke says that, in 1805, the Indians knew it as the Shocatilcum, and another name obtained from another body of the natives was Chockalilum; the two being evidently the same word differently pronounced; the accent should be on the penult.

When the name given by Gray was first changed we cannot state. It was, perhaps, done by Vancouver or Broughton.

Lewis and Clarke, in noticing the growth of trees on the Columbia, mention a fir near Astoria that was 230 feet high, and 120 feet of that height without a branch. Its circumference was 27 feet. This same tree is doubtless referred to in the narrative of the United States Exploring Expedition, where the dimensions are given as follows: $39\frac{1}{2}$ feet in circumference at eight feet above the ground; bark, 11 inches thick; height of the tree 250 feet, and perfectly straight. Visitors used to be shown "the big tree" as one of the notable sights of the locality.

Belcher says that "the timber of the Columbia, either for spars or plank, cannot be compared to that of higher latitudes; for topmasts and topgallant masts it is probably as tough, but heavier. * * * * Probably no part of Western America can produce timber of the dimensions grown in the regions of the Columbia and the northern confines of California. Amongst the *drift* trees, on the banks of the Columbia, we measured one 174 feet long by 20 feet in circumference, and many 150 feet by 13 to 18. These, of course, were washed from the banks, and therefore not the largest, which grow invariably in the thickest part of the wood."—(Vol. 1, p. 300.)

In Baker's bay, in 1851, we measured a drift tree which had been thrown upon the beach. It was 267 feet long, 27 feet in circumference with the bark peeled off, and where broken at the small end 20 inches in diameter. Very frequently, when trees are felled for cutting into lumber, the first 30 or 40 feet of the trunks are found too large for the saw-mill, and have to be cut off and left on the ground.

GENERAL COURSE OF THE COLUMBIA RIVER.

From the entrance to the mouth of the Cowlitz river the general course of the Columbia is E. by N., and the distance in a straight line 46 miles from the bar, and by the windings of the river about 52 miles. The Cowlitz runs N.NW. for 24 miles; thence NE. to its headwaters in the Cascades; it is navigated by canoes about 28 miles to the Cowlitz landing. The stream is very rapid, and boats have to be poled the greater part of the way; at high stages of the water they are pulled up by hauling upon the bushes growing upon its banks. At the Cowlitz landing travellers take mules or horses through to Puget's sound, a trip of 52 miles. On the west bank of the Cowlitz, five miles above its mouth, are a few small houses, locally known as the town of Monticello. On the south bank of the Columbia, opposite the Cowlitz, is another small settlement, called Rainier.

From the Cowlitz the next course of the Columbia is S. 32° E. for 29 miles to the mouth of the *Willamette river**. About 16 miles above the Cowlitz the Warrior branch or slough of the river makes in

* A corruption of the Indian name Wallamut. This stream is the Multnomah of Lewis and Clarke, 1805.

from the west side and runs around Multnomah island, coming into the Willamette two miles above its mouth. The Willamette continues the same general course of the Columbia for 16 miles to the falls, where is situated the town of "Oregon City," destined to become a place of importance, on account of the extensive water-power; the river there falling perpendicularly 38 or 40 feet. Six miles lower down on the Willamette is the rapidly improving town of Portland, situated at the head of ship navigation, with a population of nearly 5,000. The valley of the Willamette is well settled, contains several thriving towns, and is remarkably productive.

The river takes its rise on the western slope of the Cascade range, about latitude 43¾°, between the snow peaks of Mount Jefferson and Mount Laughlin; then runs westward to within 50 miles of the coast, and nearly in the latitude of Cape Perpetua, turning sharply to the northward, and very slowly leaving the coast.

From the mouth of the Willamette the general course of the Columbia to Fort Walla-Walla is NE. by E. ½ E., 170 miles.

Five miles above the Willamette, on the north side, is the military post of Fort Vancouver, which, with the town of Vancouver, covers part of the grounds formerly occupied by the Hudson Bay Company as a mercantile station, but then designated as Fort Vancouver. The Hudson Bay Company still have a trading station here, but their farms and grazing lands have been occupied by settlers. The site for a town is one of the most beautiful on the river, and capitally located for increasing trade.

About 30 miles further up the river we reach the foot of the Cascades, which are a series of rapids four miles long, where the river bursts through the eastern part of the Cascade range of mountains, whose basaltic walls rise precipitously over 3,000 feet on either side, presenting a magnificent sight. Below the rapids the current rushes by with great velocity and depth, but small steamboats ply regularly from Portland and Vancouver to the foot of the rapids; thence passengers are carried by stages to the head, where one or two fine steamboats convey them 50 miles to the Dalles. The Hudson Bay Company carried their large trading boats up the rapids by a system called cordelling. Steamboats have gone up one or two miles, and, in one instance, a brig, with every sail set and a moderate gale astern, was carried safely to the foot of the railroad, which runs from the head to within a mile and a half of the lower end. At each extremity of the rapids are small military posts.

The snow peaks of the volcanic Mount St. Helens and Mount Hood lie exactly in line with the Cascades, the former NW. ¼ N., 35 miles distant; the latter SE. ¼ S., 28 miles distant.

Mount Hood is an extinct volcano covered with cellular lava, and, according to Dana, is between 15,000 and 16,000 feet high. According to other authorities, it attains an elevation of 18,316 feet.

At the Dalles the river is contracted between narrow perpendicular walls, and during freshets rises 100 feet above its ordinary level.

East of the Cascades the forests cease, and above the Dalles stands the only tree in a stretch of 60 miles beyond Walla-Walla, where the river makes a great bend to the northward, in the direction of its source at the base of the Rocky mountains.

On the lower part of the Columbia and Willamette many saw-mills have been erected since the gold discovery in California, and a large trade was carried on in lumber. Between San Francisco and Portland a very large and increasing general trade exists.

The weather off the Columbia entrance is cold and wet, with occasional thunder-storms, but these are rare. Vancouver says he saw several water-spouts off it in October, 1792; some of them were quite near his vessel.

SHOALWATER BAY.

The bold cliffs of Cape Disappointment, after extending about three miles northward, change suddenly to a low, broad, sandy beach, running N. by W. ½ W. 18 miles, in nearly a straight line to the southern point of the entrance to Shoalwater bay. A mile and a quarter behind this beach lies the southern arm of the bay. Its waters reach within a mile or two of the north side of the cape, and the portage from them to the Wappalooche, emptying into Baker's bay, is said to be about a mile long, and always used by the Indians and settlers. The peninsula thus formed is covered with trees and a dense undergrowth of bushes. Within half a mile of its extremity it becomes very low and sandy, and has a covering of coarse grass, but no trees. This point was called Low Point by Meares in July, 1788. On the recent Coast Survey charts it is named Leadbetter Point. The Indian designation is Chik-lis-ilh. Its approximate geographical position, as given by the Coast Survey, is:

	° ′ ″
Latitude	46 36 45 north.
Longitude	124 00 45 west.
	h. m. s.
Or, in time	8 16 03.0

The computed magnetic variation, 20° 35′ east, July, 1851, with a yearly increase of 1′.

CAPE SHOALWATER.

From Leadbetter Point the north cape bears NW. by N. ⅜ N., 5½ miles distant. Half a mile of the cape is low, sandy, and destitute of trees, but some tolerably high land covered with wood rises immediately behind it, being the only elevated ground between Cape Disappointment and Point Grenville that approaches the shore-line. On account of this formation of the point it has been said that the entrance resembles that of Columbia river. We have been unable to detect any resemblance after passing near it several times. The isolated position of Cape Disappointment and the seaward face of its bold cliffs without trees form a peculiar feature. This, with Scarborough Hill, partly bare, lying five or six miles east of it, the high mountains inland, and in clear weather the beautiful snow-peak of Mount St. Helens, have no counterparts at Cape Shoalwater, and should remove all doubt in regard to general resemblance.

The point was named Cape Shoalwater, and placed approximately in latitude 46° 47′ by Meares in July, 1788. In 1792 Vancouver assigned the latitude of 46° 40′. It was viewed from the north side of Cape Disappointment by Lewis and Clarke in 1805, and called Point Lewis, but is now frequently known as Toke Point, from the name of an old Indian chief living here in 1854. The Indian name of the point is Quahpt-sum.

LIGHT-HOUSE AT CAPE SHOALWATER.

The light-house at the north point of the entrance to Shoalwater bay is a structure consisting of a keeper's dwelling, with a tower rising through it and surmounted by an iron lantern, painted red. Its height is 41½ feet above the ground, and about 87 feet above the mean level of the sea. The dwelling and tower are plastered and whitewashed, and situated about a mile from the extremity of the cape. The illuminating apparatus is of the fourth order of Fresnel, shows a *fixed white light varied by flashes*, and should be seen from a height of—

10 feet at a distance of 14¼ miles.
20 feet at a distance of 16 miles.
30 feet at a distance of 17 miles.

It was first exhibited on the 1st of October, 1858, and shows from sunset to sunrise. The approximate geographical position of the light, as determined by the Coast Survey, is:

	° ′ ″
Latitude	46 44 11 north.
Longitude	124 02 24 west.
	h. m. s.
Or, in time	8 16 09.6.

This light is sometimes known as Toke Point light. It was discontinued September 1, 1859, and relighted (date not known.)

The topography of the vicinity has not been executed.

ENTRANCE TO SHOALWATER BAY.

There having been no survey of Shoalwater bay previous to the preliminary one of the Coast Survey in 1852, and the completion of it in 1855, it is impossible to state what changes have taken place. Judging by the changes of the Humboldt, Umpquah, and Columbia bars, we should conclude that similar effects take place here. In less heavy weather than would cause the sea to break on the Columbia river bars, it breaks here with fury quite across the entrance. This description applies to 1852. Charts have been published by the Coast Survey of the respective dates already mentioned.

Four miles off the entrance a depth of 10 fathoms is found, and when well off shore a high double-peaked mountain shows to the eastward, well inland. Meares noticed it, and placed it in latitude 46° 30′, quite close to the coast, designating it as Saddle mountain, a name it still retains, although one of the same name is found SE. of Point Adams.

At the present time there are two channels, denominated from their position the *north* and *south channels*, with a large shoal called the *middle sands* lying between them, and partly outside of the line joining the two points.

The bar at the *south channel* has four fathoms of water upon it, is a mile wide, and lies two miles off the beach south of Leadbetter Point, with the northernmost trees bearing NE. by E. Running in on this line a vessel shoals her water from 10 fathoms three miles off shore, to 4 fathoms two miles off; then gradually deepens it to 5 fathoms, when she should haul close up under the point of breakers northward of her, and about half a mile distant; run along in from 6 to 7 fathoms until abreast of the low grassy point, when the course of the channel will be N. by W. ½ W. for 1½ mile, with from 8 to 10 fathoms, hard bottom, its outline being well marked by the breakers outside. From thence a course NE. by N. for two miles will lead to 18 fathoms, and over a mile inside the line joining Leadbetter Point and Cape Shoalwater, the western trees on Leadbetter Point bearing S. ½ E., 3¾ miles distant. If the tide is low, sand bars and flats will show on both hands, one directly ahead; the broad deep channel to the southeast distinctly marked by bare patches on either side, and a narrow deep channel to the northwest running into the north channel. From the last position the western trees on Leadbetter Point bear south, distant four miles. The greater body of water passes through this channel, and the current runs very strong. In summer, with a northwester blowing, it is a dead beat after passing the bar, and in some places the channel is less than half a mile wide between the three-fathom lines. Coasters do not enter it except with a southerly wind, and always pick out the channel from aloft. In summer they have a leading wind out, and start on the first of the ebb.

The bar at the *north channel* has about 3¼ fathoms upon it, and bears SW. by S. ¼ S., three miles from the southern extremity of Cape Shoalwater. It is about a mile in extent within the three-fathom line.

In making the bay from the southward in summer, work to the northward of Cape Shoalwater, then run in and follow the shore outside of the breakers in six or seven fathoms, gradually approaching them, and decreasing the depth to 4½ and 4 fathoms, when the southern side of the elevated ground of the cape bears NE. by N. ½ N. Then head up as near that course as possible, crossing the bar in 3¼ fathoms, and continuing in that depth for at least a mile and a quarter, taking care not to decrease it on either hand. Keep under the breakers on the north side in from 5 to 7 fathoms, hard bottom, and increase the depth to twelve well inside the point, when its southern extremity should bear NW. ½ W., distant 1½ mile. If it is low water, sand banks will show in different directions, and the channels will be tolerably well marked.

The present invariable practice of vessels entering is to seek out the channel from the mast-head. In calm weather the channels must be known, or a pilot employed, if one is to be found.

The north bar bears NW. by N. ⅜ N., distant five miles.

The *middle sands* lie between the two channels. The southern tail is SW. 1¾ mile from Leadbetter Point, runs NW. by N. ⅜ N. for 2¼ miles, then N.NE. 2¼ miles, and E.NE. 1½ mile, with an average width of 1¼ mile. One mile outside of it soundings are found in 7 fathoms.

This bay, as its name implies, is so full of shoals that at low tides about one-half of its area is laid bare. Good but narrow channels are found throughout its extent, but no direction can be given for running them Without a knowledge of them, or without a pilot, follow them only at low water. The currents then run with great velocity, and it is very difficult and frequently impossible to keep a course against them. The arm stretching southward toward Baker's bay is 15 miles long from Leadbetter Point, with an average width of not less than 3½ miles, whilst the upper portion stretches to the NE. for nine miles to the north of the Whil-a-pah river, reckoning from the middle of the line joining Cape Shoalwater and Leadbetter Point.

The principal stream emptying into the bay is the *Whil-a-pah*, at its northeast part. At about nine miles from Cape Shoalwater it is less than a quarter of a mile wide, with low swampy banks and steep bluffs on each side about a mile and a half apart.

The mouth of the *Palux*, or Copalux, lies five miles NE. ½ E. from Leadbetter Point. It is half a mile wide at its mouth, contracts very much in two miles, and is bordered by marshes, with numerous sloughs running through them.

The *Násal* enters about eleven miles south from the Palux, and abreast of the middle of Long island. It has over 20 feet water at its mouth, with bluff banks for some distance, until it begins to expand, when it is bordered by flats.

Several streams open from the north side of the bay. One of these, the Necomanche, near the Whil-a-pah, has six feet in the main channel, and shows 1½ mile wide at high tide.

There are three islands in the bay. ***Pine island,*** about 1½ mile NW. by N. off the mouth of the Palux, is a small sand islet of only four or five acres in extent, and occupied by oystermen. It is near the channel and oyster beds which stretch for a couple of miles to the N.NE. of it. The Indian name of this island is Nass-too. The north end of ***Long island*** is eight miles from Leadbetter Point. This island runs irregularly about SE. for six miles, and has an average width of 1½ mile. It is covered with a dense forest of fir and undergrowth. One mile S.SE. of Long island is a very small islet called *Round island,* of only a few acres in extent, covered with wood and bushes. The shores of the bay, except on the peninsula, are mostly composed of low, perpendicular cliffs of a sandy clay, in which are strata of recent fossil shells and the remains of trees. Where the faces of the cliffs are not washed by the waters of the bay they slope gently, and have a small grassy shore at their base.

NE. ¾ N., distant six miles from Leadbetter Point, is a sharp narrow cliff, 60 feet high, making out into the bay, which is wearing it away, and has exposed many large basaltic boulders. No other place on the bay presents this geological feature.

The *peninsula* is a long, flat, marshy, and sandy plain, elevated but a few feet above the level of the sea, and covered, like the entire surface of this country, with a dense growth of gigantic forest trees, principally spruce, fir, and cedar, with a few specimens of maple, ash, and black alder. The spruce frequently attains a diameter of eight feet. The Indian name of the peninsula is Tee-choots.

The shoals are covered with shell-fish, among which the oyster is the most abundant, and the principal article of export. They are small and have a coppery taste. Codfish and halibut abound; sturgeon, said to be of good quality, are plenty, and salmon of several varieties and excellent flavor exist in infinite numbers. In spring vast shoals of small herring enter the bay. In winter wild fowl are innumerable, but these have been made shy by the bad shooting of the Indians. Black and white swan, geese, mallards, canvas-backs, &c., always reward the experienced sportsman.

The yearly shipment of oysters is about 30,000 bushels, and of piles and spars about 30,000 feet. The average valuation of exports is $120,000. The number of vessels entering yearly is about 25, nearly all of which are schooners, counting an aggregate of 2,500 tons. In 1855 the population on the bay was 190 males and 60 females.

This bay was discovered by Lieutenant John Meares, July 5, 1788, in the Felice, when proceeding in search of the Rio de San Roque of Heceta. He approached it until the water shoaled to eight fathoms, when the breakers ahead warned him to haul off. "From the mast-head it was observed that this bay extended a considerable way inland, spreading into several arms or branches to the northward and eastward, and the mountainous land behind it was at a great distance from us." He saw "what appeared a narrow entrance at the northwest part of the bay," but it was too remote for him to discover whether it really was so, or only low land. "From under the [low] point a canoe came out, containing a man and boy," &c. Unsettled weather prevented his sending in the long-boat to sound near the shoals, in order to discover whether there was any channel. He called it Shoalwater bay.

Vancouver endeavored to enter in 1792, but, as it was breaking across the whole entrance, he considered it inaccessible to his vessels. He says, "The sandy beach was bordered by breakers extending three or four miles into the sea, and seemed to be completely inaccessible until 4 p. m., when the appearance of a tolerably good bay presented itself," and the point to the north was "somewhat more elevated than the rest of the coast," and in latitude 46° 40′.

It is not laid down on the coast chart of the United States Exploring Expedition.

It is asserted by settlers here that boats, canoes, &c., which have broken adrift and gone out of the bay, have, in every instance, been found on the beach north of the entrance, and generally between it and Gray's harbor.

From Cape Shoalwater to Point Hanson, the southern side of the entrance to Gray's harbor, the distance is 13½ miles, and the hard ocean sand beach furnishes an excellent road that can be travelled at half tide by wagons. The slightly elevated sandy bank is level, covered with coarse grass, and free from timber for nearly half a mile back, and to within two miles of the harbor. Back of this and parallel with the coast is a cranberry meadow, six miles in length, and separated by a narrow belt of scrubby fir. This meadow is drained by two small rivulets forcing their way through the sand to the ocean. San Francisco is the market for the cranberries, which are gathered by Indians and carried to Shoalwater bay and Gray's harbor. Land otter and beaver have their homes around the meadows and small streams.

GRAY'S HARBOR.

In our description of this bay we can state nothing from personal experience. It is drawn up from the reports accompanying the recent surveys of 1860, '61, and '62, and accounts received from persons who have examined it.

The entrance to the bay is formed by *Point Hanson* on the south, and the southern point of *Eld island* on the north. The northern end of this island is connected with the outer part of *Point Brown* at low water, but at high tide the beaches are one-quarter of a mile apart. The south end of the island lies N. 59° W., 1⅝ mile from Point Hanson; its length is 1¾ mile, and direction N. 50° W., with a breadth of two to four hundred yards. Half-way between Point Hanson and the island lies the northeast end of a shoal or middle ground, bare at low water, and stretching S. 15° W. for 1¾ mile, with an average breadth of three-eighths of a mile. Between the northeast end of this shoal and the south end of Eld island passes the channel, with a width of less than five-eighths of a mile and a depth of 16 fathoms.

We cannot state the position of the bar with relation to any of the above points.

In 1860 the surveying brig Fauntleroy, drawing ten feet of water, laid off the bar several days, the heavy breakers along the whole shoal allowing no clue to the bar, and the depth of water upon it unknown. At a comparatively smooth time the bar was sounded with a boat and the vessel followed, crossing on the last quarter of the ebb with 2½ fathoms. In 1861 the entrance was reported tolerably good, and comparing favorably with the other bar harbors north of San Francisco. In June, 1862, the same vessel laid off the bar several days, and finding no possibility of crossing, ran into Shoalwater bay, and the party being unable to procure a pilot that could carry her into Gray's harbor, had to work from the former bay. There were only three days during the season when work could be executed on the bar, and the result showed that no well-defined channel then existed across the bar, which was very uneven, lumpy, and in one place had only nine feet upon it. The channel was not straight, as anticipated, but the seaward end curved well to the northward. The Coast Survey chart of the entrance is about to be published.

At the time of Whidbey's survey, under the orders of Vancouver, a bar existed off the entrance, having the following position: From Point Hanson, SW. by W. ½ W., 3½ miles distant, and from Point Brown, SW. by S. ¼ S., four miles distant. He does not give the depth of water on the bar in his chart, but in the narrative states it to be three fathoms. From this bar the channel was a mile wide, and straight to the entrance between the points, was well marked by the breakers, and had from 4 to 10 fathoms in it until nearly abreast of the points, where it was contracted to half a mile, and the depth increased to 14 fathoms. Then it opened suddenly to both points, with from three to six fathoms between them. The course in, over the bar and through mid-channel, was NE. ¼ N., for 3¼ miles to between the points, with two low sand islands in range on the course, and 6½ miles from the bar. A narrow channel existed on either side of these islands towards the Chehalis; the southern channel having from three to four fathoms, and that on the north side five or six.

Whidbey believed the bar to be shifting, there being a very apparent difference in the channel between the times of his arrival and departure, when it seemed to be wider and shoaler. A dry sand bank which lay bare near their anchorage on the first evening, on the north side of the channel, was, at his departure, entirely washed away by the violence of the sea, which had broken incessantly upon the shoals and bar.

In the indentation southeast of Point Hanson lay an island with a channel on either side, but that on the west was the better. Both led to the mouth of a small stream coming in from the east. He also gives a four-fathom channel on the east side of Point Brown peninsula, and surveyed two miles up.

In 1841, in the survey by the United States Exploring Expedition, we find no island in the middle of the bay, nor any east of Point Hanson, but a large one 1¾ mile long by half a mile wide in the middle of the entrance, and connected by a shoal with Point Brown, whilst the channel ran between the island and the southern point. The bar bore SW. 2½ miles from Point Brown, and west 2½ miles from Point Hanson, with a depth of about three fathoms. This position shows that the bar had moved to the N. by E. no less than two miles. According to that survey, the course for crossing the bar was to bring Point Hanson to bear east and run for it, the channel being straight.

From a study of the map of that survey, we are satisfied that the soundings were carried outward to the inner edge of the bar, and not across it, the lines being probably stopped by the breakers.

The foregoing examinations verify our statement in 1858, that the changes are so great that the directions of one season for entering cannot be relied upon for the next. We have been off the bar, but never saw a fair chance for entering.

The Superintendent of the Coast Survey has recommended to the Light-house Board the placing of buoys to mark the channel, and especially of one on the seaward extremity of the south sands, where the water probably breaks during heavy weather in winter, so much as four or five miles off shore. This buoy would be of great service to the coasting steamers.

In 1860, while the surveying vessel was lying off the bar, a current running to the northward at the rate of 1½ mile per hour was distinctly noticed. An experience of two years has proved the set of the current along the coast to be always to the northward. Immediately off the harbor this current strikes the ebb current of the bay and deflects the mass of water to the northward, and carries the channel that way With the flood current the mass of water sets over the south sands. It is estimated that the off-shore current runs across the bar at an average rate of three miles.

The Indians use a small swash channel under Point Brown to avoid crossing the bar.

The peninsula terminated by Point Hanson is about three-quarters of a mile in breadth and 3½ miles long, and covered with fir to within half a mile of the point, which is a low sand spit embracing a small marsh. The general direction of the peninsula is northwest, and inside of it lies *South bay*, with a width of half a mile, affording the safest, and in fact the only safe anchorage near the entrance. More than half of this bay is occupied by mud flats. To secure the best position here, bring the northernmost trees on Point Hanson to bear S. 71° W., distant three-quarters of a mile, and anchor in the channel in 3½ fathoms. This position places the vessel out of the influence of the south channel running to the Chehalis.

The anchorage under Point Brown is not only uncomfortable but unsafe to a vessel without heavy ground tackle. At this point there is no protection against the full sweep of the heavy summer winds, which, blowing at times counter to the strong currents in the bay, cause a very disagreeable, short sea. Another circumstance tends to render this anchorage unsafe: between Point Hanson and Eld island lies the middle shoal, which, being bare at low water, confines the waters to a narrow regular channel; but when the tide rises sufficiently to cover this shoal the conflicting currents cause a heavy overfall, especially on the large tides, strong enough to tear a vessel from her anchors. This happened to the surveying brig in May, 1860.

The peninsula, terminated by Point Brown, is about a mile in breadth and 4½ miles long; its general direction is SE. by S. The bay shore is covered with fir. The outer shore is the commencement of a sand waste, stretching towards the Copalis river. Between the timber and this waste is a large pond or lagoon, and outside that the sand is covered with coarse beach grass and stunted lupine bushes, and cut up with the tracks of bears, cougars, wolves, elk, etc. From the north end of Eld island a body of water stretches into the sand waste parallel and near the ocean beach for about a mile. Close under the bay shore of this peninsula runs a narrow crooked channel, which Whidbey surveyed for two miles, and in which he gives four fathoms.

The secondary astronomical station of the Coast Survey is on the extremity of the fast land of Point Hanson, and within ten feet of the marsh. Its geographical position is:

	° ′ ″
Latitude	46 53 48.9 north.
Longitude	124 06 42.3 west.
	h. m. s
Or, in time	8 15 26.8.

The computed magnetic variation for 1862 is 20° 53′ east, with a yearly increase of 1′.

From Point Hanson the mouth of the Chehalis river bears N. 52° E., distant 12 miles; and this course is the general direction of the southeast side of the bay, except the indentation forming South bay. The first bluff inside the point is *Stearns*,* bearing N. 57° E., and distant 5½ miles. Around the southwest side of this bluff comes John's river. Within a mile and a half of the mouth of the Chehalis the Neuskah'l enters, coming from the southeast.

From Point Brown ***Point New***† lies N. 39° E., distant 4¾ miles, and having off it two rocks, now called Ned's rocks, and marked on Whidbey's chart.

Brackenridge bluff‡ commences about three-quarters of a mile east of Point New, and extends three miles eastward to the low land bordering the Hoquiamts river. From Point New the shore-line runs nearly straight to the Chehalis, distant eight miles, and the point of Stearns bluff lies S. 43° E., distant 4¼ miles.

* Named by the United States Exploring Expedition, 1841.

† Named by Whidbey in 1792.

‡ Named by the United States Exploring Expedition, 1841.

To the N.NW. of the line joining Points New and Brown lies *North bay*, consisting of an immense mud flat, bare at low water, and having an area of 22 square miles. At the head of it lies Saddle hill. In the stretch of four miles northwest of Point New are three small streams, called the Typso, Chinois, and Humtolapy, emptying into North bay. They work narrow crooked channels through the mud flats, but at low water there is not sufficient depth to carry a whaleboat through them.

By measurement we find that more than nine-tenths of Gray's harbor is bare at low water. Inside of the entrance the area of the surface of the water, bounded by the flats, bare at low tide, is only 4½ square miles. This will give a fair idea of the limited extent of the harbor. Through the flats lying between this available space and the Chehalis run two contracted channels. The northern commences at a point two miles N. 67° E. from Point Brown, is the only available one, and would require bouying out for its entire length. For about six miles it is three-eighths of a mile wide, with a depth of four fathoms. The south channel commences just inside Point Hanson, and is very contracted and shallow. The flats are so extensive, and the mud so soft in places, that it is impossible to reach the shore, except at high tides. This fact has retarded the development of the trade in lumber, although the shores are heavily timbered.

The trade of the bay amounts to carrying the supplies needed by a few settlers, and by the small mili, tary post on the Chehalis. During seven months in 1860 this reached one hundred and twenty-five tons.

The *Chehalis river* has been navigated by a small steamboat for 20 miles, to the mouth of the Latsop, which comes from the northward. This is the head of tide-water; but enterprise would render the river navigable much higher. Boats have come from the bend of the Chehalis, at the mouth of the Skookumchuck, near the road passing from the Cowlitz river to Puget's sound. The country behind the bay appears low and flat, and well watered by the Chehalis and tributaries, which drain a section well timbered and dotted with many small prairies and bottom lands.

In the winter of 1852–'53 the brig Willimantic was driven ashore upon Eld island, having mistaken this for Shoalwater bay. After vainly attempting to launch her toward the sea she was dragged across the island and launched on the bay side. Then the island was a mere bank of sand, bare at all tides, and covered with logs and drift-wood.

The bay was discovered by Gray in May, 1792, and named Bulfinch harbor, after one of the owners of his vessel. He placed it in latitude 46° 58′ north.

It was surveyed by Lieutenant Whidbey, in the storeship Dædalus, October, 1792, under the directions of Vancouver. He first sent in his boats, and then crossed the bar in three fathoms, with the ebb current running so strong that, although the ship was making nearly five knots an hour, little actual progress was made. He applied the present name, Gray's harbor, in compliment to its discoverer. On some old maps we have found it called Whidbey's harbor. He named Point Hanson after the commander of the Dædalus, and the northern point he called Point Brown, placing it in latitude 46° 59⅓′ north.

The southern point was called Point Chickeeles by the United States Exploring Expedition in 1841, and placed in latitude 46° 55′ 30″; and the same name was applied to the river.

In the first maps of the Coast Survey the southern point is termed Point Harrison—a clerical error. Among the few settlers in this region it is called Point Armstrong.

The name of the river is derived from the Indian tribe inhabiting the bay and river. They pronounce it Tché-hæ-lis or Tsi-hæ-lis, signifying sand.

For January, 1859, the *line of equal magnetic variation* of 21° east crosses the coast line in latitude 47° 08′, and in latitude 46° 58′ it crosses the 125° of longitude. This line moves annually a mile and a half to the southward.

COPALIS RIVER.

We know nothing of this stream except from settlers who have passed it in travelling along the shore.

From Point Brown the shore-line trends about N.NW. for ten miles to the mouth of the Copalis. The barren waste of Point Brown continues along this shore, commencing with a breadth of over one mile, stretching from the ocean to a dense forest of fir, and growing narrower as it approaches the Copalis, where the timber comes to the water's edge.

This stream is about 100 yards wide, but the mouth is almost closed by a bar. Upon its banks reside the Copalis tribe of Indians, from whom the river derives its name. Like all the streams on this coast it abounds in salmon, but those caught here are celebrated for their richness of flavor. Their general appearance is similar to those of the Columbia river, but this variety rarely exceeds two feet in length. They weigh from five to ten pounds.

In or about October, 1854, there was discovered one mile north of the Copalis the whole stern frame of the propeller General Warren, which had been wrecked on Clatsop spit, at the mouth of the Columbia river, more than two years previously, having thus been carried by currents at least 60 miles from its original position. When the hydrographic survey of the entrance to the Columbia was made by the Coast Survey parties in 1852 this wreck was found and its position determined. From Cape Disappointment it bore SE. by E. almost four miles distant, and was consequently little more than a mile from Point Adams. It then rested on the north edge of the Clatsop spit. This shows a direction of the current, corroborating Vancouver's account when anchored off Destruction island, and agreeing with our experience.

POINT GRENVILLE.

From the Copalis to this point the shore runs NW. ½ N. about 16 miles, and continues low, nearly straight, and bordered by sand beach, which changes to shingle, disposed in long rows parallel to the coast. These ridges of shingle dam the mouths of many small streams and form ponds, abounding in trout, and well stocked with beaver and otter, according to the accounts of the Indians. The high land also approaches much nearer the beach, and forms sandstone cliffs, with rocky ledges projecting into the ocean.

Point Grenville is a bluff, rocky promontory, stretching westward about a mile, and then southward about a quarter, forming a very contracted and exposed roadstead; with the three-fathom curve extending half a mile from the beach, compelling vessels, except of very light draught, to anchor so far out that the point and the rocks off it afford but little protection from the northwest winds. It is useless during the winter months. The point has high hills lying behind it, and many rocks immediately off it. Two of these, about 75 feet high, lie E. by S., 400 yards distant; another lies SW. ¾ S., half a mile distant. This, we believe, is the one that shows a large perforation through it when viewed from the southeast or northwest. It has five and six fathoms all around it. Others stretch along the coast to the northwest, one of them showing from the south as a leg-of-mutton sail. The bluff itself is composed of fine sandstone, is very steep, and may be ascended by a difficult trail, which is used by the Indians. It is said to be a great resort for sea otters, which are hunted by the natives.

Its approximate geographical position is:

	° ′
Latitude	47 20 north.
Longitude	124 14 west.
	h. m. s.
Or, in time	8 16 56.

From Cape Disappointment light it bears NW. by N. ½ N., distant 62 miles, and from the cape soundings may be had in from 8 to 15 fathoms, three or four miles from the shore.

This point is said to be the Punta de Martires of Heceta and Bodega, because in latitude 47° 20′ seven of the crew of Bodega's vessel, the Señora, were massacred by the natives.

It received its present name in 1792, from Vancouver, who placed it in latitude 47° 22′, and describes as lying off it "three rocky islets, one of which, like that at Cape Lookout, is perforated."

North of Grenville to Cape Flattery the shore is bold and rocky, with occasional short reaches of sand beach. The timber comes down to the water; moderately high hills approach the coast, through which empty numerous small streams, whilst the irregular Olympus range looms up far in the interior. In winter these mountains are covered with snow, which lies in the gorges and valleys nearly the whole summer. *Mount Olympus* is the highest peak of the range. It attains an elevation of 8,138 feet, according to determinations made in 1841 by the United States Exploring Expedition, which placed it in latitude 47° 45′ N., and longitude 122° 37′ W.

It is said to have been first seen by Perez, in 1774, who placed it in 47° 47′ N., and called it La Sierra Santa Rosalia, but the account of his voyage was not published until many years after that date, (1802.)

It was next described by Meares, in 1788, and placed in latitude 47° 10′, the error arising from its bearing, and he supposing it much nearer the coast-line than it actually is. In his sketch it is marked quite close to the shore, in latitude 47° 15′ N. He called it Mount Olympus, the only name by which it is now known.

In 1792 Vancouver determined its position approximately, and gave the latitude as 47° 50′ N.

Qué-ni-ŭtl river. The mouth of this small stream is between three and four miles NW. by W. from Point Grenville, and is almost closed by the shingle and gravel thrown up by the surf; there is, however, a contracted opening for the passage of canoes in calm weather. The closing of the entrance has so dammed the river as to form a small lake inside, upon the banks of which is situated a village of the Queniutls, a race of Indians hostile to all other tribes. Combined with others to the northward they have ever been notorious for their hostility and vindictiveness to the whites. Several Spanish, English, and Russian vessels and their crews were, in former times, taken and destroyed. Hence we meet with the names Destruction Island, Isla de Dolores, Punta de Martires, &c., in this immediate vicinity. The river is said to head in a lake at the foot of the mountains.

The name of this river is usually known by the old settlers as Qué-noith, but the Indians are said to pronounce it as if spelled Qué-ni-ŭtl, accenting the first syllable strongly, and the last so softly that many persons consider they call themselves simply Que-nai. A tribe still further north is called the Que-nait′-sath. The Mukkaws call it the Quin-aitl. De Mofras calls it "Kiniat."—(See remarks, page 377, Destruction island.)

These Indians, when travelling by canoes along the low sandy beach south of Point Grenville, push out into the rollers, keep between the line of two seas that have broken, and pole the canoe through the surf. This peculiar mode is rather apt to excite the fears of those ignorant of what a canoe can be made to do when skilfully handled.

For four miles above the Queniutl the coast trends in the same direction, NW. by W., is composed of sandstone cliffs, and bounded by many precipitous rocks, the height and direction of which are generally that of the cliff. In the Coast Survey reconnaissance of 1852, one is placed 2½ miles off shore in latitude 47° 27′, and the vessel's track is laid down inside of it. A great many large rocky islets lie close in shore in this vicinity, but northward the coast is nearly clear to Destruction island. It makes a slight curve eastward, and alternates with bold yellow cliffs and low shores.

DESTRUCTION ISLAND.

This island is the only one found deserving the appellation after leaving the Farallones. It is about 150 feet high, quite flat on the top, covered with grass, but destitute of trees, and has high perpendicular sides of the same height as the cliffs on the main. It is said that there are some remarkable perforations through a rock near it, but these are, doubtless, only seen in particular directions, for, in passing close to it, we have never noticed them. On the eastern end were formerly some rude Indian huts. In Vancouver's time he found two or three dwarf trees at either end.

In running along the coast, 10 miles off, it is very difficult to make out this island, because, being within 1½ mile of the main, it is projected against the coast cliffs and cannot be distinguished from them until close upon it. It is narrow, but about 1½ mile long in a N.NW. direction, running parallel with the coast, and has rocks for a mile off its southern end. A reef and sand bank is represented as stretching thence W.NW. three miles to broken water, and from there running nearly straight to the northern end. A detailed examination of this locality might prove that good refuge could be had under the island during heavy southeast and southwest weather. No winter harbor of refuge exists between Point Reyes and Neé-ah bay, unless this be such, in which case it is of very great importance.

Between it and the main the soundings range from 7 to 12 fathoms, and to the northward from 10 to 14.

The approximate geographical position of the north end is:

	°	″	
Latitude	47	41	north.
Longitude	124	25	west.

From Cape Disappointment it bears NW. by N. 84 miles.

This island is called Isla de Dolores upon old Spanish maps. It received its present name, by which it is only known on the coast, in 1787, from Captain Berkely, who sent a long-boat from King George's sound to explore as far south as latitude 47°. The crew of a smaller boat entered a shallow river and rowed up some distance, where they were attacked and murdered by the Indians.

In April, 1792, while Vancouver was at anchor in 21 fathoms, 3½ miles S.SW. of this island, he "had calms, and found a constant current, without intermission, setting in the line of the coast to the northward." After passing Cape Orford he had been regularly thus affected, and carried to the north 10 to 12 miles per day further than was expected. He gives the latitude of the island as 47° 37′ north.

W. by N., distant 16 miles from Point Grenville, we discovered, in June, 1855, a bank having 15 fathoms upon it, with very soft mud bottom; at 21 miles distance, 17 fathoms; and at 29 miles, 36 fathoms; and three miles S.SE. of the first position we struck 16½ fathoms, with the same bottom, in all the soundings; but had not time to make an extended examination. In April, 1856, we found 45 fathoms in latitude 46° 54′ N., longitude 125° 03′ W., being 16 miles broad off shore. The soundings of 17, 18, and 19 fathoms, one mile from shore, would indicate a greater depth than we obtained. Vancouver has 50 fathoms inside of our first soundings.

From Destruction island northward the shore is composed of cliffs which form a regular curve to a point bearing NW. ½ W. from the north end of the island, and 11 miles distant; thence the shore runs nearly straight on that course for 10 miles to two high, abrupt, and well-marked rocks, standing a mile from shore. The outer one is bold and covered with tall trees, but the inner one is bare. They are in latitude 47° 58′, longitude 124° 40′. Many others, but smaller, lie inside of them, and 19 fathoms are found close outside. Along this stretch the shore is irregular and bluff, with many high rocky islets off it. A stream opens about midway in the stretch.

In the indentation northward of Destruction island, and about four miles from it, empties a small stream, which we believe is called Hooch by the Indians.

Meares calls the curve of the coast, about Destruction island, "Queenhythe bay," evidently a corruption of the Que-ni-utl, or Que′-noith.

FLATTERY ROCKS.

From the two rocks just mentioned to Cape Flattery, in 48° 23′, the course is almost N.NW., passing through a group of high, well-marked, rocky islets, in latitude 48° 12′ N., named the Flattery Rocks. Before reaching these the coast-line curves about a mile eastward, with a bluff shore nearly free from rocks for about eight miles, when a large white rock half a mile out looms up prominently, and is distinctly seen against the main land.

Flattery rocks extend between two and three miles from shore; the outer ledge is awash with one islet in it, and the track of the coast surveying steamer is laid down inside of it, with soundings in 9 to 20 fathoms. High abrupt timbered islets lie inside, with their ocean faces nearly perpendicular, about 150 feet high, and sloping landward. Where destitute of trees, these are covered with grass, bushes, &c. The latitude of the rocks is 48° 12′ north.

In March, 1778, Cook, having been driven seaward by heavy gales off Cape Perpetua, made the land about the latitude of 47° 35′, and four leagues from shore, as he says, when he was in hopes of finding a harbor to the northward under a small round hill which appeared to be an island, but on approaching it he became almost convinced that the opening was closed by low lands, and being thus disappointed, he named the point of land to the north of it Cape Flattery, and placed it in latitude 48° 15′ N. On recent English charts the cape is placed in the position of the Flattery rocks, although Vancouver adopted the present usage on this coast. From an examination of Cook's account, with a knowledge of the coast and the currents here, we are satisfied that he was further north than he estimated on the morning of March 22, for he says the small round hill like an island bore N. ¾ E., (true,) distant six or seven leagues, while the coast extended from N. to SE., (true.) These facts convince us that his position was in latitude 47° 50′, longitude 124° 46′; from this situation the Flattery rocks are distant seven leagues, bearing N. ¾ E., (true;) the extremity of Cape Flattery bearing nearly N., (true;) the distance to the nearest point of land a little more than three leagues; and the coast northward of Point Grenville bearing SE., (true.) The point of land northward of the Flattery rocks was, therefore, his Cape Flattery, and his estimated latitude of it eight miles too small. Before next day he had a very hard gale from the SW., accompanied with rain, and he did not see land again until he reached latitude 49½°. He arrived at the conclusion that between 47° and 48° there existed no inlet, as had been asserted.

From Flattery rocks we find a high rocky coast, bordered by outlying rocks for eight miles, when a low sand beach occurs, receiving a small stream which runs E.NE. and finally north, behind the mountain constituting Cape Flattery, to within 200 yards of the beach in Neé-ah bay. A rise of 20 or 30 feet of the sea would make Cape Flattery an island, extending five miles (W.NW.) by three miles in breadth. This creek is used by the outer coast Indians during the prevalence of heavy winter gales, when the passage outside the cape would be impracticable.

From Point Grenville to Cape Flattery the hills rising from the coast are about 2,000 feet high, densely covered with trees, and cut up by innumerable valleys. The shore is inhabited by numerous tribes of Indians, accustomed to war and bitterly hostile to the whites. They are far superior to the Indians found along the southern coast. Their villages are heavily stockaded, and the houses made of cedar boards, which they have cut with great industry from the tree. We have measured and found some of these boards to be over 4 feet wide and 20 feet long; the outside edges being about an inch thick and three inches in the middle. Their houses are very large, and partitioned off into stalls for each family. The numerous streams emptying upon the coast afford them a never-failing supply of the finest salmon; and to obtain means of barter with white traders they fearlessly attack and capture the different species of whale on the coast.

TATOOSH ISLAND.

This island lies W.NW. half a mile from the point of Cape Flattery. It is composed of small islets connected by reefs, is quite flat-topped, and without trees. The surface is 108 feet above high water, and the sides are perpendicular; the entire mass is composed of coarse sandstone conglomerate with an outcrop of basalt on one of the reefs. There is a depth of two or three feet of soil upon the top, which was formerly cultivated by the Indians, who resorted here in summer, about 150 strong, and had several houses near the only boat landing on the inside of the island, (1852.) A reef extends a quarter of a mile off the west side of the island, and the whole extent of the island and reef is only half a mile W.NW. by a third of a mile. Deep water is found upon all sides, except between it and the cape, where a reef exists upon which it breaks very heavily in bad weather. We are informed that small vessels have gone through when jammed by an unfavorable wind. In so doing great risk must have been incurred, as the currents in the vicinity run very irregularly and strong.

From the top of the island a leaning rocky column, about 75 feet high and one-third of that in diameter, is seen to the southeastward close under the face of the cape. It is sometimes called Fuca's pillar.

TATOOSH ISLAND LIGHT-HOUSE.

This structure is erected on the highest part of the island, and consists of a keeper's dwelling of stone, with a tower of brick, whitewashed, rising above it, and surmounted by an iron lantern painted red, its height being 66 feet above the top of the island. The light was first exhibited December 28, 1857, and shows every night, from sunset to sunrise, a *fixed white light* of the first order of Fresnel. It is elevated 162 feet above the mean sea level, and in clear weather should be seen from a height of—

10 feet at a distance of 18.2 miles;
20 feet at a distance of 19.7 miles;
30 feet at a distance of 20.9 miles;
60 feet at a distance of 23.5 miles;

so that a vessel from the southward will make it before being up with the Flattery rocks.

The geographical position of the light, as determined by the Coast Survey, is:

Latitude	48° 23′ 15″.5 north.
Longitude	124° 43′ 50″.0 west.
Or, in time	8h. 18m. 55s.3.

Magnetic variation, 21° 46′ east, in August, 1855, with a yearly increase of 1′.

The angle of visibility from the land southward, round by the west to the extreme western visible point of Vancouver island, is 131°, and from the same starting point round by the west, up the Strait of Juan de Fuca, 263°.

This island, with its outlying reef, is the most western portion of the United States.

The present name is that given to us by the Indian tribe (Muk-kaw) inhabiting the cape and outer part of the strait. Their word to designate an island is opichuk't.

On June 29, 1788, Meares, passing the entrance to the strait, hove to off this island, was visited by the Indians, and sent an officer to examine it, who reported that it was a "solid rock covered with little verdure, and surrounded by breakers in every direction." They also "saw a very remarkable rock that wore the appearance of an obelisk, and stood at some distance from the island." To this rock he gave the name of Pinnacle rock. It is the columnar leaning rock already described. He says the "island itself appeared to be a barren rock, almost inaccessible, and of no great extent; but the surface of it, as far as we could see, was covered with inhabitants, who were gazing at the ship." "The chief of this spot, whose name is Tatooche, did us the favor of a visit, and so surley and forbidding a character we had not yet seen." The Indians evidently gave him the name of the island, which he mistook for that of the chief. His sketch of the island and cape also includes Rock Duncan.

Too-too-tche is the Nootka name for the "Thunderbird." The Mukkaws originally came from the west coast of Vancouver island.

And here we may be permitted to remark, that from this place to Cape Lookout the descriptions of Meares are confirmed by our own observations.

ROCK DUNCAN.

This is a small, low, black rock rising above the highest tides, but always washed by the western swell, which breaks over it. Deep water is found close around it. From Tatoosh Island light it bears N. 33° W., distant 2,078 yards, or more than a mile, and many vessels pass between them, as the chart shows 25 fathoms; but a rock has been reported in the channel, and it would be well to avoid it until the doubt is set at rest. Vancouver's vessels passed between them. The rock was first noticed by Mr. Duncan in 1788, and placed in latitude 48° 37′ N., which Vancouver, who gave it the present name, considered a typographical error.

During a three months' stay at Neé-ah harbor in 1852, we tried upon several occasions to land upon this rock with canoes, but could never effect our object.

DUNTZE ROCK.

Nearly a quarter of a mile off Rock Duncan, on the line from Tatoosh island, Kellet places a rock having three fathoms water upon it, and to which he gave this name.

With no wind, a heavy swell from the west, ebb current, and proximity to these outlying rocks and island, a vessel's position is unsafe, and great caution should be exercised in navigating this part of the entrance to the Strait of Fuca.

CAPE FLATTERY.

This cape forms the southern head of the entrance of the Strait of Juan de Fuca; it has a bold, wild, jagged sea-face, about 100 feet high, much disintegrated by the wearing action of the ocean; rises in a mile to an irregular hill of 1,500 or 2,000 feet in height; is cut up by gorges and covered with a dense growth of fir and almost impenetrable underbrush from the edge of the cliffs to the summit. The shore-line round to Neé-ah bay is of the same forbidding character, bordered by reefs, and having but one short stretch of beach at the foot of the hills. Upon this beach is situated (or was in 1852) Clisseet's village. The soundings half a mile from shore are deep and irregular, reaching 68 fathoms. The current runs as much as three miles per hour, and during the ebb sets irregularly round the cape, Tatoosh island, and Rock Duncan. When seen from the southwestward Cape Flattery looks like an island, on account of the valley three or four miles eastward. The best position for seeing this is when a single rock off the cape shows itself detached. From this direction the high mountains on Vancouver's island loom up and stretch far away to the northwest and to the east.

The extent of ocean shore-line from Cape Disappointment to Cape Flattery is 148 miles.

The name adopted is that which Cook gave to this headland in 1778. It has been called Cape Martinez by the Spaniards, from its asserted discovery in 1774 by Martinez, pilot to Perez, who announced many years afterward that he remembered to have observed a wide opening in the land between 48° and 49° north latitude.

In 1788 Captain Duncan anchored on the south shore of the Strait of Juan de Fuca, off a village called Claasit, or Claaset, in 48° 30′.

On recent English charts it is called Cape Classet, because, in 1792, Vancouver stated that as the name given by the Indians to distinguish it, but in a marginal note it is called "Cape Flattery." (See remarks on page in relation to this matter—Flattery rocks.) In 1852 we found that the then head chief of the Muk-kaws, a powerful man, about 40 or 45 years of age, called himself, and was called by the tribe, Clisseet′, but we could not ascertain whether this was an hereditary title.

On the western coast it is universally known as Cape Flattery.

It was near this cape that a Japanese junk was wrecked in 1833, accounts of which will be found in Belcher's narrative, and in that of the United States Exploring Expedition. See also Schoolcraft's Indian Tribes of the United States, page 217. This wreck, with that at Clatsop Point and others found at sea, shows strongly the direction of the prevailing winds and currents off shore.

BANK OFF CAPE FLATTERY.

At the entrance to the Strait of Juan de Fuca, 15 miles, by estimation, W.NW. from Cape Flattery, we have been informed that a bank exists having 18 fathoms upon it, and, moreover, that during a calm our informant fished upon it from his vessel, and caught a large number of codfish. His attention was called to it by a number of canoes fishing. While we were encamped in Neé-ah bay, in 1852, the Indians frequently went out upon some bank off the strait to fish for cod, but we looked upon their assertions with distrust, and believed they caught the fish inside of the strait. Each season in passing, as we wished incidentally to seek for this bank, we encountered southeast gales, which rendered the examination impracticable.

STRAIT OF JUAN DE FUCA.

The entrance to this strait from the Pacific lies between Cape Flattery and Cape Bonilla, on Vancouver island, which forms the northern shore. Its width is about 14 miles, and the bearing from Flattery to Bonilla NW. ¾ N. From this line the strait runs east for 40 miles, with a uniform width of 11 miles. It gradually contracts to 8 miles between Beachy Head on the north and Striped Peak on the south; changes its direction to E. by N. ½ N. for 15 miles; then expands to the northward, attaining a width of 18 to 20 miles, and divides into two ship channels, the Canal de Haro and Rosario strait, leading through the Archipelago de Haro northward to the Gulf of Georgia. It is terminated on the east by Whidbey island; at the southeast it passes into Admiralty inlet, and is bounded on the south by the main land of Washington Territory, which forms the entire southern shore of the strait. From the ocean to Whidbey island the mid-channel distance is 84 miles. The depth of water throughout the strait is remarkably great, no bottom being found in its deepest parts with 150 fathoms of line. It is the main artery for the waters of Admiralty inlet, Puget's sound, Possession sound, Hood's canal, Canal de Haro, Rosario strait, Bellingham bay, and the vast Gulf of Georgia, extending between Vancouver island and British Columbia for 120 miles, with an average width of 20. Its currents run with an average velocity of not less than three miles per hour, and off the Race island and Beachy Head over six miles an hour. Its shores are bold, abrupt, and covered with a heavy growth of varied timber and dense underbrush. On the north the mountains rise rapidly from the water, and many attain an elevation of not less than 6,000 or 7,000 feet. These are covered with fir to their summits. On the south, for 30 miles from the entrance, the shore is bounded by hills of 2,000 feet height, backed by the jagged Olympus range of 8,200 feet. For the next 50 miles the shore is generally a steep cliff, from 50 to 200 feet high, with a flat country extending nearly to the foot-hills of Olympus, and stretching further south as we move eastward. On the east the face of Whidbey island is very steep; it is about 250 feet high, and appears flat, as does the whole country eastward to the sharp-cut outline of the Cascade range, stretching its serrated ridge northward, where the snow-peak of Mount Baker * is distinctly seen, and to the southward, where the higher peak of Mount Rainier * attracts the eye.

Humboldt calls this Mount Regnier, depending upon the narrative of Frémont, who saw it in active operation, November 13, 1843. We believe it is over 15,000 feet in height.

At the time of our first visit the southern shore of the strait was inhabited by large numbers of Indians, living in heavily stockaded villages. They were tolerably expert in the use of fire-arms, of which they seemed to have a good supply. They lived mostly by fishing, but raised a fair supply of remarkably good potatoes from the stock seed of the Hudson Bay Company.

During dry summers the Indians and settlers set fire to the forests in every direction, and the country soon becomes enveloped in a vast smoke that lasts for two or three months. At such times it is frequently impossible to make out the shore at half a mile distance. The strong westerly winds coming up the strait disperse it for awhile, but only to fan the fires and give them renewed force and activity.

In summer the prevailing wind draws into the strait, increasing towards evening, and frequently blowing a ten-knot breeze before midnight; but unless the wind is strong outside little is felt in the strait, and

* Named by Vancouver, 1792.

very frequently vessels are a week from Cape Flattery to Admiralty inlet, or *vice versa*. In winter the southeast winds draw directly out, and create a very heavy cross sea off the entrance, the great southwest swell meeting that rolling out. In such cases trading vessels try to gain Neé-ah bay or San Juan harbor, and remain at anchor until the wind changes. In beating in or out vessels may run as close under either shore as wind and currents warrant, as no hidden dangers have been found half a mile off shore, except at the west side of the small indentation called Crescent bay, near Striped Peak, 44 miles inside of Rock Duncan.

At the entrance the currents acquire, during the "large tide" of each day, a velocity of four miles per hour, and after strong northwest winds, a very large, short, but regular swell is encountered west of Neé-ah bay during the ebb current. If the wind is light, and no steerage way on the vessel, the feeling is decidedly disagreeable, especially as the current seems constantly to set close around Rock Duncan and Tatoosh island. If a vessel falls into the trough of this swell she is bound to fetch away something.

Settlers are gradually advancing from Puget's sound and Admiralty inlet along the strait westward, and are destined to meet those coming up the coast from Gray's harbor and Shoalwater bay.

Washington Territory has a climate excelled only by that of California. We know not where to point to such a ramification of inland navigation, save in the British possessions to the northward. For depth of water, boldness of approaches, freedom from hidden dangers, and the immeasurable sea of gigantic timber coming down to the very shores, these waters are unsurpassed, unapproachable.

The Strait of Juan de Fuca was discovered by the long-boat of the Imperial Eagle, under the command of Berkely, in 1787.

In June, 1788, it was examined by Meares, in the Felice, he having obtained information of its existence from Berkely. At the entrance it "appeared to be 12 or 14 leagues broad. From the mast-head it was observed to stretch to the E. by N., and a clear unbounded horizon was seen in that direction as far as the eye could reach." He frequently sounded, "but could procure no bottom with 100 fathoms of line." He afterwards sent a party to explore the strait, who went up about 50 miles, determining the harbor of San Juan. He first applied the name "John de Fuca" to the strait.

After the expedition of 1775 several Spanish expeditions were fitted out for exploration in these latitudes, but we are not sufficiently acquainted with their results to state their claims and merits. Haro was in the strait in 1789, Quimper in 1790, Eliza in 1791, and Galiano and Valdez in 1792.

Gray entered the strait in 1792, penetrated 50 miles in an E.SE. direction, and found the passage five leagues wide. He gives the latitude of Tatoosh island, or Cape Flattery, 48° 24′. The extracts from his log-book, stating particulars of this and the Columbia river exploration, were not made public until 1816. Most of Gray's latitudes, distances, and courses, are good and trustworthy.

Vancouver entered the strait in 1792, and gave to the world the first detailed and authentic account of it.

THE SOUTHERN SHORE OF THE STRAIT OF JUAN DE FUCA.

NEÉ-AH BAY.

Koitlah Point, the western boundary of this bay, is four miles E. by N. ⅝ N. from the light-house on Tatoosh island. From Cape Flattery the shore is nearly straight, high, and rugged, backed by hills about 1,500 or 2,000 feet high, and covered with timber. Deep water is found within a third of a mile of the bluffs, and at a distance of half a mile, a depth of 20 fathoms is obtained. Within a mile of Koitlah Point was a large village of the Mukkaws, (1852.)

The bay is about a mile and a quarter long S.SE., and the same in width at the entrance. The western side is high, precipitous, and bordered by craggy outcropping rocks 300 or 400 yards from the shore. The three-fathom line ranges about 600 yards from the foot of the bluff. The general direction of this side is SE. for one mile, when the hills suddenly cease, and a low shore, with sand beach backed by woods, curves gradually to the NE. by E. for a mile and a quarter to Ba-ad-dah Point, formed by a spur of the hills.

The east side of the bay is formed by Waaddah island, the northern end of which lies 1½ mile from Koitlah E. by N. ½ N. This island is a narrow, high ridge, about 250 yards wide, and half a mile long, covered with trees, and having a direction SE. ¼ E., pointing toward Ba-ad-dah Point, and presenting the appearance of a continuation of that spur, but separated from it by a four-fathom channel 500 yards wide. Off the southwest part rocks extend for 250 yards, and the three-fathom line is 600 yards distant. Along the sand beach the three-fathom line is within 200 yards of the shore, the depth increasing to seven fathoms, then decreasing to five in the middle of the bay, and again increasing to ten on the outer line of the bay. Much kelp abounds in this harbor, even in deep water, the lower and thinnest portion being used by the Indians for fishing-lines. When coiled away and dry they break like grass, but soaking them in salt water renews their elasticity and strength.

The best anchorage is in the south part of the bay, in about five fathoms, being then off the small stream which comes in at the eastern foot of the hills. No direction can be given about anchoring off any particular village, as the Indians change their location so frequently; but near this stream will generally be found some houses, with an abundance of fresh water. During southerly weather little swell is felt here, and the wind can do no harm; but when a large westerly swell is coming up the strait it reaches here, and a vessel rolls uncomfortably unless she rides head to it.

The low ground abreast of the anchorage, and but two or three hundred yards from the beach, is the head of a small stream that runs through the low prairie lands behind Cape Flattery, and empties into Nisco bay south of the cape, near a winter village of the Mukkaws, called Wa-atch. This stream is frequently used by them in winter, when they cannot take their canoes outside the cape.

The primary astronomical station of the Coast Survey was just back of the beach, about 400 yards east of the small stream before referred to. From the NW. end of Waaddah island it bears S. by W. ½ W., distant 1¾ mile. Its geographical position is:

	° ′ ″
Latitude......	48 21 48.8 north.
Longitude......	124 37 12.0 west.
	h. m. s.
Or, in time......	8 18 28.8.

Magnetic variation 21° 30′ east, in August, 1852, with a yearly increase of 1′.

Soon after occupying this station the Indians dug up and destroyed all the marks fixed to recover it, under the belief that evil spirits were buried with them.

Tides.—The corrected establishment, or mean interval between the time of the moon's transit and the time of high water, is XII*h.* XXXIII*m.* The mean rise and fall of tides is 5.6 feet; of spring tides, 7.4 feet; and of neap tides 4.8 feet. The mean duration of the flood is 6*h.* 20*m.*, and of the ebb 6*h.* 06*m.* The average difference between the corrected establishments of the a. m. and p. m. tides of the same day is 1*h.* 18*m.* for high water, and 1*h.* 02*m.* for low water. The differences when the moon's declination is greatest are 2*h.* 20*m.* and 1*h.* 56*m.*, respectively. The average difference in height of those two tides is 1.7 foot for the high waters, and 3.5 feet for the low waters. When the moon's declination is greatest those differences are 2.8 feet and 5.0 feet, respectively. The average difference of the higher high and lower low waters of the same day is 8.2 feet, and when the moon's declination is greatest, 9.5 feet. The higher high water in the twenty-four hours occurs about 11*h.* 54*m.* after the moon's upper transit, (southing,) when the moon's declination is north, and about 32*m.* before, when south. The lower low water occurs about 7*h.* after the higher high water. The greatest observed difference between two low waters of one day was 6.0 feet, and the greatest difference between the higher high and lower low waters of one day was 12.0 feet.

To find the times of high and low waters, first compute them for Astoria, and from the numbers thus obtained subtract 9 minutes for Neé-ah bay.

This bay was known as Poverty cove by the early fur traders on the coast; next as Port Nuñez Guona, by Quimper, in 1790. In 1792 the Spaniards, then establishing themselves at Nootka sound, attempted to found a colony here, and as late as 1847 bricks were found near the small stream abreast of the anchorage. We searched for vestiges of the settlement so late as 1852, but found nothing. In 1860 a brick was dug up from the depth of two feet, on the site pointed out by the Indians. Vancouver noted the indentation of the coast here in 1792. It was next called "Scarborough harbor," by the United States Exploring Expedition in 1841. The Indian name is that now adopted, and the only one by which it is known on the coast.

In 1852, the Mukkaws about Flattery could muster 300 or 400 warriors, mostly armed with muskets and knives. They had several large stockaded villages and hundreds of canoes. We have counted over 70 at one time fishing for salmon in the bay. They were brave and fearless; made voyages to Nitinat, Clayoquot, and Nootka sounds, and pursued the whale and black fish successfully. In three months they sold over 7,500 gallons of oil to the traders. They maintain trade with the Indians on the west of Vancouver, forcing them to dispose of their oil and skins to themselves directly, and not to the traders. By this means they make a large profit as intermediate traders. They estimate their wealth by the number of slaves and blankets, and the quantity of oil, they possess. In the fall of 1852 the small-pox was introduced among them, and nearly swept off the tribe, more than two-thirds falling victims to the disease—among them the principal chief, Clisseet', and the second chief, Flattery Jack.

Two miles east of Waaddah island, and within the limits of the kelp, is a rock 150 feet high, called Sail rock by the United States Exploring Expedition, and by Kellet, Klaholoh, (seals.) The Indian name is Saelok. Behind it enters a small stream called the Okho on the Admiralty charts, but this is not the Indian name.

CALLAM BAY.°

From the eastern point of Neé-ah bay to *Sekou Point*,* the western part of Callam bay, the course is E. ½ S., and distance 13½ miles. The shore-line is nearly straight, bluff, and bordered by rocks, with an occasional stretch of sandy beach. One mile off shore the average depth of water is 20 fathoms. The bay is at the western termination of a high, bold, wooded ridge, running parallel to the shore, with an almost perpendicular water face, and falling away rapidly inshore. This easily recognized ridge is about 1,000 feet high and seven miles long. The western extremity lies E. ⅛ S. from Waaddah island, is distant 16 miles, and called *Slip Point;** the eastern is designated *Pillar Point.** The width of the bay from Sekou Point to Slip Point is two miles, and the bearing E. by N. ½ N. Outside these limits 15 fathoms water may be struck. The form of the bay is nearly semicircular, and the depth of the curve nearly a mile, with six fathoms about the middle. Into it empties a small stream from the southeast, having low land on its eastern side, and a small rise on the west. Some sunken rocks are said to lie off Slip Point.

The water along the face of the ridge is very deep, and the bottom rocky and irregular. About half way along it is the entrance to a vein of lignite, which has been worked, but it is not fit for steamship consumption. Off this mine, at a distance of a cable's length, a depth of 35 fathoms is found, with a swell upon the rocks sufficient to destroy any boat loading there. The so-called coal is very easily broken, and crumbles by exposure to the weather. We saw it fairly tried upon a steamer, and it did not answer. An analysis of some of the best specimens yielded 68 per cent. of carbon, and we judge it to be bitumen. The geological formation of the whole region is opposed to the existence of coal. Among the bituminous shales we searched in vain for any specimens of fossil impressions.

Pillar Point is nearly E. ½ S. from the north end of Waaddah island, and distant 23 miles. Its latitude is 48° 13′ N. The peak is slightly separated from the main ridge by a depression. From this point the shore trends S.SE. about a mile, and receives a stream coming from the westward, called *Canel river.** An Indian village exists here. The Indian name of the stream is Pisht-st.

From Pillar Point the next prominent object is a wooded hill called *Striped Peak*,* bearing E. by N., and distant 17 miles. The shore retreats to the southward of this line about three miles, having alternate bluff and low shores, with many little streams opening upon them, and at the distance of 11 or 12 miles from Pillar Point, *Low Point* * makes out at the mouth of a stream called the Lyre.† Rocks abound close along the shore. The kelp generally extends out to five fathoms, and the average depth of water, a mile off, is 10 fathoms. One mile before reaching the western part of Striped Peak is a sunken rock, upon which the sea breaks at low water. A slight indentation of the shore here has received the name of *Crescent bay.**

Striped Peak is several hundred feet high, and wooded, and was doubtless named from a well-marked line upon its water side, occasioned by a land slide from its summit. This mark is being rapidly obliterated by the growth of vegetation. The base of the hill towards the water presents a straight line, running E. by N. for three miles, with deep water off it.

*Freshwater bay.**—The eastern part of Striped Peak, with several rocks off it, is called Observatory Point on the Admiralty charts, and forms the western boundary of Freshwater bay. The eastern side is the low delta called Angelos Point, at the mouth of the river Elwha, and the line joining the two runs E. by N. ⅜ N. three miles across. Inside of this line the depth of the curve is about 1¼ mile, with water ranging from 16 fathoms to four or five close inshore. The western shore of the bay is bluff, the eastern ow, with bluff in the rear. The waters of the Elwha bring down such quantities of earth that we findl only 10 fathoms water at a distance of three-quarters of a mile off its mouth.

° English Admiralty chart, 1847.
† English Admiralty chart, 1847. The Indian name of this river is Kwa-ha-mish.

PORT ANGELES, OR FALSE DUNGENESS.

Four miles east of the Elwha commences a long, low, very narrow sand spit, stretching out from the bluff in a general E.NE. direction for three miles, to the point called *Ediz Hook*,* which lies 1½ mile off the main shore, thus forming an excellent and extensive harbor, with deep water of 25 to 30 fathoms, sandy bottom, close under the inside of the sand spit, almost to the head of the bay. Through the centre of the bay we found a line of 15 fathoms, sticky bottom, and between that and the main it shoals very regularly with the same kind of bottom. On the outside of the spit very deep water is found close to it, and the Hook may be rounded within a cable's length in 25 fathoms. In the indentation between Angelos Point and the head of the bay the water is shoal, 10 fathoms being found two miles from shore.

The Hook is covered with coarse grass, and in many places with driftwood, showing that the sea sometimes washes over it. Although it lies well out of the line of vessels bound either in or out of the strait, it would be advisable to mark it with large, easily-recognized beacons, or to plant trees along part of it, as it cannot now be distinguished, even in good weather, until a vessel is close upon it. From the middle of the strait it cannot be made out unless the appearance of the bluff beyond is known. At the head of the bay is a large salt-water lagoon. Fresh water is found on the south shore in several places, but the extensive flats render it hard to obtain. The bluff, 70 feet high, comes directly to the high-water line, and is covered with trees. Three Indian villages of the Clallums † existed on its shores in 1852, when a secondary astronomical station of the Coast Survey was established near the Indian graveyard at the head of the harbor. Its geographical position is:

	° ′ ″	
Latitude	48 07 52.0	north.
Longitude	123 27 21	west.
	h. m. s.	
Or, in time	8 13 49.4.	

From this station the extremity of Ediz Hook bears NE. by E., distant 2⅜ miles.

The bay was first discovered by the Spaniards, and by them made known to Vancouver in 1792. We first heard of the name, False Dungeness, in 1852, when at Cape Flattery, from traders there. The United States custom-house for this district was located here in 1862. On the 16th of December, 1863, the village and custom-house were destroyed by a torrent of water bursting from a gorge behind the town, where an accumulation of fallen timber had dammed up the waters. A preliminary chart of False Dungeness was published by the Coast Survey in 1853, and a second edition in 1856.

Coal of fair quality is reported to have been found within three miles of the harbor.

NEW DUNGENESS BAY.

The shore from Point Angelos gradually curves to the northeast, and about eight or nine miles from Ediz Hook another long, low, narrow sand spit, covered with grass, leaves the bluff shore and stretches in a general N.NE. direction for 3¾ miles, forming the northwestern shore of the roadstead of New Dungeness. On the inside, one mile from the eastern extremity, another narrow sand spit makes 1½ mile southward towards the main shore, forming a large inner shoal bay, with a narrow opening, through which the water passes, as over a rapid at low tide. Abreast of this point is a small stream, affording an abundance of fresh water but boats must obtain their supply at low tide, and come out when the tide has sufficiently risen. The western side of this stream is a bluff 60 feet high, and upon it is a large village of the Clallums. The eastern shore of the stream is low, swampy, and covered with trees and brush. It forms the southern or main shore of the roadstead, and off it lie extensive mud flats, which are bare at low water for five-eighths of a mile, and run as far as Washington, or Budd's harbor. Shoal water exists some distance outside of these flats. About 20 fathoms are found a quarter of a mile south of the Light-house Point, the depth regularly decreasing across the bay, with a soft, tenacious, muddy bottom. The usual and best anchorage is to bring the light-house to bear about N. by E. ½ E., half a mile distant, when 10 fathoms are found one

* English Admiralty chart of 1847; E-ediz on that of 1859.

† The tribes now generally but erroneously known by this name call themselves the Nūs-klai-yum; they occupy the American side of the strait from the O'ke-ho, 13 miles from Neé-ah bay. Their congeners are the T'sōk and Sūgh-us on part of the Vancouver side.

third of a mile, broad off the beach. With the light-house bearing NW. by N. three-quarters of a mile distant, the same depth and bottom are found. The nearest shore will bear south 1¼ mile, and the mud flat three-quarters of a mile in the same direction. A southeast wind drawing out of the strait blows directly into this harbor, but the bottom will hold any vessel with good ground tackle. The only difficulty will be to get the anchors out of the mud after riding a couple of days to a gale. In the last position a vessel can readily get under way and clear the point.

This point is so low that vessels bound in or out, before the erection of the light-house, were upon it before they were aware of their danger. Several had run ashore on the outside beach, and in 1855, while we were anchored close in, with the weather thick and hazy, a vessel from Admiralty inlet had been set out of her course by the currents, and came driving in with studding-sails out, and only saw her mistake and danger when the black hull of our vessel attracted her attention.

A shoal with 2½ fathoms makes out from the end of the point for half a mile, and a heavy tide-rip runs over it at the change of the currents.

A hydrographic sketch of New Dungeness was issued from the Coast Survey office in 1856.

LIGHT-HOUSE AT NEW DUNGENESS.

The structure is about one-sixth of a mile from the outer end of the point, and consists of a keeper's dwelling of stone, with a tower of brick; the upper half being a dark lead color, the lower half white. The tower is surmounted by an iron lantern painted red; the entire height being 92 feet, and its elevation above the mean sea-level 100 feet.

The light was first exhibited December 14. 1857, and shows every night, from sunset to sunrise, a *fixed white light* of the third order of Fresnel. It should be seen from a height of—

10 feet at a distance of 15 miles.
20 feet at a distance of 16½ miles.
30 feet at a distance of 17¾ miles.

Its geographical position, as determined by the Coast Survey, is:

	°	′	″	
Latitude	48	10	58.9	north.
Longitude	123	06	07	west.
	h.	*m.*	*s.*	
Or, in time	8	12	24.5.	

Magnetic variation, 21° 43′ east, in August, 1856, with a yearly increase of 1′.

From it we have the following bearings and distances:

Striped Peak, SW. by W. ½ W., distant 21 miles.
Race Rocks light-house west, distant 18 miles.
Esquimalt Harbor light-house, N. 66° W. 20 miles.
Victoria harbor, NW. by W. ¾ W., distant 17¾ miles.
Smith's Island light-house, N. 31° E., distant 13½ miles.
Point Wilson, E. by N., distant 14¾ miles.
Admiralty Head light-house, S. 73° W., 17⅝ miles.

Fog-bell at New Dungeness.—Upon the outer extremity of the point a fog-bell of 1,100 pounds weight has been placed, and is sounded every ten seconds during foggy or other thick weather day and night. "The striking machinery is in a frame building, with the front open to receive the bell, painted black, raised 30 feet above the ground on an open structure, whitewashed."

Tides.—The approximate corrected establishment is III*h.* III*m.*, and the approximate mean rise and fall of tides 5.0 feet.

Our experience in these waters suggests that the light-house building should be painted black, or a color most readily made out in foggy or smoky weather. Several years since we urged the advantage of planting trees along the spit to afford large dark masses, that a lookout might see the danger before being upon it. A few settlers are now located about the bay.

This harbor was first examined and made known by Vancouver, who applied the present name in 1792. It is known by no other.

Eastward of Dungeness the shore is indented by Washington harbor, Port Discovery, and Admiralty inlet, the northwest point of the entrance to which is Point Wilson.

WASHINGTON, OR BUDD'S HARBOR.

From New Dungeness roadstead to the entrance to this harbor the immediate shore is low, flat, covered with trees, and bordered by an extensive mud flat; but behind it, at a very short distance, rises a level plateau. The bluff at the NE. point of the harbor is seen from Dungeness Point. The entrance to the harbor is nearly closed by a low sand spit stretching across it from the east, almost to the western part, where a narrow channel way exists having two fathoms through it. This cannot be seen from Dungeness Point, which is 6½ miles NW., on account of the outward curving of the intermediate shore. Inside of the harbor we found 17 fathoms. Its width is a little over a mile, and regular, its length about three miles, and the general direction SE. by S. One mile outside of the sand spit a depth of 10 and 12 fathoms exists, deepening rapidly to 30 and 35, with a bottom of stiff mud.

This harbor was surveyed first by the United States Exploring Expedition, and called Budd's harbor; but there being a sheet of water in Puget's sound bearing a similar name, we have adopted Kellett's appellation. The Indian name of the bay is S'quim, by which it is generally known to the settlers.

Quimper in 1790 explored the harbors in this vicinity, as did Galiano and Valdes in 1791.

PROTECTION ISLAND.

The western extremity of this island lies E. ⅜ S., distant 7½ miles from Dungeness light-house, and extends 1¾ mile NE. ½ E., being narrow, curved outward to the strait, and having a low point at each end, with shoal water stretching from the western. Its sides are very steep, and about 200 feet high, the seaward part covered with timber, and that towards Port Discovery undulating and covered with fern. It lies two miles directly off (NW.) the entrance to Port Discovery. On the inside is found very deep water, but upon the outside a line of kelp, about half a mile out, marks the four-fathom curve, and from this a bank runs out N.NW. for three miles, having from five to fifteen fathoms upon it, with a shoal spot of three and four fathoms two miles from the island. It affords a good anchorage, with light airs and strong adverse currents. The bottom is irregular and falls off suddenly. This shoal has been named the Dallas bank by the United States Coast Survey.

This island, with Port Angeles and New Dungeness, afford the first examples of the peculiar feature of low, sandy, and gravelly points covered with coarse grass and bushes, making out from the high cliffs, where the tendency of strong currents would seem to be to cut them off.

It was called Protection island by Vancouver in 1792, and on account of its position in relation to Port Discovery is very aptly named.

PORT DISCOVERY.

From Dungeness light the west side of the entrance to Port Discovery, called Challam Point, bears E. by S. ⅓ S., distant nine miles. From Washington harbor the distance is four miles. The intermediate shore is composed of high steep cliffs. Cape George, the eastern point of the entrance, bears NE. ¼ E. 1½ mile from Challam Point, and is a steep bluff, rising directly from the water. The average width of the bay is nearly 1¾ mile for nine miles of its length, and then decreases rapidly to the Salmon river. It makes four general courses from the entrance to the head, as follows: 1¾ mile south, four miles E. by S. ⅜ S., 2½ miles S. by E., and 1¾ mile SW. by S. The shores are abrupt, and covered with wood to their edges, and the projecting parts are all terminated by low points stretching out short distances. On the second point, on the eastern side, were (1856) the remains of an extensive stockaded village of the Clallums. Mount Chatham* lies off the south-western part of the bay, and reaches a height of 2,100 feet.

When well in this bay Protection island so completely shuts up the entrance as to make it appear as a large lake. The great drawback to this port is the depth of water, which in mid-channel is not less in any place than 25 fathoms, and in some is 40. Under the second low point on the east we could not find less than 25 fathoms a few ship's lengths from the beach, but found good anchorage in 20 fathoms, soft bottom, on the western shore, two miles S.SE. from Challam Point, and abreast of a low swampy beach. At the head of the bay it contracts in width, the water shoals, a large mud flat exists for the last mile, and the shores become higher, but in places the hills retreat, and give a scanty space for a few settlers' cabins. For a few years after the settling of San Francisco many vessels came here for piles and spars; but a saw-mill has been built here.

* Named by the United States Coast Survey in 1855.

It was discovered in 1790 by Quimper, and called Port Quadra. In 1791 the Spanish discovery brig Sutil, Señor Don D. Galiano, and the schooner Mexicano, Señor Don C. Valdez, refitted their ships here.

It was first surveyed and made known by Vancouver in 1792, who refitted his ships and established an observatory at the second low point on the western shore. He gave it the present name, after one of his ships, and it is known by no other.

In 1855 we found on the bluff back of Challam Point great numbers of trees that had been twisted off and uprooted by a tornado from the southeastward. The prostrated trees were plainly visible on the sloping hillside from the bay.

Point Wilson is the western point of the entrance to Admiralty inlet. From Dungeness light it bears E. by N., distant nearly 15 miles, this course passing over the outer edge of the three-fathom shoal (Dallas bank) off Protection island. The extremity of the point is composed of low sandy hillocks, covered with coarse grass; but west of it the hill rises 200 or 300 feet, and again falls inshore. This appearance is well seen in approaching it from the strait, and is a good mark. Between the point and Port Discovery the shore is high, with steep yellow cliffs, and about midway a slightly projecting angle is formed, called Middle Point. To the northwest of the point 15 fathoms can be obtained a mile from the shore, but the water shoals suddenly, and in running in a fog the lead must be kept going. Off the eastern end of the point 20 fathoms can be got a ship's length from shore. During ebb tides a very strong eddy current sets to the eastward along shore between Discovery and Point Wilson. In 1855, when coming out of the inlet on the large ebb, with scarcely any wind, we kept outside of the rip showing the line of the eddy. A vessel two or three miles ahead was in the eddy at the same time. We were carried past Protection island, but she was drifted back to Point Wilson. The Indians when bound to Dungeness keep well out in the ebb.

A light-house was recommended for this point, as it presents many advantages over the head on the opposite side of the inlet.

When we were last there (1857) a small unfinished log hut, called Fort Mason, stood upon it.

It received its present name from Vancouver in 1792.

QUIMPER PENINSULA.

Between Port Discovery and Port Townshend lies a peninsula three miles in breadth and ten miles in length, offering great advantages as a location for a town. No name has hitherto been applied to it, and we have ventured to designate it as above.

For the description of Admiralty inlet, Puget's sound, and adjacent waters, see pages and ——.

VANCOUVER ISLAND,

Originally called Quadra and Vancouver by the Spanish commander and Vancouver, who met in the Gulf of Georgia in 1792, the former entering from the north, and the latter from the south, through the Strait of Juan de Fuca. The name Quadra has fallen into disuse.

NORTH SHORE OF THE STRAIT OF JUAN DE FUCA.

From Point Bonilla to Owen Point, forming the western head of the entrance to Port San Juan, the shore runs 13 miles E. ⅓ N. It is nearly straight, rocky, and bluff, with high mountains rising immediately behind it, and all heavily wooded. From 10 to 20 fathoms are found within half a mile from the shore. Vessels are apt to lose much of the wind when close under either shore, and at present it is impossible to say where the strongest currents run.

PORT SAN JUAN.

The eastern head of the entrance is formed by several large rocks, called Observatory rocks on the Admiralty chart of 1847. From Tatoosh Island light they bear NE. by N. ¼ N., 14 miles distant. The width of the bay is 1⅜ mile from point to point, and their bearing E. ¼ S. and W. ¼ N. from each other. The length of the bay is 3½ miles on a general course NE. ¾ N., and the width almost uniform at 1¼ mile to the very head, where several streams enter, amongst which are Cooper inlet at the northeast, and the river Gordon at the north, where stands a large Indian village called Onismah.* Across the entrance a depth of ten fathoms is found, except near Observatory rocks,* where 17 exists close to them. Outside we find from 15 to 20, and

* English Admiralty Chart, 1847.

inside the bottom is very regular in seven to ten fathoms, up to the head, where it decreases evenly to four within half a mile of the shore. The eastern side has the least number of rocks, and a mid-channel course clears everything well. In heavy southerly weather a swell rolls straight in, but by anchoring well up on either side vessels avoid it. The sides are steep, high, and backed by heavily timbered hills and mountains. At a distance in very clear weather it is difficult to distinguish the entrance unless one is acquainted with the locality, but in moderately hazy weather the indentation is readily made out.

The approximate geographical position of Observatory rocks is:

	°	′	″
Latitude	48	31	30 north.
Longitude	124	28	15 west.

Meares first noted this bay in his map, and called the western point Point Hawksbury. He called Bonilla Point Point Duffire, after his first officer. It was afterwards examined by the Spaniards, and Vancouver stretched over to this shore and plotted it on his chart. It was surveyed by the United States Exploring Expedition in 1841, and by Kellet in 1847.

From Observatory rocks the shore preserves the same features, running east in a straight line to *Sheringham Point** 23½ miles, with soundings in from six to twenty fathoms a mile from shore, and in some places ten fathoms at least two miles off, then suddenly dropping into 50 and 60 fathoms. From Sheringham on an E. ½ N. course to *Otter Point** the distance is 4½ miles, with a curve in the shore of one mile, but the shore is generally so uniform in its character that it is hard to recognize these points in sailing close abreast of them.

SOOKE INLET.

From Sheringham Point to *Beechy Head** the distance is 11½ miles, and the course E. ¼ N. The shore is varied by an indentation one mile deep, called Sooke bay, and at a distance of four miles from Otter Point is broken by a very narrow crooked entrance, which is Sooke inlet. This leads to a large sheet of water three miles inland, called Sooke basin. One mile east of this inlet is a large islet called Secretary island,* and on the western side is a bright yellow bluff, from which makes out a low sand spit NE. for half a mile across the entrance. To the eastward of this spit is the passage, only 100 or 200 yards wide, with an irregular and rocky bottom, and some sunken rocks. The currents run through with great velocity, and a thorough knowledge of these and the channel is necessary to enter this place. When a depth of ten fathoms is struck off the entrance a high hill called Mount Maguire* will bear about NE. It is partially covered with trees, but the bare rock shows distinctly in many places, and this feature now commences to distinguish the southeast part of Vancouver island. The shore in many places is bare and rocky, with patches of land covered with fern and destitute of trees, and the houses of settlers begin to appear.

Off Beechy Head the water is very deep, and the currents go by with a rush. In this vicinity we recollect the instance of a United States revenue cutter striking the bold shore with her flying jib-boom, and only striking her forefoot after the jib-boom had been carried away.

The approximate geographical position of Beechy Head is:

	°	′	″
Latitude	48	18	30 north.
Longitude	123	39	27 west.

The pronunciation of Sooke is exactly like that of the English word "soak." The Indian word is T'sōk.

*Beecher bay** lies to the eastward of Beechy Head. Its general direction is north for about a mile and a half, width about the same, and the bottom is rocky and irregular, with deep water. Many rocky islets are found upon the eastern side of the bay, and two large ones at the northern part. The channel runs between these with about 20 fathoms, and with from seven to ten fathoms beyond the eastern one. The eastern head is formed by *Cape Church.** This bay is enclosed by high rocky hills.

RACE ROCKS.

From Beechy Head the outermost of these rocky islets bears E. by N., distant five miles, and its distance from Bentinck island,* close under the main shore, is one mile. This cluster of islets numbers about ten principal ones, which cover an area of not less than half a mile square. They are low, and the larger ones are

* English Admiralty chart, 1847.

covered with grass, but are without trees or bushes. Stretching SE. from them for half a mile the bottom is irregular, with points of rock in five fathoms. The currents rush by with great velocity and irregularity, attaining a rate of six miles per hour, as we have measured by the log. This is a hard place for sailing vessels when the airs are light. See remarks in the directions for Esquimalt and Victoria harbors from the Race rocks.

LIGHT-HOUSE ON RACE ROCKS.

The light-house on the Great Race has an elevation of 118 feet above high water.

The light is a *white light, showing a bright flash* every ten seconds. The illuminating apparatus is of the second order of Fresnel, and was first exhibited January 1, 1861. Under a favorable state of the atmosphere it should be seen from a height of—

10 feet at a distance of 16.1 miles.

20 feet at a distance of 17.6 miles.

30 feet at a distance of 18.8 miles.

The approximate geographical position of the light is:

	° ′ ″
Latitude	48 17 30 north.
Longitude	123 32 15 west.
	h. m. s.
Or, in time	8 14 09.

Computed magnetic variation 22° 04′ east in 1861.

Notice has been published by order of the governor of Vancouver island that after the first day of October, 1864, the tower of the light-house on the Race rocks will be painted in alternate broad horizontal bands of black and white.

From Race rocks the strait opens to the northward, and we have the following bearings and distances to several important positions:

Esquimalt Harbor light, north 8½ miles.

Entrance of Victoria harbor, N. by E. ½ E. 9 miles.

Trial islands, NE. by N. 10½ miles.

Discovery island, NE. by N. 15 miles.

Smith's Island light, N. 65° E. 26½ miles.

New Dungeness light, east 18 miles.

From Race rocks the shore is very much broken to Esquimalt harbor, first by a narrow deep indentation called Pedder bay,* its northern point called William Head;* then Parry bay* and Albert Head,* and just before reaching Esquimalt a long, low spit, with a salt lagoon behind it. Along this shore the ebb current runs with great strength, the water being from 40 to 50 fathoms deep, and the general set on the Race islands.

DIRECTIONS FOR ESQUIMALT AND VICTORIA HARBORS FROM THE RACE ROCKS.

The Race Rocks tower can be distinctly seen at a distance of 12 miles. On nearing it vessels should round it at a distance of not less than half a mile to a mile. The outermost danger is a rocky patch of five feet, lying SE. by E., nearly half a mile from the tower.

On rounding the rocks Esquimalt Harbor fixed light will be seen, and should be steered for on a bearing N. ½ W., which will lead clear of the reef extending a short distance off Albert Head. Keep the bright light in full view. If a vessel gets too far to the westward it will appear dim, and shortly become shaded *green*, when she should immediately steer to the eastward until it again shows bright. This precaution is necessary on account of the currents, which during spring tides run as much as six knots in the neighborhood of the Race rocks. The ebb runs almost in a direct line from the Canal de Haro to the rocks, and sets between them and the shore. There are also tide rips in the vicinity dangerous to boats and small craft.

When to the northward of Albert Head, and wishing to anchor in Royal bay, a vessel should bring Esquimalt light to bear N. by W., when she will have 10 fathoms good withholding ground about one mile from the light, or, if desired, she may stand to the westward until the light becomes shaded green, when she should *immediately* anchor.

* English Admiralty chart, 1847.

In entering Esquimalt harbor the light should be left from three to four hundred yards on the port hand, and when it bears S. by W. a ship may anchor in seven fathoms, or stand into Constance cove, (Village bay.) When the light bears NW. by W. it changes from bright to *red*, and shows the latter color in the harbor.

In entering Esquimalt from the eastward the light should not be steered for until it shows bright, which is the mark for clearing Brotchy ledge off Victoria, and Scrogy rocks off Esquimalt. When the light changes from red to bright it leads clear of the Scrogy rocks about 120 yards.

The course for the entrance to Victoria harbor, after rounding the Race light, is N. ¾ E., and when Esquimalt light changes from bright to red a vessel will be one mile from the shore in 33 fathoms.

Ships, however, above the size of coasters, unless acquainted with the neighborhood, are recommended not to run for Victoria at night, when they cannot enter, but rather to anchor in Royal bay for daylight. With southeasters and stormy weather a ship should invariably run into Esquimalt harbor, which she can readily do with the assistance of the light on Fisgard island.

ESQUIMALT HARBOR.

This is the bay where all the British men-of-war lie. It is in the deepest part of the large indentation called Royal bay.* The entrance is a quarter of a mile wide, and has two rocky heads on either hand, the western having Fisgard† island off it, and the eastern outlying sunken rocks south of it, with several islets. From the entrance the general direction of the bay is N.NW., and the extreme length two miles. After passing the heads the harbor opens to the east, forming a small beautiful bay, called Village bay, or Constance cove, where men-of-war anchor in a uniform depth of six fathoms. In the entrance are seven and eight fathoms, and the approaches for a mile give from 10 to 13 fathoms.

At the head of the harbor is Mount Seymour.*

Five miles west of the head of Esquimalt bay is the head of a large bay coming from the north, and opening into the inside channel to the Nahny'moh coal mines.

LIGHT-HOUSE AT ESQUIMALT HARBOR.

The building is erected on Fisgard island, on the western side of the entrance to Esquimalt harbor. It consists of a keeper's dwelling of brick, with a tower 57 feet in height, whitewashed, and surmounted by a lantern painted red.

The illuminating apparatus is of the fourth order of the system of Fresnel, and shows a *fixed light*, visible through an arc of 220° of the horizon. Through 20° it exhibits a green light, through 58° a bright or white light, and through 142° a red light. It will show *green* when bearing between N. by E. ⅝ E. and N. ¼ W., *white* from N. ¼ W. to NW. by W. ⅓ W., and *red* towards the harbor, or from NW. by W. ⅓ W. to S.SE.

It is placed at an elevation of 70 feet above the level of the sea at high water, and in favorable states of the atmosphere should be visible from a height of—

10 feet at a distance of 13.2 miles.

20 feet at a distance of 14.7 miles.

The approximate geographical position of the light is:

	° ′ ″
Latitude	48 25 38 north.
Longitude	123 27 10 west.
	h. m. s.
Or, in time	8 13 48.7.

Computed magnetic variation 22° 05′ east in 1861.

The light was first exhibited November 19, 1860.

VICTORIA HARBOR.

The entrance to this harbor is 2¼ miles east of Esquimalt. As the channel is very contracted, crooked, and obstructed with a 10-feet bar, vessels usually anchor outside in 10 or 15 fathoms, taking care to avoid *Brotchy ledge*,* with only seven feet of water upon it, lying about half a mile S.SE. of the eastern head, and SW. ⅜ W. from Mount Beacon,* upon which was a range, with one on the shore. We believe, however, that the ledge has been marked by a spar buoy since our visit there. The channel inside is well marked out by

* English Admiralty chart, 1847.
† English charts of 1851 call it Fishguard.

buoys, but a pilot is necessary to carry a vessel in. The whole length of the harbor is about three or four miles, with an average width of one-fifth of a mile. It is very tortuous, and the head stretches west nearly to the head of Esquimalt bay, where a portage exists.

The approaches to the harbor are deep outside of Brotchy ledge, and from 10 to 20 fathoms are found inside of it.

The approximate geographical position of Mount Beacon is:

	°	′	
Latitude	48	24½	north.
Longitude	123	22¼	west.

The Hudson Bay Company has a flourishing settlement and trading establishment a mile and a half within the entrance, and much of the surrounding country is well cultivated, but the settlement hereabout must spread toward Esquimalt, or upon that harbor, not only on account of its superior excellence, but because fresh water is scarce about Victoria. A steamer runs regularly between Victoria and Portland, (1864.)

The shores are comparatively low, but rocky, and covered in part by trees, reminding one of the rocky parts of the coast of Massachusetts and Maine.

TRIAL ISLANDS.

These islands lie four miles E.SE. from the entrance of Victoria harbor, with a rocky, irregular, and moderately low shore. The islands are small in extent, and the currents set by them with great velocity.

DISCOVERY AND CHATHAM ISLANDS.

The former of these two islands lies 2½ miles off the southeast point of Vancouver island. It is about a mile in extent, 230 feet high, partially covered with trees, and consists of granite rock, which shows in places without a particle of vegetation.

Northwest of it, and separated by a narrow and intricate channel full of rocks, lies Chatham island, (composed of several small islets,) somewhat smaller in extent, and not so high as Discovery island, but similar in appearance and formation. Between these two islands and Vancouver lies an extensive bay nearly filled with rocks and reefs, the main body being called the Chain islands. Close around the western side of Discovery and Chatham is a channel, having from 7 to 17 fathoms, but it is only fit for small craft. From the western part of Chatham to Cadboro' Point the distance is about three-quarters of a mile. Numerous rocks show close to the point.

The approximate geographical position of the middle of Discovery island is:

	°	′	
Latitude	48	26	north.
Longitude	123	14½	west.

A light-house is much needed upon Discovery island, as marking the southwest point of the southern entrance to the Canal de Haro.

The islands were named by Kellett after Vancouver's two ships.

ARCHIPELAGO DE HARO.

This extensive group of islands was first seen by Lopez Gonzales de Haro, in 1789; next by Quimper, in 1790; and first circumnavigated by Don Francisco Eliza, in 1791. Vancouver, in 1792, passed through the Rosario strait from the south, and gives a good representation of the channel and islands, his boats evidently working among them. Galiano and Valdes, in 1792, about a month later than Vancouver, passed through one of the straits from the north, and represented the mass of islands as one which they designated Isla de San Juan. The agents and factors of the Hudson Bay Company, doubtless, knew most of the channels and islands subsequently; still, up to 1853, they exhibited only eye-sketches of the Canal de Haro, north and east of Sidney island. In 1841 the United States Exploring Expedition made the reconnaissance of the archipelago, but did not lay down the islands on the western side of the Canal de Haro. The Rosario strait was surveyed, and called Ringgold's channel. Most of the islands, channels, points, &c., were named after officers and vessels of the navy, and it is said to have been intended to call the whole group the Navy archipelago. The Canal de Haro is erroneously called the Canal de Arro.

The Canal de Haro and Rosario strait were surveyed by the United States Coast Survey in 1853 and 1854, and the archipelago called Washington sound.

CANAL DE HARO.

The southern entrance to this strait may be said to lie between Discovery island and the point of Bellevue or *San Juan island*,* nearly northwest and seven miles distant. Starting from this line and about three miles from Discovery, a course NW. by N. for 16 miles will run through the first stretch of the strait; thence an abrupt turn is made towards the eastward, and the way out can be readily seen between the islands. The next course is NE. ½ E. for 11 miles; finally, N.NW. 2½ miles, and a run of seven miles on that course will carry a vessel into the middle of the Gulf of Georgia.

Commencing at the starting point, we have Bellevue island on the eastward, and pass it at the distance of 1½ mile. Its mountains rise to 1,070 feet, and some of them are only partially covered with wood. The bluffs are very precipitous and inaccessible, and the depth of water close to them is as much as 150 fathoms. The greater extent of the strait is to the westward, stretching off into bays and passages among the islands. *Cordova bay*† is the only available anchorage about this entrance. It commences at Gordon Head, 5½ miles NW. by W. ¼ W. from Discovery island; then stretches westward for two miles, and gradually curves to the N.NW., with a long high bluff, broken and bright, at *Cowichin Head*.‡ Back of the southwest part of the bay rises a bold rocky-topped hill, (named *Mount Douglas*,†) which reaches a height of 690 feet. Fresh water is obtainable on the southern shores of the bay. The northern limit of the bay is *Darcy island*,† N. ¼ W. four miles from Gordon Head, and on this course and 1¾ mile from the head is *Zero rock*,† a small white rock, showing a few feet above water, with plenty of water around it, but foul bottom and a patch of kelp a few hundred yards N.NW. of it. A mile and a quarter west of it is a sunken rock. In the bay a depth of not over 20 fathoms is found, decreasing irregularly in advancing, but in the southern portion affording capital holding ground in 10 fathoms. A mile and a half E.SE. from Gordon Head are patches of kelp and foul bottom.

When 8½ miles within the entrance the width of the strait decreases to 3¼ miles, having Darcy island (low and wooded) on the west, with a small islet off its NE. face, and very large fields of kelp stretching far off the southeast point into the Canal. In one of these fields we discovered in 1854 a sharp-pointed rock, which has been named *Unit rock*,(1) lying S. 72° E. from the SE. point of Darcy island, and distant from it three-quarters of a mile. The small, sharp apex of this rock rises about three feet above the very lowest tides. In recent charts deep water is placed around it, and when the coast surveying brig Fauntleroy beat through the field the existence of this danger was unknown.

Since its discovery several rocks covering a space of half a mile square, and bearing S. 72° E. from the SE. point of Darcy island, have been found. They are marked by a field of kelp, and one point uncovers at the lowest tides. Near mid-channel a depth of 155 fathoms is found.

The island to the eastward, nearly abreast of Darcy, with a small cove at its southern end, is *Henry island*,(2) having a high, rocky precipitous front, and a swirling current around it. Further on and to the westward is the southeast end of *Sidney island*,(3) 1½ mile northward of Darcy, with the Dot rocks between them, but nearer Sidney. This island is not high like those on the other side of the channel, and a landing is easily made at any point. The channel here, 10 miles from the entrance, is 2¾ miles wide. To the eastward it opens beyond the north end of Henry island, with high mountainous islands bounding the view. To the westward lie a couple of long, narrow islands a mile from Sidney, and between them and the latter is good anchorage and capital fishing ground for halibut; that near the canal is named Halibut island.(1) The moderately low wooded islands, three or four miles ahead, and on the western side of the channel, have not been named. Between them runs the inside channel for steamers to the Nahnymoh coal mines. The background of the view is occupied by wooded islands, overlapping each other and appearing like a continuous shore. The large high island on the eastern side, 15 miles from the entrance, is *Stuart island*,(4) and the canal is here contracted to a breadth of only two miles, this being the narrowest part. Two and one-eighth

* San Juan on English Admiralty charts of 1847 and -'59; Bellevue by the Hudson Bay Company; Rodgers by the U. S. Exploring Expedition, 1841.

† English Admiralty chart, 1847. On that of 1859 Cordova bay is called Cormorant bay.

‡ The name of the Indian tribe in this vicinity. Admiralty chart, 1847.

(1) Named by the U. S. Coast Survey, 1854.
(2) Named by the U. S. Exploring Expedition, 1841.
(3) English Admiralty chart, 1847.
(4) Named on the English Admiralty chart, 1847.

miles S. 67° W. from the western point of Stuart island, the British surveying steamer Plumper found (1858) a rock covered at a quarter flood, and having irregular bottom around it for the space of half a mile square, with soundings from 5 to 20 fathoms. One mile NW. of Stuart's island a depth of 190 fathoms is found.

Stuart island in many places is very high and precipitous, and covered with timber, but in some parts sparsely. Near its southwest head a perpendicular wall of rock serves also to distinguish it. After passing the western end of this island at the distance of a mile, the channel takes an abrupt turn to the eastward, and the Gulf of Georgia is seen. The course now is NE. ½ E. for 11 miles, having on the northwest side *Saturna island*, which rises into mountains. *Java Head*,(1) near its eastern extremity, stands up perpendicularly nearly 700 feet, but the extreme part, called *East Point*,* is a long sloping point, in many places destitute of trees. The small island lying off its north shore is Tumbo.*

On the east side the waters open well to the southeast, and the islands rise in high hills and mountains. The large island abreast of Java Head is *Waldron*,* which has good anchorage off its southwest side, where the shore-line curves well in. The western point is low and sandy; the southern, called *Point Disney*,* is perpendicular, high and rocky. Off its northern face lie two islets, called *Skipjack islands*.(2) The western one is about a mile from Waldron, moderately high, and wooded; the eastern is smaller, about 40 feet high, destitute of trees, but covered with grass, and lies a mile east of the former. Between these lies a sunken rock, and the current rushes by with great velocity.

On some recent maps two islands, called Adolphus and George, are laid down close to the Skipjacks, but in 1853 we examined the vicinity and satisfied ourselves that they did not then exist.

When East Point bears NW. by W. ¾. W two miles distant, the west end of *Patos island*(3) will bear N.NE 2½ miles, and the west end of the *Sucia group*,(4) E.NE. 3½ miles; the course out lying N.NW. between Patos and East Point, which are 2¾ miles apart. Seven miles on this course carries to the middle of the Gulf of Georgia. Close off East Point is found a depth of 120 fathoms, and off Patos island 170 fathoms. All these islands are moderately high and covered with wood. They are rugged and irregular, composed of sandstone and conglomerate, upheaved until the strata are nearly perpendicular in some places, and interspersed with small veins of lignite.

West's reef(5) lies S. 66° W., one mile from the SW. point of Sucia; it has less than two fathoms upon it, and is marked by a large mass of kelp.

The approximate geographical position of two or three points will serve to check the courses above given:

East point of Discovery island, latitude 48° 25′ N., longitude 123° 14′ W.

West point of Stuart island, latitude 48° 41′ 17″.5 N., longitude 123° 14′ 29″.6 W.

West point of Patos island, latitude 48° 47′ 03″ N., longitude 122° 57′ 31″.2 W.

The number of islands and the intricate channels lying between the two straits we shall not attempt to describe. A proper appreciation of them can only be obtained from the chart. The position of the islands are shown on sketches issued from the Coast Survey office in 1854 and 1858.

SMITH'S ISLAND.

Returning to the Strait of Fuca to enter the Rosario strait, we notice, first, *Smith's island*, lying at the eastern termination of the Strait of Juan de Fuca, within six miles of Whidbey island, and seven miles broad off the southern entrance to the Rosario strait. It is quite small, not occupying half a square mile, and rises regularly from the eastern to the western extremity, where it attains a height of about 55 feet, with an almost perpendicular cliff of clay and gravel. It sustained a few dreary looking trees, but none of great thickness or height, and the surface is covered with a growth of bushes ten or twelve feet high. There is no fresh water to be found on the island, and two or three feet below the surface is a stratum of hard, dry clay with pebbles.

(1) Named by the U. S. Exploring Expedition in 1841. On the English Admiralty chart of 1859 it is called Monarch Head.

* Named by the U. S. Exploring Expedition, 1841.

(2) So called by the U. S. Exploring Expedition, 1841. Named Wooded island and Bare island by U. S. Coast Survey in 1853.

(3) Old Spanish name. Called Gourd island by the U. S. Exploring Expedition, 1841.

(4) Old Spanish name. Sucia signifies muddy. The harbor on the east has a soft muddy bottom. The U. S. Exploring Expedition called them the Percival group, 1841. The Indian name is Choo-sá-nung.

(5) Discovered and named by the U. S. Coast Survey, 1858. Called Plumper reef on English Admiralty chart, 1859.

A very small, low islet called *Minor*,* exists one mile northeast of Smith's island, and at very low tides is connected with it by a narrow ridge of boulders and rocks. A field of kelp extends to the westward of Smith's island for 1½ mile, and has a width of a mile. In sailing through this field we found the depth of water very uniform at 6½ fathoms, and in no place did we get less. The bottom is hard and sandy, and no rocks have been discovered in it. Another smaller field is seen to the westward of the one just mentioned. Good anchorage is found on the north side of the island, east of the kelp, in from 10 to 5 fathoms, and on the south side, east of the kelp, in from 10 to 8 fathoms, hard bottom. We parted our cable here in a south-east gale, but the smooth sandy bottom enabled us afterwards to secure the anchor. Off the eastern end of the small islet very deep water is found close to it.

THE LIGHT-HOUSE ON SMITH'S ISLAND.

This structure consists of a keeper's dwelling, with a tower rising through it, and surmounted by an iron lantern painted red. Its height is 41½ feet above the surface of the ground, and about 90 feet above the mean level of the sea. The dwelling and tower are plastered and whitewashed, and situated on the highest part of the island, near the southwest point. All the trees have been cut down to afford a clear horizon in every direction. The illuminating apparatus is of the fourth order of Fresnel, shows a *revolving white light, with a flash every half minute*, and should be seen from a height of—

10 feet at a distance of 14½ miles.
20 feet at a distance of 16 miles.
30 feet at a distance of 17 miles.

It was first exhibited on the 18th of October, 1858, and shows from sunset to sunrise.

The approximate geographical position of the light, as determined by the Coast Survey, is:

	°	′	″	
Latitude	48	19	01.0	north.
Longitude	122	50	02	west.
	h.	m.	s.	
Or, in time	8	11	20.1.	

The light shows into the entrances of Canal de Haro, Rosario strait, and Admiralty inlet, and out into the Strait of Juan de Fuca.

The following bearings and distances will show the relative position of Smith's island:

From Discovery island it lies east 16½ miles.
From Race Island light NE. by E. ¾ E. 26½ miles.
From New Dungeness light NE. by N. 13⅝ miles.
From Point Wilson NW. ½ N. 11 miles.
From southwest point of the entrance to Rosario strait S. ½ E. 6⅜ miles.

This island was discovered by Eliza in 1791, and named Isla de Bonilla.

Vancouver gave it no name.

It was called Blunt's island by the United States Exploring Expedition in 1841.

Called Smith's island on the English Admiralty chart of 1847, and is generally known by it.

Fields of kelp.—Three miles S. ½ E. of Smith's island is a field of kelp over a mile long by a mile wide. Through it the soundings range from six to twelve fathoms, and the bank stretches off to the E.SE. for two miles, with ten and twelve fathoms upon it. This locality requires sounding out, as it would prove a great advantage for vessels drifting at the mercy of the currents to know of the existence of such anchoring grounds. The detailed hydrography of all this sheet of water eastward of the Race islands will develop many interesting features of bottom.

Bearing W. ½ S. from Smith's island, and eight miles distant, is another field of kelp nearly a mile in extent. We came unexpectedly upon it at night, in 1854, during a heavy blow, with rain. It was not then marked on any chart. Next morning we sounded through it, and found the depth of water very uniform at 5 fathoms.

Recent partial examinations show that this field marks the NE. portion of the bank lying nearly north and south, with a length of 4 miles, and a breadth of 1½ mile within the limits of the 20-fathom line.

We have named it the *Hein bank*.

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* Named by the U. S. Coast Survey in 1854.

The field laid down on the Amiralty chart of 1847—nearly on this course, and four miles from Smith's island, having only 2 fathoms marked upon it—has been sought for, but not found.

One mile south of the southeastern point of Bellevue island, and 8½ miles NW. by W. ¼ W. from Smith's island, lies a small field of kelp about half a mile square, with three fathoms marked upon it; but we have been informed that the Hudson Bay Company's steamer Otter found as little as 6 feet of water within its limits. Recent examinations show that this is connected by a 4-fathom bank with the SE. end of San Juan island, and stretches S.SE. therefrom for 2½ miles, with a breadth of three-quarters of a mile within the limit of the 10-fathom line. It is named the *Salmon bank*.

All these fields and patches of kelp should be avoided, as they denote rocky bottom; and isolated points of rock frequently exist among them and escape even a very scrutinizing survey.

Shoals.—E. by N. 5½ miles from Discovery island, and S. by W. ⅓ W. 4½ miles from the Hudson Bay Company's settlement on Bellevue island, is an 11-fathom shoal a mile or two in extent; but the very few soundings upon it leave the precise extent and smallest depth of water doubtful, (1857.)

Recent partial examinations show that the extent of this *Middle bank* is about 2½ square miles within the limits of the 20 fathom line.

NE. ½ N. 7½ miles from Race rocks, and SE. by S. 4 miles from the entrance to Victoria harbor, are a couple of spots showing 9 and 13 fathoms. It is named the *Constance bank*.

Off Point Partridge (the western head of Whidbey island) is a 10-fathom bank, with muddy bottom. We have run across it and found this depth, but the locality has not been sounded out.

This bank was discovered by Vancouver in 1792.—(Vol. I, p. 291.)

We have named it the *Partridge bank*.

ROSARIO STRAIT.

This strait was first seen by Quimper from Port Discovery, and called "Boca de Flon." From Protection island he could see through the whole length of the strait; he could not see Deception Pass from there.

Eliza passed through it in 1791, and called it the Canal de Fidalgo.

Vancouver passed through it in 1792, and gives its peculiarities very well.

Galiano and Valdes came through it in 1792, and called it Canal de Fidalgo.

The United States Exploring Expedition, in 1841, called it Ringgold's Pass channel.

The English Admiralty chart of 1847 has it Rosario strait, and by this name it is always known on the Pacific.

Rosario strait is the eastern of the two principal channels running through the Archipelago de Haro, between Vancouver island and the main. Its southern entrance lies N. by E., distant 7 miles from Smith's island, and is 4½ miles wide. The western point of the entrance is formed by a point running out from *Watmough Head*,(1) which is 450 feet high and on the southeast part of *Lopez island*.(2) Off this point lie several rocky islets, with deep water among them and a rushing current. The outer one, named Southwest island,(3) is about 50 feet high, rocky, flat-topped, destitute of bush or tree, narrow, and about one-third of a mile in length, east and west. S. 83° E. from it, at a distance of half a mile, lies *Entrance rock*, possibly bare at the lowest tides. A patch of kelp exists upon and around it, but the kelp is generally run under the surface of the water by the strength of the current. We discovered and named this rock in 1854, The English Admiralty chart of 1859 calls it Davidson's rock.

The whole southern face of Lopez island is guarded by rocks and reefs. The island itself is very rocky and moderately low.

On the eastern side of the entrance is a small wooded islet called Deception island,(3) at the mouth of *Deception Pass*, an intricate and very narrow 3-fathom channel, 3 miles long, running between the north end of Whidbey island and the south end of *Fidalgo island*.(4) In 1841 the United States brig Bainbridge

(1) Named Watmough Head by the U. S. Exploring Expedition in 1841. On the first sheets of the U. S. Coast Survey called Walmough Head. On the English Admiralty chart of 1859 called Walmouth Hill. The Indian name is Noo-chaad-kwun.

(2) Vancouver determined it to be an island in 1792. In 1841 the U. S. Exploring Expedition named it Chauncey's island. English Admiralty chart of 1847 has it Lopez island, and always known by this name on the coast.

(3) Named by the U. S. Coast Survey in 1854.

(4) Named by Eliza in 1791. Called Perry's island by the U. S. Exploring Expedition in 1841.

passed through it from the eastward. It is the Boca de Flon of Eliza, 1791, but is now known only by the apt designation given above.

Vancouver called it Deception Pass in 1792; Galiano and Valdez called it Boca de Flon, thinking with Eliza that it was the strait of that name seen by Quimper in 1790. It was named Deception Pass by the United States Exploring Expedition in 1841.

In the middle of the entrance to Rosario strait Vancouver anchored in 37 fathoms, black muddy bottom, in 1792.

When at the entrance, and 1½ mile from the western side, a line will pass clear of everything from one end of the strait to the other. This course is N. by W. ½ W., and the distance 19½ miles to the north entrance. It passes between Bird and Belle rocks, and almost tangent to Point Lawrence, on Orcas island. Taking the courses through the mid-channel we should have the following: NW. by N. ⅜ N. for 11¼ miles; N. by E. ¾ E. for 3¾ miles; and NW. ½ W. for 6½ miles—making a total of 21½ miles.

The shore for the first two miles on the western side is moderately high, declining to a point, a quarter of a mile off which lies Kellett's ledge,(1) bare at the lowest tides, and having deep water all around it. The ledge is marked by a mass of kelp. Thence the shore makes a deep bend for a mile to the westward, with a low beach and marsh, over which *Lopez bay*(2) can be seen. This bend is called *Shoal bight*,(3) and has from 6 to 10 fathoms for a mile out, with level sandy bottom. In mid-channel rise the *Bird Rocks*,(4) about 40 feet high, consisting of three small rocky islets very close together, and running in a north direction. They are somewhat pyramidal in form, and during the summer show yellowish, on account of the parched grass and the color of the rocks. Abreast of them, on the western side, is a narrow opening between two low rocky heads of Lopez and *Decatur islands*.(4) Inside is a line of islets ranging from the north head, and making the channel run towards the south. This barrier is called the Lopez Chain,(1) and the entrance the Lopez Pass.(1) Several large islands are found inside. Vancouver's boats evidently were in this bay, as his chart gives a good general idea of it. The anchorage of Shoal bight continues some distance northward of this opening, and abreast of some moderately high white bluffs. N.NE. three-quarters of a mile from Bird rocks lies *Belle rock*, directly in mid-channel, making a very dangerous position. It shows 4 feet above the very lowest tides, and is covered by a patch of kelp, which is, however, generally run under by the strength of the currents. The rip upon it can sometimes be seen when the water is smooth, but with light winds and high tides its existence would not be suspected. On all sides of it the water is very deep. The extent of rock above water is about 20 feet square. We discovered and named this danger in 1854, and while placing a signal upon it noticed that the tide rose nearly 1½ foot while the current was yet running ebb at the rate of 3 miles an hour. Between it and the Bird rocks there is a submarine ridge with plenty of water, but marked by strong eddies. The steamship Republic lately ran upon this rock, and more recently the pilot-boat Potter.

After passing Deception island on the east side of the entrance, the face of Fidalgo island is high, precipitous, and bare for two or three miles in a northwest direction. This is called Sares Head.* It then sweeps to the north, changing to the westward until abreast of and two miles from Belle rock. In this deep bay, and lying well off shore, are, first, *Williamson's rocks*,* a cluster of rocky islets about 40 feet high, with deep water close around them. From Deception island they bear NW. ⅝ W. 3 miles distant, and from Southwest island off Watmough Head, NE. 5 miles. Half a mile northward of them is *Allan island*,* which is about three-quarters of a mile in extent, and about 200 feet high, with its southern face partly bare. A quarter of a mile off its SW. face lies the *Denis rock*.* This is never bare, but its position is marked by a patch of kelp.

North of Allan island, and separated from it by a channel a quarter of a mile wide, is *Burrows's island*,* 1½ mile long SE. and NW. by half a mile in breadth. The island is between six and seven hundred feet high, and has a remarkably flat top, is wooded, and may be seen from the Strait of Fuca. At the eastern end of the

(1) Named by the U. S. Coast Survey in 1854. Lopez pass is called Maury pass on the English Admiralty chart, 1859.

(2) Called the Macedonian Crescent by the U. S. Exploring Expedition in 1841; named Lopez bay by the United States Coast Survey in 1854.

(3) Named by the U. S. Coast Survey in 1854. We were the first to discover this available anchorage. It is called Davis's bay on the English Admiralty chart of 1859.

(4) Named by the U. S. Exploring Expedition in 1841.

* Named by the U. S. Exploring Expedition, 1841.

passage, between the last two islands, is a small one called *Young island.** Through all the channels formed by these islands a good depth of water exists, and no dangers have been discovered.

The breadth of Rosario strait at Belle rock is 3½ miles; but it is soon contracted by *James island,** on the western side, and opens into a channel N.NE. called the *Bellingham channel,*† which is about two miles wide at its entrance. A small channel runs from it more to the eastward along the north shore of Fidalgo island, and leads into Padilla bay. Upon Fidalgo rises Mount Eric* to a height of 1,250 feet, covered with woods, and presenting a flat appearance from certain directions. James's island consists of two heads a mile apart, and 250 feet high, but connected by a narrow ridge. The southern head is the higher, and not very heavily timbered. Close to the west of the ridge lies another head, connected with Decatur island by a low sand beach.

Just below James's island is an opening on the west between Decatur island and Blakely island,* with 25 fathoms in it, but a rock, covered at a quarter flood, exactly in the middle of the entrance. On the east, half a mile up the strait, appears the SW. point of *Cypress island,*‡ off which lie rocks and foul bottom for half a mile on a line to Burrows's island. Around this locality extends a large body of kelp. The southern face of Cypress island consists of alternate perpendicular white cliffs, and sloping ground covered with fern or trees. On its western side, and 1¼ mile from the southwest point, is found a snug little harbor called *Strawberry bay,*‡ which is formed by the retreating of the shore-line, and an outlying rocky islet called Strawberry or Hautboy island.* In this bay excellent anchorage is found in from 6 to 10 fathoms, muddy bottom. Good fresh water is plenty here. A high white cliff is seen to the south of the harbor, from the shores of which rise rapidly the Lake mountains,(1) to an elevation of 1,525 feet, and among whose peaks we found two large sheets of fresh water. These peaks are very noticeable from the Strait of Fuca, and being connected by comparatively low ridges with other hills on the island, they present a saddle-like appearance from the southward and westward.

Abreast of Strawberry island the channel contracts to a width of 1½ mile, where the bold rocky face of Blakely island rises to a height of between 900 and 1,000 feet. The greatest elevation of the northern part of the island is 1,044 feet. Nearly half a mile SE. from its east face lies a very small low rock called *Black rock,*(1) and half way between it and the south end of the island is a *white rock,*(1) a quarter of a mile from the shore. In this narrow part of the strait the depth of water is about 60 fathoms, and the current goes through with a roar like the sound of a gale of wind through a forest. When at anchor in 10 fathoms, under the low point 1½ mile north of Strawberry island, we found the current four miles per hour, and swirling so much that the vessel had to be steered to prevent her breaking her sheer. Thence the strait widens northward, and at the north end of Blakely, two miles above Strawberry island, two channels lead to the westward around Obstruction island,(2) which lies between Blakely and Orcas islands. Both are narrow, and off the entrance to the south lie some sunken rocks, and others above water. Blakely island and Orcas island are three-quarters of a mile apart.

When in the narrowest part of Rosario strait, a very marked perpendicular rocky peak is seen to the north over the low point of Cypress, and soon shows rising abruptly from the water's edge to a height of 750 feet. It is called Bald Peak.(3) Abreast of it the channel takes the first turn, changing its course to N. by E. ¾ E. for 3¾ miles. Half a mile off the north end of Cypress island is a small islet covered with trees, and called Rock island.(1) NW. of it are some sunken rocks, but their exact position is not accurately known. The comparatively low island half a mile N.NE. of Cypress is *Sinclair island,*(4) the highest part of which is towards the eastern end. Off the northeast face of Sinclair island, and stretching half a mile, is Boulder reef,(5) visible at extreme low tides. It is covered with kelp, which is, however, generally kept under the surface of the water by strong currents. A huge erratic granite boulder is seen at ordinary tides inside of the outer point of the reef, and bears from it S. 70° E., distant 500 yards. From the western point of the island the reef bears exactly north, distant three-quarters of a mile. The revenue cutter

* Named by the U. S. Exploring Expedition, 1841.

† Named by the U. S. Coast Survey, 1854. The Indian name is Tut-segh.

‡ Named by Vancouver, 1792. The Indian name for Strawberry bay is Tutl-ke-teh-nas.

(1) Named by the U. S. Coast Survey, 1854.

(2) Named by the U. S. Exploring Expedition, 1841.

(3) Named by the U. S. Coast Survey in 1854. The Indian name is Sheh-ung-tlh, signifying the home of the Thunder-bird.

(4) Laid down by Galiano and Valdes as Isla de Ignaso. Received its present name from the U. S. Exploring Expedition in 1841.

(5) Named by the U. S. Coast Survey in 1854. Called Panama reef on English Admiralty chart of 1859.

Jefferson Davis and the steamship Panama have been upon it since we discovered it in 1854. On the north side of the island is anchorage in 10 to 15 fathoms half a mile off shore.

Three miles from Sinclair island lies *Orcas,* on the northwest side of the strait. It is a large island, with a mountain 1,120 feet high near its southern end. The point stretching furthest east and coming down to the water is *Point Lawrence,** and the low, treeless islets and reef passed 1½ mile before reaching this point, and lying over half a mile off shore, are the Peapods.* Deep water is found close to them. When upon this same mid-channel course, the island ahead is *Lummi island.*† Its southern half is very much higher than the northern, and attains an elevation of 1,560 feet. The rock nearly 100 feet high off the highest part of the ridge, and a third of a mile from shore, is the *Lummi rock,*‡ and a capital boat harbor is found on its northwest side. A mile off its south end are the *Viti rocks,** about 25 feet high, with plenty of water around them.

Abreast of Point Lawrence the channel is over three miles wide, and it there changes to NW. ½ W. for 6½ miles to a line joining the *Matia group* with the north end of Lummi island. From Point Lawrence, along the north face of Orcas, the shore is rocky and precipitous, and rises by two or three plateaux to Mount Constitution,§ which is less than a mile in-shore and 2,423 feet high.

The geographical position, as determined by the Coast Survey in 1854, is:

	°	′	″
Latitude	48	40	37.2 north.
Longitude	122	49	0.83 west.

The course out passes on the west some small rocky islets called *The Sisters,** marked by one or two stunted fir trees; then *Clark's island** and *Barnes's island,** close under its western side, leaving a channel a mile wide between it and the north shore of Orcas, with very deep water and no anchorage. Abreast of Clark's island, on Lummi island, is a contracted anchorage and shelter from northerly winds under a low point called Village Point.* The anchorage is in 10 to 15 fathoms, but there is no fresh water, and the large Indian village is now deserted. After passing this point, anchorage may be obtained half a mile from shore in from 8 to 15 fathoms. Close to Clark's and Barnes's islands the depth is 50 and 60 fathoms, and a very strong current runs near them. The channel between Village Point and these islands is two miles wide.

W.SW. of the north end of Lummi island, and four miles distant, are three islands very close together, called the *Matia group.*(1) A mile and a half to the westward of them lies the *Sucia group,* consisting of one large and six small islands, with a reef off the north side of the group, and a beautiful harbor a mile long and half a mile wide, opening to the east, and carrying from 10 to 15 fathoms sticky, mud bottom.‖ To the westward of this group lies *Patos island,* and a much smaller one close to its SW. point. The eastern point of Patos island bears W. ¾ S., 9 miles from the north end of Lummi. Two or three miles N.NE. of Lummi island opens a shoal bay, backed by low marshy ground, which is covered with trees and swamp undergrowth. Into it empties one or two mouths of the Lummi river. The main entrance of that stream is at the north part of the bay, and can be reached with boats only at high tide. The NW. boundary of the bay is a low grassy point with a few bushes upon it, called *Sandy Point.** From the north point of Lummi island it bears N. by W. ½ W., distant 2¼ miles. Between these two points anchorage is had in from four to six fathoms, but the south end of Sandy Point should not be approached within less than half a mile. Down the east side of Lummi island, which is about a mile in breadth, runs Hale's passage,* three-quarters of a mile wide. It leads from Bellingham bay. In this passage 1½ mile, and bearing E. by S. ½ S. from the north end of

* Named by the U. S. Exploring Expedition, 1841.

† Called Isla de Pacheco by Eliza in 1790; McLaughlin's island by the U. S. Exploring Expedition in 1841; named Lummi island in 1853 by the U. S. Coast Survey, because inhabited by that tribe. It is known by no other name.

‡ Named by the U. S. Coast Survey in 1854.

§ Named by the U. S. Exploring Expedition in 1841. The Indian name is Sweh-lagh.

(1) Called "Edmund's group" by the U. S. Exploring Expedition in 1841. The small one on the east is called Puffin island on the English Admiralty chart of 1859.

‖ Partially examined by the U. S. Coast Survey in 1853 and 1858.

Lummi island, is a low sandy point, upon which was established in 1853 a secondary astronomical station of the United States Coast Survey. Its geographical position is:

	°	′	″
Latitude	48	44	01.7 north.
Longitude	122	40	36.9 west.
	h.	*m.*	*s.*
Or, in time	8	10	42.5.

This places the north end of Lummi island in—

	°	′	″
Latitude	48	44	53.2 north.
Longitude	122	42	11.9 west.

The following geographical positions will serve to check the courses and distances we have given:

	°	′	″
Matia island, east, latitude	48	44	36.8 north.
" " longitude	122	48	28.6 west.
South end of Strawberry island, latitude	48	33	34.3 north.
" " " longitude	122	43	26.7 west.
Southwest island, off Lopez island, latitude	48	24	53.3 north.
" " longitude	122	48	33.9 west.

Alden's shoal.—From the north point of Lummi anextensive shoal bears W. by N. $\frac{1}{4}$ N. $5\frac{1}{3}$ miles, and NW. by N. $\frac{1}{2}$ N. $3\frac{1}{2}$ miles from the eastern of the Matia group. It lies upon the last direct course out of the strait, but has not been completely sounded out. Within the 15-fathom curve it is at least two miles square, and may be used when a vessel loses the wind and has a strong adverse current; but the swirls and eddies upon and around it will be very apt to foul any anchor.

The least water found on this bank is $2\frac{3}{4}$ fathoms, and this spot bears N. 35° W., $3\frac{1}{2}$ miles from the eastern islet of the Matia group.

From about its middle part we have the following bearings of prominent objects:

Eastern of Matia group, SE. by S. $\frac{1}{2}$ S. $3\frac{1}{2}$ miles.

North point of Lummi island, E. by S. $\frac{1}{4}$ S. $5\frac{1}{3}$ miles.

NW. point of Sucia group, with the wooded island of the Skipjacks just open, SW. $\frac{1}{4}$ S. four miles.

This position will bring the west side of Clark's island just on with Point Lawrence.

The shoal was discovered by the United States Coast Survey in 1853.

It is named Alden's bank on the English Admiralty chart of 1859.

In 1857 we attempted to reach this bank four or five times, from an anchorage off Hale's passage, with light airs, but the currents invariably swept us away from it. Recently it has been anchored upon by the United States Coast Surveying brig Fauntleroy.

GULF OF GEORGIA.*

Once in the Gulf of Georgia, through either channel, the three-mile face and timber-covered bluffs of Point Roberts† (showing almost as an island) is seen to the northwest. On the west the mountains of Vancouver and its bordering islands rise up precipitously, and on the eastern or main shore a series of wooded cliffs 200 feet high. Far to the eastward the Cascade range is seen rising above intermediate ridges, with the snow-covered summit of Mount Baker,* which rears its head 10,900 feet above the level of the sea. To the W.NW. stretch the waters of the Gulf of Georgia, nine miles wide, abreast of Point Roberts, where it is narrowest, but spreading out to 20 miles, and having a length of 120. A short distance above the 49th parallel it receives Fraser's river, (the third great stream of the northwest coast,) the branches of which spread towards the Cascade range of mountains.

If bound up the Gulf, vessels hold well to the eastern shore to avoid the rushing currents, and to take the chances of an anchorage if the wind fails.

* Named by Vancouver, 1792.

† Named by the U. S. Exploring Expedition, 1841. The Indian name is Now-uk-sen.

From Sandy Point to *Point Whitehorn** the general trend of the shore is NW. ½ W., and the distance 7 miles. The shore is a steep bluff, about 150 feet high, and covered with wood. At Whitehorn the face of the point is worn away by the action of the sea, and shows bright, with rocks at its base.

BIRCH BAY.

The southern point of this fine bay is Point Whitehorn, and the northwest shore is formed by a long rounding high bluff, bearing about NW. from Whitehorn, and distant 3 miles. The bay runs N.NE. 2½ miles, with a width of 1½. The bottom is very uniform, with capital holding-ground of soft mud in from 4 to 10 fathoms. The immediate shores are low, and edged with marshy patches, thick undergrowth, and heavy wood. No directions are necessary for entering, as there is a depth of 15 to 20 fathoms a mile outside, and 10 fathoms water on the line of the entrance. During the heaviest southeast weather no swell is felt here in a properly selected anchorage. We searched for fresh water, but found none in the space of more than a mile along its southeastern side.

The approximate geographical position of Point Whitehorn is—

	° ′ ″	
Latitude	48 53 07.3	north.
Longitude	122 46 27.1	west.

It received its present name in 1792 from Vancouver, who placed it in latitude 48° 53½′.—(Vol. 1, pp. 315, 316.) The Indian name is Tsan-wuch.

This is the furthest point northward to which our personal examinations have extended.

Drayton harbor.—Passing the bluff NW. of Birch bay the shore trends about N.NE. for nearly 3 miles, and terminates in a long, low, sandy point, behind which lies Drayton harbor—a small land-locked bay having a depth of 10 fathoms just inside the entrance, but very shoal over nine-tenths of it. It opens to the north at the extremity of the sand point. With the end of the point bearing N. 60° W., half a mile distant, the anchorage would be in 6 fathoms. South of this position it shoals gradually for over half a mile to 12 feet, with sticky bottom.

The approaches to the bay do not show over 5 fathoms at a distance of a mile from the shore, and the same depth is found on gradually nearing the end of the low point. The southeast shore of the harbor is flat and marshy, and is not separated by much more than a mile from Birch bay.

In this harbor the United States and British steamers attached to the Northwestern Boundary Survey were accustomed to anchor (1857.) The American commissioner encamped on the bluff about a mile north of the boundary, the site having been selected on account of fresh water, but it has an extensive flat in front.

Drayton harbor was examined by the United States Exploring Expedition in 1841.

A map of it was published by the United States Coast Survey in 1858.

Semi-ah-moo bay.—This extensive bay stretches three or four miles to the westward of Drayton harbor, and is bounded on the north by a bluff from 300 to 400 feet high, covered with fir. The bottom is very regular, and the depth ranges from 10 fathoms soft, about two miles south of the bluffs, to 3 fathoms within half a mile of them.

Tides.—The corrected establishment, or mean interval between the time of the moon's transit and the time of high water, is IV*h.* L*m.*, and the difference between the greatest and least intervals is 2*h.* 24*m.* The mean rise and fall of tides is 5.9 feet; of spring tides, 10.9 feet. The mean duration of the flood is 6*h.* 11*m.*; of the ebb, 6*h.* 19*m.*, and of the stand 29*m.*

To find the times of high and low water first compute them for Fort Townshend, and add 1*h.* for Semi-ah-mo bay.

A map of this bay was published by the United States Coast Survey in 1858.

Stretching to the northwest is a large shallow marshy bay, fringed with trees and bushes. From its northern shore low land extends as far back as Fraser river. The western boundary of the bay is formed by the eastern shore of Point Roberts. It is named Mud bay on the United States Coast Survey map.

POINT ROBERTS.

When seen from the northern entrances of the Canal de Haro and Rosario strait this point stands out near the middle of the Gulf of Georgia as a bold wooded island. From Rosario strait the southwestern point bears nearly NW. by W. about 18 miles. From Point Whitehorn it bears west distant 12 miles.

* Named by the U. S. Exploring Expedition, 1841.

On the outer or Gulf of Georgia side of Point Roberts the shore runs about NW. $\frac{1}{4}$ W. for 9 miles to the southern and principal mouth of Fraser river. To the mouth of the river at the outer edge of the *Sturgeon bank* the bearing is W. by N. and distance $9\frac{3}{8}$ miles. The south face runs E.NE. $2\frac{1}{2}$ miles, and presents for nearly the entire distance a bold bluff about 150 feet high, and covered with wood. Half a mile off this shore anchorage may be had in from 10 to 15 fathoms, but in southerly weather it must be avoided. The eastern shore of the point runs nearly parallel with the western for 4 or 5 miles. Off the southeast point rocks and foul bottom stretch out SE. for quite a mile.

The geographical position of the southwestern point, as determined by the United States Coast Survey, is—

	° ′ ″
Latitude	48 58 15.1 north.
Longitude	123 04 16.5 west.

It is therefore nearly two miles south of the northwestern boundary of the United States. Between this station and the bluff lies a marsh.

Point Roberts was discovered and named the Peninsula de Cèpèda in 1791. It was named Point Roberts by Vancouver in 1792, and is called Roberts Point on English Admiralty charts of 1847 and 1859.

BRITISH COLUMBIA.

The southern part of this territory was named New Georgia by Vancouver in 1792. It received its present name by order of the British government in 1858.

FRASER RIVER.

The mouth of the river on the Gulf edge of the Sturgeon bank lies W. by N. $9\frac{3}{8}$ miles from the southwest part of Point Roberts. That part of the bank south of the river is now called Roberts's bank, and to that northward is retained the name Sturgeon bank, given to the whole by Vancouver in 1792.

The current of the river is said to have a velocity from 5 to 8 miles in some parts. Throughout its navigable extent it is very narrow and crooked. Since the discovery of gold in this region a large traffic has arisen, and several steamboats run upon the river.

The southern point of the entrance to the river is named Pelly Point; and the northern, Garry Point.

The following official notice in relation to the buoys through the Sturgeon bank is all that we have to present. It was published in September, 1859:

The entrance to Fraser river has been rebuoyed. All the buoys are placed on the northern or port side of the channel on entering, with the exception of one on the south sand head.

The following memorandum points out the position and gives the description of each buoy:

On the south sand head.—A spar-buoy moored in 11 feet at low water. The spar is painted white and black in horizontal stripes, and surmounted by a ball of the same colors, also in horizontal stripes.

On the north sand head.—A spar-buoy moored in 11 feet. The spar is painted black and white in vertical stripes, and surmounted by a ball painted in the same manner.

On the north side of the channel.—A spar-buoy moored in 9 feet. The spar is painted in black and white in horizontal stripes, and surmounted by a red ball.

1. A spar-buoy moored in 12 feet. The spar is painted in black and white horizontal stripes, and surmounted by a white diamond marked 1.

2. A spar-buoy moored in 12 feet. The spar is painted white and surmounted by a black diamond marked 2.

3. A spar-buoy moored in 11 feet. The spar is painted white and surmounted by a red diamond marked 3.

4. A spar buoy moored in 11 feet. The spar is painted white and surmounted by a crescent red and black, marked 4.

5. A spar-buoy moored in 12 feet. The spar is painted in black and white vertical stripes, surmounted by a red crescent, marked 5.

On entering the river, the Sand head buoy should not be approached within half a mile until the passage between them is brought to bear N. $\frac{1}{2}$ E., when a vessel may steer in, mid-channel, or pass the north Sand head buoy and the first one inside it about 300 yards.

The remaining five buoys on the north side of the channel may be passed from 100 to 250 yards, keeping them on the port hand. After passing the inner buoy a straight course may be steered for Garry Point.

It should be remembered that the ebb current sets to the southward over Roberts' bank, and the flood to the northward over the Sturgeon bank.

The buoys assume a leaning position, varying from an angle of 35° to 80° according to the state of the current and wind, and can be plainly seen from vessels' decks at a distance of 3 miles in clear weather

By following the foregoing directions, a vessel drawing from 15 to 16 feet of water may enter the Fraser river with safety at half tide.

Vessels from the southward passing Point Roberts must avoid Roberts' bank, which is very steep; by not bringing the low part of the point to the southward of east the bank will be cleared.

The river was discovered by Eliza in 1790; and in 1792 Galiano informed Vancouver that it was called the Rio Blancho, (Blanco,) in honor of the then prime minister of Spain, but that it had been searched for in vain. It receives its present name from its explorer.

The shoal off it Vancouver called *Sturgeon bank* in 1792.

NANAIMO BAY.

This bay lies on Vancouver island beyond the 49th parallel, and we refer to it because supplies of coal (lignite) are there obtained by many steamers.

The outer entrance to the harbor is in latitude 49° 12′ north, longitude 123° 51′ west, and bears W. ¼ N. 33 miles from Point Roberts. From the entrance the mid-channel course runs S. ½ W. five miles, passing a small island on the northwest at the distance of a mile, and a large island, with islets off its north point, three-quarters of a mile on the east. This course gradually approaches Douglas island on the west, abreast of a wide channel to the east, and is rounded quite close. The mines will then lie about W.SW. a mile distant, with a small islet in front of them. The bottom is uneven; some sunken rocks occur, and the anchorage near the rivers is so contracted that vessels must moor. Pilots will be found here to take vessels in.

The price of the coal per ton is about six dollars, but it is light; occupies one-fifth more space than Welsh coal; burns rapidly with flame and much smoke; disengages a great deal of gas, and produces clinker in abundance. It is, however, superior to the coal of Bellingham bay.

The usual spelling of this name is Nanaimo, but that best representing the sound is Nah-ny′-moh.

Of the western shores of the Gulf of Georgia we can say but little. The currents rush past its precipitous shores with great velocity, and quite recently the coast surveying brig drifted, with 38 fathoms of chain at her bows, in a calm, for miles along and within 80 yards of the rocks before she brought up. In one or two instances preceding this the lead indicated bottom in 10 fathoms, the next cast showing 40 or 50 fathoms.

ARCHIPELAGO DE HARO.

THE TWO STRAITS.

The experience of three seasons' surveying in this immediate locality has not increased our relish for navigating these channels in sailing vessels. With plenty of wind no navigation could be better, but in a calm vessels will frequently be jammed close to rocks, with only a few fathoms inside of their positions, but 40 or 50 outside, and a swirling current that renders towing with boats utterly impossible. Frequently, too, boats have been nearly swamped by the tide rips that exist through them. Off East Point, as an instance, a five-oared whale-boat entirely failed in trying to hold her own against the current, which we judged to be *rushing* (the only term applicable) at the rate of seven miles per hour. Throughout the Canal de Haro the roar of the conflicting currents can be heard for miles, and the main current runs frequently six miles per hour. No anchorages exist in this channel, except at Cordowa bay, but it is free of known hidden dangers, except *Unit rock*, and the continuation of the reef off Darcy island. It is 10 miles longer than the Rosario strait, and makes a right angle in its course, but is a mile wider, and has much deeper water. Rosario strait is less curved, has several anchorages and known dangerous rocks, and a current of about 1½ mile less per hour. For steamers, either channel, or even some of the narrow intermediate channels, may be used; but for a sailing vessel the Rosario passage is preferable, although the total distance from the middle of the Strait of Juan de Fuca to the middle of the Gulf of Georgia is five miles longer. The winds are apt to fail in both channels, and during summer frequent calms prevail.

BELLINGHAM BAY.

Before passing to a description of Admiralty inlet we will notice this bay, as mines of coal (lignite) have been opened upon its shores.

After leaving Rosario strait, the course upon entering the Bellingham channel,* two miles wide, opening south of Cypress island, is NE. for two miles. The width then decreases to a mile upon turning sharp around the SE. point of Cypress, and to the eastward are seen the bright bluffs of *Guemes island*. Between these two islands the channel runs about three miles on a N. by W. ½ W. course. Abreast of the north end of Guemes, (which is a steep bluff,) and on the west side of the channel, are several small, high, wooded islets, called the *Cone islands*.† The moderately low, wooded island facing the channel is Sinclair; vessels pass between the southeast point of it and the north end of Guemes. The island a couple of miles to the NE. is *Vendovi*;† pass north of it, but south of the small islet, (off Eliza's island,) which is two miles NE. by N. from the NW. point of Vendovi, and the southern part of Bellingham bay opens to the southeast; its northern part opens to the N.NW.

If the current be flood and the wind light, keep close around Guemes and Vendovi, so as not to be set past Sinclair island. The low, bare, rocky islets, 1½ mile NW. of Vendovi, are the Viti rocks;† and the point between them and Eliza's island is the southern extremity of Lummi island. From the islet last passed, a point on the eastern shore lies nearly north five or six miles distant. Run past this and follow the trend of the shore for two or three miles to the deepest part of that part of the bay, when houses, &c., will denote the position of the mines and the villages of Sehome and Whatcom. (3) Half a mile from the shore is capital anchorage in four fathoms, soft bottom, and the bay there is very smooth.

The general direction of Bellingham bay is SE. and NW.; its width three miles and length 14, extending from latitude 48° 33′ to latitude 48° 48′. The depth of water ranges from 3 to 20 fathoms, with good sticky bottom.

We believe there are several companies mining here, but the amount of coal obtained is not great. Its quality is not good, the furnaces producing sometimes as much clinker and ashes in bulk, and half the amount in weight, of the coal put in. Deleterious gas is freely disengaged, and the combustion also evolves clouds of black smoke. In the experiment which we witnessed, in 1853, the steamer's furnaces could not, in two attempts, be kept up so as to produce a sufficiency of steam.

A saw-mill is located upon the bay at one of the villages.

Bellingham bay was first surveyed by Whidbey, under Vancouver's orders, in 1792, and then received its present name. In some recent maps the northern portion is called Gaston bay, and for the southern part the original name is retained; but Vancouver's designation is that universally adopted on the western coast.

A military station is located at the upper part of the bay, opposite to the coal mines.

A hydrographic sketch of the bay was published in the Coast Survey report for 1856.

The amount of shore-line in the Archipelago de Haro, Bellingham bay, Possession sound, &c., is 627 miles.

We never heard thunder in this Territory, except in one instance, at Cypress island, in Rosario strait.

ADMIRALTY INLET.

General features.—This inlet may be described as a vast canal, commencing at the southeast extremity of the Strait of Juan de Fuca, and running in a general SE. by S. direction for 60 miles to the south end of Vashon's island. It has for that length an average width of 3½ miles, and then branches into a multitude of arms, which cover an area of about 14 by 22 miles. Their general direction is SW. ¾ S., and they comprise what is called *Puget's sound*.

At 16 miles from the entrance to the inlet an arm called *Hood's canal* opens upon the western side, and runs 60 miles S. by W., with an average width of 1½ mile. Twenty-five miles from the entrance of the inlet another arm opens on the eastern side, runs north and northwest behind Whidbey island, forming Possession sound, Ports Gardner and Susan, &c., and leads on to the Strait of Juan de Fuca through Deception Pass, at the north end of Whidbey island.

The shores are generally bluffs, ranging from 50 to 500 feet in height, with their sides kept bright by

* Named by the U. S. Coast Survey in 1854.

† Named by the United States Exploring Expedition, 1841.

(3) The Indian name for "Noisy Water," the outlet of the lake.

the gradual wearing action of the water, and their tops covered with trees and thick undergrowth to their very edges. There is so much sameness in the shores that it requires some acquaintance with the different points to recognize them by their trifling peculiarities. The depth of water in the channels is remarkably great, perhaps averaging 100 fathoms, and it is sometimes difficult to find anchorage sufficiently far from the shore to afford room for getting under way. Many superior harbors are found in every direction, and small settlements are gradually springing up in favorable localities.

Admiralty inlet, Hood's canal, and Puget's sound, have an aggregate shore-line of not less than 803 miles, yet the number of dangers known to exist in them is remarkably few.

One of the inlets or arms of Puget's sound reaches within two miles of the head of Hood's canal, and between them lies a large lake. The southern waters of this sound are also within 65 miles, in a direct line, of the Columbia river, at the mouth of the Cowlitz, which is 52 miles from Cape Disappointment; and within 20 miles of the upper waters of the Chehalis river, which runs into Gray's bay. At present the route travelled from the Columbia is by canoes, for 28 miles, up the Cowlitz to the settlement at "Cowlitz Landing," (or by horse over a somewhat bad path,) and then by horses or mules to Olympia, 52 miles, over a tolerably level country, and by a road moderately good in summer but bad in winter. The distance can be made in one day with a good horse. From where the road strikes the Chehalis the river is said to be navigable for large boats to Gray's harbor. We judged the stream to be about 100 yards wide. It had apparently plenty of water and a slow current. The Cowlitz has a rapid current, and at a low stage of the water canoes are poled up its channel; during freshets they are dragged up, the crews clinging to the branches of the trees upon its banks. Two days of labor are then required for the trip, but in summer it is made in one.

The importance of these close relations of the waters of the Columbia river, Puget's sound, Admiralty inlet, Gray's harbor, and Shoalwater bay, in view of the prosperity of the two Territories, must be manifest without entering into details of the feasibility of their connection by railroads and canals.

The inlet was discovered by Quimper, in 1790, and called the Canal de Caamano. It was first explored and made known, in 1792, by Vancouver, who applied the present name to it.

A reconnaissance sketch of Admiralty inlet was published by the Coast Survey in 1854.

We shall not attempt to give in full and explicit detail all the peculiarities of this vast area of waters, but, following the mid-channel courses, will only note generally the objects as they come under the eye of the navigator.

The entrance to the inlet lies between Point Partridge, on Whidbey island, and Point Wilson, on the main, at the entrance to Port Townshend. The bearing of the latter point from the former is SE. by S. ½ S., 4½ miles; and the bluff head lying two or three miles to the east of this line, and destitute of trees and marked by a light-house is Admiralty head, around which the ebb current, and an ebb eddy on the flood, sweeps with force.

The first course inside of the entrance of the inlet is E.SE. 6½ miles, passing Port Townshend on the south, Admiralty head on the north, and changing the course abreast of Marrowstone Point on the W.SW.

Point Partridge is the western point of Whidbey island, and directly faces the Strait of Juan de Fuca. It is very steep and yellow, and flat on the summit, which is covered with spruce, fir, and cedar. The point is so rounding that it is not easily recognized on coming from the westward, but from the south and north it is well marked and prominent. Its face is composed of loose sand, which, being blown up the hill by the strong west winds, has formed a very peculiar ridge on the outer face of the top. This is so narrow that it can hardly be travelled, and in many places it is 35 feet above the ground inside; yet, being overgrown with bushes, the ridge is now permanent.

The highest part of the point is about 260 feet above low water.

The triangulation station of the Coast Survey was on the southern part of the point, and its approximate geographical position is:

	° ′ ″
Latitude	48 12 59 north.
Longitude	122 45 07 west.

From Point Wilson it bears NW. by N. ½ N., 4¼ miles.

From Admiralty Head light-house NW. by W. ¾ W., 5¼ miles.

The point received its present name from Vancouver in 1792.

PORT TOWNSHEND.

This harbor is favorably situated at the termination of the Strait of Juan de Fuca, at the outlet of the waters of Admiralty inlet, Puget's sound, &c., and in proximity to the great inland waters of British Columbia. The entrance lies between Point Wilson* and Marrowstone Point,* the latter bearing E.SE. 3¾ miles from the former. Upon this line, and even outside of it, lies a bank extending two-thirds of the distance from Marrowstone, and having from 6 to 15 fathoms, with hard, sandy bottom. Inside of Point Wilson, which is composed of low, sandy hillocks, as heretofore described, lies another low point called Point Hudson,† distant 1¾ mile, SE. by S. ½ S.

Starting from the entrance line, about 1½ mile from Marrowstone, the mid-channel course of the bay is S.SW., three miles, with an average width of two; thence SE. ½ S. for 3½ miles, with an average width of 1½. The depth of water throughout is very regular, and ranges from 8 to 15 fathoms, with soft, muddy bottom inside of Point Hudson. Vessels coming from the strait steer for Point Hudson, as soon as it is opened by Point Wilson, passing the latter close, as 20 fathoms are found 100 or 200 yards off it. Upon approaching Point Hudson, and when within half a mile of it, gradually keep away about a quarter of a mile in from 5 to 10 fathoms, and, as it opens, run quite close, with the summer wind off shore, to save making a tack; keep along half a mile to the town situated under the Prairie bluff, and anchor anywhere off the end of the wharf, in 10 to 12 fathoms, about a quarter of a mile from shore. In winter anchor further out, to clear Point Hudson in getting under way with a southeaster.

When coming down the inlet, bound into the bay, with the current ebb, pass Marrowstone nearly three-quarters of a mile before heading in for the town, and so avoid a very strong eddy which comes out of the bay along the bluff shore west of this point. If the wind be light and the current strong, pass the point quite close by; run along the outside of the rip, and try to get upon the bank as soon as practicable.

In summer vessels frequently drift about the entrance for days, without a breadth of wind, and in very strong currents.

Tides.—The corrected establishment or mean interval between the time of the moon's transit and the time of high water is III*h*. XLIX*m*. The mean rise and fall of tides is 4.6 feet, of spring tides 5.5 feet, and of neap tides 4.0 feet. The mean duration of the flood is 6*h*. 34*m*., and of the ebb 5*h*. 52*m*. The mean difference between the corrected establishments of the a. m. and p. m. tides of the same day is 2*h*. 22*m*. for high water, and 0*h*. 35*m*. for low water. When the moon's declination is greatest these differences are 4*h*. 38*m*. and 0*h*. 27*m*., respectively; and when the moon's declination is zero they are 0*h*. 40*m*. and 0*h*. 29*m*. The mean difference in height of these two tides is 1.1 foot for the high waters, and 4.6 feet for the low waters; when the moon's declination is the greatest, they are 0.6 foot and 7.3 feet, and when the moon's declination is zero 1.4 foot and 1.4 foot. When the moon's declination is greatest, and north, the two high waters of the day follow the moon's upper transit, respectively, by about 6*h*. 8*m*. and 13*h*. 56*m*., and when greatest, and south, by about 1*h*. 30*m*. and 18*h*. 34*m*., the height of the two being about equal. When the moon's declination is zero, and passing from north to south, they follow the moon's transit by about 4*h*. 9*m*. and 15*h*. 55*m*., and the first rises about 1.4 foot higher than the second. When the moon's declination is zero, and passing from south to north, they follow the moon's transit by about 3*h*. 29*m*. and 16*h*. 35*m*., and the second rises higher than the first by the same quantity. When the moon's declination is greatest, north or south, the two low waters follow the moon's transit by about 9*h*. 41*m*. and 22*h*. 7*m*., but when north the second falls lower than the first by about 7.3 feet, and when south the first falls lower by that quantity. When the moon's declination is zero, the two low waters fall nearly equally. The greatest difference observed between the heights of the two low waters of a day was 8.6 feet, and the greatest difference between the higher high and the lower low water of a day was 10.1 feet.

For the method of computing the times and heights of high and low waters see the example given for San Francisco, and use the tables for Port Townshend, at the end of the Directory.

The geographical position of the triangulation station of the Coast Survey, upon Point Wilson, is:

	° ′ ″
Latitude	48 08 42.7 north.
Longitude	122 44 49.4 west.
	h. m. s.
Or, in time	8 10 59.6.

* Named by Vancouver in 1792. On one edition of the maps of the United States Exploring Expedition the latter point is called Point Carroll, and on another Point Ringgold.

† Named by the U. S. Exploring Expedition, 1841.

The position of the triangulation station on the extremity of Point Hudson, computed from the secondary astronomical station near the town, is:

	° ′ ″
Latitude	48 07 06.7 north.
Longitude	122 44 25.8 west.
	h. m. s.
Or, in time	8 10 57.7.

Magnetic variation 21° 40′ east, in August, 1856, with a yearly increase of 1.′

From the above it will be seen that Point Hudson is about 1*m.* 25*s.* west of Telegraph hill, San Francisco.

The town of Port Townshend has increased very much since the discovery of gold on Fraser river. No fresh water is to be had, but vessels can obtain a small supply near the military post. Some fine farms, lie near the town, and vegetables are plenty at reasonable prices. The place was noted for the rough character of its "beach combers."

A military post has been established on the bluff, 2½ miles S. by W. from the town, and on a site which commands one of the most beautiful views in these waters, having the bluff and varied shores of the bay on either hand; Admiralty Head, 6 miles distant, in the middle ground; several distant, wooded ridges, and in the back ground the snow-covered, double summit of Mount Baker, 10,900 feet in height, with the mouth of the crater distinctly visible between the peaks, and at times emitting vast volumes of smoke. The elevation of the line of perpetual snow upon this mountain is 3,145 feet. Humboldt is wrong in his description.

On the east side of the bay, abreast of the town, lies a long sand spit, nearly closing the north entrance to *Kilisut harbor*, which runs parallel to the inlet, and is separated by an island a mile wide and 6 miles long. At high tide this harbor communicates, by a crooked boat channel, with Oak cove, at the south end.

At the head of Port Townshend is a narrow channel opening into a large flat, bounded by a low, sandy beach, separating it from Oak cove. The Indians frequently use this as a portage.

The shores are generally bluffs, about 120 feet high, and covered with wood, except behind the town. Between the town and Fort Townshend are two low pieces of grass and sand beach, backed by marsh and ponds. The 5-fathom curve extends but a few hundred yards from any part of the shores. A small patch of kelp lies off the southern point of Prairie Bluff, and another off the north face of Marrowstone Bluff.

Port Townshend was surveyed and first made known in 1792, by Vancouver, who gave it the present name, by which it is always known.

A chart of it was published by the Coast Survey in 1858.

In 1855–'56 a law was passed appropriating a sum for building a light-house upon "Red Bluff," but the recommendations of seafaring men had fixed generally upon Point Wilson as the most suitable location. Red Bluff, or Admiralty Head, has the advantage of being seen further up the inlet, but is shut out from Smith's Island light, while Point Wilson commands both it and Dungeness light. Around Point Wilson all the navigation and commerce of the inlet and sound turn, and from it vessels take their departure when going out in foggy or smoky weather. A vessel entering Port Townshend at night could easily know her position with the light on Point Wilson, and could enter it with certainty. Coming out of the inlet and bound into the bay she would have a good course to run by, when the light was opened by Marrowstone Point.

Marrowstone Point is a low sandy point stretching 300 yards eastward from the base of the bluff, and forming an indentation on its southern face, where anchorage may be had in 12 fathoms, with a current or eddy invariably running ebb. Small craft coming out of the inlet with a head wind can easily take advantage of this for 2 or 3 miles above the point.

It received its present name from Vancouver in 1792.

ADMIRALTY HEAD,

Abreast of the entrance to Port Townshend, is a perpendicular cliff 80 feet high, falling on the eastern side to a low, pebbly shore, which runs 2 miles to the E.NE. and strikes the high cliffs on the eastern side of the inlet. Behind this beach is a large lagoon, and off it is Admiralty bay, with hard, sandy bottom, in irregular ridges, and a depth of 15 to 25 fathoms of water. A strong current always makes out of the bay, and it is exposed to the full sweep of southeasters. The current is so strong that a vessel rides to it, and consequently lies in the trough of the sea.

LIGHT-HOUSE ON ADMIRALTY HEAD.

The structure consists of a keeper's dwelling, with a tower rising through the roof at one end; both are painted white, and the iron lantern surmounting the tower is painted red. The height of the tower from the base to the focal plane is 41 feet, and the elevation of the focal plane above the mean level of the inlet is 119 feet.

The illuminating apparatus is of the fourth order of the system of Fresnel, and shows a *fixed white light*. It was first exhibited January 20, 1861, and shows from sunset to sunrise. Under a favorable state of the atmosphere it should be seen—

From a height of 10 feet at a distance of 16.1 miles.
From a height of 20 feet at a distance of 17.6 miles.

Its geographical position, as determined by the Coast Survey, is:

	°	′	″	
Latitude	48	09	21.6	north.
Longitude	122	40	08	west.

The magnetic variation was 21° 40′ in August, 1856, and the present yearly increase is 1′.

It illuminates an arc of 270° of the horizon, and commands Admiralty inlet and the approaches. It sees New Dungeness light, but Smith's Island light is hidden by Point Partridge.

From Point Wilson it bears NE. by E., distant 3¼ miles.
From Marrowstone Point N. by W. ¼ W., distant 3¼ miles.
From New Dungeness light N. 73° E., distant 17⅝ miles.
From Point Partridge S. 60° E., distant 5⅜ miles.

Admiralty Head was named Red Bluff by the United States Exploring Expedition in 1841, but it has now no color to suggest the appellation. Both names are used on the Pacific coast.

Starting from abreast Marrowstone Point the mid-channel course up Admiralty inlet runs SE. by S. ½ S. for 7 miles. The shores on either hand are bluffs of apparently uniform height, covered with trees. About 5 miles on this course is passed, on the eastern shore, a low point, with one or two clumps of trees and bushes, to which has been given the name *Bush Point*.* On the western shore is a rounding bluff point one mile north of the point which forms the northeast part of Oak cove. Off this point is good anchorage in 12 or 15 fathoms. The peculiar geological formations found in the vicinity suggested the designation *Nodule Point*,* which it now bears. The high bold headland, several miles directly ahead, is Foulweather Bluff,† and that to the E. SE. destitute of trees, except one large clump, which marks it conspicuously from this direction, is *Double Bluff*.* The deep indentation between it and Bush Point, with low land in the rear, is *Mutiny bay*,* in the northern part of which exists a narrow bank of 11 fathoms, affording an excellent fishing ground. At the end of the course *Oak cove*‡ opens to the westward, and stretches towards the waters of Port Townshend. It has bluff shores nearly all around it, those on the southwest face being limestone; but Basalt Point,§ at the south, derives its name from its geological structure. The depth of water is 5 to 15 fathoms, except N.NW. of Basalt Point, where it reaches 25 and 30 fathoms. The length of the bay is 3 miles, and its average width about 1½ mile. In beating out of the inlet, with a favorable current, vessels must not attempt to work to this bay for the sake of a long tack.

Vancouver named it Oak cove, his people having reported that oak trees stood upon its shores. We have traversed the greater part of the shores but found none.

The opening west of Foulweather bluff is *Hood's Canal*. Vessels bound into it keep close to the western shore of the bluff, and pass two low points lying near together. The water off them is deep. Off the north face of Foulweather, for nearly a mile, less than 15 fathoms may be found. Kelp exists under the face of the bluff, and vessels may pass around it in 6 and 7 fathoms. The bottom along the edge of the kelp is rocky. On the west side of the entrance to Hood's Canal is Port Ludlow, which will be described hereafter.

The next or third course up the inlet is E.SE. for ten miles, passing on the eastward Double bluff, which stretches northeast for a mile, and rises 300 or 400 feet in height, having its top covered with wood. The bluff

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* Named by the U. S. Coast Survey in 1855.
† So named by Vancouver in 1792. The Indian name for Foulweather is Pitch-pol.
‖ Named by Vancouver in 1792.
§ Named by the U. S. Coast Survey in 1856.

running also to the northward forms *Useless bay.** This has deep water over the greater portion of it, with a large shallow bay called *Deer lagoon*† at its head. The high bluff forming the southern point of Useless bay is *Satchet head.*‡ A similar bluff lies 2 miles E. by S. of it. These form the southern extremity of Whidbey island, in latitude 47° 54′ north, and are the turning points into Possession sound.

The two heads are about 300 feet high, covered with wood, and separated by a depression, which is in part overflowed at high tide, and then presents the appearance of a small bay. From the eastern head round the western, and a mile toward Useless bay, the low-water line makes out half a mile, the shore being bare where some recent maps have deep water. For nearly a mile south of both heads a depth of 8 and 10 fathoms and smooth sandy bottom can be found. We found, when anchored for several days off the eastern head, a strong under current running into Possession sound, and an upper current setting to the westward, at all tides. Vancouver makes mention of the shoal, and states that beating into the inlet he stood on the bank until he got 5 fathoms, but want of time precluded his examining it.

On the western side of the last mid-channel course we passed Fowlweather bluff, which is perpendicular on its N.NW. face, and about 225 feet high, with heavy firs upon its summit. It slopes towards the east to a bluff 40 feet high, but is steep on the side next to Hood's Canal. The low point 4 miles east of it is *Point No Point,*§ making well out, and destitute of trees or bushes. Between it and Foulweather is a deep bight, and the distance across the neck to Hood's Canal is only a quarter of a mile in one part, marked by the track of a recent tornado that has twisted off and uprooted firs of 3 and 4 feet diameter. On the south side of Point No Point is good anchorage in 10 fathoms; and thence the western shore runs nearly straight SE. by S. for ten miles.

At the end of the last course, which carried us 3 miles beyond Point No Point, the inlet expands to a width of 7 miles. A course E.NE. for 3½ miles carries us to the entrance of Possession sound, the first 6 miles of which run N. ½ W., with a width of 2 miles and bluff shores. It then turns to the northwestward to Port Gardner. The water is deep in the entrance, and affords no anchorage. The low point on the shore, 4 miles after entering, is *Point Elliott,*‖ and the bay opening to the northeast receives the Sinahomis or Seaget river.

The next, or fourth, mid-channel course up the inlet is S.SE. for 21 miles to Allen's bank, which lies a mile off the north end of Vashon's island. Five miles on this course, or seven from Point No Point, brings us to an excellent little harbor on the western side of the inlet, called *Apple Tree cove,** having a low point on the north side, with a soft mud flat extending several hundred yards up the inlet. From 5 to 12 fathoms water and sticky bottom are found off it and in the cove. There is no fresh water in the vicinity, but very good timber may be procured suitable for boat spars and booms. On the eastern shore of the inlet, abreast of this cove, are two low points, a mile apart, making out from the bluff. The indentation between them forms a good though small anchorage, and the chances are good for fresh water at high tide. The southern point is named *Point Wells,** the northern *Point Edmund.** The inlet is here only 3 miles wide, and continues so to *Point Jefferson,** two miles southward of Apple Tree cove. This is a moderately low, straight bluff, with the ground rising behind it, and covered with timber. Stretching broad off its eastern face for three-quarters of a mile we discovered, in 1856, a 9-fathom shoal, which affords capital anchorage for vessels when drifting with light airs and adverse currents.

PORTS MADISON AND ORCHARD.

Point Jefferson is the northern side of the entrance to this port, which runs 3 miles W.SW., with an average width of 2 miles and a large depth of water, except under Point Jefferson, where anchorage may be had in 10 and 15 fathoms, hard sandy bottom, with patches of kelp inshore.

The southeast point of the entrance is low and sandy, making out from high wooded ground. One mile west of it is the narrow entrance to a natural canal, upon which, in full view, are situated the Port Madison

* Named by the U. S. Exploring Expedition, 1841.

† Discovered and named by the U. S. Coast Survey, 1856.

‡ Named by the U. S. Exploring Expedition, 1841. The proper spelling is Skadg'-it, and the Indian name of the point, Skoolhks.

§ Named by U. S. Exploring Expedition, 1841. The Indian name for the point is Hahd-skus.

‖ Named by U. S. Exploring Expedition, 1841.

saw-mills. At the SW. part of the bay is the very narrow entrance to *Port Orchard*. The channel is somewhat crooked, but it has 3 and 4 fathoms water in it. On the western side of this entrance are some white patches of beach, formed by clam shells. In 1857 an Indian village was situated here, and an Indian sub-agency. Both sides of the entrance are bluffs. Vessels not well acquainted with the channel must enter under easy sail, and keep a lead going on each side of the vessel to ascertain where the deepest water lies. After getting through give the point, one mile off on the western side, a berth of nearly half a mile, to avoid a shoal which makes out east from it. Thence it is plain sailing in 15 to 25 fathoms of water. After passing the first point an arm opens to the NW., and many vessels load there with spars. Ten miles up the southern channel is, or was, a saw-mill. In coming out of this port vessels should not trust the southern entrance, but leave as they entered. See remarks under heading Restoration Point, page 411.

Port Orchard was examined and named by Vancouver in 1792.

Port Madison was named by the United States Exploring Expedition in 1841. The Indian name is Noo-soh′-kum.

Bainbridge island lies between Port Orchard, Port Madison, and Admiralty inlet. It is 8 or 9 miles long by 2½ in breadth, and its general direction is SE. by S. A few loggers' huts stand on the western side and the Madison saw-mill at the north end. On the SE. part it is indented by two small harbors. It was named by the United States Exploring Expedition in 1841.

DUWAMISH BAY.

Abreast of Port Madison the eastern shore of the inlet retreats and there receives several small streams of water, but it gradually makes out into a very long, low sand point, called *West Point*,* which forms the extreme northwest part of the entrance to Duwamish bay. The bay runs E. by S. 6½ miles and has a width of 2 miles. To the south point, called *Battery Point*,† which is low and bare, with a curiously shaped mound rising sharply behind it, the course is about SE. by S., and distance 4½ miles. Under West Point there is anchorage in 10 to 15 fathoms after getting towards the bluff; but on the north side of the point the water is very deep. Through the centre of the bay the depth ranges from 88 to 40 fathoms. On the north side of Battery Point a vessel anchoring in 20 fathoms cannot have a greater scope of chain than 35 fathoms without being too close to the shore. When we anchored there in 13 fathoms and veered to 25 fathoms of chain the vessel's stern was in 2½ fathoms. The beach is smooth and very regular, being composed of sand and gravel. On this side of Battery Point is the deserted town of Alki, (the Indian phrase for "by and by.") The town has had several names, but there is nothing about it to command trade.

The bluff head within the bay, 2 miles N.NE. of Battery Point, is Duwamish Head.‡ It is steep, about 150 feet high, covered with timber, and the beach at low water stretches out over a quarter of a mile N.NW. from it. The head of the bay receives the Duwamish river, and for one or two miles is an extensive flat, bare at low water.

The town of Seattle is on a small point at the NE. part of the bay, a little over 5 miles inside of West Point. It consists of a few houses and stores, a church, and a small saw-mill; and a number of university buildings are to be erected, (1862.) It has but little trade.

Seattle has been proposed as the terminus of the northern trans-continental railroad, penetrating the Cascade mountains by the Yakima Pass, and thereby making the line 140 miles shorter than by the Columbia River Pass, which is remarkably favorable, whilst the former is only possibly practicable.

The usual anchorage is directly off the wharf in 10 to 15 fathoms water, with the large white house on the extreme point bearing about E. or E. by S. and at a distance from the beach about 500 yards. This position will enable a vessel to work out well by making the first tack to the southward towards the flat. If it be high water this flat cannot be distinguished, and the lead must be kept going. When a depth of 15 fathoms is struck go about, for it shoals to 3 fathoms very suddenly, and keeping on would soon bring up a vessel on the flat. If the current be ebb, vessels bound out should stand well into the inlet; and if bound up, work close under and around Duwamish Head to Battery Point. If the current be flood, vessels bound out should work under the north shore, and close to West Point; if bound up, work under the north shore about 3½ miles to Magnolia bluff, beyond a low marshy indentation in the shore, or until they can fetch well clear of Battery Point.

There is said to be some good agricultural prairie land on the Duwamish river. Some distance up it is

* Named by the U. S. Exploring Expedition, 1841.

† Named by the U. S. Coast Survey, 1856. The Indian name is Me-kwah-mooks.

‡ Named by the U. S. Coast Survey, 1856.

connected with *Lake Washington*, which is reported to be 25 miles long and several miles broad, with islands in it. It is but a few miles in a direct line east of Seattle. Another small lake exists about a mile back from the beach, a mile west of Seattle. This is reached by a trail.

The town of Seattle was attacked by a small body of Indians in 1855, but the assault was repelled by the United States steamer Massachusetts.

The bay was called Elliott's bay by the United States Exploring Expedition in 1841, but the present name is that by which it is invariably known, and was adopted from the name of the tribe of Indians inhabiting its shores. The name of the town is derived from that of the chief, Se-at-tlh.

The Coast Survey report for 1854 was accompanied by a reconnaissance sketch of Duwamish bay and Seattle harbor.

RESTORATION POINT.

From the SE. point of Port Madison to this point the shore is bluff and somewhat irregular, and is indented first by *Eagle harbor*,* having a long pebbly spit making out 300 or 400 yards SE. from its north point; and next, at Point Restoration, by *Blakely harbor*,* having off its entrance a large rock, 15 feet high, with deep water all round it. The rock bears nearly N.NW. three-quarters of a mile from the point, and the bottom between is irregular, the depth ranging from 20 to 40 fathoms. Blakely harbor is only a quarter of a mile wide and three-quarters long, with 18 fathoms sticky bottom at its mouth, and shoaling gradually inside, but most on the south side. A hydrographic sketch of the harbor will be found in the Coast Survey Report for 1856.

Eagle harbor is larger and more commodious than Blakely. We discovered the shoal off its north point in 1856.

Restoration Point is in some respects very peculiar; no other in these waters, except Battery Point, presenting the same formation. For 300 yards it is flat, about 10 feet above high water, and has a foot depth of soil covered with grass over a limestone rock, upheaved nearly on edge, the direction of the strata pointing toward Battery or a little south of it. Inshore it rises up sharply about 100 feet, its sides covered with grass and the summit with fir trees. Around the whole SE. face of the point these peculiarities exist. On the upper levels of the high land adjacent our party found small lakes of water.

From the extremity of the point a ledge, bare at low tides, makes out 300 yards, but the depth is 6 fathoms 100 yards off its extremity, and 16 fathoms at a quarter of a mile. On the tail of this ledge the United States sloop-of-war Decatur struck in 1855. S.SE. of the point anchorage may be had in 15 fathoms, sticky bottom, a quarter of a mile distant; or, as a rule for finding anchorage, bring the rock north of it to range just over and inside of the point. Kelp exists along the southern face.

The geographical position of the triangulation station of the Coast Survey upon this point is:

	° ′ ″
Latitude...	47 35 05.8 north.
Longitude...	122 28 15.2 west.
	h. m. s.
Or, in time...	8 09 53.0.

From this point Battery Point bears E. by N. ½ N., distant 2½ miles.

Tides.—The approximate corrected establishment is IV*h.* IV*m.*, and the approximate mean rise and fall of tides 7.4 feet.

Vancouver anchored under this point in 1792; found large numbers of Indians located near, and first called it Village Point, but changed it to its present name in commemoration of the day on which he anchored. From this place his boats explored all the waters adjacent.

South of Restoration the inlet opens to the westward for a couple of miles into a bay, in which is situated an island about three-quarters of a mile in extent, called *Blake island*.* From the northwest part of the bay leads a narrow crooked pass 3 miles long to the southern part of Port Orchard, which spreads out into several arms. The pass is obstructed by rocks and is difficult of navigation. The winds are variable, light, and uncertain at its narrowest part, where it makes a sharp turn, and is only a couple of hundred yards wide, with a rushing swirling current. The channel generally used, although narrower than the one just mentioned, is that leading into Port Madison.

* Named by the United States Exploring Expedition, 1841.

Our last course brought us to *Allen's bank*,* off the north end of Vashon's island, with Blake island to the westward, and three-quarters of a mile distant. This bank is nearly a mile in extent, and has as little as 10 fathoms upon it, with a variable bottom, in some places mud, and in others hard sand. At our anchorage upon it in 11 fathoms the south end of Blake island bore N. 81° W., and the NW. point of Vashon's island S. 5° E. Between the anchorage and Blake island the water regularly deepens to about 18 fathoms in soft mud. This anchorage has already proved of service to vessels losing the wind and having adverse currents. In some recent maps 25 to 30 fathoms are marked in the position of this shoal. The eastern point of Blake island is low and pebbly, and called by the natives Tatugh. Under it is anchorage in 17 and 18 fathoms, soft mud. The northeast point of Vashon's island is Dolphin Point,† the northwest point Point Vashon,‡ the point abreast of it is Point Southworth,‡ and the mile-wide channel, commencing between the last two points, is *Colvos passage*,‡ running west of Vashon's island.

The extent of shore-line from the entrance of Admiralty inlet to the north end of Vashon's island is 241 miles.

The main body of the inlet continues about SE. for 8 miles, then S.SW. 8 miles further, with an average width of 2 miles. In this stretch the currents are moderately strong, the chances for anchoring few, and it is sometimes calm while a fine breeze is blowing through Colvos Passage.

Brace Point§ lies on the east side of the inlet, NE. from Dolphin Point. The round-topped point having two or three lone fir trees upon it, and situated on the same side of the inlet, 4 miles above Brace Point, is called *Point Pully*.‡ The water is very deep close to it on either side.

The geographical position of the triangulation station of the Coast Survey on the summit of the mound at Point Pully is:

	° ′ ″
Latitude	47 27 07.3 north.
Longitude	122 22 21.5 west.
	h. m. s.
Or, in time	8 09 29.4.

There is a small bight north of Brace Point, and between it and another low point, called *Fauntleroy cove*,† having good anchorage in 10 and 12 fathoms, and fresh water is easily obtained in the vicinity. Between Brace Point and Point Pully two or three small streams of water empty, and another from the valley a mile east of the high bluff at Pully. Off this valley a flat makes out with deep water at its edge.

Under Dolphin Point there is very deep water; but off the north end of the island, near this point, we found anchorage in 14 fathoms, hard bottom.

Colvos passage is the usual, we may say the invariably used ship channel towards Puget's sound. It is about a mile wide, with high bluff shores, varied by numerous small, low, sand points making out from the face of the bluff, and having deep water off them. The passage is 11 miles long to the south end of Vashon's island, which is called Dalco Point,‡ and it runs with a nearly straight course S. by E. A mile and a half inside of Point Vashon there is a small curve in the shore line called *Fern cove*,† with excellent anchorage in 5 and 10 fathoms. Abreast of Dalco Point on the western shore there is a small harbor, with a narrow and shoal entrance, called *Gig harbor*.‡ Looking out of the passage to the north, Mount Baker shows distinctly in clear weather.

COMMENCEMENT BAY.

When abreast of Dalco Point this bay, at the termination of Admiralty inlet, opens to the E.SE., and over its low background shows the high snow-covered peak of Mount Rainier. The general direction of the bay is E. by S. ½ S., with a length of three or four miles, a width of two miles, and a great depth of water up to the line of the extensive flat at its head, which is backed by marsh. There are no settlements upon it, but in 1857 we found some deserted fishing stations.

It was named in 1792 by Vancouver, who thought this the entrance to some large arm of the inlet, on account of the low country beyond.

We believe the Indian name for this bay is Puyallup.

* Discovered and named by the United States Coast Survey in 1857.

† Named by the United States Coast Survey, 1857.

‡ Named by the United States Exploring Expedition, 1841.

§ Named by the United States Coast Survey in 1856.

Vashon's island, lying between the southern extremity of the inlet and Colvos passage, is $11\frac{1}{2}$ miles long, with an average width of $2\frac{1}{2}$ miles. Half way down on its eastern side lies a curiously shaped peninsula, formed by a narrow, low, sandy neck of land, which makes out into the inlet, and then runs towards the south point of the island. The space between this peninsula and the island is an excellent harbor four or five miles long, and three-quarters of a mile wide, with five to ten fathoms water in it. The southeast face of the peninsula is high and steep, and bordered by water from 40 to 50 fathoms deep.

The island is high, with steep shores, covered with wood and undergrowth. Its surface is marshy in many parts that are quite elevated. The present name was given by Vancouver in 1792. The harbor formed by it and the peninsula was called *Quartermaster's harbor* by the United States Exploring Expedition in 1841.

POINT DEFIANCE AND THE NARROWS.*

The high, sharp yellow bluff facing the south entrance to Colvos passage is called Point Defiance, and between it and the western shore pass all the waters of Puget's sound. This passage is called the Narrows. Its average width is three-quarters of a mile, and very uniform; the shores are high, bold, and in some places rocky. For two miles to the SE. its course is a regular curve. The next turn is to the southward, and at a distance of two miles in that direction the waters of the sound open ahead, with a narrow pass between the main and Fox island to the west; and a small indentation, backed by low ground, and formed on the south by a small peninsula, on the east. In this bight is anchorage in 15 fathoms, with swirling eddies. On the south face of this peninsula, and outside of the kelp, anchorage may also be had.

PUGET'S SOUND.

This collection of inlets commences after passing "The Narrows," and covers an area of 14 miles by 22, with a general direction SW. $\frac{3}{4}$ S. The aggregate shore-line of this sound, and the adjacent part of Admiralty inlet, with Colvos passage, to the north end of Vashon's island, is not less than 370 miles. Upon its shores are situated the settlements of Steilacoom, Nisqually, Olympia, and Newmarket.

It received its present name in 1792 from Vancouver, in compliment to Lieutenant Puget, who explored it.

STEILACOOM.

On the eastern shore of Puget's sound, nine miles south of Point Defiance, is situated the town or village of Steilacoom, upon a rising bluff. It consists of only a few houses. Fort Steilacoom stands about a mile inland, upon a piece of gravelly prairie, and roads lead from it to the town and the creek.

The neighboring country is only moderately well adapted to agriculture except along the bottoms of the small streams.

The usual anchorage is off the small wharf, in 15 fathoms, hard bottom, and about 400 or 500 yards from the shore. An island lying $2\frac{1}{4}$ miles distant to the west of that position is called McNeil, and between it and Fox island, to the northward, there is a passage a mile and a half wide. The passage on the south side of McNeil island, between it and Anderson island, is generally known as Balch's passage. It bears about SW. by W. from the anchorage, and is marked by a small wooded islet in it, called Eagle island, off which lies rocky bottom, and vessels keep closer to the north shore. This passage is the direct channel to Olympia, instead of following the broad one to the southward of Steilacoom.

The north end of the island, showing to the southward, and $1\frac{1}{2}$ mile from the anchorage, is Kitson island.

One mile north of the anchorage is the mouth of a small stream called the Steilacoom river.

In coming to Steilacoom, or bound direct for Olympia, a patch of kelp, with foul bottom and less than three fathoms of water upon it, must be avoided. It bears S.SE. one mile from the south end of Fox island, and NW. by W. $1\frac{3}{4}$ mile from Steilacoom wharf. The tide-rip upon it and abreast of the town is very great; quite sufficient with a little wind to swamp a small boat. The shores of the main and islands are bold, nearly uniform in height, and covered with trees.

Tides.—The corrected establishment or mean interval between the time of the moon's transit and the time of high water is IV*h*. XLVI*m*. The mean rise and fall of tides is 9.2 feet, of spring tides 11.1 feet, of

*Named by the United States Exploring Expedition in 1841.

neap tides 7.2 feet. The mean duration of the flood is 6*h*. 3*m*., of the ebb 6*h*. 25*m*., and of the stand 28*m*. The difference between the rise of the highest tide and the fall of the lowest tide observed was 18.3 feet. The greatest difference observed between the height of the two low waters of one day was 12.2 feet, and the greatest difference between the higher high and lower low waters of a day was 17.7.

When the moon's declination is greatest north the two high waters of the day follow her transit, respectively, by about 6 and 16 hours, and when greatest, and south, by 3½ and 18½ hours, the height of the two being about equal. When the moon's declination is zero they follow the moon's transit by about 4*h*. 46*m*. and 17*h*. 12*m*., but the first is higher than the second by about 2.7 feet when the moon's declination is changing from north to south, and when changing from south to north the second is higher than the first by that quantity. When the moon's declination is greatest, north or south, the two low waters follow the moon's transit by about 11*h*. 11*m*. and 23*h*. 37*m*., but when north the second falls lower than the first by about 9.7 feet, and when south the first falls lower than the second by that quantity. When the moon's declination is zero the two low waters are nearly equal in height; when changing from north to south they follow the moon's southing by about 11*h*. 41*m*. and 23*h*. 7*m*., and when changing from south to north by 10*h*. 41*m*. and 24*h*. 7*m*.

To find the times of high and low waters, first compute them for Port Townshend, and to the numbers thus obtained add 57 minutes.

The pronunciation of the name Steilacoom, as given to us by Indians, is Tchil'-æ-cum. On the Admiralty maps of 1847 we find it Chelakoom.

A reconnaissance sheet of Steilacoom harbor was published by the Coast Survey in 1856.

Nisqually, five miles south of Steilacoom, and on the same side of the sound, is, at present, a place of no trade or importance. It was one of the early posts of the Hudson Bay Company, and is still occupied by them. An extensive mud flat exists off the mouth of the wide, marshy valley, but the depth of water is very great close to it, and the anchorage room very much contracted. The river Nisqually empties here, and we believe there are two small saw-mills upon it. The name is Indian.

OLYMPIA.

It would be almost useless to attempt to describe the route to Olympia from Steilacoom, as a pilot or a map is absolutely necessary in making the passage. The mid-channel course is 21 miles in length, and its width from half a mile to a mile and a half.

Olympia is situated at the head of Budd's inlet,* which is six miles long, three-quarters of a mile wide, and runs nearly south. The shores are steep and wooded, and the head of the bay an immense mud flat behind which is the town. It acquires prospective importance by being the capital of the Territory, but especially on account of its proximity to the Columbia river valley, and to the headwaters of the Chehalis. There is a saw-mill at Newmarket, two miles south on the Tumwater, and three others in the vicinity, besides one or two grist-mills.

A depth of three fathoms can be carried on the west side of Budd's inlet, within one and a half mile of the wharf; and one fathom within a mile on the eastern side. Vessels are brought up to the wharf at the highest tides, and then rest in the mud until ready to leave.

The greatest difference between the highest and lowest tides is reported about 24 feet, and is doubtless more than this when we compare its position with that of Steilacoom. The approximate corrected establishment is V*h*. VIII*m*., and the mean rise and fall of tides 9.2 feet.

The approximate geographical position of the wharf is:

	° ′ ″
Latitude	47 03 00 north.
Longitude	122 55 00 west.
	h. m. s.
Or, in time	8 11 42.

The computed magnetic variation 20° 47′ east, in July, 1856, and the present yearly increase 1′.

A hydrographic reconnaissance of Budd's inlet was published by the Coast Survey in 1856.

A small saw-mill has been built on Hammersley's inlet,* and another on Henderson's inlet.*

* Named by the U. S. Exploring Expedition in 1841.

HOOD'S CANAL.*

The entrance to this arm of Admiralty inlet lies between Basalt Point and Foulweather bluff, the latter bearing E. ¾ S., distant 3½ miles from the former.

The first mid-channel course is SE. for four miles, pointing directly into Port Gamble, at the entrance to which the houses and mill are plainly visible; and passing a high, round, wooded peninsula on the west side of the channel, and connected to the main by a narrow neck of low sand beach. This is frequently mistaken for an island, and is called Hood's Head.† Between this head and Port Gamble the canal changes its course and runs in nearly a straight line S. by W. 40 miles, with an average width of 1½ mile. In latitude 47° 21′ N. it makes an abrupt turn, and runs for 12 or 13 miles about NE.

PORT LUDLOW.

Close to Basalt Point lie some rocks, with others about half a mile SE., called the Colvos rocks,* among which is one 25 feet high, but of small extent. Close in shore, and abreast of this, is a rock just awash at high tide, but between the two runs a channel with 15 fathoms water, having soft, muddy bottom. The bright bluff head 1¼ mile SE. of the Colvos rocks, and about two miles SW. by W. from Foulweather bluff, is *Tala Point*.‡ Half-way between the Colvos and this point is the usual entrance, over a sand bar having 4½ fathoms. The 3-fathom line stretches half a mile SE. of Colvos. If the wind and currents do not suit for this channel, run inside of the Colvos, carrying deep water and eight fathoms, soft, muddy bottom, anywhere inside of Tala Point, even past the saw-mill, if necessary. The general direction of the shore from Basalt Point to the saw-mill on the low sand point inside, is S. SE. 2½ miles. Abreast of Tala the width of the bay is three-quarters of a mile, but it gradually contracts to less than half a mile at the saw mill, at which vessels load. Inside of the saw-mill point is an excellent anchorage in seven and eight fathoms. About a mile from the mill is an ample water-power, with an available head of 80 feet, but it is not used.

We believe the Pacific Mail Steamship Company were to have established a coal depot here for their Puget's sound steamships; but since the breaking out of the Fraser river gold excitement other arrangements have been made.

Of all the small harbors in these waters we do not hesitate to give this the preference, as it is completely land-locked, and protected from gales from every quarter by the high land and high trees around it. The first steamboat built in these waters was launched here in 1860.

It received its present name from the United States Exploring Expedition in 1841.

The first rocks off Basalt lie at the narrow mouth of a small boat harbor, called Mats-mats. The entrance to it is over a half mile long, about 100 yards wide, and at the sharp turn obstructed by rocks, which allow a channel of only three feet water. Inside, the depth ranges to two fathoms, and the extent of the harbor is about three-quarters of a mile by a third in breadth.

A map of Port Ludlow and Mat-mats was published by the Coast Survey in 1856.

PORT GAMBLE.

After passing Foulweather bluff keep closer to the eastern shore than to the western, to avoid the strong current passing round the low point which makes out from Hood's Head. Run for the saw-mill, plainly in sight, on the western side of the entrance to the bay, and when within a mile of it approach the eastern bluff within the third of a mile, in about 10 or 15 fathoms, gradually drawing closer in shore, and passing between the outer white and inner black can buoys. At the lowest tides the white one is in 15 feet, the black in 12½, and the small spar buoy between them in mid-channel in 17 feet, but it rarely shows above water at any tide. After passing these buoys the mill bears almost S.SE. half a mile distant. Steer SE., or half-way between the mill wharf and the east point, pass to the east of the white spar buoy, which is in 12½ feet, and run through the entrance, passing the wharf at about one-third of the distance between the points. Do not round up to the eastward, as a shoal makes out almost parallel with the point. It may be here noticed that these buoys were made and placed by the Puget Mill Company, for the benefit of vessels trading to the port.

* Named by Vancouver, 1792.

† Named by the U. S. Coast Survey in 1856.

‡ Named by the U. S. Exploring Expedition in 1841.

If the wind is ahead while beating up, it will be impossible for a large sized-vessel to get in, as the channel is half a mile long, and not over 100 yards wide at the narrowest part. Anchor off the buoys, and drop in with the early flood, or warp in with the last of the ebb. On the shoal forming the western side of the passage ten feet may be found until up with the white spar buoy.

Inside of the points the bay appears to open well under the eastern one, but the 3-fathom line makes out on a line with the end of the point. On the western side is a crib, around which a shoal has formed—anchor just beyond it in five fathoms, soft muddy bottom. The depth of water throughout the bay is from four to nine fathoms, with mud bottom. The length of the bay is 2¼ miles, its width three-quarters of a mile, and its direction southeast. The shores are steep, but not high, and are bordered by sand and pebble beach, offering capital chances for laying a vessel out. A better place, however, for that purpose, is at the end of the store wharf, especially for vessels with large dead rise.

In summer the wind generally blows into the harbor lightly; in winter the SE. gales draw directly out. Loaded vessels must warp out in summer, or trust to a light southerly air in the morning, with an ebb tide. None but small, smart working vessels can beat out, and few of those have done so within the channel limits.

The approximate geographical position of the eastern point of the entrance is:

	° ′ ″
Latitude	47 51 32 north.
Longitude	122 33 56 west.
	h. m. s.
Or, in time	8 10 15.7

The saw-mill here is the largest and most effective in this part of the Territory, cutting at the rate of six or seven millions of feet of lumber per year. Attached to it are lath, shingle, and planing machines. A large quantity of the lumber and rough spars for masts are carried to Australia and the Sandwich Islands. Within two or three seasons, ending with that of 1857, the number of outward-bound vessels trading to the Sandwich Islands was 15; the average passage 26½ days; the shortest passage 19 days, and the longest 32. From the islands to the mill the number of vessels arriving was 16; average passage 25½ days; shortest passage 15 days, and the longest 35 days. Of these one reported a passage of 15 days to the mouth of Fuca strait, and nine days thence to the port, in the early part of September, having encountered nearly continuous calms in the strait and inlet.

From this place, called Teekalet, (the Indian name of the bay,) a road is being constructed (1857) by the Mill Company to Port Madison.

The steam and smoke from the saw-mill are distinctly visible from part of Port Townshend over the low ground between that bay and Oak cove.

It received its present name from the U. S. Exploring Expedition in 1841.

The Coast Survey Report for 1856 contained a hydrographic sketch of Port Gamble.

Three miles from Hood's Head, on the western side of the canal, *Suquamish harbor** opens. A large sand bank occupies its centre, and extends a mile in length N.NW., by half a mile in width. The approaches to the shoal, which is in part bare, are detected in thick weather by the lead, the soundings decreasing regularly from 20 fathoms. Keep, however, close under the northern shore, which runs two miles W.SW. from the low point called Termination Point.*

Fourteen miles from Hood's Head the canal curves more to the southward, and then to the S.SW. around Hazel Point,† on the west side of which a large arm of the canal makes north for ten miles, bifurcating near its head. On its western side the eastern spurs of the Olympus range reach its waters, and form the western shore-line of the canal to the great bend. The sharp peak named Mount Constance‡ attains an elevation of 7,777 feet.

Two miles south of Hazel Point, and on the eastern side of the canal, is a fine harbor, formerly called ***Hahainish harbor,**** but the name has been changed by settlers, who have lately built a small saw-mill there. It is formed by Seabock island on the west, and is about a mile long by half a mile wide, with good bottom in from 10 to 15 fathoms, the depth decreasing to the head.

South of the harbor Hood's canal is slightly contracted in width, but continues in the same general direction to about latitude 47° 21′ N., ("Vancouver's farthest,") where it takes an abrupt turn, and stretches E. by N. ½ N. four miles. The width in that part contracts to half a mile, and the shores overlap. From this it takes another slight bend, runs NE. by N. eight or nine miles, and reaches within two or three miles of the

* Named by the U. S. Exploring Expedition in 1841.
† Named by Vancouver in 1792.
‡ Named by the U. S. Coast Survey in 1855.

northern extremity of Case inlet,* an arm of Puget's sound. A large lake lies between the inlet and the canal. When Vancouver reached the first sharp turn he thought he saw the termination of the canal, and has plotted it in accordance with that view on his chart, four miles beyond the point marked "Vancouver's farthest" on the Admiralty charts. This was, in fact, the highest point to which he carried his boats.

The name, Hood's Canal, was given to it in 1792 by Vancouver. Its extent of shore-line is not less than 192 miles.

Before quitting our undertaking we are induced to append the following meteorological table, as it will give a good idea of the summer climate in this section. The observations were made upon a vessel in the waters of Fuca strait, Admiralty inlet, and Puget's sound, the instruments being kept in the best shade practicable. The barometer was an aneroid, read at the hours 10 a. m. and 4 p. m., except in heavy weather, when it was read every hour. The thermometer readings are Fahrenheit, and reduced to the standard.

Abstract of meteorological observations made on board the United States Coast Surveying brig R. H. Fauntleroy, in the Strait of Juan de Fuca, Archipelago de Haro, Admiralty Inlet, and Puget's Sound, during the summers of 1855, *'56, and '57.*

1855.	Means of daily maxima.	Means of daily minima.	Highest readings, maxima.	Range of maxima.	Lowest readings, minima.	Range of minima.	Greatest range of temperature in one day.	Range of barometer.	Rain.
	°	°	°	°	°	°	°	*Inches.*	*Inches.*
July	71.5	53.3	90.9	29.9	48.2	9.4	33.7	0.44	Not measured.
August	70.2	53.4	83.3	24.7	49.8	6.6	29.7	.43	
September	65.8	52.5	77.7	18.3	49.3	8.6	20.0	.91	
Three weeks in October.	63.2	52.2	76.7	20.2	45.3	11.9	27.6	.38	

Greatest range of temperature during the above period, 45°.6.
Greatest range of barometer from June 24 to October 18, = 0.92 inch.
A dry season; heavy SE. gales in September.

1856.	Means of daily maxima.	Means of daily minima.	Highest readings, maxima.	Range of maxima.	Lowest readings, minima.	Range of minima.	Greatest range of temperature in one day.	Range of barometer.	Rain.
	°	°	°	°	°	°	°	*Inches.*	*Inches.*
May	67.1	48.7	85.7	31.1	45.0	7.4	38.1	0.53	Not measured.
June	69.0	51.2	84.4	27.4	45.7	10.3	34.0	.53	
July	72.5	51.7	84.7	29.7	43.4	14.0	41.3	.43	
August	72.2	53.5	83.7	25.5	48.4	10.2	30.2	.56	
September	72.8	51.1	85.1	27.5	42.0	14.4	36.5	.69	

Greatest range of temperature during the above period, 43°.7.
Greatest range of barometer from April 25 to September 30, 0.85 inch.
A wet season.

* Named by the United States Exploring Expedition, 1841.

1857.	Means of daily maxima.	Means of daily minima.	Highest readings, maxima.	Range of maxima.	Lowest readings, minima.	Range of minima.	Greatest range of temperature in one day.	Range of barometer.	Rain.
	°	°	°	°	°	°	°	*Inches.*	*Inches.*
Three weeks in May	71. 7	48. 4	101. 5	46. 9	38. 5	18. 1	46. 0	0. 52	0. 79
June	78. 2	50. 7	90. 1	29. 2	43. 0	13. 1	36. 9	. 62	1. 19
July	74. 9	51. 6	89. 2	26. 5	46. 9	9. 3	33. 1	. 44	0. 01
August	73. 8	51. 1	88. 0	28. 0	47. 1	9. 7	37. 8	. 46	0. 08
September	65. 5	49. 8	76. 4	23. 3	45. 2	8. 5	30. 8	. 73	0. 70
Two weeks in October	60. 1	48. 9	68. 7	16. 3	43. 4	7. 8	25. 1	. 65	0. 74

Greatest range of temperature during the above period, 63°. 0.

Greatest range of barometer from May 12 to October 13, 0. 79 inch.

A dry season, and marked by a week of remarkably hot weather at the close of May and beginning of June.

The working season of 1858 was wet. The working season of 1859 was dry.

The following table will give a few additional items of the winter months of 1860–'61. The observations were made at Olympia, at the office of the surveyor general.

	1860. December.	1861. January.	1861. February.
Maximum temperature	52°	49°	52°
Minimum temperature	23°	14°	31°
Mean temperature	39°. 7	38°. 4	42°. 3
Amount of snow in inches	No record	6. 4	9
Amount of rain and melted snow in inches	do	3. 1	8. 9
Days on which snow fell	do	4	2
Days on which snow lay on the ground	do	8	4
Days on which rain fell	13	12	13
Days on which no rain fell	18	19	15
Number of frosty mornings	11	6	7
Number of clear days	6	4	8

The cerealia generally grow well, but the climate is too cold for maize. During the winter a great amount of rain falls—as much as 60 inches—and heavy weather prevails principally from the southward. It is never cold enough to form thick, clear, solid ice, which has to be brought from Sitka for the San Francisco market.

Table of geographical positions of important headlands, bays, rivers, light-houses, &c., on the western coast.—Compiled from the "Directory for the Pacific Coast of the United States."

EXPLANATION.—Primary astronomical stations in small capitals; secondary astronomical stations designated by the mark 2 A; light-houses and light-house sites in italics, with the order of the light in Roman numerals; F. signifies fixed; Fl., flashing; Var., varied; Rv., revolving; W., white; Rd., red; Nat., natural color; M., minutes; and the Arabic numerals denote the distance at which the light may be seen, under ordinary states of the atmosphere, from a height of twenty feet above the sea.

Number.	Name of station.	Locality.	Latitude north.	Longitude, west. In arc.	Longitude, west. In time.	Magnetic variation, east.	Time of determination.
	CALIFORNIA.		° ′ ″	° ′ ″	h. m. s.	′ ″	
1	Los Coronados, (belonging to Mexico)	The highest part of the largest islet	32 23 46	117 13 21	7 48 53.4	....	....
2	Initial point	Monument on the boundary between Mexico and the United States.	32 31 58.5	117 06 11	7 48 24.7	....	....
3	*Point Loma light-house,* III—F. W.—29	West side of the entrance to San Diego bay, 450 feet high	32 40 13.0	117 13 17	7 48 53.0	....	....
4	SAN DIEGO	Observatory Hill, near La Playa, San Diego bay	32 41 57.9	117 13 22	7 48 53.5	12 29	April, 1851.*
5	San Clemente. 2 A	At the northwest extremity of the island (Santa Barbara channel.)	33 02	118 34 00	7 54 16.0	....	....
6	Cortes Shoal	Two and a half fathom spot. The Bishop rock (Santa Barbara channel.)	32 25¾	119 05	....	....	....
7	San Nicolas. 2 A	At the southeast end of the island (Santa Barbara channel.)	33 14 11.6	119 25 00	7 57 40.0	....	....
8	Santa Catalina. 2 A	At the great transverse break of the island, (north side) (Santa Barbara channel.)	33 26 31.8	118 28 45	7 53 55	....	....
9	Santa Barbara island	23 miles W. by S. from the N. end of the Santa Catalina (Santa Barbara channel.)	33 30	119 02	....	....	....
10	San Pedro bay. 2 A	Edge of the bluff at the landing (Santa Barbara channel.)	33 43 19.6	118 16 03	7 53 04.2	13 30	Nov., 1853.
11	Anacapa	Eastern point of the island (Santa Barbara channel.)	33 01	119 19	....	....	....
12	Point Hueneme, proposed *light-house site*	N. side of the eastern entrance to the Santa Barbara channel. (Santa Barbara channel.)	34 08	119 09	7 56 36	....	....
13	Prisoner's harbor. 2 A	North side of the island of Santa Cruz (Santa Barbara channel.)	34 01 09.8	119 40 00	7 58 40.0	....	....
14	Cuyler's harbor. 2 A	At the NE. part of the island of San Miguel (Santa Barbara channel.)	34 03	120 20 27	8 01 21.8	....	....
15	*Santa Barbara light-house.* IV—F. Rd.—12	Two miles southwestward of the landing, 180 feet high (Santa Barbara channel.)	34 23 35.4	119 42 05	7 58 48.3	....	....
16	Santa Barbara. 2 A	At the landing (Santa Barbara channel.)	34 24 24.7	119 40 18	7 58 41.2	....	....
17	*Point Concepcion light-house.* I—Rv. W. Fl. ½ M.—23.—Bell	Point Concepcion, 250 feet high (Santa Barbara channel.)	34 26 46.6	120 27 00	8 01 48.0	....	....
18	POINT CONCEPCION	Valley of El Coxo (Santa Barbara channel.)	34 26 56.5	120 25 39	8 01 42.6	13 50	Sept., 1850.
19	Point Arguello	12 miles NW. by W. ¼ W. from Point Concepcion	34 34	120 38	....	....	....
20	San Luis Obispo bay. 2 A	At the small gully west of the creek	35 10 37.5	120 43 31	8 02 54.1	14 17	Feb., 1854.
21	San Simeon bay. 2 A	Near the landing	35 38 24.2	121 10 22	8 04 41.5	....	....
22	Piedras Blancas	White rocks near San Simeon bay, outer one	35 39	121 15	....	....	....
23	Point Sur	51 miles SE. ¼ S. from Point Año Nuevo	36 19	121 52	....	....	....
24	*Point Pinos light-house.* II—F. Nat.—16	At the NW. point of the trees, 91 feet high	36 37 52	121 55 00	8 07 40.0	....	....
25	POINT PINOS	SW. point of Monterey bay, near light-house	36 37 59.3	121 54 25	8 07 37.7	14 58	Feb., 1851.
26	Santa Cruz harbor. 2 A	At the Embarcadero, northern part of Monterey bay	36 57 26.9	122 00 10	8 08 00.7	....	....
27	Point Año Nuevo, proposed *light-house site*	40 miles SE. by S. from San Francisco bar bell-boat	37 07	122 19	....	....	....
28	Point San Pedro	13 miles S. by E. ½ E. from Boneta light	37 35 45	122 30 34	8 10 02.3	....	....
29	*South Farallon light.* I—Rv. W. Pr. Fl. every M.—27.—Whistle.	23½ miles SW. by W. ¾ W. off entrance to San Francisco bay, 360 ft.	37 41 48.8	122 59 05.2	8 11 56.3	....	....
30	*Point Lobos light-house* site	The S. head of entrance to San Francisco bay	37 46 50.5	122 29 39.5	8 09 58.6	....	....
31	Rincon Point. 2 A	NW. of South Park, San Francisco city	37 47 07.0	122 22 32	8 09 30.1	....	....
32	PRESIDIO	Near the Presidio of San Francisco	37 47 29.8	122 26 15	8 09 45.0	15 27	Feb., 1852.
33	TELEGRAPH HILL	Near the "San Francisco Observatory"	37 47 52.8	122 23 19.4	8 09 33.3	....	....
34	Telegraph Hill	Triangulation station, summit of the hill	37 48 00.1	122 23 19.4	8 09 33.3	....	....
35	*Fort Point light-house.* V—F. Nat.—12½.—Bell	S. side of the entrance to San Francisco bay, 53 feet high	37 48 31.0	122 27 37.9	8 09 50.5	....	....
36	*Point Boneta light-house.* II—F. Nat —25.—Bell	N. head of the entrance to San Francisco bay 306 feet high	37 49 03.7	122 30 50.3	8 10 03.3	....	....

37	*Alcatraz Island light.* III—F. Nat.—14. Bell	In the harbor of San Francisco, 162 feet high	37 49 26.6	122 24 18.8	8 09 37.2		
38	Punta de los Reyes. 2 A	At landing on Sir Francis Drake's bay	37 59 35.0	122 57 35.9	8 11 50.4		
39	*Punta de los Reyes light-house* site	On the western head of the point	37 59 39.4	123 00 13.2	8 12 00 9		
40	Bodega. 2 A	Bodega bay, W. end of Sandy Point	38 18 20.4	123 02 17.4	8 12 09.2		
41	Haven's Anchorage. 2 A	On the bluff at the landing	38 47 58.0	123 34 01	8 14 16.0		
42	Mendocino bay. 2 A	On the bluff near the landing	39 18 06.1	123 47 25.6	8 15 09.7		
43	Punta de Arena	NW. extremity of the point	38 57	123 45			
44	Shelter Cove, (Point Delgado.) 2 A	On the bluff near the landing	40 01 13.7	124 03 03	8 16 12.2		
45	Cape Mendocino	Extremity of cape	40 25	124 22			
46	HUMBOLDT	Red Bluff, Humboldt bay	40 44 40.2	124 10 30	8 16 42	17 04	April, 1854.
47	*Humboldt light-house.* IV—F. W.—13½	On the N. point, one mile from entrance, 53 feet high	40 46 03.6	124 12 21	8 16 49.4		
48	Bucksport. 2 A	Town of Bucksport, Humboldt bay	40 46 37.1	124 10 44	8 16 42.9	17 06	July, 1853.
49	Trinidad. 2 A	Town of Trinidad, Trinidad bay	41 03 20.0	124 08 08	8 16 32.5		
50	*Crescent City light-house.* IV—F. W. Var. by Fl.—15½	On the extreme W. part of the point, 80 feet high	41 44 34.2	124 11 22	8 16 45.4		
51	Crescent City. 2 A	W. of the town, near Point St. George	41 44 44.0	124 11 14	8 16 44.9		
	OREGON.						
52	Port Orford. 2 A	In the town of Port Orford, near the landing	42 44 28.2	124 28 13	8 17 52.8		
53	PORT ORFORD	On the bluff W. of the town	42 44 21.7	124 28 47	8 17 55.1	18 29	Nov., 1851.
54	Cape Orford or Blanco	Extremity of the cape	42 50	124 30			
55	Cape Gregory	NW. part of the cape off Koos bay	43 20⅓	124 22½			
56	*Umpquah River light.* III—F. W.—16½	On the S. side of the river, at its mouth, 100 feet high	43 40 18.5	124 11 00.3	8 16 44.2		
57	Umpquah. 2 A	One mile from entrance to the river, (W. side)	43 41 45.0	124 09 57	8 16 39.8		
58	Cape Perpetua	Middle part of the headland	44 19	124 06			
59	Cape Foulweather	Southern part of the cape.	44 45	124 04			
60	Cape Lookout	Sharp point furthest W.	45 20	124 00			
61	Cape Meares	NW. part. The Cape Lookout of Meares and Vancouver	45 30	123 58			
62	Cape Falcon, or False Tillamook	Northern part	45 47	123 58			
63	Tillamook Head	SE. by S. ¾ S., 19 miles from Disappointment light	45 58	123 59			
64	Astor Point. 2 A	Near Astoria, Columbia river	46 11 27.6	123 49 31.7	8 15 18.1		
65	Point Adams	South Point, entrance to Columbia river, half a mile inside	46 12 30.4	123 56 55.8	8 15 47.7		
	WASHINGTON TERRITORY.						
66	*Cape Disappointment light-house.* I—F. W.—22½.—Bell	Near the highest part of the cape	46 16 32.7	124 02 13	8 16 08.9		
67	CAPE DISAPPOINTMENT	North Point, entrance to Columbia river, highest part	46 16 35.4	124 02 01	8 16 08.1	20 45	July, 1851.
68	Leadbetter Point	S. point of the entrance to Shoalwater bay	46 36 (45)	124 00 (45)	8 16 (03)		
69	*Cape Shoalwater light house.* IV—F. W. Var. by Fl.—16	W. point of the entrance to Shoalwater bay, 87 feet high	46 44 11	124 02 24	8 16 09 6		
70	Point Hanson	S. point of the entrance to Gray's harbor	46 53 48.6	124 06 42.3	8 16 26.8		
71	Point Grenville	Point of the bluff at the anchorage	47 20 (00)	124 14 (00)	8 16 (56)		
72	Destruction island	North Point	47 41	124 25			
73	Flattery Rocks	Northwestern rocky islet	48 12	124 43			
74	†*Tatoosh Island light-house.* I—F. W.—20	Off Cape Flattery, Strait of Juan de Fuca	48 23 15.5	124 43 48	8 18 55.2	21 30	Aug., 1852.
75	NEE' AH BAY	Near the creek, in Neé-ah bay, Strait of Juan de Fuca	48 21 48.8	124 37 12	8 18 28.8	21 47	Aug., 1855.
76	Port Angelos. 2 A	Head of the bay, Strait of Juan de Fuca	48 07 51.5	123 27 21	8 13 49.4		
77	*New Dungeness light-house.* III—F. W.—16½	On the end of the Sand Point, Strait of Juan de Fuca	48 10 59.0	123 06 07	8 12 24.5		
78	*Smith's Island light house.* IV—Rv. W. Var. Fl. every ½ M.	SW. point of the island	48 19 01.0	122 50 01	8 11 20.1		
79	Point Wilson	W. point of entrance to Admiralty inlet	48 08 42.7	122 44 49.4	8 10 59.3		
80	Point Hudson. 2 A	In Port Townshend, extremity of the point	48 07 02 7	124 44 46.5	8 10 59.1	21 40	Aug., 1856.
81	*Admiralty Head light-house.* IV—F. W.—17½	E. side of entrance to Admiralty inlet, 119 feet high	48 09 21.6	122 40 08	8 10 40.5		

* 12° 32 , September, 1853.

† *Rock Duncan* bears N. 35° W. (magnetic) from Tatoosh Island light, distant 1.02 mile.

TABLE OF GEOGRAPHICAL POSITIONS—Continued.

Number.	Name of station.	Locality.	Latitude, north.	Longitude, west. In arc.	Longitude, west. In time.	Magnetic variation, east.	Time of determination.
			° ′ ″	° ′ ″	h. m. s.	′ ″	
82	Port Gamble	Four miles inside the entrance to Hood's canal, East Point	47 51 32.0	122 33 56	8 10 15.7	....	....
83	Restoration Point. 2 A	SE. point of Bainbridge island, Admiralty inlet	47 35 05.8	122 28 00.0	8 09 52.0	....	....
84	Point Pully. 2 A	E. side of Admiralty inlet, opposite Vashon's island	47 27 07.3	122 22 21.5	8 09 29.4	....	....
85	Lummi. 2 A	Sand point on the NE. side of the island	48 44 01.7	122 40 37	8 10 42.5	....	....
86	Lummi North	N. point of the island	48 44 53.2	122 42 12	8 10 48.8	....	....
	VANCOUVER ISLAND.		From	the Admiralty	charts.		
87	Observatory Rocks	SE. point of San Juan harbor, Strait of Juan de Fuca	48 31 30	124 28 15	8 17 53.0	....	....
88	Beechy Head	E. of Sooke inlet, Strait of Juan de Fuca	48 18 30	123 39 27	8 14 37.8	....	....
89	*Race Rocks light-house.* II—Fl. W. every 10 secs	Southernmost point of Vancouver, Strait of Juan de Fuca, 118 ft.	48 17 30	123 32 15	8 14 09.0	....	....
90	*Fisgard Island light-house.* IV—F.—15. See page 391	W. side of entrance to Esquimault harbor, Strait of Juan de Fuca, 70 feet high.	48 25 38	123 27 10	8 13 48.7	....	....

TIDE TABLES FOR SAN DIEGO.*

TABLE I.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	9 25	9 40	9 52	10 3	10 12	10 20	10 25	10 29	10 29	10 25	10 19	10 10	10 0	9 47	9 30
0 30	9 15	9 30	9 42	9 53	10 2	10 10	10 15	10 19	10 19	10 15	10 9	10 0	9 50	9 27	9 20
1 0	9 8	9 23	9 35	9 46	9 55	10 3	10 8	10 12	10 12	10 8	10 2	9 53	9 43	9 30	9 13
1 30	9 1	9 16	9 28	9 39	9 48	9 56	10 1	10 5	10 5	10 1	9 55	9 46	9 36	9 23	9 6
2 0	8 54	9 9	9 21	9 32	9 41	9 49	9 54	9 58	9 58	9 54	9 48	9 39	9 29	9 16	8 59
2 30	8 49	9 4	9 16	9 27	9 36	9 44	9 49	9 53	9 53	9 49	9 43	9 34	9 24	9 11	8 54
3 0	8 48	9 3	9 15	9 26	9 35	9 43	9 48	9 52	9 52	9 48	9 42	9 33	9 23	9 10	8 53
3 30	8 48	9 3	9 15	9 26	9 35	9 43	9 48	9 52	9 52	9 48	9 42	9 33	9 23	9 10	8 53
4 0	8 52	9 7	9 19	9 30	9 39	9 47	9 52	9 56	9 56	9 52	9 46	9 37	9 27	9 14	8 57
4 30	8 56	9 11	9 23	9 34	9 43	9 51	9 56	10 0	10 0	9 56	9 50	9 41	9 31	9 18	9 1
5 0	9 15	9 30	9 42	9 53	10 2	10 10	10 15	10 19	10 19	10 15	10 9	10 0	9 50	9 37	9 20
5 30	9 37	9 52	10 4	10 15	10 24	10 32	10 37	10 41	10 41	10 37	10 31	10 22	10 12	9 59	9 42
6 0	9 55	10 10	10 22	10 33	10 42	10 50	10 55	10 59	10 59	10 55	10 49	10 40	10 30	10 17	10 0
6 30	10 12	10 27	10 39	10 50	10 59	11 7	11 12	10 16	10 16	11 12	11 6	10 57	10 47	10 34	10 17
7 0	10 18	10 33	10 45	10 56	11 5	11 13	11 18	11 22	11 22	11 18	11 12	11 3	10 53	10 40	10 23
7 30	10 20	10 35	10 47	10 58	11 7	11 15	11 20	11 24	11 24	11 20	11 14	11 5	10 55	10 42	10 25
8 0	10 22	10 37	10 49	11 0	11 9	11 17	11 22	11 26	11 26	11 22	11 16	11 7	10 57	10 44	10 27
8 30	10 24	10 39	10 51	11 2	11 11	11 19	11 24	11 28	11 28	11 24	11 18	11 9	10 59	10 46	10 29
9 0	10 18	10 33	10 45	10 56	11 5	11 13	11 18	11 22	11 22	11 18	11 12	11 3	10 53	10 40	10 23
9 30	10 10	10 25	10 37	10 48	10 57	11 5	11 10	11 14	11 14	11 10	11 4	10 55	10 45	10 32	10 15
10 0	10 0	10 15	10 27	10 38	10 47	10 55	11 0	11 4	11 4	11 0	10 54	10 45	10 35	10 22	10 5
10 30	9 53	10 8	10 20	10 21	10 40	10 48	10 53	10 57	10 57	10 53	10 47	10 38	10 28	10 15	9 58
11 0	9 45	10 0	10 12	10 23	10 32	10 40	10 45	10 49	10 49	10 45	10 39	10 30	10 20	10 7	9 50
11 30	9 36	9 51	10 3	10 14	10 23	10 31	10 36	10 40	10 40	10 36	10 30	10 21	10 11	9 58	9 41

TABLE II.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	9 30	9 16	9 4	8 53	8 44	8 36	8 31	8 27	8 27	8 31	8 37	8 46	8 56	9 9	9 26
0 30	9 21	9 6	8 54	8 43	8 34	8 26	8 21	8 17	8 17	8 21	8 27	8 36	8 46	8 59	9 16
1 0	9 14	8 59	8 47	8 36	8 27	8 19	8 14	8 10	8 10	8 14	8 20	8 29	8 39	8 52	9 9
1 30	9 7	8 52	8 40	8 29	8 20	8 12	8 7	8 3	8 3	8 7	8 13	8 22	8 32	8 45	9 2
2 0	9 0	8 45	8 33	8 22	8 13	8 5	8 0	7 56	7 56	8 0	8 6	8 15	8 25	8 38	8 55
2 30	8 55	8 40	8 28	8 17	8 8	8 0	7 55	7 51	7 51	7 55	8 1	8 10	8 20	8 33	8 50
3 0	8 54	8 39	8 27	8 16	8 7	7 59	7 54	7 50	7 50	7 54	8 0	8 9	8 19	8 32	8 49
3 30	8 54	8 39	8 27	8 16	8 7	7 59	7 54	7 50	7 50	7 54	8 0	8 9	8 19	8 32	8 49
4 0	8 58	8 43	8 31	8 20	8 11	8 3	7 58	7 54	7 54	7 58	8 4	8 13	8 23	8 36	8 53
4 30	9 2	8 47	8 35	8 24	8 15	8 7	8 2	7 58	7 58	8 2	8 8	8 17	8 27	8 40	8 57
5 0	9 21	9 6	8 54	8 43	8 34	8 26	8 21	8 17	8 17	8 21	8 27	8 36	8 46	8 59	9 16
5 30	9 43	9 28	9 16	9 5	8 56	8 48	8 43	8 39	8 39	8 43	8 49	8 58	9 8	9 21	9 38
6 0	10 1	9 46	9 34	9 23	9 14	9 6	9 1	8 57	8 57	9 1	9 7	9 16	9 26	9 39	9 56
6 30	10 18	10 3	9 51	9 40	9 31	9 23	9 18	9 14	9 14	9 18	9 24	9 33	9 43	9 56	10 13
7 0	19 24	10 9	9 57	9 46	9 37	9 29	9 24	9 20	9 20	9 24	9 30	9 39	9 49	10 2	10 19
7 30	10 26	10 11	9 59	9 48	9 39	9 31	9 26	9 22	9 22	9 26	9 32	9 41	9 51	10 4	10 21
8 0	10 28	10 13	10 1	9 50	9 41	9 33	9 28	9 24	9 24	9 28	9 34	9 43	9 53	10 6	10 23
8 30	10 30	10 15	10 3	9 52	9 43	9 35	9 30	9 26	9 26	9 30	9 36	9 45	9 55	10 8	10 25
9 0	10 24	10 9	9 57	9 46	9 37	9 29	9 24	9 20	9 20	9 24	9 30	9 39	9 49	10 2	10 19
9 30	10 16	10 1	9 49	9 38	9 29	9 21	9 16	9 12	9 12	9 16	9 22	9 31	9 41	9 54	10 11
10 0	10 6	9 51	9 39	9 28	9 19	9 11	9 6	9 2	9 2	9 6	9 12	9 21	9 31	9 44	10 1
10 30	9 59	9 44	9 32	9 21	9 12	9 4	8 59	8 55	8 55	8 59	9 5	9 14	9 24	9 37	9 54
11 0	9 51	9 36	9 24	9 13	9 4	8 56	8 51	8 47	8 47	8 51	8 57	9 6	9 16	9 29	9 46
11 30	9 42	9 27	9 15	9 4	8 55	8 47	8 42	8 38	8 38	8 42	8 48	8 57	9 7	9 20	9 37

* For the manner of using these tables, see the example for San Francisco, pages 311-316.

TABLE III.

Days from moon's greatest declination.		South declination. Low water. (Small.)	South declination. High water. (Large.)	South declination. Low water. (Large.)	North declination. Low water. (Large.)	North declination. High water. (Small.)	North declination. Low water. (Small.)	Days from moon's greatest declination.	
		h. m.	*h. m.*	*h. m.*	*h. m.*	*h. m.*	*h. m.*		
Before.	7	5 44	12 28	18 44	6 16	12 16	18 00	7	Before.
	6	5 18	11 56	18 40	6 42	12 46	18 04	6	
	5	5 00	11 34	18 34	7 00	13 10	18 10	5	
	4	4 47	11 12	18 25	7 13	13 32	18 19	4	
	3	4 34	10 54	18 20	7 26	13 50	18 24	3	
	2	4 24	10 38	18 14	7 36	14 06	18 30	2	
	1	4 17	10 28	18 11	7 43	14 16	18 33	1	
	0	4 12	10 20	18 08	7 48	14 24	18 36	0	
After.	1	4 14	10 20	18 06	7 46	14 24	18 38	1	After.
	2	4 24	10 28	18 04	7 36	14 16	18 40	2	
	3	4 38	10 40	18 02	7 22	14 04	18 42	3	
	4	5 01	10 58	17 57	6 59	13 46	18 47	4	
	5	5 25	11 18	17 53	6 35	13 26	18 51	5	
	6	5 49	11 44	17 55	6 11	13 00	18 49	6	
	7	6 18	12 18	18 00	5 42	12 26	18 44	7	

TABLE IV.

Time of moon's transit.	South declination.—Days from moon's greatest declination.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
0	4.7	4.5	4.3	4.2	4.1	4.1	4.1	4.1	4.2	4.3	4.5	4.8	5.1	5.5	5.8
1	4.6	4.4	4.2	4.1	4.0	4.0	4.0	4.0	4.1	4.2	4.4	4.7	5.0	5.4	5.7
2	4.4	4.2	4.0	3.9	3.8	3.8	3.8	3.8	3.9	4.0	4.2	4.5	4.8	5.2	5.5
3	4.1	3.9	3.7	3.6	3.5	3.5	3.5	3.5	3.6	3.7	3.9	4.2	4.5	4.9	5.2
4	3.8	3.6	3.4	3.3	3.2	3.2	3.2	3.2	3.3	3.4	3.6	3.9	4.2	4.6	4.9
5	3.6	3.4	3.2	3.1	3.0	3.0	3.0	3.0	3.1	3.2	3.4	3.7	4.0	4.4	4.7
6	3.6	3.4	3.2	3.1	3.0	3.0	3.0	3.0	3.1	3.2	3.4	3.7	4.0	4.4	4.7
7	3.7	3.5	3.3	3.2	3.1	3.1	3.1	3.1	3.2	3.3	3.5	3.8	4.1	4.5	4.8
8	3.8	3.6	3.4	3.3	3.2	3.2	3.2	3.2	3.3	3.4	3.6	3.9	4.2	4.6	4.9
9	4.4	4.2	4.0	3.9	3.8	3.8	3.8	3.8	3.9	4.0	4.2	4.5	4.8	5.2	5.5
10	4.7	4.5	4.3	4.2	4.1	4.1	4.1	4.1	4.2	4.3	4.5	4.8	5.1	5.5	5.8
11	4.8	4.6	4.4	4.3	4.2	4.2	4.2	4.2	4.3	4.4	4.6	4.9	5.2	5.6	5.9

TABLE V.

Time of moon's transit.	North declination.—Days from moon's greatest declination.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
0	5.7	5.9	6.1	6.2	6.3	6.3	6.3	6.3	6.2	6.1	5.9	5.6	5.3	4.9	4.6
1	5.6	5.8	6.0	6.1	6.2	6.2	6.2	6.2	6.1	6.0	5.8	5.5	5.2	4.8	4.5
2	5.4	5.6	5.8	5.9	6.0	6.0	6.0	6.0	5.9	5.8	5.6	5.3	5.0	4.6	4.3
3	5.1	5.3	5.5	5.6	5.7	5.7	5.7	5.7	5.6	5.5	5.3	5.0	4.7	4.3	4.0
4	4.8	5.0	5.2	5.3	5.4	5.4	5.4	5.4	5.3	5.2	5.0	4.7	4.4	4.0	3.7
5	4.6	4 8	5.0	5.1	5.2	5.2	5.2	5.2	5.1	5.0	4.8	4.5	4.2	3.8	3.5
6	4.6	4 8	5.0	5.1	5.2	5.2	5.2	5.2	5.1	5.0	4.8	4.5	4.2	3.8	3.5
7	4.7	4.9	5.1	5.2	5.3	5.3	5.3	5.3	5.2	5.1	4.9	4.6	4.3	3.9	3.6
8	4.8	5.0	5.2	5.3	5.4	5.4	5.4	5.4	5.3	5.2	5.0	4.7	4.4	4.0	3.7
9	5.4	5.6	5.8	5.9	6.0	6.0	6.0	6.0	5.9	5.8	5.6	5.3	5.0	4.6	4.3
10	5.7	5.9	6.1	6.2	6.3	6.3	6.3	6.3	6.2	6.1	5.9	5.6	5.3	4.9	4.6
11	5.8	6.0	6.2	6.3	6.4	6.4	6.4	6.4	6.3	6.2	6.0	5.7	5.4	5.0	4.7

NOTE.—To use these tables with a chart on which the soundings are referred to mean low water, subtract 1.2 foot from the numbers in the tables for all places from San Diego to Astoria.

TABLE VI.

Time of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER.															FROM SMALL LOW WATER TO LARGE HIGH WATER.															Time of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.															
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	4.0	3.4	3.0	2.6	2.3	2.1	2.0	2.0	2.1	2.3	2.7	3.2	3.8	4.6	5.2	5.1	4.9	4.7	4.5	4.4	4.3	4.2	4.2	4.1	4.1	4.0	4.0	3.9	3.9	4.0	0
1	3.8	3.2	2.8	2.4	2.1	1.9	1.8	1.8	1.9	2.1	2.5	3.0	3.6	4.4	5.0	4.9	4.7	4.5	4.3	4.2	4.1	4.0	4.0	3.9	3.9	3.8	3.8	3.7	3.7	3.8	1
2	3.5	2.9	2.5	2.1	1.8	1.6	1.5	1.5	1.6	1.8	2.2	2.7	3.3	4.1	4.7	4.6	4.4	4.2	4.0	3.9	3.8	3.7	3.7	3.6	3.6	3.5	3.5	3.4	3.4	3.5	2
3	3.0	2.4	2.0	1.6	1.3	1.1	1.0	1.0	1.1	1.3	1.7	2.2	2.8	3.6	4.2	4.1	3.9	3.7	3.5	3.4	3.3	3.2	3.2	3.1	3.1	3.0	3.0	2.9	2.9	3.0	3
4	2.2	1.6	1.2	0.8	0.5	0.3	0.2	0.2	0.3	0.5	0.9	1.4	2.0	2.8	3.4	3.3	3.1	2.9	2.7	2.6	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.1	2.1	2.2	4
5	1.7	1.1	0.7	0.3	0.0	-.2	-.3	-.3	-.2	0.0	0.4	0.9	1.5	2.3	2.9	2.8	2.6	2.4	2.2	2.1	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.6	1.6	1.7	5
6	1.8	1.2	0.8	0.4	0.1	-.1	-.2	-.2	-.1	0.1	0.5	1.0	1.6	2.4	3.0	2.9	2.7	2.5	2.3	2.2	2.1	2.0	2.0	1.9	1.9	1.8	1.8	1.7	1.7	1.8	6
7	2.3	1.7	1.3	0.9	0.6	0.4	0.3	0.3	0.4	0.6	1.0	1.5	2.1	2.9	3.5	3.4	3.2	3.0	2.8	2.7	2.6	2.5	2.5	2.4	2.4	2.3	2.3	2.2	2.2	2.3	7
8	2.9	2.3	1.9	1.5	1.2	1.0	0.9	0.9	1.0	1.2	1.6	2.1	2.7	3.5	4.1	4.0	3.8	3.6	3.4	3.3	3.2	3.1	3.1	3.0	3.0	2.9	2.9	2.8	2.8	2.9	8
9	3.7	3.1	2.7	2.3	2.0	1.8	1.7	1.7	1.8	2.0	2.4	2.9	3.5	4.3	4.9	4.8	4.6	4.4	4.2	4.1	4.0	3.9	3.9	3.8	3.8	3.7	3.7	3.6	3.6	3.7	9
10	4.2	3.6	3.2	2.8	2.5	2.3	2.2	2.2	2.3	2.5	2.9	3.4	4.0	4.8	5.4	5.3	5.1	4.9	4.7	4.6	4.5	4.4	4.4	4.3	4.3	4.2	4.2	4.1	4.1	4.2	10
11	4.3	3.7	3.3	2.9	2.6	2.4	2.3	2.3	2.4	2.6	3.0	3.5	4.1	4.9	5.5	5.4	5.2	5.0	4.8	4.7	4.6	4.5	4.5	4.4	4.4	4.3	4.3	4.2	4.2	4.3	11

TABLE VII.

Time of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER.															FROM LARGE LOW WATER TO SMALL HIGH WATER.															Time of moon's transit.
	Days from moon's greatest declination.															Days from moon's greatest declination.															
	Before—								After—							Before—								After—							
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
H.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
0	5.2	5.8	6.2	6.6	6.9	7.1	7.2	7.2	7.2	6.9	6.5	6.0	5.4	4.6	4.0	4.1	4.3	4.5	4.7	4.8	4.9	5.0	5.0	5.1	5.1	5.2	5.2	5.3	5.3	5.2	0
1	5.0	5.6	6.0	6.4	6.7	6.9	7.0	7.0	6.9	6.7	6.3	5.8	5.2	4.4	3.8	3.9	4.1	4.3	4.5	4.6	4.7	4.8	4.8	4.9	4.9	5.0	5.0	5.1	5.1	5.0	1
2	4.7	5.3	5.7	6.1	6.4	6.6	6.7	6.7	6.6	6.4	6.0	5.5	4.9	4.1	3.5	3.6	3.8	4.0	4.2	4.3	4.4	4.5	4.5	4.6	4.6	4.7	4.7	4.8	4.8	4.7	2
3	4.2	4.8	5.2	5.6	5.9	6.1	6.2	6.2	6.1	5.9	5.5	5.0	4.4	3.6	3.0	3.1	3.3	3.5	3.7	3.8	3.9	4.0	4.0	4.1	4.1	4.2	4.2	4.3	4.3	4.2	3
4	3.4	4.0	4.4	4.8	5.1	5.3	5.4	5.4	5.3	5.1	4.7	4.2	3.6	2.8	2.2	2.3	2.5	2.7	2.9	3.0	3.1	3.2	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.4	4
5	2.9	3.5	3.9	4.3	4.6	4.8	4.9	4.9	4.8	4.6	4.2	3.7	3.1	2.3	1.7	1.8	2.0	2.2	2.4	2.5	2.6	2.7	2.7	2.8	2.8	2.9	2.9	3.0	3.0	2.9	5
6	3.0	3.6	4.0	4.4	4.7	4.9	5.0	5.0	4.9	4.7	4.3	3.8	3.2	2.4	1.8	1.9	2.1	2.3	2.5	2.6	2.7	2.8	2.8	2.9	2.9	3.0	3.0	3.1	3.1	3.0	6
7	3.5	4.1	4.5	4.9	5.2	5.4	5.5	5.5	5.4	5.2	4.8	4.3	3.7	2.9	2.3	2.4	2.6	2.8	3.0	3.1	3.2	3.3	3.3	3.4	3.4	3.5	3.5	3.6	3.6	3.5	7
8	4.1	4.7	5.1	5.5	5.8	6.0	6.1	6.1	6.0	5.8	5.4	4.9	4.3	3.5	2.9	3.0	3.2	3.4	3.6	3.7	3.8	3.9	3.9	4.0	4.0	4.1	4.1	4.2	4.2	4.1	8
9	4.9	5.5	5.9	6.3	6.6	6.8	6.9	6.9	6.8	6.6	6.2	5.7	5.1	4.3	3.7	3.8	4.0	4.2	4.4	4.5	4.6	4.7	4.7	4.8	4.8	4.9	4.9	5.0	5.0	4.9	9
10	5.4	6.0	6.4	6.8	7.1	7.3	7.4	7.4	7.3	7.1	6.7	6.2	5.6	4.8	4.2	4.3	4.5	4.7	4.9	5.0	5.1	5.2	5.2	5.3	5.3	5.4	5.4	5.5	5.5	5.4	10
11	5.5	6.1	6.5	6.9	7.2	7.4	7.5	7.5	7.4	7.2	6.8	6.3	5.7	4.9	4.3	4.4	4.6	4.8	5.0	5.1	5.2	5.3	5.3	5.4	5.4	5.5	5.5	5.6	5.6	5.5	11

TIDE TABLES FOR ASTORIA.*

TABLE I.

Time of moon's transit.	SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	12 42	12 55	13 5	13 18	13 28	13 38	13 41	13 45	13 46	13 44	13 40	13 34	13 24	13 14	13 2
0 30	12 36	12 49	12 59	13 12	13 22	13 32	13 35	13 39	13 40	13 38	13 34	13 28	13 18	13 8	12 56
1 0	12 29	12 42	12 52	13 5	13 15	13 25	13 28	13 32	13 33	13 31	13 27	13 21	13 11	13 1	12 49
1 30	12 23	12 36	12 46	12 59	13 9	13 19	13 22	13 26	13 27	13 25	13 21	13 15	13 5	12 55	12 43
2 0	12 15	12 28	12 38	12 51	13 1	13 11	13 14	13 18	13 19	13 17	13 13	13 7	12 57	12 47	12 35
2 30	12 9	12 22	12 32	12 45	12 55	13 5	13 8	13 12	13 13	13 11	13 7	13 1	12 51	12 41	12 29
3 0	12 3	12 16	12 26	12 39	12 49	12 59	13 2	13 6	13 7	13 5	13 1	12 55	12 45	12 35	12 23
3 30	11 58	12 11	12 21	12 34	12 44	12 54	12 57	13 1	13 2	13 0	12 56	12 50	12 40	12 30	12 18
4 0	11 57	12 10	12 20	12 33	12 43	12 53	12 56	13 0	13 1	12 59	12 55	12 49	12 39	12 29	12 17
4 30	12 0	12 13	12 23	12 36	12 46	12 56	12 59	13 3	13 4	13 2	12 58	12 52	12 42	12 32	12 20
5 0	12 8	12 21	12 31	12 44	12 54	13 4	13 7	13 11	13 12	13 10	13 6	13 0	12 50	12 40	12 28
5 30	12 15	12 28	12 38	12 51	13 1	13 11	13 14	13 18	13 19	13 17	13 13	13 7	12 57	12 47	12 35
6 0	12 25	12 38	12 48	13 1	13 11	13 21	13 24	13 28	13 29	13 27	13 23	13 17	13 7	12 57	12 45
6 30	12 36	12 49	12 59	13 12	13 22	13 32	13 35	13 39	13 40	13 38	13 34	13 28	13 18	13 8	12 56
7 0	12 45	12 58	13 8	13 21	13 31	13 41	13 44	13 48	13 49	13 47	13 43	13 37	13 27	13 17	13 5
7 30	12 55	13 8	13 18	13 31	13 41	13 51	13 54	13 58	13 59	13 57	13 53	13 47	13 37	13 27	13 15
8 0	13 3	13 16	13 26	13 39	13 49	13 59	14 2	14 6	14 7	14 5	14 1	13 55	13 45	13 35	13 23
8 30	13 8	13 21	13 31	13 44	13 54	14 4	14 7	14 11	14 12	14 10	14 6	14 0	13 50	13 40	13 28
9 0	13 10	13 23	13 33	13 46	13 56	14 6	14 9	14 13	14 14	14 12	14 8	14 2	13 52	13 42	13 30
9 30	13 9	13 22	13 32	13 45	13 55	14 5	14 8	14 12	14 13	14 11	14 7	14 1	13 51	13 41	13 29
10 0	13 5	13 18	13 28	13 41	13 51	14 1	14 4	14 8	14 9	14 7	14 3	13 57	13 47	13 37	13 25
10 30	12 59	13 12	13 22	13 35	13 45	13 55	13 58	14 2	14 3	14 1	13 57	13 51	13 41	13 31	13 19
11 0	12 53	13 6	13 16	13 29	13 39	13 49	13 52	13 56	13 57	13 55	13 51	13 45	13 35	13 25	13 13
11 30	12 46	12 59	13 9	13 22	13 32	13 42	13 45	13 49	13 50	13 48	13 44	13 38	13 28	13 18	13 6

TABLE II.

Time of moon's transit.	NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	13 10	12 57	12 47	12 34	12 24	12 14	12 11	12 7	12 6	12 8	12 12	12 18	12 28	12 38	12 50
0 30	13 4	12 51	12 41	12 28	12 18	12 8	12 5	12 1	12 0	12 2	12 6	12 12	12 22	12 32	12 44
1 0	12 57	12 44	12 34	12 21	12 11	12 1	11 58	11 54	11 53	11 55	11 59	12 5	12 15	12 25	12 37
1 30	12 51	12 38	12 28	12 15	12 5	11 55	11 52	11 48	11 47	11 49	11 53	11 59	12 9	12 19	12 31
2 0	12 43	12 30	12 20	12 7	11 57	11 47	11 44	11 40	11 39	11 41	11 45	11 51	12 1	12 11	12 23
2 30	12 37	12 24	12 14	12 1	11 51	11 41	11 38	11 34	11 33	11 35	11 39	11 45	11 55	12 5	12 17
3 0	12 31	12 18	12 8	11 55	11 45	11 35	11 32	11 28	11 27	11 29	11 33	11 39	11 49	11 59	12 11
3 30	12 26	12 13	12 3	11 50	11 40	11 30	11 27	11 23	11 22	11 24	11 28	11 34	11 44	11 54	12 6
4 0	12 25	12 12	12 2	11 49	11 39	11 29	11 26	11 22	11 21	11 23	11 27	11 33	11 43	11 53	12 5
4 30	12 28	12 15	12 5	11 52	11 42	11 32	11 29	11 25	11 24	11 26	11 30	11 36	11 46	11 56	12 8
5 0	12 36	12 23	12 13	12 0	11 50	11 40	11 37	11 33	11 32	11 34	11 38	11 44	11 54	12 4	12 16
5 30	12 43	12 30	12 20	12 7	11 57	11 47	11 44	11 40	11 39	11 41	11 45	11 51	12 1	12 11	12 23
6 0	12 53	12 40	12 30	12 17	12 7	11 57	11 54	10 50	11 49	11 51	11 55	12 1	12 11	12 21	12 33
6 30	13 4	12 51	12 41	12 28	12 18	12 8	12 5	12 1	12 0	12 2	12 6	12 12	12 22	12 32	12 44
7 0	13 13	13 0	12 50	12 37	12 27	12 17	12 14	12 10	12 9	12 11	12 15	12 21	12 31	12 41	12 53
7 30	13 23	13 10	13 0	12 47	12 37	12 27	12 24	12 20	12 19	12 21	12 25	12 31	12 41	12 51	13 3
8 0	13 31	13 18	13 8	12 55	12 45	12 35	12 32	12 28	12 27	12 29	12 33	12 39	12 49	12 59	13 11
8 30	13 36	13 23	13 13	13 0	12 50	12 40	12 37	12 33	12 32	12 34	12 38	12 44	12 54	13 4	13 16
9 0	13 38	13 25	13 15	13 2	12 52	12 42	12 39	12 35	12 34	12 36	12 40	12 46	12 56	13 6	13 18
9 30	13 37	13 24	13 14	13 1	12 51	12 41	12 38	12 34	12 83	12 35	12 39	12 45	12 55	13 5	13 17
10 0	13 33	13 20	13 10	12 57	12 47	12 37	12 34	12 30	12 29	12 31	12 35	12 41	12 51	13 1	13 13
10 30	13 27	13 14	13 4	12 51	12 41	12 31	12 28	12 24	12 23	12 25	12 29	12 35	12 45	12 55	13 7
11 0	13 21	13 8	12 58	12 45	12 35	12 25	12 22	12 18	12 17	12 19	12 23	12 29	12 39	12 49	13 1
11 30	13 14	13 1	12 51	12 38	12 28	12 18	12 15	12 11	12 10	12 12	12 16	12 22	12 32	12 42	12 54

* For the manner of using these tables, see the examples for San Francisco, pages 311–316.

TABLE III.

Days from moon's greatest declination.		South declination. Low water. (Small.)	South declination. High water. (Large.)	South declination. Low water. (Large.)	North declination. Low water. (Large.)	North declination. High water. (Small.)	North declination. Low water. (Small.)	Days from moon's greatest declination.	
		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.		
Before.	7	6 38	12 59	19 17	6 18	12 03	18 41	7	Before.
	6	6 14	12 33	19 15	6 42	12 29	18 43	6	
	5	5 55	12 13	19 14	7 01	12 49	18 44	5	
	4	5 34	11 47	19 09	7 22	13 15	18 49	4	
	3	5 20	11 27	19 03	7 36	13 35	18 55	3	
	2	5 09	11 07	18 54	7 47	13 55	19 04	2	
	1	5 05	11 01	18 52	7 51	14 01	19 06	1	
	0	5 03	10 53	18 46	7 53	14 09	19 12	0	
After.	1	5 05	10 51	18 42	7 51	14 11	19 16	1	After.
	2	5 11	10 55	18 40	7 45	14 07	19 18	2	
	3	5 18	11 03	18 41	7 38	13 59	19 17	3	
	4	5 32	11 15	18 39	7 24	13 47	19 19	4	
	5	5 50	11 35	18 41	7 06	13 27	19 17	5	
	6	6 11	11 55	18 40	6 45	13 07	19 18	6	
	7	6 35	12 19	18 40	6 21	12 43	19 18	7	

TABLE IV.

South declination.—Days from moon's greatest declination.

Time of moon's transit.	Before— 7	Before— 6	Before— 5	Before— 4	Before— 3	Before— 2	Before— 1	0	After— 1	After— 2	After— 3	After— 4	After— 5	After— 6	After— 7
Hour.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
0	8.0	8.3	8 4	8.5	8.6	8.6	8.6	8.6	8.5	8.4	8.3	8.1	7.7	7.4	7.0
1	8.0	8.2	8.4	8.5	8.6	8.6	8.6	8.6	8.5	8.4	8.2	8.1	7.7	7.4	7.0
2	7.8	8.1	8.2	8.4	8.4	8.4	8.4	8.4	8.3	8.2	8.1	7.9	7.5	7.2	6.8
3	7.5	7.8	7.9	8.1	8 1	8.1	8.1	8.1	8.0	7.9	7 8	7.6	7.2	6.9	6.5
4	7.1	7.4	7.5	7.7	7.7	7.7	7.7	7.7	7.6	7.5	7.4	7.2	6.8	6.5	6.1
5	6.7	7.0	7.2	7.3	7.3	7.3	7.3	7.3	7.2	7.1	7.0	6.8	6.5	6.1	5.7
6	6.5	6.8	7.0	7.1	7.1	7.1	7.1	7.1	7.0	6.9	6.8	6.6	6.3	5.9	5.5
7	6.7	7.0	7.1	7.2	7.3	7.3	7.3	7.3	7.2	7.1	7.0	6.8	6.4	6.1	5.7
8	7.0	7.3	7.5	7.6	7.6	7.6	7.6	7.6	7.5	7.4	7.3	7.1	6.8	6.4	6.0
9	7.5	7.8	8.0	8.1	8.1	8.1	8.1	8.1	8.0	7.9	7.8	7.6	7.3	6.9	6.5
10	7.9	8.2	8.4	8.5	8.5	8.5	8 5	8.5	8.4	8.3	8.2	8.0	7 7	7.3	6.9
11	8.1	8.4	8 6	8.7	8.7	8.7	8.7	8.7	8.6	8.5	8.4	8.2	7.9	7.5	7.1

TABLE V.

North declination.—Days from moon's greatest declination.

Time of moon's transit.	Before— 7	Before— 6	Before— 5	Before— 4	Before— 3	Before— 2	Before— 1	0	After— 1	After— 2	After— 3	After— 4	After— 5	After— 6	After— 7
Hour.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.	Feet.
0	7.4	7.1	6.9	6.8	6.8	6.8	6.8	6.8	6.9	7.0	7.1	7.3	7.6	8.0	8.4
1	7.4	7 1	6.9	6.8	6.8	6.8	6.8	6.8	6.9	7.0	7.1	7.3	7.6	8.0	8.4
2	7.2	6.9	6.8	6.6	6.6	6.6	6.6	6.6	6.7	6.8	6.9	7.1	7.5	7.8	8.2
3	6.9	6.6	6.5	6.3	6.3	6.3	6.3	6.3	6.4	6.5	6.6	6.8	7.2	7.5	7.9
4	6.5	6.2	6.1	5.9	5.9	5.9	5.9	5.9	6.0	6.1	6.2	6 4	6.7	7.1	7.5
5	6.1	5.9	5.7	5.6	5.5	5.5	5.6	5.6	5.7	5.7	5.9	6.0	6.4	6.7	7.1
6	5.9	5.7	5.5	5.4	5.3	5.3	5.3	5.4	5.5	5.5	5.7	5.9	6.2	6.5	6.9
7	6.1	5.8	5.6	5.5	5.5	5.5	5.5	5.5	5.6	5.7	5.8	6.0	6.3	6.7	7.1
8	6.4	6.2	6.0	5.9	5.8	5.8	5.8	5.8	5.9	6.0	6.2	6.3	6.7	7.0	7 4
9	6.9	6.7	6.5	6.4	6.3	6.3	6.3	6.4	6.4	6.5	6.7	6.8	7.2	7 5	7.9
10	7.3	7.1	6.9	6.8	6.7	6.7	6.7	6.8	6.9	6.9	7.0	7.2	7.6	7 9	8.3
11	7.5	7.2	7.1	7.0	6.9	6.9	6.9	6.9	7.0	7.1	7.2	7.4	7.8	8.1	8.5

NOTE.—To use these tables with a chart on which the soundings are referred to mean low water, subtract 1.2 foot from the numbers in the tables for Astoria and 1.7 for Neeah bay.

TABLE VI.

Hours of moon's transit.	SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER.														
	Days from moon's greatest declination.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
H.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
0	7.4	6.7	6.0	5.4	5.0	4.6	4.5	4.5	4.6	4.7	5.1	5.5	6.2	6.9	7.8
1	7.5	6.8	6.1	5.5	5.1	4.7	4.6	4.6	4.7	4.8	5.2	5.6	6.3	7.0	7.9
2	7.2	6.5	5.8	5.2	4.8	4.4	4.3	4.3	4.4	4.5	4.9	5.3	6.0	6.7	7.6
3	6.6	5.9	5.2	4.6	4.2	3.8	3.7	3.7	3.8	3.9	4.3	4.7	5.4	6.1	7.0
4	5.9	5.2	4.5	3.9	3.5	3.1	3.0	3.0	3.1	3.2	3.6	4.0	4.7	5.4	6.3
5	5.2	4.5	3.8	3.2	2.8	2.4	2.3	2.3	2.4	2.5	2.9	3.3	4.0	4.7	5.6
6	4.8	4.1	3.4	2.8	2.4	2.0	1.9	1.9	2.0	2.1	2.5	2.9	3.6	4.3	5.2
7	5.0	4.3	3.6	3.0	2.6	2.2	2.1	2.1	2.2	2.3	2.7	2.1	3.8	4.5	5.4
8	5.5	4.8	4.1	3.5	3.1	2.7	2.6	2.6	2.7	2.8	3.2	3.6	4.3	5.0	5.9
9	6.3	5.6	4.9	4.3	3.9	3.5	3.4	3.4	3.5	3.6	4.0	4.4	5.1	5.8	6.7
10	7.0	6.3	5.6	5.0	4.6	4.2	4.1	4.1	4.2	4.3	4.7	5.1	5.8	6.5	7.4
11	7.3	6.6	6.9	5.3	4.9	4.5	4.4	4.4	4.5	4.6	5.0	5.4	6.1	6.8	7.7

FROM SMALL LOW WATER TO LARGE HIGH WATER.															Hours of moon's transit.
Days from moon's greatest declination.															
Before—								After—							
7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
Ft	*Ft*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft*	*Ft*	*H.*
8.0	7.8	7.5	7.2	6.8	6.4	6.3	6.2	6.1	6.2	6.2	6.3	6.3	6.3	6.4	0
8.1	7.9	7.6	7.3	6.9	6.5	6.4	6.3	6.2	6.3	6.3	6.4	6.4	6.4	6.5	1
7.8	7.6	7.3	7.0	6.6	6.2	6.1	6.0	5.9	6.0	6.0	6.1	6.1	6.1	6.2	2
7.2	7.0	6.7	6.4	6.0	5.6	5.5	5.4	5.3	5.4	5.4	5.5	5.5	5.5	5.6	3
6.5	6.3	6.0	5.7	5.3	4.9	4.8	4.7	4.6	4.7	4.7	4.8	4.8	4.8	4.9	4
5.8	5.6	5.3	5.0	4.6	4.2	4.1	4.0	3.9	4.0	4.0	4.1	4.1	4.1	4.2	5
5.4	5.2	4.9	4.6	4.2	3.8	3.7	3.6	3.5	3.6	3.6	3.7	3.7	3.7	3.8	6
5.6	5.4	5.1	4.8	4.4	4.0	3.9	3.8	3.7	3.8	3.8	3.9	3.9	3.9	4.0	7
6.1	5.9	5.6	5.3	4.9	4.5	4.4	4.3	4.2	4.3	4.3	4.4	4.4	4.4	4.5	8
6.9	6.7	6.4	6.1	5.7	5.3	5.2	5.1	5.0	5.1	5.1	5.2	5.2	5.2	5.3	9
7.6	7.4	7.1	6.8	6.4	6.0	5.9	5.8	5.7	5.8	5.8	5.9	5.9	5.9	6.0	10
7.9	7.7	7.4	7.1	6.7	6.3	6.2	6.1	6.0	6.1	6.1	6.2	6.2	6.2	6.3	11

TABLE VII.

Hours of moon's transit.	LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER.														
	Days from moon's greatest declination.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
H.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*
0	7.0	7.7	8.4	9.0	9.4	9.8	9.9	9.9	9.8	9.7	9.3	8.9	8.2	7.5	6.6
1	7.1	7.8	8.5	9.1	9.5	9.9	10.0	10.0	9.9	9.8	9.4	9.0	8.3	7.6	6.7
2	6.8	7.5	8.2	8.8	9.2	9.6	9.7	9.7	9.6	9.5	9.1	8.7	8.0	7.3	6.4
3	6.2	6.9	7.6	8.2	8.6	9.0	9.1	9.1	9.0	8.9	8.5	8.1	7.4	6.7	5.8
4	5.5	6.2	6.9	7.5	7.9	8.3	8.4	8.4	8.3	8.2	7.8	7.4	6.7	6.0	5.1
5	4.8	5.5	6.2	6.8	7.2	7.6	7.7	7.7	7.6	7.5	7.1	6.7	6.0	5.3	4.4
6	4.4	5.1	5.8	6.4	6.8	7.2	7.3	7.3	7.2	7.1	6.7	6.3	5.6	4.9	4.0
7	4.6	5.3	6.0	6.6	7.0	7.4	7.5	7.5	7.4	7.3	6.9	6.5	5.8	5.1	4.2
8	5.1	5.8	6.5	7.1	7.5	7.9	8.0	8.0	7.9	7.8	7.4	7.0	6.3	5.6	4.7
9	5.9	6.6	7.3	7.9	8.3	8.7	8.8	8.8	8.7	8.6	8.2	7.8	7.1	6.4	5.5
10	6.6	7.3	8.0	8.6	9.0	9.4	9.5	9.5	9.4	9.3	8.9	8.5	7.8	7.1	6.2
11	6.9	7.6	8.3	8.9	9.3	9.7	9.8	9.8	9.7	9.6	9.2	8.8	8.1	7.4	7.5

FROM LARGE LOW WATER TO SMALL HIGH WATER.															Hours of moon's transit.
Days from moon's greatest declination.															
Before—								After—							
7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	
Ft.	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*Ft.*	*H.*
6.4	6.6	6.9	7.2	7.6	8.0	8.1	8.2	8.3	8.2	8.2	8.1	8.1	8.1	8.0	0
6.5	6.7	7.0	7.3	7.7	8.1	8.2	8.3	8.4	8.3	8.3	8.2	8.2	8.2	8.1	1
6.2	6.4	6.7	7.0	7.4	7.8	7.9	8.0	8.1	8.0	8.0	7.9	7.9	7.9	7.8	2
5.6	5.8	6.1	6.4	6.8	7.2	7.3	7.4	7.5	7.4	7.4	7.3	7.3	7.3	7.2	3
4.9	5.1	5.4	5.7	6.1	6.5	6.6	6.7	6.8	6.7	6.7	6.6	6.6	6.6	6.5	4
4.2	4.4	4.7	5.0	5.4	5.8	5.9	6.0	6.1	6.0	6.0	5.9	5.9	5.9	5.8	5
3.8	4.0	4.3	4.6	5.0	5.4	5.5	5.6	5.7	5.6	5.6	5.5	5.5	5.5	5.4	6
4.0	4.2	4.5	4.8	5.2	5.6	5.7	5.8	5.9	5.8	5.8	5.7	5.7	5.7	5.6	7
4.5	4.7	5.0	5.3	5.7	6.1	6.2	6.3	6.4	6.3	6.3	6.2	6.2	6.2	6.1	8
5.3	5.5	5.8	6.1	6.5	6.9	7.0	7.1	7.2	7.1	7.1	7.0	7.0	7.0	6.9	9
6.0	6.2	6.5	6.8	7.2	7.6	7.7	7.8	7.9	7.8	7.8	7.7	7.7	7.7	7.6	10
6.3	6.5	6.8	7.1	7.5	7.9	8.0	8.1	8.2	8.1	8.1	8.0	8.0	8.0	7.9	11

TIDE TABLES FOR PORT TOWNSHEND.*

TABLE I.

SOUTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.

Time of moon's transit.	Before— 7	Before— 6	Before— 5	Before— 4	Before— 3	Before— 2	Before— 1	0	After— 1	After— 2	After— 3	After— 4	After— 5	After— 6	After— 7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
0 0	3 45	3 21	2 51	2 2	1 32	1 13	1 26	1 44	2 2	2 21	2 42	2 57	3 15	3 33	3 45
0 30	3 38	3 14	2 44	1 55	1 25	1 6	1 19	1 37	1 55	2 14	2 35	2 50	3 8	3 26	3 38
1 0	3 32	3 8	2 38	1 49	1 19	1 0	1 13	1 31	1 49	2 8	2 29	2 44	3 2	3 20	3 32
1 30	3 26	3 2	2 32	1 43	1 13	0 54	1 7	1 25	1 43	2 2	2 23	2 38	2 56	3 14	3 26
2 0	3 21	2 57	2 27	1 38	1 8	0 49	1 2	1 20	1 38	1 57	2 18	2 33	2 51	3 9	3 21
2 30	3 18	2 54	2 24	1 35	1 5	0 46	0 59	1 17	1 35	1 54	2 15	2 20	2 48	3 6	3 18
3 0	3 16	2 52	2 22	1 33	1 3	0 44	0 57	1 15	1 33	1 52	2 13	2 28	2 46	3 4	3 16
3 30	3 17	2 53	2 23	1 34	1 4	0 45	0 58	1 16	1 34	1 53	2 14	2 29	2 47	3 5	3 17
4 0	3 21	2 57	2 27	1 38	1 8	0 49	1 2	1 20	1 38	1 57	2 18	2 33	2 51	3 9	3 21
4 30	3 26	3 2	2 32	1 43	1 13	0 54	1 7	1 25	1 43	2 2	2 23	2 38	2 56	3 14	3 26
5 0	3 32	3 8	2 38	1 49	1 19	1 0	1 13	1 31	1 49	2 8	2 29	2 44	3 2	3 20	3 32
5 30	3 41	3 17	2 47	1 58	1 28	1 9	1 22	1 40	1 58	2 17	2 38	2 53	3 11	3 29	3 41
6 0	3 52	3 28	2 58	2 9	1 39	1 20	1 33	1 51	2 9	2 28	2 49	3 4	3 22	3 40	3 52
6 30	4 1	3 37	3 7	2 18	1 48	1 29	1 42	2 0	2 18	2 37	2 58	3 13	3 31	3 49	4 1
7 0	4 8	3 44	3 14	2 25	1 55	1 36	1 49	2 7	2 25	2 44	3 5	3 20	3 38	3 56	4 8
7 30	4 15	3 51	3 21	2 32	2 2	1 43	1 56	2 14	2 32	2 51	3 12	3 27	3 45	4 3	4 15
8 0	4 18	3 54	3 24	2 35	2 5	1 46	1 59	2 17	2 35	2 54	3 15	3 30	3 48	4 6	4 18
8 30	4 19	3 55	3 25	2 36	2 6	1 47	2 0	2 18	2 36	2 55	3 16	3 31	3 49	4 7	4 19
9 0	4 18	3 54	3 24	2 35	2 5	1 46	1 59	2 17	2 35	2 54	3 15	3 30	3 48	4 6	4 18
9 30	4 15	3 51	3 21	2 32	2 2	1 43	1 56	2 14	2 32	2 51	3 12	3 27	3 45	4 3	4 15
10 0	4 10	3 46	3 16	2 27	1 57	1 38	1 51	2 9	2 27	2 46	3 7	3 22	3 40	3 58	4 10
10 30	4 6	3 42	3 12	3 23	1 53	1 34	1 47	2 5	2 23	2 42	3 3	3 18	3 36	3 54	4 6
11 0	4 0	3 36	3 6	2 17	1 47	1 28	1 41	1 59	2 17	2 36	2 57	3 12	3 30	3 48	4 0
11 30	3 54	3 30	3 0	2 11	1 41	1 22	1 35	1 53	2 11	2 30	2 51	3 6	3 24	3 42	3 54

TABLE II.

NORTH DECLINATION.—DAYS FROM MOON'S GREATEST DECLINATION.

Time of moon's transit.	Before— 7	Before— 6	Before— 5	Before— 4	Before— 3	Before— 2	Before— 1	0	After— 1	After— 2	After— 3	After— 4	After— 5	After— 6	After— 7
h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h.m.	h. n.
0 0	3 45	4 9	4 39	5 28	5 58	6 17	6 4	5 46	5 28	5 9	4 48	4 33	4 15	3 57	3 45
0 30	3 38	4 2	4 32	5 21	5 51	6 10	5 57	5 39	5 21	5 2	4 41	4 26	4 8	3 50	3 38
1 0	3 32	3 56	4 26	5 15	5 45	6 4	5 51	5 33	5 15	4 56	4 35	4 20	4 2	3 44	3 32
1 30	3 26	3 50	4 20	5 9	5 39	5 53	5 45	5 27	5 9	4 50	4 29	4 14	3 56	3 38	3 26
2 0	3 21	3 45	4 15	5 4	5 34	5 53	5 40	5 22	5 4	4 45	4 24	4 9	3 51	3 33	3 21
2 30	3 18	3 42	4 12	5 1	5 31	5 50	5 37	5 19	5 1	4 42	4 21	4 6	3 48	3 30	3 18
3 0	3 16	3 40	4 10	4 59	5 29	5 48	5 35	5 17	4 59	4 40	4 19	4 4	3 46	3 28	3 16
3 30	3 17	3 41	4 11	5 0	5 30	5 49	5 36	5 18	5 0	4 41	4 20	4 5	3 47	3 29	3 17
4 0	3 21	3 45	4 15	5 4	5 34	5 53	5 40	5 22	5 4	4 45	4 24	4 9	3 51	3 33	3 21
4 30	3 26	3 50	4 20	5 9	5 39	5 58	5 45	5 27	5 9	4 50	4 29	4 14	3 56	3 38	3 26
5 0	3 32	3 56	4 26	5 15	5 45	6 4	5 51	5 33	5 15	4 56	4 35	4 20	4 2	3 44	3 32
5 30	3 41	4 5	4 35	5 24	5 54	6 13	6 0	5 42	5 24	5 5	4 44	4 29	4 11	3 53	3 41
6 0	3 52	4 16	4 46	5 35	6 5	6 24	6 11	5 53	5 35	5 16	4 55	4 40	4 22	4 4	3 52
6 30	4 1	4 25	4 55	5 44	6 14	6 33	6 20	6 2	5 44	5 25	5 4	4 49	4 31	4 13	4 1
7 0	4 8	4 32	5 2	5 51	6 21	6 40	6 27	6 9	5 51	5 32	5 11	4 56	4 38	4 20	4 8
7 30	4 15	4 39	5 9	5 58	6 28	6 47	6 34	6 16	5 58	5 39	5 18	5 3	4 45	4 27	4 15
8 0	4 18	4 42	5 12	6 1	6 31	6 50	6 37	6 19	6 1	5 42	5 21	5 6	4 48	4 30	4 18
8 30	4 19	4 43	5 13	6 2	6 32	6 51	6 38	6 20	6 2	5 43	5 22	5 7	4 49	4 31	4 19
9 0	4 18	4 42	5 12	6 1	6 31	6 50	6 37	6 19	6 1	5 42	5 21	5 6	4 48	4 30	4 18
9 30	4 15	4 39	5 9	5 58	6 28	6 47	6 34	6 16	5 58	5 39	5 18	5 3	4 45	4 27	4 15
10 0	4 10	4 34	5 4	5 53	6 23	6 42	6 29	6 11	5 53	5 34	5 13	4 58	4 40	4 22	4 10
10 30	4 6	4 30	5 0	5 49	6 19	6 38	6 25	6 7	5 49	5 30	5 9	4 54	4 36	4 18	4 6
11 0	4 0	4 24	4 54	5 43	6 13	6 32	6 19	6 1	5 43	5 24	5 3	4 48	4 30	4 12	4 0
11 30	3 54	4 18	4 48	5 37	6 7	6 26	6 13	5 55	5 37	5 18	4 57	4 42	4 24	4 6	3 54

* For the manner of using these tables see the example for San Francisco, pages 311–316.

TABLE III.

Days from moon's greatest declination.		South declination. Low water.	South declination. High water.	South declination. Low water.	North declination. Low water.	North declination. High water.	North declination. Low water.	Days from moon's greatest declination.	
		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.		
Before.	7	6 05	12 26	18 05	5 39	12 26	18 31	7	Before.
	6	6 38	13 14	18 20	5 06	11 38	18 16	6	
	5	7 18	14 14	18 40	4 26	10 38	17 56	5	
	4	8 13	15 52	19 23	3 31	9 00	17 13	4	
	3	8 36	16 52	20 00	3 08	8 00	16 36	3	
	2	8 43	17 30	20 31	3 01	7 22	16 05	2	
	1	8 12	17 04	20 36	3 32	7 48	16 00	1	
	0	7 40	16 28	20 32	4 04	8 24	16 04	0	
After.	1	7 18	15 52	20 18	4 26	9 00	16 18	1	After.
	2	6 59	15 14	19 59	4 45	9 38	16 37	2	
	3	6 38	14 32	19 38	5 06	10 20	16 58	3	
	4	6 24	14 02	19 22	5 20	10 50	17 14	4	
	5	6 10	13 26	19 00	5 34	11 26	17 36	5	
	6	5 59	12 50	18 35	5 45	12 02	18 01	6	
	7	5 42	12 26	18 28	6 02	12 26	18 08	7	

TABLE IV.

Time of moon's transit.	North declination.—Days from moon's greatest declination.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
0	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9
1	6.7	6.4	6.0	6.2	6.5	7.0	7.3	7.5	7.6	7.6	7.6	7.6	7.7	7.8	8.0
2	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9
3	6.3	6.0	5.6	5.8	6.1	6.6	6.9	7.1	7.2	7.2	7.2	7.2	7.3	7.4	7.6
4	6.0	5.7	5.3	5.5	5.8	6.3	6.6	6.8	6.9	6.9	6.9	6.9	7.0	7.1	7.3
5	5.9	5.6	5.2	5.4	5.7	6.2	6.5	6.7	6.8	6.8	6.8	6.8	6.9	7.0	7.2
6	6.1	5.8	5.4	5.6	5.9	6.4	6.7	6.9	7.0	7.0	7.0	7.0	7.1	7.2	7.4
7	6.4	6.1	5.7	5.9	6.2	6.7	7.0	7.2	7.3	7.3	7.3	7.3	7.4	7.5	7.7
8	6.5	6.2	5.8	6.0	6.3	6.8	7.1	7.3	7.4	7.4	7.4	7.4	7.5	7.6	7.8
9	6.5	6.2	5.8	6.0	6.3	6.8	7.1	7.3	7.4	7.4	7.4	7.4	7.5	7.6	7.8
10	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9
11	6.6	6.3	5.9	6.1	6.4	6.9	7.2	7.4	7.5	7.5	7.5	7.5	7.6	7.7	7.9

TABLE V.

Time of moon's transit.	South declination.—Days from moon's greatest declination.														
	Before—								After—						
	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7
Hour.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
0	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
1	7.7	8.0	8.4	8.2	7.9	7.4	7.1	6.9	6.8	6.8	6.8	6.8	6.7	6.6	6.4
2	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
3	7.3	7.6	8.0	7.8	7.5	7.0	6.7	6.5	6.4	6.4	6.4	6.4	6.3	6.2	6.0
4	7.0	7.3	7.7	7.5	7.2	6.7	6.4	6.2	6.1	6.1	6.1	6.1	6.0	5.9	5.7
5	6.9	7.2	7.6	7.4	7.1	6.6	6.3	6.1	6.0	6.0	6.0	6.0	5.9	5.8	5.6
6	7.1	7.4	7.8	7.6	7.3	6.8	6.5	6.3	6.2	6.2	6.2	6.2	6.1	6.0	5.8
7	7.4	7.7	8.1	7.9	7.6	7.1	6.8	6.6	6.5	6.5	6.5	6.5	6.4	6.3	6.1
8	7.5	7.8	8.2	8.0	7.7	7.2	6.9	6.7	6.6	6.6	6.6	6.6	6.5	6.4	6.2
9	7.5	7.8	8.2	8.0	7.7	7.2	6.9	6.7	6.6	6.6	6.6	6.6	6.5	6.4	6.2
10	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3
11	7.6	7.9	8.3	8.1	7.8	7.3	7.0	6.8	6.7	6.7	6.7	6.7	6.6	6.5	6.3

NOTE.—To use these tables with a chart on which the soundings are referred to mean low water, subtract 2.3 feet from the numbers in the tables for Port Townshend and 2.7 for Semiahmoo and Steilacoom.

TABLE VI.

SMALL EBB TIDE, OR FROM SMALL HIGH WATER TO SMALL LOW WATER.

Days from moon's greatest declination.

Hours of moon's transit.	Before— 7	6	5	4	3	2	1	0	After— 1	2	3	4	5	6	7
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
0	4.5	5.6	6.9	8.0	8.6	8.9	8.8	8.8	8.7	8.7	8.5	8.0	7.3	6.6	5.5
1	4.5	5.6	6.9	8.0	8.6	8.9	8.8	8.8	8.7	8.7	8.5	8.0	7.3	6.6	5.5
2	4.4	5.5	6.8	7.9	8.5	8.8	8.7	8.7	8.6	8.6	8.4	7.9	7.2	6.5	5.4
3	4.1	5.2	6.5	7.6	8.2	8.5	8.4	8.4	8.3	8.3	8.1	7.6	6.9	6.2	5.1
4	3.5	4.6	5.9	7.0	7.6	7.9	7.8	7.8	7.7	7.7	7.5	7.0	6.3	5.6	4.5
5	3.1	4.2	5.5	6.6	7.2	7.5	7.4	7.4	7.3	7.3	7.1	6.6	5.9	5.2	4.1
6	3.1	4.2	5.5	6.6	7.2	7.5	7.4	7.4	7.3	7.3	7.1	6.6	5.9	5.2	4.1
7	3.3	4.4	5.7	6.8	7.4	7.7	7.6	7.6	7.5	7.5	7.3	6.8	6.1	5.4	4.3
8	3.5	4.6	5.9	7.0	7.6	7.9	7.8	7.8	7.7	7.7	7.5	7.0	6.3	5.6	4.5
9	3.7	4.8	6.1	7.2	7.8	8.1	8.0	8.0	7.9	7.9	7.7	7.2	6.5	5.8	4.7
10	4.1	5.2	6.5	7.6	8.2	8.5	8.4	8.4	8.3	8.3	8.1	7.6	6.9	6.2	5.1
11	4.4	5.5	6.8	7.9	8.5	8.8	8.7	8.7	8.6	8.6	8.4	7.9	7.2	6.5	5.4

FROM SMALL LOW WATER TO LARGE HIGH WATER.

Days from moon's greatest declination.

Hours of moon's transit.	Before— 7	6	5	4	3	2	1	0	After— 1	2	3	4	5	6	7
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
0	3.5	3.9	4.6	6.0	7.2	8.4	9.0	9.5	9.6	9.4	9.2	8.7	8.2	7.9	7.1
1	3.5	3.9	4.6	6.0	7.2	8.4	9.0	9.5	9.6	9.4	9.2	8.7	8.2	7.9	7.1
2	3.4	3.8	4.5	5.9	7.1	8.3	8.9	9.4	9.5	9.3	9.1	8.6	8.1	7.8	7.0
3	3.1	3.5	4.2	5.6	6.8	8.0	8.6	9.1	9.2	9.0	8.8	8.3	7.8	7.5	6.7
4	2.5	2.9	3.6	5.0	6.2	7.4	8.0	8.5	8.6	8.4	8.2	7.7	7.2	6.9	6.1
5	2.1	2.5	3.2	4.6	5.8	7.0	7.6	8.1	8.2	8.0	7.8	7.3	6.8	6.5	5.7
6	2.1	2.5	3.2	4.6	5.8	7.0	7.6	8.1	8.2	8.0	7.8	7.3	6.8	6.5	5.7
7	2.3	2.7	3.4	4.8	6.0	7.2	7.8	8.3	8.4	8.2	8.0	7.5	7.0	6.7	5.9
8	2.5	2.9	3.6	5.0	6.2	7.4	8.0	8.5	8.6	8.4	8.2	7.7	7.2	6.9	6.1
9	2.7	3.1	3.8	5.2	6.4	7.6	8.2	8.7	8.8	8.6	8.4	7.9	7.4	7.1	6.3
10	3.1	3.5	4.2	5.6	6.8	8.0	8.6	9.1	9.2	9.0	8.8	8.3	7.8	7.5	6.7
11	3.4	3.8	4.5	5.9	7.1	8.3	8.9	9.4	9.5	9.3	9.1	8.6	8.1	7.8	7.0

TABLE VII.

LARGE EBB TIDE, OR FROM LARGE HIGH WATER TO LARGE LOW WATER.

Days from moon's greatest declination.

Hours of moon's transit.	Before— 7	6	5	4	3	2	1	0	After— 1	2	3	4	5	6	7
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
0	6.5	5.4	4.1	3.0	2.4	2.1	2.2	2.2	2.3	2.3	2.5	3.0	3.7	4.4	5.5
1	6.5	5.4	4.1	3.0	2.4	2.1	2.2	2.2	2.3	2.3	2.5	3.0	3.7	4.4	5.5
2	6.4	5.3	4.0	2.9	2.3	2.0	2.1	2.1	2.2	2.2	2.4	2.9	3.6	4.3	5.4
3	6.1	5.0	3.7	2.6	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.6	3.3	4.0	5.1
4	5.5	4.4	3.1	2.0	1.4	1.1	1.2	1.2	1.3	1.3	1.5	2.0	2.7	3.4	4.5
5	5.1	4.0	2.7	1.6	1.0	0.7	0.8	0.8	0.9	0.9	1.1	1.6	2.3	3.0	4.1
6	5.1	4.0	2.7	1.6	1.0	0.7	0.8	0.8	0.9	0.9	1.1	1.6	2.3	3.0	4.1
7	5.3	4.2	2.9	1.8	1.2	0.9	1.0	1.0	1.1	1.1	1.3	1.8	2.5	3.2	4.3
8	5.5	4.4	3.1	2.0	1.4	1.1	1.2	1.2	1.3	1.3	1.5	2.0	2.7	3.4	4.5
9	5.7	4.6	3.3	2.2	1.6	1.3	1.4	1.4	1.5	1.5	1.7	2.2	2.9	3.6	4.7
10	6.1	5.0	3.7	2.6	2.0	1.7	1.8	1.8	1.9	1.9	2.1	2.6	3.3	4.0	5.1
11	6.4	5.3	4.0	2.9	2.3	2.0	2.1	2.1	2.2	2.2	2.4	2.9	3.6	4.3	5.4

FROM SMALL LOW WATER TO LARGE HIGH WATER.

Days from moon's greatest declination.

Hours of moon's transit.	Before— 7	6	5	4	3	2	1	0	After— 1	2	3	4	5	6	7
H.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.	Ft.
0	7.5	7.1	6.4	5.0	3.8	2.6	2.0	1.5	1.4	1.6	1.8	2.3	2.8	3.1	3.9
1	7.5	7.1	6.4	5.0	3.8	2.6	2.0	1.5	1.4	1.6	1.8	2.3	2.8	3.1	3.9
2	7.4	7.0	6.3	4.9	3.7	2.5	1.9	1.4	1.3	1.5	1.7	2.2	2.7	3.0	3.8
3	7.1	6.7	6.0	4.6	3.4	2.2	1.6	1.1	1.0	1.2	1.4	1.9	2.4	2.7	3.5
4	6.5	6.1	5.4	4.0	2.8	1.6	1.0	0.5	0.4	0.6	0.8	1.3	1.8	2.1	2.9
5	6.1	5.7	5.0	3.6	2.4	1.2	0.6	0.1	0.0	0.2	0.4	0.9	1.4	1.7	2.5
6	6.1	5.7	5.0	3.6	2.4	1.2	0.6	0.1	0.0	0.2	0.4	0.9	1.4	1.7	2.5
7	6.3	5.9	5.2	3.8	2.6	1.4	0.8	0.3	0.2	0.4	0.6	1.1	1.6	1.9	2.7
8	6.5	6.1	5.4	4.0	2.8	1.6	1.0	0.5	0.4	0.6	0.8	1.3	1.8	2.1	2.9
9	6.7	6.3	5.6	4.2	3.0	1.8	1.2	0.7	0.6	0.8	1.0	1.5	2.0	2.3	3.1
10	7.1	6.7	6.0	4.6	3.4	2.2	1.6	1.1	1.0	1.2	1.4	1.9	2.4	2.7	3.5
11	7.4	7.0	6.3	4.9	3.7	2.5	1.9	1.4	1.3	1.5	1.7	2.2	2.7	3.0	3.8

Table of magnetic east declination on the Pacific coast of the United States for the year 1863.

Latitude N.	Longitude west.			
	110°.	115°.	120°.	125°.
°	°	°	°	°
30	11⅔	12	12	....
31	12	12½	12¼	....
32	12½	12⅔	12¾	....
33	12¾	13	13	13¼
34	13¼	13½	13¾	14
35	13½	14	14	14¼
36	....	14¼	14¾	15
37	....	14¾	15	15½
38	....	15	15⅔	16
39	....	15½	16	16½
40	....	16	16⅔	17
41	....	16½	17	17½
42	....	17	17⅔	18
43	....	17½	18¼	18¾
44	....	18	18¾	19¼
45	....	18⅔	19⅓	19¾
46	....	19⅓	19¾	20⅓
47	....	19⅔	20½	21
48	....	20¼	21	21½
49	....	20⅔	21½	....

APPENDIX No. 40.

TRIBUTE TO THE MEMORY OF THE LATE COLONEL WILLIAM R. PALMER, U. S. ARMY.

At a meeting of the assistants and other persons engaged in the Coast Survey, held at the Coast Survey Office, in Washington, on the 19th of June, the following resolutions were submitted by Assistant J. E. Hilgard, and were unanimously adopted:

Whereas we have received with deep regret the intelligence of the death of Major William R. Palmer, corps of topographical engineers, and brevet colonel U. S. army, whose long association with the work of the Coast Survey had founded among its members respect and lasting esteem: Therefore

Resolved, That, in deploring his death as an associate, who had become endeared to us by his most excellent qualities of head and heart, efficient in the execution of every duty, cordial in co-operation, kind in command, we recognize that our grief is deepened by his loss to the country at this time as an able and energetic officer, and a devoted defender of its rights.

Resolved, That we will attend the funeral in a body to-morrow at noon, and the usual badge of mourning be worn by us for thirty days.

Resolved, That we offer our sympathy to the bereaved family, and that a copy of the above resolutions be transmitted to them.

Upon the adoption of the resolutions, Professor Bache, Superintendent of the Coast Survey, made the following remarks, which were listened to with deep emotion by those present:

Brevet Lieut. Col. Palmer was born in London, where his parents were temporarily, on the 15th of April, 1809. His home was at Elizabethtown, New Jersey, which had long been the home of his family. Our intimacy goes so far back that I can hardly remember when I did not know him well. It was in fact a hereditary friendship, for his mother and mine were from youth onward very intimate friends. Though pursuing very different careers, our lines of life have touched so often that I feel almost as if they had been very near, throughout his too short life. As a child, he was amiable, quick of apprehension, and easy in acquisition. As a boy, perseverance of purpose developed itself, which, notwithstanding intervals of ill health in early manhood, secured professional attainment and skill, culminating in his career in connexion with the present war, for which he had already received a brevet for gallant and meritorious services. Time only was wanting to secure to him the honors already earned, and to give opportunity for new ones.

The fatigues, excitements, and exposures of the campaign in the malarious region between the York and James rivers were too much for his physical constitution, and brought on an attack of fever, which terminated in typhoid, and carried him off about noon on the 18th of June. By a merciful Providence his cousin, Mrs. General Ricketts, was led to the White House, near the Pamunky river, and finding him so ill brought him home, securing for his last days the nursing of attentive friends, and for his last hours the comforts of his home and the tender care of a devoted wife.

I wish to say a few words of three specially interesting parts of William Ricketts Palmer's life. As he grew towards youth, he determined to prepare himself for the profession of a civil engineer, and came to West Point to look for the instruction in mathematics, which was much less diffused in our country at that day than now. It was a somewhat bold adventure thus to come as an outside pupil among the regular recipients of the instruction of that school. It required no little perseverance to overcome obstacles which this position naturally raised up. It required his good temper and tact to make friends of those who held the keys of the cabinet of knowledge, and to induce them to open to him. It required facility of acquisition not to make the task too heavy for his volunteer guides through this treasure cabinet. He succeeded not only in this, but in making friends for life. Among the most prominent of these were Robert P. Parrott, now of the West Point foundry, then an instructor in the Military Academy, who is now in his fame, as he was then in preparing for distinction, the dear friend of our deceased comrade.

Governeur Kemble, long the able manager of the West Point foundry, with whom Palmer was in constant intercourse at this time, was a friend derived from his mother's family, who early noticed William Palmer's capacity, and pushed his fortunes then and subsequently with consistent and characteristic kindness and tenacity of friendship. During the years I remained at West Point as instructor, William Palmer was my room-mate, and I had the opportunity to note the faithfulness with which, avoiding all the temptations around, he steadily kept to the purpose for which he had sought the academy, winning by his conduct the good opinion of Colonel Thayer (that upright judge of many of our country's youth) and of the professors generally.

Mr. Kemble caused Palmer to enter the West Point foundry, and subsequently, when the corps of topographical engineers was organized in 1838, obtained for him a lieutenant's commission in it. Here, under the training of able and experienced officers, he perfected himself in the practical operations of the field, and developed his abilities as a constructing and surveying officer.

In 1852 Captain Palmer took charge of a triangulation party on the Coast Survey, working principally upon rivers of Virginia, to be a few years later the scene of such important operations in war. In reconnaissance he was very ready, and in laying out the work and in its execution very neat and well-defined in his purposes. His triangles always closed well, verifying his accuracy of eye and judgment in time and circumstances of observation. As a chief of party, he was mild and gentlemanly in enforcing duties, expecting to do most by example in his own person. His work always gave entire satisfaction.

In 1856 Captain Palmer took charge of the Coast Survey Office, during the absence of Captain (now General) H. W. Benham in Europe, which he administered so successfully that he was recalled to it in 1858, and retained it until called to the more stirring duties of military reconnaissance and the field of war. His administration was easy, characterized by great tact and by observation of men's character, which enabled him readily to keep up a steady but gentle pressure.

As the rebellion developed itself, it was easy to see that Captain Palmer would soon make choice of more stirring duties. He entered the staff, first of General Mansfield and then of General McClellan; made two reconnaissances, at Mathias Point on the Potomac, and at Flint's Hill, which showed that the qualities of the topographical engineer of the field were his in a high degree—coolness, determination, judgment, and discretion.

As the army of the Potomac crossed the river into Virginia, Major Palmer was nominated by the Hon. E. M. Stanton, Secretary of War, for the brevet of lieutenant colonel, and was at once confirmed by the Senate.

As second to General A. A. Humphreys, Major Palmer accompanied the staff of General McClellan to the Peninsula as topographical engineer, and took a full part in the siege of Yorktown. At Williamsburg he was one of the first, if not the first, of our officers under fire, and General Stoneman, of the cavalry, who had applied for his services for his command, speaks in the most complimentary terms of the services which he rendered in that hardly-contested fight. Accompanying General McClellan in the passage of the Chickahominy he rendered excellent service, enjoying a full share of the general's confidence, regard, and affection. The insidious disease which attacked him early in June was called at first neuralgic headache, but soon proved to be fever of a violent type, and he was brought to his home only to die, to end his consistent career of a gallant officer; of an effective, respected, and beloved member of the corps of topographical engineers; of useful administration in the Coast Survey, and of its work in the field; of full and persevering preparation for the profession of the engineer, which he had early selected.

So much for the outward career; but friendship recognizes in him deeper and higher claims to distinction. As a son, as a brother, and in the family relations generally, William Palmer was permanently kind, generous, and dutiful. To a large family circle his loss is irreparable. He has preceded to the tomb a mother whose every recollection is of his goodness and care throughout a diversified life.

The prayers of many have ascended to the throne of grace for him during his illness. These prayers have failed to keep him with us. His life is now with Christ in God.

TRIBUTES TO THE MEMORY OF THE LATE GENERAL STEVENS AND CAPTAIN SMEAD.

At a meeting of the officers and employés of the Coast Survey Office, held on the 12th of September, to give expression of their sense of the loss sustained by the death of Brigadier General I. I. Stevens, United States volunteers, and Captain John R. Smead, United States army, both of whom had long been connected (the last quite recently) with the Coast Survey, the following addresses, prepared by Professor Bache, who is absent from the city, were read, and the subjoined resolutions passed.

My Friends: How soon we are called upon again to mourn and publicly to express the feelings which move us. One of our old associates, a leader among us, as he was in the armies of his country, has perished upon the field of glory. The colors of his regiment in his clenched hand, he has died as the brave love to die, as he had expressed his wish to die. His whole mind was given to the enthusiastic encouragement of his troops at the instant the death shot pierced his temple.

How little like are such scenes to those in which we best knew General Stevens in this office, and yet how fully persuaded we all have been that just so he would act under such circumstances! He was not one of those who led by looking on, but by example.

As we knew him in the Coast Survey Office, so he was in every position of life—so in action in civil life, so in the field.

Brought up to an active life upon his father's farm near Andover, Massachusetts, his bodily frame had early been hardened, and his spirit had shared in the process, so that energy and mental power were developed in a well-knit frame. He was prepared for West Point only by the instruction acquired at the common school, and yet was so prepared that by the exercise of the faculties with which nature had richly endowed him, and which labor had shaped, he was prepared successfully to cope with many older, many better instructed, many more accomplished than himself, and to wrest in the hardy academic struggle the palm of the generous West Point strife, the first place in a distinguished class. His friendships were many and ardent, and he was admired as well as loved. The spirit of self-reliance which he cultivated, and which circumstances aided him to cultivate, did not prevent the warmest attachments, nor interfere with an intrinsic modesty which only disappeared when the ardor of an enthusiastic and impulsive character carried him beyond his ordinary self.

He selected the engineer corps of the army as affording him the best opportunity of usefulness, laboring by study and practice to prepare himself for any career which might offer in the future. He was distinguished in the war with Mexico, breveted captain for meritorious and gallant services at Contreras and Churubusco, and major for Chepultepec. In 1849 he was selected by the chief engineer, General Totten, to fill an application for an officer in charge of the Coast Survey Office, and with words of commendation which showed how well he had served his chief and his country in his career in the engineers. This place he filled, more than filled, for four years, with a devotion, an energy, a knowledge not to be surpassed, and which left its mark upon our organization, our progress, our personnel, upon the execution of what was passing in the present, and what reached into the future. He knew how to read personal character, to stimulate, to encourage, communicating some part of his own hopeful and ardent character to those connected with him. His very fault of thinking too favorably of men was the source of much good to them, for it often induced them to efforts which otherwise they would not have made. His sense of even-handed justice was very great; he gave it to all, and expected it in return. His tact in bringing about a sharp and well-defined result, even in a complicated case, was very remarkable, and his drilling of those employed by him to precision, which was one manifestation of his quality, was wonderful. Generous and noble in his impulses, he left our office with the esteem and regret of all, and with the most enthusiastic expressions of admiration of his character, appreciation of his services, and hope for his future success. He left us to conduct the reconnaissance of the northwestern Pacific railroad route, to be governor of Washington Territory, and the leader of its people in a fierce and savage Indian war, to be its delegate in Congress, a volunteer at the breaking out of the rebellion, the colonel of a distinguished regiment in the volunteer army of the country, a brigadier general, the hero of the well-fought field of Chantilly. We claim the privilege to mourn him with his associates in the army, with the citizens of the State of his birth, with those of the State of his adoption, with his countrymen of the Union, who educated him, and to whom he gave his life.

We mourn him as heroes should be mourned. We embalm his memory in our hearts, as Massachusetts has embalmed his mortal remains. We preserve his spirit in our heart, as Rhode Island has his ashes in her soil.

Resolved, That, having looked in sorrow on the mortal remains of the late gallant Brigadier General Isaac I. Stevens, we tender our condolence to his family, under a sense of the depth of their bereavement in the loss of one whose memory was dear to us in the associations of the past.

Resolved, That we recognize in the remarks which have been read in our hearing the strength of character and ability by which the deceased general was known to us at an earlier period of the survey, and that we mourn his loss to the sacred cause of the nation, to which he devoted his energies and his life.

MY FRIENDS: Let us not part without the tribute of sorrow for another of the heroic dead, the gallant Captain Smead, of the United States army, one of the first volunteers for the defence of Washington during her darkest days. The war found him in charge of one of the divisions of the Coast Survey Office—a charge in which his duty was most creditably and acceptably performed. The first tap of the drum aroused him, and, placing himself at the head of volunteer citizens of Washington, he soon converted them into well-organized soldiers, and led them into active service. When the first emergency was passed he returned to his position in the regular army, and was constantly in the field. He served with distinction with the fifth regiment U. S. artillery, and laid down his life for the defence of the capital of the nation in the bloody fight of Saturday, August 30.

Resolved, That in the death of the brave Captain Smead, United States artillery, we have cause to mourn the loss of a recent associate, whose amiable character and manly bearing had endeared him to us. His devotion to the cause of the country had been followed with admiration, and we now grieve for the untimely death which has closed a career that promised varied usefulness in the public service.

Resolved, That we offer our sympathy to the bereaved family, and that a copy of the above resolution be transmitted to them.

INDEX OF SKETCHES.

NOTE.—Those of the above maps and charts which represent portions of the coast under blockade at the time of publication of this report will not appear.

National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

Please Note:

This project currently includes the imaging of the full text of each volume up to the "List of Sketches" (maps) at the end. Future online links, by the National Ocean Service, located on the Historical Map and Chart Project webpage (http://historicals.ncd.noaa.gov/historicals/histmap.asp) will includes these images.

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