

REPORT OF THE SUPERINTENDENT

OF THE

U. S. COAST AND GEODETIC SURVEY

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THE PROGRESS OF THE WORK

DURING THE

FISCAL YEAR ENDING WITH

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P 207

The times are given with a near approach to precision at special places where long series of observations were recorded in past years, but with somewhat less exactness for intermediate positions. For some years the tables have been regarded as necessary aids in the navigation of our coasts. These tidal predictions result from the application of systems of analysis and discussion that have been from time to time improved, but chiefly by modifications of methods formerly in use. The last improvement in analysis, and known as the "harmonic method," was devised by Sir William Thomson, and has been adopted by the tidal committee of the British Association for the Advancement of Science. By this treatment the tide is followed hourly, and is scanned in strict accordance with time through the entire series of observations.

The tidal records of Pulpit Harbor, North Haven, in the Fox Island group, Penobscot Bay, Maine, for a period of six years, have been analyzed by the harmonic method and discussed by Mr. William Ferrel of the Coast and Geodetic Survey. His report on the subject (Appendix No. 11) explains the principles of this kind of analysis which, in application, is not restricted to tidal observations, but may be used for any series of numerous observations made at equal intervals of time. Then follows, in the paper, the application of these principles for the determination of tidal constants of all the principal tide components, derived from the Pulpit Harbor observations. The results are thoroughly discussed and compared with theory, and with results obtained by the same method in other parts of the world. Means are thus afforded for a careful examination of the tidal theory. In this connection, also, the paper shows that much study has been given to the character of the tides in shallow waters. Mr. Ferrel, in concluding, applies results for computing and predicting tides along the whole coast of New England, the type of the tide appearing to be the same throughout, as shown by comparing results from the Pulpit Harbor series with those derived from the series recorded in Boston Harbor.

To illustrate the nature of the work proposed in the detailed estimates which were submitted to the department in October last, a synopsis was given showing the field and office operations of the past fiscal year. The synopsis is here inserted as usual in previous annual reports. It will be noticed that the work has been advanced in upwards of one hundred localities on the Atlantic coast, Gulf of Mexico, and Pacific coast of the United States, including geodetic stations intermediate between the eastern and western coasts. For convenience, the work of the land and hydrographic parties will be recapitulated in the usual geographical order. The work afloat and the geodetic and other operations of the fiscal year ending June 30, 1878, include—soundings in the seaward approaches of Mount Desert Island, off the coast of Maine; and in that vicinity topographical surveys at the head of Frenchman's Bay and Blue Hill Bay; hydrography of the vicinity of Deer Isle and Isle au Haut, and tidal observations in Penobscot entrance; geodetic work at Gunstock Mountain and at Gilford, for determining geographical points in New Hampshire; triangulation for the harbor commissioner's survey of Boston upper harbor; determination of the positions of light-houses on the coast of Massachusetts; development of the action of sea currents as affecting navigation across the Gulf of Maine; tidal observations at Providence, R. I.; shore-line survey and soundings in Duck Island Harbor, Conn.; detailed topographical survey of the north and west approaches to New Haven, Conn., and of the western shore of Jamaica Bay, including Rockaway Inlet; survey of Coney Island, and of the shores of Sheepshead Bay and Gravesend Bay, Long Island, N. Y.; hydrography of Rockaway Inlet and of the adjacent parts of Jamaica Bay; pendulum observations at New York City; tidal observations at Governor's Island and at Sandy Hook; topography of the shores of Hudson River near Peekskill, N. Y.; tidal bench-marks at Stuyvesant and Albany, established by lines of level; primary triangulation connected with geodetic stations in New Hampshire, Vermont, and Massachusetts; latitudes and longitudes for State commissioners in adjustment of the boundary line between New York and Pennsylvania; geodetic points determined in the northern part of New Jersey and in Eastern Pennsylvania; latitude, longitude, and the magnetic elements at Harrisburg; points determined and special observations of tides and currents in the Delaware River at and near Philadelphia; triangulation for light-house positions in Delaware Bay; topographical survey continued eastward of Norfolk, Va.; tidal observations at Fort Monroe; special observations in the waters of Chesapeake Bay in regard to salinity and density; bench-marks along the Potomac near Washington, D. C., for comparing flood levels; magnetic declination, dip, and intensity determined at Washington; lines with spirit level run between

Survey of Coney Island, N. Y.—In the field operations of last year the triangulation of the south coast of Long Island had been brought as far eastward as Manhattan Beach. One of the stations was at the east end of Coney Island, and another was occupied in the village of Gravesend. For continuing work in the present season, Assistant Donn found and reoccupied two of the stations, and from them observed with the theodolite on a number of cupolas along the line of Coney Island. Three additional stations were occupied, including Fort Tompkins, and from the angular measurements points were provided for the plane-table survey. The topography was commenced on the 1st of May of the present year. Interruptions were frequent by wind, rain, and fog.

Each feature, natural or artificial, is shown in its proper position on the plane-table sheet of Mr. Donn, and for this part of the coast of Long Island the sheet is an excellent standard for comparison with future surveys. Of the changes now going on in the vicinity, he remarks: "Sheepshead Bay and the creek connecting it with Gravesend Bay are rapidly filling up, and it is altogether probable that Coney Island will be an island only in name at no distant day."

Field work in the vicinity of Coney Island was completed early in June. The following are statistics:

Coast and bay shore surveyed, miles.....	12
Creeks, miles.....	10
Roads, miles.....	18

During the summer, Assistant Donn was engaged in Jamaica Bay in the prosecution of a survey which was commenced in the summer of 1877. Of this work mention will be made in my next report.

Pendulum experiments.—After careful preparation, Assistant C. S. Peirce arranged the pendulum, which he had previously used under other conditions, to swing in vacuo, and during the month of September, 1877, it was swung at various pressures with the heavy end down. For these operations time was determined before and after experiments with the pendulum.

While abroad as a delegate to the International Geodetic Association, Mr. Peirce at intervals made comparisons of the length of our pendulum standard with that of the Prussian Geodetical Institute.

In November tests were made of certain scales used for the measurement to hundredths of a second of the traces on chronograph sheets, the aim being to measure the chronograph record without estimations.

The pendulum was swung in December with the heavy end up, and in the course of the winter Assistant Peirce compared all the micrometers which he had used in previous experiments. Subsequently an elaborate series of measures was made for comparing our pendulum meter with a German meter.

In April and May of the present year the pendulum was swung at New York in air of which the temperature was about 100 degrees Fahrenheit.

Among other operations conducted this season were experiments for the coefficients of expansion of two meter bars and micrometer tests with reference to the spectrum meter. Additional observations were made to compare the statical and dynamical flexures of the stand which supports the pendulum. The records of the various experiments mentioned in this abstract are contained in twenty-six volumes.

Tidal observations.—At Governor's Island, in New York Harbor, the series of observations with a self-registering tide gauge has been kept up by Mr. R. T. Bassett. In freezing weather the difficulty of maintaining a continuous record has been met by applying heated water to keep the working parts of the apparatus free from ice. A nineteen-year cycle, including continuous observations during winter, will soon be completed at this station. The record, as heretofore, is frequently resorted to by local engineers for adjusting the levels proper for bridges, wharves, sewers, dikes, and harbor improvements generally. For comparison with the results at Governor's Island the same observer occasionally records day observations at Hamilton Avenue Ferry wharf in Brooklyn.

In October, 1875, a well-furnished self-registering tide gauge was established at Sandy Hook on one of the wharves of the New Jersey Southern Railroad, and was put in charge of Mr. J. W. Balford, who, having charge of the depot and the direction of the laborers employed about the