OCEAN TEMPERATURES

OF THE

EASTERN COAST OF THE UNITED STATES,

WITH

THIRTY-TWO CHARTS.

By RICHARD RATHBUN.

OCEAN TEMPERATURES OF THE EASTERN COAST OF THE UNITED STATES, FROM OBSERVATIONS MADE AT TWENTY-FOUR LIGHT-HOUSES AND LIGHT-SHIPS.

[With thirty-two charts.]

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INTRODUCTION.

Temperature has long been recognized as having an important influence upon the general movements of fishes, and especially of those species that migrate periodically from one region to another. The salmon, shad, and alewives ascend the rivers in the spring, and at about the same time large schools of mackerel and menhaden approach the coast from the direction of the Gulf Stream, and, to some extent at least, work northward as the season advances. Cod are abundant near shore only during the colder months, while lobsters retreat into deeper water at the beginning of winter, and return again in the spring. Whatever may be the impelling power that incites these and other species to change their grounds at stated periods, whether the necessity of seeking new sources of food or more congenial waters for the purposes of breeding, it has generally been observed that their migrations coincide more or less closely with certain changes in temperature, and the latter, therefore, appears to exert a controlling or restraining influence upon their movements. Until recently, however, very little has been published respecting the precise relations of temperature to fish migrations, and the subject is but little understood.

In a history of the menhaden, published in 1879,* Mr. G. Brown Goode discusses the water temperatures taken at several stations along the Atlantic coast of the United States for a period of three years, in connection with such information as was then obtainable respecting the movements of menhaden during their spring migrations. In prefacing this subject, Mr. Goode remarks that "the date of the earliest appearance of the schools of menhaden at any given point upon the coast corresponds very closely with that of the arrival of scup, shad, bluefish, and other of the non-resident species. It depends primarily upon the temperature of the water, [and the departure of the schools] is regulated by the same causes. At the approach of settled warm weather the schools make their appearance in the coast waters. They remain in the bays and near the shores until they are warned away by the breath of coming winter. The date of their appearance is earlier in the more southern waters, and the length of their sojourn longer. It is manifestly impracticable [from the data he then possessed] to give anything but approximate dates to indicate the time of their movements. In fact, the comparison of two localities, distant apart 100 or 200 miles, would indicate very little. When wider ranges are compared there becomes perceptible a proportion in the relations of the general averages. There is always a balance in favor of earlier arrivals at the more southern localities. Thus it becomes apparent

* The Natural and Economical History of the American Menhaden, by G. Brown Goode. U. S. Commission of Fish and Fisheries. Report of the Commissioner for 1877, Appendix A, 529 pp., 31 plates. Washington, 1879.

that the first schools appear in Chesapeake Bay in March and April, on the coast of New Jersey in April and early May, and on the south coast of New England in late April and May, off Cape Ann about the middle of May, and in the Gulf of Maine about the latter part of May and the first of June. Returning, they leave Maine in late September and October; Massachusetts in October, November, and December; Long Island Sound and vicinity in November and December; Chesapeake Bay in December, and Cape Hatteras in January. Farther to the south they appear to remain more or less constantly throughout the year."

In his concluding remarks the same writer states that "these facts [which he sets forth in considerable detail] appear to indicate that under ordinary circumstances the menhaden prefers a temperature of 60° to 70° Fahrenheit. When the rising temperature of spring has passed the limit of 50° to 51°, the fish are certain to appear, and when the falling temperature of autumn reaches that point, their departure is equally sure, though a few individuals may linger in waters not congenial to them. The opposite limit seems to be marked by the line of 80° or perhaps 75°. An easterly or northerly wind, lowering temporarily the surface temperature, causes the schools to sink below the surface. The chill of night also drives them down. These conclusions are not to be regarded as final. The movements of the fish about Cape Hatteras are very puzzling, and need to be interpreted by a series of careful temperature observations."

More recently similar comparisons of water temperatures have been made by Col. Marshall McDonald with respect to the shad and river herrings or alewives,* the observations he makes use of being relatively more extensive than was the case in Mr. Goode's studies of the menhaden. His observations are restricted to the Chesapeake Bay region, with special reference to the Potomac River, and are accompanied by instructive diagrams, on which the relations of temperature to the abundance of the two species of herring and the shad are graphically represented.

His final conclusions are as follows: "The diagram showing fluctuations of water temperature in the Chesapeake Bay region furnishes very interesting and suggestive data for discussion. During the winter months the water temperatures on the ocean plateau, outside of the capes, is higher than that of Chesapeake Bay or the Potomac River. The latter part of February or early in March the temperature of the bay waters rises above that of the ocean waters outside. Coincident with this the shad make their appearance in the Chesapeake and are taken in the pounds which are set in salt-water along the shores of the bay. About the first of April the temperature of the water in the Potomac River rises above the temperature of the water in the bay. Coincident with this is the beginning of the shad season in the river. The lesson taught by the diagram is that shad do not enter our rivers to spawn until the temperature of the river waters is higher than that of the salt-water from which they come. Should the waters of either the Potomac or Susquehanna continue during the season at a lower temperature than those of the bay, we would have no run either of shad or glut herring during the season."

Our object in prefacing this introduction with the above extracts from two of the most important contributions on the subject of water temperatures in their relation to the migration of fishes, has been to give a practical illustration of the great value of such studies, which have been strangely neglected by investigators. With respect to the oceanic species, there are, of necessity, many difficulties, some of them insurmountable, in the way of obtaining observations, as permanent stations for that purpose must be located mostly on or very near the coast, while the larger schools of fishes often remain some distance from the land. River stations for observ-

* The Shad—*Clupea sapidissima*, by Marshall McDonald. The Fisheries and Fishery Industries of the United States, by George Brown Goode and a staff of associates. Section I: Natural History of Aquatic Animals, pp. 594-607, plates 214, 215. Washington, 1884. Also in Report United States Commissioner of Fish and Fisheries for 1883 (1885), p. 1034, pl. 1.

ing water temperatures conjointly with the migrations of fishes can be readily established, and excellent opportunities for good work in this direction are afforded by all the larger rivers of our country.

The practical value as well as scientific importance of investigations of this character, in their bearing upon many of our most extensive sea and inland fisheries, has been fully recognized by the U. S. Fish Commissioner, and in all the explorations carried on under his direction the observation of water temperatures has been made a conspicuous feature. Unfortunately, the field work of the Fish Commission is, necessarily, limited to a comparatively short season in each year, during which operations have, for the most part, been confined within narrow areas, changing more or less from year to year, or have been extended irregularly from place to place, dependent upon the movements of the steamers. The temperature observations made by the Commission do not, therefore, form continuous series sufficiently complete in themselves for detailed comparison with the movements of fishes during an entire season of their migrations. In order to supplement and extend this class of investigations with reference to the surface waters and surface schooling fishes, the co-operation of the U. S. Light-House Board and U. S. Signal Service was obtained, and for a number of years past continuous series of observations have been taken at some sixty stations belonging to these two services, distributed along the entire Atlantic and Gulf coasts of the United States from Eastern Maine to Southern Texas.

In this report we have given the temperature results of the light-house stations only, reserving those of the Fish Commission and Signal Service for a future one. Most of the light-house stations form a series which can well be considered apart from the others, all of the stations here included being located on exposed portions of the coast, while those of the Signal Service are mostly situated in inclosed bays or harbors. A few of the light stations are, however, in similar situations to those of the Signal Service and will be considered with them. Before describing the positions and relations of the stations, it may be best to note briefly the character of observations required for application to the problem of fish migrations.

While general temperature results are of much interest, it is evident that they are totally inadequate to explain the varying movements of fishes. The changes in temperature from day to day and from season to season must be studied in great detail in order to ascertain their precise influence in regulating the arrival, progress, and departure of the schools. If mackerel appear at an earlier date in one year than in another, is that earlier appearance accompanied by a more rapid rise in temperature? If more abundant or more widely distributed during one season than another, is it due to warmer temperatures covering a wider area than usual, or to other causes? Answers to these questions are to be sought in a better understanding of the conditions of temperature along our coast, although it cannot be denied that other subjects, such as the distribution and abundance of food, and the influence of the winds and currents, need to be considered in the same connection. In order to make this precise study of the temperatures it is necessary to establish numerous stations at successive points along the course followed by the fishes in their migrations. These stations should be located at a sufficient distance from the coast to be beyond the influence of local conditions, and at such an ideal series of observing posts the determination of the relations of temperature to fish migrations would be simply a question of time, but unfortunately it is impossible to locate many such stations, and inferior ones have to be selected to complete the series. Observations should be made continuously throughout each season of migrations for several successive years, and by this means many parallel series of records would be obtained suitable for the work of comparison.

In this report we have to do only with the surface temperature of the waters immediately

bordering the coast, considered also in their relations to the temperature of the air. The outside light stations selected for taking the observations are twenty-four in number, and represent the entire eastern coast of the United States from Southern Florida to Eastern Maine. As enumerated and described below, it will be noticed that some are light-ships anchored off the land, while others are light-houses, situated on islands or on the main coast. Those of the first class are infinitely better located for temperature purposes than either of the others. At most of the stations observations were begun as early as 1878, but prior to 1881 so many breaks occurred in the records that it has been found inexpedient to make use of any of the data relating to the first three years. This report, therefore, covers a period of only five years, from 1881 to 1885, inclusive. Although the depths at the different stations vary greatly, ranging from a few feet to 18 fathoms, it was thought advisable to have the observations cover the bottom as well as the surface waters, but the former having been entirely neglected at nearly every station, no reference is made to bottom temperatures on the following pages.

The record blanks supplied to the light-house stations call for the following observations: Depth of water where the observations are taken, at mean low tide; time of observations, which are to be made twice each day at the first high water and first low water after 7 a. m.; temperature of the water at the surface and at the bottom, and by exposing the thermometer in the open air; direction and force of the wind, and state of the sky at the time of taking the temperature observations; occurrence and duration of rain or snow; occurrence and movements of any kinds of fish, singly or in schools, especially menhaden, herring, cod, mackerel, swordfish, horse-mackerel, bluefish, &c., and also of seals or whales.

As the observations are taken at the first high water and first low water after 7 a. m., they are not made at the same time every day, but generally fall within the twelve hours following 7 a. m., or between 7 a. m. and 7 p. m. Should the time for taking the first observation come immediately after 7 a. m., the second observation would be made soon after noon. As, in some places, there is considerable difference between the temperature of the water at high tide and low tide, this method of regulating the hours of observation appeared to afford the most satisfactory means of equalizing results. As elsewhere explained, the temperature observations were limited at most stations to the surface water and the air. Observations respecting the direction and force of the wind, the state of the sky and the occurrence of rain were generally well kept, but the opportunities for observing the movements of fishes were not equally good at all stations, nor was it to be expected that a constant outlook would be maintained by volunteer observers already burdened with other and more important duties. Nevertheless many interesting and valuable records were made in that line, although nothing of importance was learned respecting the regular migratory movements.

The thermometers employed were of two kinds, both of which were especially designed for taking water temperatures not only at the surface, but also in slight depths. During the first few years the stations were supplied with the excellent pattern made for the Signal Service, and kindly lent for the purpose. These thermometers are inclosed in a stout bronze case, with suitable openings for the entrance of water, and every instrument was carefully compared with a standard before being sent out. From time to time the Signal Service thermometers have been replaced by a new and equally reliable pattern, made by Charles Wilder, of Peterboro', N. H., for this special kind of work, and at present all the light-house observations are taken with these instruments. The tube is protected in a cylindrical copper case, somewhat similar in construction to that of the Signal Service, but of larger size. All instruments are compared and none having a large error are made use of. Occasionally, at some of the stations, when the regulation ther-

mometer has accidentally been broken, the observations have been continued by means of a lighthouse thermometer, or of one purchased at a neighboring town, pending the receipt of a new instrument, but such instances have been of rare occurrence and not likely to make any appreciable difference in the character of the records for the short periods involved.

While the light keepers have not been specially trained in the methods of taking temperature observations, their monthly returns testify to their high grade of intelligence and to their great zeal in fulfilling these additional duties without extra compensation. We are led to believe that their records contain comparatively few serious errors for which they are directly responsible, excepting in those cases which will be explained hereafter; and that, in the main, their observations have been conscientiously made and are deserving of consideration. It is also worthy of comment that so extensive an undertaking as this should have been carried on successfully at so little expense and with so little friction.

As above explained, detailed temperature observations rather than general results are essential for comparison in studying the migrations of the fishes. For that reason the reductions plotted on the accompanying charts have been made for comparatively short intervals, the entire year being divided into periods of ten days, each of which is equivalent to about one-third of a calendar month. As two observations are made daily, the mean of each ten days is derived from twenty observations, and small errors are thereby practically eliminated. Each station is represented by a chart on which the ten-day means of surface-water temperatures are given for each of the five years from 1881 to 1885, inclusive, and the air temperatures from 1881 to 1883, inclusive. The method of representing the temperatures is by curves connecting the ten-day periods, as explained on the charts. At the stations north of Cape Hatteras there were frequent indications of careless observation during exceedingly cold weather in the months of January and February, the thermometer, at times, not being read quickly enough after it had been withdrawn from the water. As such readings would manifestly afford a lower mean temperature than the actual, it has been deemed best to omit the records for those two months at the northern stations. At some of the shore stations the observations also show the effects of local influences which render them inapplicable to the open waters of the coast; but special explanation of those stations is made further on.

In addition to the charts of ten-day means, there are also seven isothermal charts on which the temperature observations at all the stations are combined, in order to afford more convenient means of comparison. Five of these charts represent the separate years from 1881 to 1885, inclusive, a sixth, the means of the same five years, and the final one, the relations of the air isotherms to the surface isotherms. The isotherms are plotted for every 5° of temperature, Fahrenheit, from 40° to 80°, inclusive. The isotherm of 35° F. occurs only at the northern stations, and there mainly in the months of January and February, the records for which have not been used. The writer has refrained from drawing any conclusions from the temperature results presented in this report, and his remarks on the following pages are mostly confined to describing the stations and indicating some of the main features with respect to the temperature curves and the isotherms. The Fahrenheit scale of temperatures has been exclusively used both in making the observations and in the construction of the charts.

The work of reducing the many observations to ten-day means and of making the original plottings of the same has been done by Miss M. J. Rathbun, while the writer is responsible for the computations for, and the plottings of, the isotherms. The charts were prepared for engraving by Mr. C. E. Gorham.

ENUMERATION AND BRIEF DESCRIPTIONS OF THE STATIONS.

The light-houses and light-ships selected as temperature stations numbered thirty-six in all, distributed at intervals along the eastern coast of the United States, from Petit Manan Island in Eastern Maine, to the Tortugas Reefs in Southern Florida. As explained before, twenty-six of these stations were located off shore, or on exposed portions of the coast, and the remainder in more or less inclosed bays, sounds, and harbors. The outside stations are alone considered in this report, and of this class the two following have been omitted, reducing the number to twenty-four. The observations were continued for so short a period at Minot's Ledge light-house, in Massachusetts Bay, that it was deemed inexpedient to make use of them; and the records for Race Point light-house, at the northern extremity of Cape Cod, show such extreme variations within short periods, due probably in part to the very gradually sloping shore in front of the light, as to render their value questionable until further examination can be made.

The outside stations differ widely in the character of their surroundings, and therefore do not afford the means of obtaining observations of equal value respecting the open waters along the coast. Ten are light-ships, anchored off shore, in depths of 5 to 18 fathoms, and consequently possessing unusual advantages for the taking of ocean temperatures; nine are located on small islands or reefs, more or less widely separated from the mainland; and five are situated on the shore of the mainland or on large islands, the last, as a rule, forming the least desirable stations of the series. Some of those stations situated on small islands or reefs also show considerable variations of temperature due to local influences, as described further on.

The arrangement of stations followed in this report is generally from south to north, this order affording the most natural sequence for comparing the different ranges of temperature in successive latitudes. The locations and general characteristics of the stations are as follows: *

THE FLORIDA REEFS.

Dry Tortugas light-house.—Located on the western island of the Tortugas, at the southwestern extremity of the Florida Reefs. The light-house is situated on the eastern side of Loggerhead Key (or island), which is bordered by a channel having depths of 10 to 12 fathoms and occupied by strong tidal currents. The surface temperature observations were taken where the water is only 5 feet deep, and show indications of local influences, which render them more or less unsatisfactory with respect to the open waters surrounding the reefs.

Carysfort Reef light-house.—Located near the northeastern end of the Florida Reefs, about 158 miles from the Dry Tortugas light-house, and on the outer side of Carysfort Reef. Depths of 50 fathoms occur within 2 miles of the light. Observations were taken in a depth of only 3 feet, but evidently in a more exposed position than at the Tortugas station, as the effects of local influences are less apparent in the surface temperature records.

Fowey Rocks light-house.—Located on the outer edge of Fowey Rocks, at the northeastern extremity of the Florida Reefs, and 23 miles from Carysfort Reef. The 100-fathom curve is distant about 2¼ miles. The depth of water at the place of observation is 5 feet, and the water temperature records compare favorably with those of Carysfort Reef, indicating a similar exposure.

SOUTH CAROLINA.

Martin's Industry light-ship.—Anchored in 9 fathoms of water, about 8¼ miles from land, off the entrance to Port Royal Sound; distant about 390 miles from Fowey Rocks light-house.

Rattlesnake Shoal light-ship.—Anchored in 5 fathoms of water, about 5 miles off land, just north of the entrance to Charleston Harbor, and about 56 miles from Martin's Industry light-ship.

NORTH CAROLINA.

Frying Pan Shoals light-ship.—Anchored in 10 fathoms of water, about 17 miles southeast of Cape Fear, and about 108 miles from Rattlesnake Shoal light-ship.

Cape Lookout light-house.—Located on the outer shore, about 3 miles north of the extremity of Cape Lookout, and 90 miles from Frying Pan Shoals light-ship. The observations were taken at the lower edge of the beach in a depth of 1 foot of water. The bottom slopes gradually, and attains a depth of 10 fathoms about 5 miles from shore. Although the maximum and minimum surface temperatures at this station correspond closely with the same at Frying Pan Shoals, the surface curves are much less regular, and show direct atmospheric influence.

* For more complete descriptions, reference should be made to the explanations of the charts.

Body's Island light-house.—Located near the southern end of Body's Island, about 35 miles north of Cape Hatteras, and 86 miles from Cape Lookout. The shore is similar in character to that at Cape Lookout, but the surface observations were taken where the depths are from 7 to 9 feet. The temperature curves for the surface and air are almost precisely alike, and the observations cannot be regarded as of any value with respect to the open waters off shore.

VIRGINIA.

Winter Quarter Shoal light-ship.—Anchored in 10½ fathoms of water, 8½ miles off Assateague Island, and about midway between the entrances to Chesapeake Bay and Delaware Bay; distant about 128 miles from Body's Island.

NEW JERSEY.

Five-Fathom Bank light-ship.—Anchored in 12 fathoms of water, about 14 miles off the coast, just east of Cape May, and off the entrance to Delaware Bay; distant about 56 miles from Winter Quarter Shoal light-ship.

Absecon light-house.—Located on the beach in front of Atlantic City, and just south of the entrance to Absecon Inlet; 34⅝ miles distant from Five Fathom Bank light-ship. The shore is faced with shoals, but the surface observations were taken in the channel leading to the inlet, in depths of 9 to 15 feet of water. The surface records are much more satisfactory than at either of the previous shore stations (Cape Lookout and Body's Island), and the surface curves are nearly as regular as at Five Fathom Bank light-ship.

NEW YORK.

Sandy Hook light-ship.—Anchored in 14 fathoms of water off the entrance to New York Bay; 6 miles east of Sandy Hook, N. J., the nearest land; and about 70 miles from Absecon light.

Fire Island light-house.—Located on the east side of Fire Island Inlet, south side of Long Island, 31 miles from Sandy Hook light-ship. The surface observations were taken in the entrance to Great South Bay, between Fire Island and Oak Island, in 3 feet of water. A strong current flows through the channel, which is somewhat similar in character to the entrance to Absecon Inlet.

RHODE ISLAND.

Block Island southeast light-house.—Located at the southeastern corner of Block Island, 82 miles from Fire Island light. The observations were taken at the lower edge of the beach, which faces the open sea to the south. The surface temperature curves are comparatively regular and show less variation from local influences than would be expected at a shore station of its character.

Brenton's Reef light-ship.—Anchored in 14½ fathoms of water, off the entrance to Narragansett Bay, and about 1⅞ miles from land; 17¾ miles distant from Block Island southeast light.

MASSACHUSETTS.

Vineyard Sound light-ship.—Anchored in 15 fathoms of water, on the western side of the southern entrance to Vineyard Sound, 2½ miles from Cuttyhunk Island, the nearest land, and 17½ miles from Brenton's Reef light-ship.

Nantucket New South Shoal light-ship.—Anchored in 16 to 18 fathoms, at the southern edge of Nantucket shoals, and 21 miles southeast of Nantucket Island, the nearest land; distant about 58 miles from Vineyard Sound light-ship. This station occupies a very important position with reference to the off-shore fisheries.

Pollock Rip light-ship.—Anchored in 5 to 7 fathoms of water, in the eastern entrance to Nantucket Sound, and 3½ miles SE. by E. ½ E. from Monomoy Point light-house, Cape Cod; distant about 36 miles from Nantucket New South Shoal light-ship. This light-ship is mostly surrounded by numerous shoals which are separated by channels occupied by strong tidal currents.

Thatcher's Island lights.—Located on Thatcher's Island, off the eastern extremity of Cape Ann, about 73 miles from Pollock Rip light-ship. Depths of 60 fathoms occur within a distance of 6½ miles to the eastward. The surface temperature observations were taken where the water is 7 feet deep, and show variations from local influences. Observations were first made at this station by one of the light-house keepers, but after April, 1881, by an observer of the U. S. Signal Service.

MAINE.

Boon Island light-house.—Boon Island is a small rocky island lying off York Harbor, and 5¾ miles from the nearest land. It is distant about 35 miles from Thatcher's Island, and is surrounded by depths of 5½ to 25 fathoms within a radius of 1 mile. The depth of water where the surface observations were taken is 9 feet. Many gaps occur in the records of this station, and the reductions plotted on the chart are therefore probably not reliable.

Seguin Island light-house.—Seguin Island is small and rocky, and is situated about 2½ miles off the nearest point of the mainland, on the eastern side of the entrance to Kennebec River, and about 47 miles from Boon Island. The light-house is on the western side of the island, where the water is from 6 to 8 fathoms deep close inshore at the place of observation.

Matinicus Rock light-house.—Matinicus Rock is a rocky islet about 14 miles south of Vinal Haven, at the mouth of Penobscot Bay, and about 80 miles from Seguin Island. Depths of 4 to 45 fathoms occur within a radius of 1 mile, the depth where the surface observations where taken ranging from 6 to 12 fathoms.

Mount Desert Rock light-house.—Mount Desert Rock is similar in character to Matinicus Rock, and is situated about 18 miles off Mount Desert Island and 34 miles from Matinicus Rock. Within a radius of 5 miles the depths

range from 50 to 95 fathoms; the depths of water where the observations were taken were 2 to 10 fathoms; the records are about as imperfect at this station as at Boon Island.

Petit Manan light-house.—Petit Manan Island consists of a group of low, rocky islets, situated about 2 miles from land, off the western entrance to Pigeon Hill Bay, and 27 miles from Mount Desert Rock. They are surrounded by deep water, the observations having been taken where the depths range from 8 to 15 fathoms.

RELATIVE POSITIONS OF THE STATIONS.

The three most southern of the temperature stations, those at the Tortugas, Carysfort Reef, and Fowey Rocks, are located on the northern and western edge of a deep and comparatively narrow channel, called the Straits of Florida, which extends first easterly from the Gulf of Mexico and then northerly into the Atlantic Ocean. This channel, which is occupied for its entire width and length by the Gulf Stream, is bounded on the north and west by Florida, on the south by Cuba, and on the east by the Bahama banks and islands. Its length is about 350 miles, but the temperature stations are limited to its central and western portions, all being situated on the Florida Reefs. In front of the Tortugas, the 100-fathom curve is distant about 15 miles from the southern edge of the reefs, which are located at the southern end of the submerged continental slope bordering the west coast of Florida for a width of 110 to 145 miles. At Carysfort Reef, the *100-fathom curve is distant only about 7 miles from shore, and at Fowey Rocks only 2½ miles.* The deepest water in the straits occurs at the western entrance, opposite the Tortugas, and in places exceeds 1,000 fathoms, the southern and eastern sides of the straits being generally deeper than the northern and western. The influence of the great body of warm water composing the Gulf Stream is felt directly upon the Florida Reefs, although these reefs are known to be bathed by a narrow counter current flowing to the westward. The axis or warmest band of the Gulf Stream passes nearer the southern and eastern than the Florida side of the channel.

The Tortugas Reefs are situated at the western end of the Straits of Florida, on the northern side, where the distance across from land to land is about 90 miles. The Tortugas station, however, is in a somewhat protected position, and local influences are perceptible in the temperature records. At Fowey Rocks, the width of the channel is reduced to about 40 miles, this width being the least of any in the straits. The stations at Carysfort Reef and Fowey Rocks both occupy more exposed positions than the one at the Tortugas, and are therefore better located for ascertaining the temperature of the open waters bordering the reefs.

Between the Florida Reefs and the first station to the north (Martin's Industry light-ship, South Carolina), a distance of about 6½ degrees of latitude intervenes. Within this distance the 100-fathom curve and the inner edge of the Gulf Stream gradually recede from the coast line as far as Georgia, whence to near Cape Lookout, North Carolina, they retain a nearly uniform distance from the shore. Along this section of the coast the submerged continental plateau has an *average width of about 55 miles to the 100-fathom curve, which lies just within the inner edge* of the Gulf Stream or "Cold Wall." The bottom slopes gradually from the shore into depths of about 50 fathoms, beyond which the descent is very rapid. Just south of Cape Lookout the 100-fathom curve bends in somewhat toward the shore, and in front of Cape Hatteras the submerged continental border is only about one-third as wide as it is farther south, the Gulf Stream also approaching nearer to the land. North of Cape Hatteras the 100-fathom curve again recedes from the shore and the Gulf Stream is deflected toward the east.

Between Georgia and Cape Hatteras there are four stations, of which three are light-ships, located several miles off shore, in depths of 5 to 11 fathoms. Martin's Industry light-ship is off the entrance to Port Royal Sound, South Carolina, in front of Martin's Industry Shoal, which separates the south and southeast channels; Rattlesnake Shoal light-ship is just north of the

entrance to Charleston Harbor, and Frying Pan Shoals light-ship is 17 miles off Cape Fear, North Carolina. It is possible that the fresh waters emptying into the sea in the neighborhood of the two former stations may influence the surface temperatures to a greater or less degree, but the distance of these light-ships from shore makes this supposition improbable. Cape Lookout light-house is a shore station affording results of local value only, and Body's Island light-house, about 35 miles north of Cape Hatteras, is of the same character.

At Winter Quarter Shoal light-ship, Virginia, the next station north of Body's Island, the 100-fathom curve is distant about 55 miles from shore, the submerged continental plateau having about the same width here as to the south of Cape Lookout. At Five-Fathom Bank the width increases to over 65 miles; opposite New York Bay entrance it is about 100 miles wide, and in front of Nantucket Island about 80 miles wide. The slope of the bottom along this part of the coast is also very gradual until a depth of about 50 fathoms is reached, the distance between the 50 and 100 fathom curves being only 5 to 15 miles. The inner edge of the Gulf Stream is distant from the shore at Winter Quarter Shoal about 100 miles; at Five-Fathom Bank about 140 miles; at Nantucket Island about 200 miles, and, therefore, bears no relation to the submerged continental border, north of Cape Hatteras, as determined by the 100-fathom curve.

Winter Quarter Shoal and Five Fathom Bank light-ships are the two most southern stations on this part of the plateau, and both are favorably situated, the former 8½ miles off shore in a depth of 10 fathoms; the latter 14 miles off shore in a depth of 12 fathoms. The next light-ship to the north is that off Sandy Hook, New Jersey, which is anchored in 14 fathoms of water. Being located directly off the mouth of New York Bay, the surface waters at this station may possibly be influenced to some extent by the outflow from the Hudson River, especially in the early spring after the ice has broken up, but there is no special evidence to that effect. Between Delaware Bay and Rhode Island there are three shore stations, two (Absecon and Fire Island) situated upon tidal inlets, and one (Block Island) upon an ocean beach. The two former have furnished better observations than would ordinarily be considered possible in such places.

East of Block Island there are four temperature stations off the southern coast of New England, all of which are well located. The Brenton's Reef and Vineyard Sound light-ships belong to the area included between Block Island and Martha's Vineyard. Pollock Rip light-ship is at the eastern entrance to Nantucket or Vineyard Sound, and, although surrounded by shoals, is in the midst of strong tidal currents, which are probably not influenced by the neighboring land. Nantucket New South Shoal light-ship occupies one of the most exposed positions on the coast, and is distant over 20 miles from the nearest land. A series of stations like this one, distributed along the entire coast, could be made to furnish most important data respecting the fisheries.

The Gulf of Maine, in which the remaining stations are located, is a moderately deep basin, surrounded on the west, north, and northeast by land, on the south by George's Bank, and on the east by Brown's Bank, in part, and the shoal water off Cape Sable, Nova Scotia. The Bay of Fundy opens into it from the northeast. This area contains many banks and ledges, and the bottom contour lines are very irregular. The 50-fathom curve is nowhere distant from the land, and along the northern coast, where most of the stations are situated, approaches close to it. The 100-fathom curve is also not very far distant from the Massachusetts coast, and approaches the coast of Maine between Mount Desert and Machias. The most southern station is on Thatcher's Island, off Cape Ann, an important location, though, unfortunately, the observations were taken in too shallow water to make them of value with respect to the open waters of the gulf. Boon Island is in the western part of the gulf, midway between Cape Ann and Portland. Seguin Island, Matinicus Rock, and Mount Desert Rock are in nearly the same latitude, the first mentioned being near

the mainland, the two latter close to the 50-fathom curve. Petit Manan Island, like Seguin, lies but a short distance off the mainland, and is the most northern and eastern station of the series.

COMPARISON OF THE STATIONS WITH RESPECT TO TEMPERATURE.

As explained elsewhere, the stations do not all afford temperature observations of equal value on account of differences in the nature of their surroundings. Many of the stations included in this report do not, therefore, furnish correct data with respect to the open waters of the coast, but the character of the surface observations may be more or less accurately determined by a study of their relations to the air temperatures. The light-ships, being all located off shore in depths exceeding 5 fathoms, are naturally best adapted for the taking of ocean temperatures, while next in order of excellence, as a rule, are the light-houses situated on small islands and reefs, more or less distant from the mainland. The records for January and February at nearly all the stations north of Cape Hatteras have not been used, on account of the manifest errors of observation sometimes made during extremely cold weather, by not reading the thermometer quickly enough after it has been withdrawn from the water. These errors do not appear to extend much into either December or March, although at some stations the records for those months may show too low a range of temperature by a very small amount. However, the winter surface temperatures are not of much importance in connection with any fishery problem north of Cape Hatteras.

At the extreme south we recognize a group of stations which differ from all the others in the conditions of temperature. It includes only the three light-houses of the Florida Reefs, bordering the Gulf Stream. At Carysfort Reef and Fowey Rocks the curves of surface temperature are more regular than at the Tortugas and correspond less closely with the air curves, indicating fewer local influences or more open exposures at the places of observation. The three succeeding light-ships, Martin's Industry, Rattlesnake Shoal, and Frying Pan Shoals, afford more or less uniform results, the plottings forming much more pronounced curves than at the Florida Reefs; the surface curves are most regular at the first mentioned light-ship. Cape Lookout is a shore station at which the irregularities in the air curves are almost exactly repeated in the surface curves, although the maximum surface temperature is no higher than at Frying Pan Shoals light-ship. At Body's Island, another station on the mainland, both the air and surface curves indicate extreme fluctuations in temperature, which are almost precisely alike for both the air and surface. The surface lines at Winter Quarter Shoal and Five-Fathom Bank light-ships correspond closely in their general curvature, and also in many of their details. At Absecon Inlet, the third shore station, the water curves are more regular than at either Cape Lookout or Body's Island, but the maximum temperature is the same for both the air and water. The surface curves differ considerably from those of the air at Sandy Hook light-ship, and at Fire Island and Block Island the results are much more satisfactory than at any of the other shore stations, in both cases the maximum surface temperatures being about 8°.5 lower than the maximum air temperatures. At the three succeeding light-ships, Brenton's Reef, Vineyard Sound, and Nantucket New South Shoal, the surface curves are all comparatively regular; but at Pollock Rip light-ship, they present many irregularities which do not, in all cases, correspond with those of the air. The fluctuations of temperature are still greater at Thatcher's Island, where the observations were taken in a sheltered position in shallow water. Of the islands in the northern part of the Gulf of Maine, the most regular and uniform series of surface curves are presented by Matinicus Rock, Seguin Island affording the next best series in that respect. At the three other stations the surface curves are less regular, especially from 1881 to 1883, inclusive, but the irregularities do not appear to be due, in most cases, to atmospheric influence.

THE FLORIDA REEFS.—Excluding the observations for the Tortugas, the extreme range of surface temperature at the Florida Reefs is 16°.5, with a maximum of 86°.5. The maximum at the Tortugas is about the same, but the minimum is 5° lower. The air temperature presents a range of 18° to 21°.5, the air maximum being about the same as the surface maximum at Fowey Rocks, 2°.5 higher at the Tortugas, and 2°.5 lower at Carysfort Reef. At none of the other stations along the coast do we find nearly so short a range either of surface or air temperature, and these are the only stations that are situated directly within the influence of the Gulf Stream.

SOUTH CAROLINA TO VIRGINIA.—At the light-ships of Martin's Industry Shoal and Rattlesnake Shoal, the range of air temperature is 41°, the surface range 38°, the maximum for the air being 86°.5, the maximum for the water 85°, or about 1°.5 lower than at the Florida Reefs. The greater range of temperature at these two light-ships, and at the stations immediately following them toward the north is due to the much lower temperatures of winter, amounting to over 20°, the differences in the maximums being slight. At Frying Pan Shoals light-ship, the maximums of both air and surface temperatures are slightly lower, the air range being the same as at Rattlesnake Shoal, the surface range only 33°, with a maximum of 82°.5. The records for Cape Lookout and Body's Island, show approximately the same range for both air and surface temperature at each, amounting to about 42° at the former station, and 64° at the latter.

VIRGINIA TO NEW YORK.—North of Chesapeake Bay the maximums of surface temperature are much lower than to the south, reaching 76°.5 at Winter Quarter Shoal light-ship, and about the same at Five-Fathom Bank light-ship. This is 6° lower than at Frying Pan Shoals, the first light-ship south of Cape Hatteras, and about 9° lower than at Rattlesnake Shoal and Martin's Industry light-ships. At the northern stations, beginning with Winter Quarter Shoal light-ship, the temperature plottings for January and February have been omitted in most cases, and the ranges of temperature, where given, are, unless otherwise stated, for only ten months. At Absecon Inlet, on the mainland, the surface maximum is about 3° higher (79°.5) than at the two preceding light-ships, and agrees with the air maximum; at Sandy Hook light-ship the surface maximum is 1½° to 2° lower than at Five-Fathom Bank and Winter Quarter Shoal, and 7° lower than the air maximum at the same place; at Fire Island the surface maximum is 8° lower than the air maximum, and about the same as the surface maximum at Sandy Hook, showing more satisfactory observations than at any of the previous shore stations.

BLOCK ISLAND TO CAPE COD.—The surface maximum at Block Island is 8°.5 lower than the air maximum, and only 1°.5 higher (70°.5) than at the nearest light-ship, which is about 18 miles distant. Brenton's Reef and Vineyard Sound light-ships afford closely corresponding results, the maximum of both air and surface temperature being slightly lower at the latter station. The surface maximum at Brenton's Reef is 69°, being 5°.5 lower than at Sandy Hook, 7°.5 lower than at Winter Quarter Shoal, 16° lower than at Martin's Industry, and 17°.5 lower than at the Florida Reefs, the maximum for Brenton's Reef being a little lower than the minimum for the Florida Reefs. At Nantucket New South Shoal, and Pollock Rip light-ships, the maximums of surface temperature are approximately the same, about 62°, and the range of temperature is but slightly less at the former station; the air maximum is 3° higher at Nantucket than at Pollock Rip. The surface maximum is the same at these two light-ships as at Boon Island, in the Gulf of Maine, which has also approximately the same range, 29° for 10 months. This range is much shorter than at Vineyard Sound light-ship and preceding stations, while the air range remains about the same. The surface curves at Nantucket New South Shoal and Pollock Rip are, therefore, straighter in comparison with the air curves than at the more western stations, and this same feature will also be found characteristic of the stations in the Gulf of Maine.

GULF OF MAINE.—Considerable differences occur in the maximums of both air and surface temperatures at the several stations in the Gulf of Maine. Aside from Thatcher's Island, the highest air maximum is 75°.5, at Mount Desert Rock, the lowest 65°, at Matinicus Rock; the highest water maximum is 62°, at Boon Island, the lowest 54°, at Matinicus Rock. As to the surface curves, *Boon Island agrees most closely with Pollock Rip and Nantucket New South Shoal, while* Matinicus Rock and Mount Desert Rock afford the lowest surface maximums of any of the stations on the entire coast.

Table showing the minimum and maximum temperatures of the air and surface water, and the ranges of air and surface temperature at the light-house stations, for the five years from 1881 to 1885, inclusive.

Stations.*	Period.	Air temperature.			Surface temperature.		
		Minimum.	Maximum.	Range.	Minimum.	Maximum.	Range.
		° F.	° F.	° F.	° F.	° F.	° F.
Petit Manan Island, Me	March 1 to January 1.	20	70	50	31	58.5	27.5
Mount Desert Rock, Me	do	25.5	75.5	50	33	54.5	21.5
Matinicus Rock, Me	do	23	65	42	32.5	54	21.5
Seguin Island, Me	do	24	70.5	46.5	33	58	25
Boon Island, Me	do	22.5	73.5	51	33	62	29
Thatcher's Island, Mass	Entire year	30	78.5	48.5	35	67	32
Pollock Rip, Mass	March 1 to January 1.	27	66	39	32	62.5	30.5
Nantucket N. S. Shoal, Mass	Entire year	26	69	43	33.5	62	28.5
Vineyard Sound, Mass	March 1 to January 1.	28.5	71.5	43	31	68	37
Brenton's Reef, R. I	do	29	74.5	45.5	34	69	35
Block Island, R. I	do	22	79	57	29.5	70.5	41
Fire Island, N. Y	do	35	83.5	48.5	35	75	40
Sandy Hook, N. Y	do	31.5	81.5	50	33	74.5	41.5
Absecon Inlet, N. J	do	33	79.5	46.5	34.5	79.5	45
Five-Fathom Bank, N. J	do	36.5	83.5	47	37	76	39
Winter Quarter Shoal, Va	do	33	81	48	35.5	76.5	41
Body's Island, N. C	Entire year	27	91	64	28	91	63
Cape Lookout, N. C	do	43	84	41	42	84	42
Frying Pan Shoals, N. C	do	44	85	41	49.5	82.5	33
Rattlesnake Shoal, S. C	do	45.5	86.5	41	47	85	38
Martin's Industry, S. C	do	45	86.5	41.5	47	85	38
Fowey Rocks, Fla	do	68	86	18	70	86.5	16.5
Carysfort Reef, Fla	do	65.5	84	18.5	71.5	86.5	15
Tortugas, Fla	do	67	88.5	21.5	65.5	86	20.5

* The names of light-ships are printed in italics.

RELATIONS OF THE TEMPERATURE CURVES.

A comparison of the temperature curves for corresponding years at successive stations shows great uniformity in their relative positions and also in those irregularities which are indicative of more or less rapid changes of temperature. This uniformity often extends to stations that are widely separated or differently situated. Between January 20 and April 10, 1881, there were three separate periods during which the temperature fell below the average for that time of year at the southern stations. These several periods of low temperature are well brought out for both the air and surface by marked deflections in the curves beginning at the Tortugas and extending as far as Body's Island, the most northern station at which the temperature observations have been plotted for January and February. North of Body's Island, the last of these three periods, occurring between March 21 and April 10, can be traced as far as the Gulf of Maine, although at the northern stations the temperature at that time was not always lower than in other years. Again, between November 16 and December 16, 1882, another unusually cold spell is indicated on all the charts from the Tortugas to the Gulf of Maine. Many other indications of conformity between the

temperature curves at different stations will be observed on even a very superficial comparison of the charts. It will also be noticed that, while at the southern stations the temperature curves are generally most regular during the summer months, the reverse is true of the extreme northern ones.

THE SURFACE ISOTHERMS.

The purpose in view in preparing the charts of surface isotherms (Nos. 26 to 31), has been to present the temperature observations on which this report is based, in what appears to be the most convenient form for use in connection with such fishery problems as are suggested by the migrations of surface schooling fishes. If such species as the mackerel are controlled in their movements toward the north by conditions of temperature that are constant for all latitudes, a line drawn upon a chart to indicate their progress with reference to time must agree more or less closely with some line of equal temperature projected from point to point along the same coast. This supposition expresses in a general way the belief of many persons who have studied the migrations of mackerel and other economic fishes, but up to the present time sufficient data have not been collated to render possible the practical application of the principle to those species that live solely in salt water.

The isothermal charts are seven in number; one for each of the five years from 1881 to 1885, inclusive, one representing the means of the same five years, and the final one illustrating the relations of the air and surface isotherms. The annual charts are of most importance for fishery purposes, as, in showing the changes of position of the isothermal lines from year to year, they may possibly serve to explain the causes of the irregularity in the appearance of certain species upon different parts of the eastern coast in different years. A few words of explanation are necessary respecting the construction and contents of these charts.

Although, as elsewhere explained, the temperature results are not of equal value at all the stations, the latter have all been included in the charts, for the reason that it was impossible to determine satisfactorily, excepting in a few cases, which should be excluded. The observations at Cape Lookout, Body's Island and Absecon Inlet evidently do not apply to the open waters of the coast, and the same is probably true to some extent with respect to a few of the other mainland and island stations. The three stations specially referred to have not generally been considered in discussing the isothermal charts. The data for the construction of the charts has been taken from the original temperature records, and not from the reductions to ten-day means, although the latter have been considered in deciding every date used in constructing the isotherms. In determining the dates for each isotherm no observations were considered unless the means of twenty consecutive observations (ten days) equalled or exceeded the temperature of that isotherm, except in a few instances elsewhere explained. The temperature of 40°, for example, might be reached at any station either within the first ten-day period indicated upon the special chart of that station (charts of ten-day means) as having a mean of more than 40°, or in the latter part of the previous ten-day period; but the mean temperature for the ten days following and including the date of the isotherm must not be under 40°. For the isotherms during the period of falling temperature in the last half of the year this order is reversed.

In constructing the charts, the names of the stations have been arranged vertically, in geographical sequence, on the left hand side of the chart. The remainder of the chart is divided into thirteen vertical spaces, each representing one month, that on the extreme right being for the month of January of the year following that to which the chart relates. Each month is further divided by the fainter lines into five equal parts, for convenience in reading the dates. The iso-

thermal lines are constructed for every five degrees of temperature from 40° to 80°, and are carried vertically from station to station, connecting the dates at which the temperatures they represent were reached at each station; the data for each separate station are to be read across the chart from left to right. Two series of isotherms are actually included on each chart, one relating to the period of rising temperatures in the first half of the year, the other to that of falling temperatures in the last half of the year. The space included between any two isotherms of equal value is supposed to represent a period during which the temperature was always equal to or above that indicated by the isotherms. Those portions of the isothermal lines consisting of dashes denote the lack of observations for the stations opposite them. Complete breaks in the lines generally indicate that the temperature did not reach the isotherm at that station during the year, or during the period of either rising or falling temperature.

In explanation of the arrangement, reference may be made to the isothermal chart for 1881 (No. 26). In that year the isotherm of 40° did not extend south of Body's Island, where the temperature reached 40° about the middle of February. At Winter Quarter Shoal the same temperature was reached March 20; at Five-Fathom Bank, April 15; at Absecon Inlet, March 20; at Sandy Hook, April 14; at Fire Island, April 8; at Block Island, April 16. The temperature remained above 40° throughout the rest of the year, and until after January, 1882, at Body's Island, Winter Quarter Shoal, Five-Fathom Bank, and Sandy Hook; until January 2, 1882, at Absecon Inlet; until December 31, at Fire Island; and until January 1, at Block Island. The isotherms of 45°, 50°, 55°, &c., are reached at successively later dates during the period of rising temperature, and at earlier dates during the period of falling temperature, but the intervals between them vary greatly at the different stations.

RANGES OF THE ISOTHERMS.

A detailed comparison of the isothermal charts would tend to confuse rather than to aid reference to them, and our remarks on the subject will be limited to a few statements respecting the range and general position of the isotherms.

The isotherms of 40° and 45° are generally co-extensive in their range. They always reach as far north as Petit Manan, and frequently as far south as Body's Island, but may stop at either Winter Quarter Shoal or Five-Fathom Bank; in 1882, the isotherm of 40° extended south only as far as Absecon Inlet. The isotherm of 50° begins at the north at Petit Manan, and at the south may terminate at Cape Lookout or Martin's Industry. The isotherms of 55° to 70°, inclusive, always reach south to Martin's Industry, but no farther; while those of 75° and 80° are the only ones ranging along the Florida Reef stations to the Tortugas. A temperature of 55° is often recorded at Petit Manan, but seldom at the next two stations to the westward—Mount Desert Rock and Matinicus Rock. South of here the isotherm of 55° is generally continuous. The temperature usually reaches 60° at Boon Island and Thatcher's Island (although at the latter station observations are wanting for 1884 and 1885), but during some years remains lower than this at Pollock Rip and Nantucket New South Shoal. The isotherm of 65° generally extends northward to Vineyard Sound, but in 1884 it began at Brenton's Reef; that of 70° extends north to Fire Island or Block Island. Absecon Inlet is the northern limit of the isotherm of 75°, which in some years, however, does not reach north of Body's Island or Cape Lookout. The isotherm of 80° does not pass north of Body's Island.

CHANGES IN POSITION OF THE ISOTHERMS IN DIFFERENT YEARS.

During the five years represented by the charts there is considerable change in the positions of the isotherms of equal value from year to year, frequently amounting to a month in time, and

occasionally to much more. The differences are greater at some stations than at others, and are seldom nearly the same at any station for two or more isotherms of different values. At Nantucket New South Shoal, for example, the isotherms of 40° for five years, during the periods of rising temperature, all appeared within four days of the same date, while those of 45° are distributed over a period of about eighteen days. At the next station to the north—Pollock Rip—the isotherms of 40° cover a period of over forty days, and those of 45°, a period of twenty-four days. At Petit Manan the isotherms of 40° and 45° are remarkably constant in position from year to year. The isotherms of 45° and 50° appear to be the most uniform in that respect for their entire range during the five years; but no two isotherms of equal value retain the same relative positions throughout their range. There may be comparative regularity with respect to several consecutive stations, but they generally cross one another one or more times, and while the isotherm of 40° for 1881 precedes that of 40° for 1882, between Mount Desert and Pollock Rip, at the more southern stations the reverse is true. The differences and irregularities in the positions of the yearly isotherms are so great that no definite laws respecting their relations over an extended range of coast can be deduced from the materials used in the preparation of this report.

GENERAL POSITIONS OF THE ISOTHERMS.

FORTY DEGREES.—The five isotherms of 40° (1881-'85), during the period of rising temperature in the spring, pass from Winter Quarter Shoal to Fire Island in March and the first half of April, from Block Island to Pollock Rip mostly in April, and reach the Gulf of Maine in the latter part of April or first half of May. At Petit Manan this temperature appears with great regularity about the middle of April. During the period of falling temperature, the isotherms of 40° are confined for the most part to the month of December, although they sometimes extend into January of the following year, and, as a whole, are more nearly vertical in their direction than those of the first half of the year.

FORTY-FIVE DEGREES.—From Winter Quarter Shoal to Fire Island the isotherms of 45°, during the period of rising temperature, fall mostly within the month of April, but during two years at Absecon Inlet, and one year at Winter Quarter Shoal, that temperature first appeared in the last half of March. From Block Island northward the same isotherms extend, in a general way, obliquely across the month of May into the first part of June at Matinicus Rock and Mount Desert Rock; they reach Petit Manan in the last of April or first part of May, or earlier than at any other station in the Gulf of Maine. During the period of falling temperature, the isotherms of 45° in the Gulf of Maine are mostly confined to the month of November, and farther south to the last part of November and December.

FIFTY DEGREES.—On the coast of South Carolina, the isotherms of 50° occur in January and February, during the rise of temperature; at Winter Quarter Shoal not until May, and at Absecon Inlet in the last part of April and first half of May. From this point they extend obliquely across the months of May and June, reaching Nantucket New South Shoal in the first part of June, Matinicus Rock in July, Mount Desert Rock between May 24 and July 12, and Petit Manan between June 8 and July 10. The same irregularities in the positions of the isotherms occur during the period of falling temperature in the Gulf of Maine, where they cover a period extending from September 10 to November 26. From Pollock Rip to Absecon Inlet the same isotherms are mostly limited to the month of November, and from Five-Fathom Bank to Martin's Industry they extend from the last of November into the first part of January.

FIFTY-FIVE DEGREES.—None of the isotherms of 55° can be plotted continuously east of Seguin Island, although at Petit Manan this temperature was recorded during all the four years

from 1882 to 1885, inclusive, and at Mount Desert Rock, during short periods in 1881 and 1883. South of Cape Lookout, the isotherms of 55°, during the season of rising temperature, occupy very different positions every year, ranging from January 1 to April 1. From Winter Quarter Shoal to Fire Island, they occur mostly between the 10th and last of May, from Block Island to Nantucket New South Shoal in June, and farther north in the last part of June or in July. During the period of falling temperature, they occur in the last part of August, September, or the first part of October, at Seguin Island, and in December or January on the coast of South Carolina.

SIXTY DEGREES.—The isotherms of 60° for 1885, are the only ones that extend northward continuously to Boon Island, the isotherms of that temperature during other years generally stopping at Nantucket New South Shoal. On the coast of South Carolina these isotherms are confined to March and April; from Winter Quarter Shoal to Fire Island, they occur during the last of May and first half of June; from Block Island to Vineyard Sound, in June; and at Nantucket New South Shoal, between July 14 and August 28. During falling temperature they appear at Nantucket New South Shoal between August 14 and October 1, and reach Martin's Industry between November 26 and December 18.

SIXTY-FIVE DEGREES.—The isotherms of 65°, during rising temperature, occur in April at Martin's Industry and Rattlesnake Shoal, in the first part of May at Frying Pan Shoals, but at Winter Quarter Shoal not until the middle of June or first part of July. Between Five-Fathom Bank and Fire Island they appear mostly in June, at Block Island in July, and at Brenton's Reef and Vineyard Sound in the last part of June and in July. During falling temperature, they occur at Vineyard Sound in August; at Block Island are exceedingly variable in position, ranging from August 8 to the last of September; and on the coast of South Carolina are mainly confined to the month of November.

SEVENTY DEGREES.—The isotherms of 70° sometimes extend to Block Island, but generally terminate at Fire Island. South of Cape Hatteras they are almost entirely confined to the month of May. From Winter Quarter Shoal northward they are exceedingly variable in position from year to year, during the periods of both rising and falling temperature, their extreme range in time in the former period being from June 18 to August 18, and in the latter from July 23 to October 14.

SEVENTY-FIVE DEGREES.—The isotherms of 75° are difficult to plot at the Florida Reefs on account of the frequent fluctuations in temperature, which generally occur between November and the following May. During those months there were often brief periods of higher temperature than 75°, which it was impossible to represent in connection with the isotherms, but they are all shown on the special charts of the three Florida stations. At Carysfort Reef and Fowey Rocks the isotherm of 75° may appear as late as the 18th of April, during rising temperature, and as early as the 24th of November during falling temperature. At Martin's Industry, during the period of rising temperature, they occur mostly in the extreme latter part of May and at Frying Pan Shoals in the first part of June. From Winter Quarter Shoal northward to Absecon, these isotherms, when they appear, are mainly confined to the last part of July and August.

EIGHTY DEGREES.—The period of higher temperature than 80° is shorter at the Tortugas than at the more northern stations of the Florida Reefs, and the isotherms of 80° of both series bend inward upon the chart at that place. At Carysfort Reef and Fowey Rocks these isotherms, on the rising temperature, were distributed, during the five years, between the 10th and the very last of May; at Martin's Industry and Rattlesnake Shoal between the 12th and last of June; and at Frying Pan Shoals between the 1st and middle of July. During the period of falling temperature they occupy a wider range in time, and extend obliquely from Frying Pan Shoals to Carysfort

Reef, at the former station occurring between August 1 and September 20, and at the latter between October 20 and December 8.

EIGHTY-FIVE DEGREES.—The surface waters seldom reach a temperature of 85° excepting for short periods at the extreme south, and it has been impossible to construct isotherms for more than one year at Martin's Industry and the Florida Reef stations. Temperatures of 85° and over were recorded between the 8th and last of July, 1881, at Rattlesnake Shoal, Fowey Rocks, and the Tortugas; between the first part of July and the last of August, 1883, at Carysfort Reef and Fowey Rocks; and in 1885, from August 2 to 26, at Martin's Industry, from July 29 to September 28, at Fowey Rocks, and from July 9 to September 25, at Carysfort Reef.

NINETY DEGREES.—A surface temperature of 90° was occasionally recorded at some of the extreme southern stations, but never for more than a day or two at a time.

MEAN ISOTHERMS BASED UPON FIVE YEARS' OBSERVATIONS.

In constructing chart No. 31, it was impossible, in all cases, to obtain the reductions of five years' observations, on account of occasional breaks in the records, but the number of years plotted is never less than three and generally more than four. The exact number in each instance may be determined by reference to the annual isothermal charts (Nos. 26–30).

On this chart the surface isotherms are represented as being much more regular and more uniformly distributed with reference to time than on any of the yearly charts. On the left-hand side of the chart, north of Body's Island, there is a wide area of low temperatures, bounded by the isotherms of 40°. From Winter Quarter Shoal to Fire Island, inclusive, this area represents a period of about seventy-five to one hundred days, being shortest at Five-Fathom Bank, and longest at Sandy Hook; from Block Island northward the length of this period varies from one hundred to one hundred and thirty-five days, being shortest at Brenton's Reef and longest at Boon Island. A narrower space of maximum temperatures extends vertically through the center of the chart, occupying principally the month of August, which is not crossed by any of the isotherms, although a few of them extend a short distance into it. The length of time elapsing between successive isotherms is generally from about twelve to twenty-four days, seldom less but often more. The isotherms are more numerous and follow one another more rapidly at the intermediate stations of the series than at the northern and southern stations; toward the north and south they diverge somewhat and become more widely separated. This naturally results from the fact that at the intermediate stations there is a much greater range of temperature (above a minimum of 40°) than at the northern and southern ones. In the eastern part of the Gulf of Maine there are only three continuous isotherms of the value of those plotted (40° to 50°, inclusive); in the western part four such isotherms (40° to 55°, inclusive). On the southern coast of New England there are five isotherms at Nantucket New South Shoal (40° to 60°, inclusive), and six from Vineyard Sound to Block Island (40° to 65°, inclusive); seven extend from Fire Island to Body's Island (40° to 70°, inclusive); four occur on the coast of South Carolina (55° to 70°, inclusive), and two at the Florida Reefs (75° to 80°, inclusive, and sometimes 85°).

North of Body's Island the isotherms of both series extend in a slightly oblique direction trending inward toward the north. At Cape Hatteras they bend abruptly, and the same isotherms appear much earlier in the year to the south of that important cape.

At Frying Pan Shoals, the first reliable station south of Hatteras, the isotherm of 55° appears about ninety days earlier than at Winter Quarter Shoal; the isotherm of 60° about sixty days earlier; the isotherm of 65° about fifty days earlier; and the isotherm of 70° also about fifty days earlier.

The isotherms of 75° and 80° also bend abruptly between South Carolina and the Florida Reefs, that of 75° occurring at Fowey Rocks about sixty days in advance of Martin's Industry, and that of 80° about twenty-six days in advance.

RELATIONS OF THE AIR AND SURFACE ISOTHERMS.

As stated in the explanation of Chart No. 32, there appears to be no constant relation between the air and surface isotherms at any of the light-house stations. During the periods of both rising and falling temperature, *the air temperature of any degree, as a rule, precedes the surface temperature* of the same degree, but the length of time intervening may vary from two or three days to over a month.

THE WIND RECORDS.

Very complete records respecting the direction of the winds were kept at all the stations excepting Thatcher's Island, the observations being taken twice each day, at the same time as the temperatures. The wind records are even more complete than are those for surface temperature, having fewer breaks at any of the stations; and as temperature is greatly influenced by the wind, it has been thought advisable to present in this connection a tabulation of the observations made. In this table (p. 176) the means of five years' observations for each month are arranged according to quadrants of the compass, beginning with the northeast quadrant. Northerly winds have been included in the same quadrant with northwesterly winds, to which they appear to be most nearly related in their effects upon temperature. The extent of the several quadrants is, therefore, as follows: *Northeast*, from NNE. to E., inclusive; *southeast* from ESE. to S., inclusive; *southwest* from SSW. to W., inclusive; *northwest* from WNW. to N., inclusive.

The general arrangement of the table scarcely requires an explanation. The data respecting the several stations are classified by quadrants under each month, and that for each station extends from left to right across the table. In the columns of figures, each one-tenth of a unit represents one observation, and each unit ten observations, extending through five years, the latter being equivalent to one day's observations for five years. The time ratio for each quadrant is, therefore, represented by days and fractions of a day. For example, at the Tortugas station in January, which has thirty-one days, the northeast quadrant shows a mean record of 14.9 days; the southeast of 7.2 days; the southwest of 2 days, and the northwest of 5.9 days, making a total of thirty days. The discrepancy of one day results from calms and variable winds. The terms used by the observers to express the velocity of the winds not being uniform at the different stations, it has been impossible to tabulate them.

At the Florida Reef stations northeasterly and southeasterly winds prevailed throughout the entire year, the records for the northwest and southwest quadrants being relatively small during nearly every month. Northeasterly winds predominated at the Tortugas during every month excepting June, in which the prevailing winds were southeasterly, and they afford an exceedingly high record during October, November, and December. The records for Carysfort Reef and Fowey Rocks, which are situated only about 23 miles apart, present some, though not considerable differences. At the former station northeasterly winds prevailed during February, May, September, October, and November; at the latter, during September, October, November, and December; the prevailing winds for the same stations during the other months being southeasterly. Northwesterly winds very rarely occur at the Florida Reefs during the summer months, and in only one instance did they exceed a mean of eight days during the winter months, that being at Carysfort Reef in December. Continuous winds from the north and northwest cause a marked reduction in

the temperature, as is strikingly illustrated in the chart for the Tortugas during March, 1881, and November and December, 1882. The same conditions of temperature prevailed to some extent at Carysfort Reef and Fowey Rocks during the same periods, but northwesterly winds were far less prevalent at those stations during 1881 and 1882 than at the Tortugas. This subject is further discussed in the explanations of the charts for the three Florida stations.

Passing northward from the Florida Reefs, the prevailing winds gradually change from northeasterly and southeasterly to northwesterly and southwesterly. From Martin's Industry Shoal, South Carolina, to Cape Lookout, North Carolina, northeasterly winds generally prevailed during January, February, April, May, August, September, October, November, and December; and southwesterly winds during March, June, and July. A few slight exceptions to this rule are presented by some of these stations, and the wind records for two or even three quadrants are sometimes nearly alike during the same month. Northwesterly winds are no more common than at the Florida Reefs.

Body's Island, North Carolina, and Winter Quarter Shoal, Virginia, occupy an intermediate position between the southern and northern stations with respect to the winds as well as geographically. Northeasterly winds are less prevalent and northwesterly winds more common, especially during the colder months. At Five-Fathom Bank, New Jersey, northeasterly winds prevailed only during October, but they also furnished a relatively high record during May, August, and September. The prevailing winds at that station for January, February, March, April, November, and December were northwesterly; for May, June, July, August, and September, southwesterly. At Absecon Inlet, New Jersey, northeasterly and southeasterly winds prevailed from April to October, inclusive, and northwesterly winds during the other months. North of this station, northeasterly winds rarely prevailed during any month, but northeasterly and southeasterly winds are of much more frequent occurrence at the northern stations than are northwesterly and southwesterly winds at the extreme southern ones. Northwesterly winds generally prevailed from November to April, and southwesterly from April to November, but there are numerous exceptions to this rule, and at some of the stations southwesterly winds continued to be the prevalent ones through November and December. At Boon Island and Petit Manan, in the Gulf of Maine, southeasterly winds predominated during most of the summer months, and the record of winds from the northeast quadrant is very high at Boon Island, as also at some of the other stations on the coasts of Massachusetts and Maine.

*Table showing the direction of the winds, by quadrants, for each month of the year, at the light-house temperature stations on the eastern coast of the United States, being the means of five years' observations, from 1881 to 1885, inclusive.**

Stations.	January.				February.				March.				April.			
	NE.	SE.	SW.	NW.	NE.	SE.	SW.	NW.	NE.	SE.	SW.	NW.	NE.	SE.	SW.	NW.
Petit Manan, Me	5.5	3.6	9.5	12.4	5	6	7.3	9.9	8.6	6	9.2	7.2	6.8	5.7	10.7	6.8
Mt. Desert Rock, Me	4.9	4.5	8.5	12.9	5.6	4.9	8	9.4	7.2	6.8	7.1	9.6	5.4	5.3	10.1	7
Matinicus Rock, Me	5.7	4.8	9.1	12.9	4.6	4.9	6.4	11.7	5.3	4.8	7.4	13.5	6.3	4.8	8	7.9
Seguin Island, Me	7.4	2.1	9.5	11.6	7.6	3.1	7.8	8.8	9	4.3	8	9.2	6.5	5.4	8.6	8.6
Boon Island, Me	7.8	3.2	9	10.9	9	3.6	7.2	6.4	9.3	5.9	5.5	10.5	9.1	8.8	3.9	8
Pollock Rip, Mass	4.5	5.3	7.7	13.4	5.4	3.9	8	10.7	5.7	4.1	10	10.7	6.6	4.1	10.5	7.6
Nantucket N. S. Shoal	4.8	4.4	7.1	13.7	4.1	4.2	5.7	12.6	5	4.5	5.8	13.8	7.3	3.6	8.2	8.8
Vineyard Sound light-ship, Mass	5.8	2.4	8.6	13.8	6.5	4.5	5.3	10.2	6.3	4.3	7.8	11.7	6.9	3.6	10.7	6.8
Brenton's Reef, R. I	4	3	8.7	14	5	3.3	6.3	12.1	5.5	4.4	6.4	13.2	6.2	4.6	9.6	8.5
Block Island, R. I	6.7	4.3	7.5	12.5	4.8	4.2	6.2	8.8	8.1	2.3	8.2	11.7	8.7	3.5	11	6.8
Fire Island, N. Y	5.8	1.7	7.3	11.6	4.6	4.2	6.4	9.6	5.3	3.8	6.6	10.9	4.5	4.6	8.9	7.6
Sandy Hook light-ship, N. Y	7	3	4.9	15.6	6.7	3.1	3.7	12.6	6	4.6	3.8	16	5.3	5.5	5.7	11.5
Absecon Inlet, N. J	5.2	2.8	6.9	16	7.2	2.8	5.3	12.9	7.8	4.3	6.2	12.7	9.7	6.7	4.9	8.5
Five-Fathom Bank, N. J	*5.2*	*1.8*	*7.8*	*14.4*	*6.1*	*2.9*	*6.3*	*11.5*	*6.9*	*3.7*	*6.8*	*13.4*	*6.8*	*5.2*	*6.6*	*8.9*
Winter Quarter Shoal, Va	9.5	2.7	8.6	8.9	7.7	4	7.8	7.9	8.1	5.3	6.8	9.9	9.4	5.7	6.9	6
Body's Island, N. C	8.4	3.5	10	9.1	8.2	5.3	6.4	7.5	9.6	5.1	8.9	7.4	12.9	6	6.7	5.2
Cape Lookout, N. C	11.5	2.9	7.5	7.7	10.2	2.7	9	4.6	8.6	3.9	10	6.8	10.8	3.2	8	4
Frying Pan Shoals, N. C	13.5	2.2	9.6	5	11.3	4.5	8.4	3.9	11	2.5	10.8	5.7	11.2	2	11.2	3.9
Rattlesnake Shoal, S. C	12.1	3	8.5	5.2	11.1	5.8	6.6	3.1	7	5.8	13.3	3.9	9.9	6.9	10	2.6
Martin's Industry Shoal, S. C	12	4.4	6.9	5.2	10.3	5.5	6.2	3.9	7.6	7.1	10.3	5.5	9.8	7.8	7.1	4.4
Fowey Rocks, Fla	11.6	13.1	2.9	3.3	9.1	10.3	2.3	5.9	8.9	10.5	4.2	6.8	9	12.1	4.5	3.7
Carysfort Reef, Fla	*8.4*	*15*	*2.6*	*4.8*	*11*	*7*	*2.2*	*8*	*8.6*	*11.9*	*4.5*	*5.4*	*8.2*	*12.8*	*3.6*	*5.4*
Tortugas, Fla	14.9	7.2	2	5.9	15.1	7	1.1	4.4	13.4	8.4	2.2	5.6	11.6	10.2	1.8	6

Stations.	May.				June.				July.				August.			
	NE.	SE.	SW.	NW.	NE.	SE.	SW.	NW.	NE.	SE.	SW.	NW.	NE.	SE.	SW.	NW.
Petit Manan, Me	*8.5*	*10.5*	*8.4*	*3.6*	*3.7*	*11.7*	*11.8*	*3.4*	*3*	*14.8*	*11.4*	*1.8*	*3.8*	*13.6*	*11.3*	*2.3*
Mt. Desert Rock, Me	7.1	8.3	10.9	3	2.5	8.9	13.3	3	1.7	9.9	14.3	2	3	7.3	14	3.1
Matinicus Rock, Me	6.6	9.6	9.2	4.3	2.7	8.5	12.8	4.4	2.4	9.4	13.9	2.9	3.7	7.8	12.9	3.4
Seguin Island, Me	9.3	8.8	9.2	2.9	4.9	6.8	13.8	3.4	3.9	7.4	15.6	3.2	4.9	7.5	14.2	3.4
Boon Island, Me	9.9	13	4.5	3.2	5.3	13.3	5.6	4.8	5.8	12.9	7.7	3.8	7.5	10	10.5	2.6
Pollock Rip, Mass.	9.9	5.1	9.9	4.2	4.3	5.9	14.6	4	4	6	15.8	3.3	6.7	5.7	12.2	3.5
Nantucket N. S. Shoal	9.4	5.1	9.9	4	5.2	3.9	14.8	2.2	4.1	5.4	13	2.1	8.1	4.6	10.5	3.9
Vineyard Sound light-ship, Mass	8.6	6.8	12.3	3	4.3	5.5	16.3	2.9	4.4	5.3	16	3.6	6.3	5.4	14.8	2.1
Brenton's Reef, R. I	7.1	7.6	10.8	4	2.7	6.2	15	3.8	2.8	6	15.5	4	4.6	4.8	15.9	4.1
Block Island, R. I	8.9	5.6	10.7	4.6	5.2	4	16.9	3.7	4.1	3.8	16.7	4.2	6	4	17.6	3.2
Fire Island, N. Y	5	8	8.7	3.9	3.3	4.7	12.7	3.6	3.2	4.7	13.2	4.9	5.3	5.5	12.5	2.1
Sandy Hook light-ship, N. Y	6.4	10.4	4.9	7	3.6	11	7.1	6.7	2.5	9.5	8.3	8.1	6.6	8.3	7.3	7
Absecon Inlet, N. J	10.3	11.2	4.8	4.5	7.9	12.1	6.3	3.5	8.5	10	7.5	4.6	9.8	9.4	6.9	4.6
Five-Fathom Bank, N. J	9	6	10	5	6	7	12.9	3.1	5.5	5.5	14.1	4.2	9.3	5.9	10.5	3.8
Winter Quarter Shoal, Va	11.6	3.6	10.8	1.9	7.5	9.3	9.6	1.8	5.5	5.1	14.1	2.8	12.2	5.4	9.5	2.2
Body's Island, N. C	14.1	5.5	9.1	2.3	10	5	11.5	1.5	9.8	5.7	13.1	1.9	14.7	7	7.9	1.2
Cape Lookout, N. C	12.7	5.2	10.5	1.6	9.2	5.4	13.9	.8	7.3	3.7	17.2	2.1	12.8	3.9	10.7	1.2
Frying Pan Shoals, N. C	8.5	4.1	8.7	2.8	9	3.3	15.2	1	5.8	1.5	21.1	.7	10.9	3.2	11.6	2.2
Rattlesnake Shoal, S. C	10.6	9	8.4	1.6	6.7	8.2	13	1.4	6.4	9	14.3	.8	10.9	8.1	9.3	1.6
Martin's Industry Shoal, S. C	11	9.9	7.1	2.4	7.8	10.6	9.4	1.5	7	7.8	13.5	1.4	10.5	7.5	8.6	2.6
Fowey Rocks, Fla	11.6	11.8	4.4	1.9	5.3	16.9	5.5	1.1	6.8	15.4	6.4	1.3	6.7	16.7	4.4	1.6
Carysfort Reef, Fla	11.6	16.1	6.4	2.8	8.8	17.1	3.2	.8	6.7	17.9	4.9	.9	9.1	17.2	2.8	1.9
Tortugas, Fla	14	8.2	2.4	5.2	9.6	15.6	2.2	2	11.4	10.8	5.2	2	12.8	9.4	3.6	4

* The northeast quadrant includes NNE. to E., inclusive; the southeast, ESE. to S., inclusive; the southwest, SSW. to W., inclusive; the northwest, WNW. to N., inclusive. In the columns of figures, each one-tenth of a unit represents one observation, and each unit ten observations extending through five years, the latter being equivalent to one day's observations for five years. The time ratio for each quadrant is, therefore, represented by days and fractions of a day.

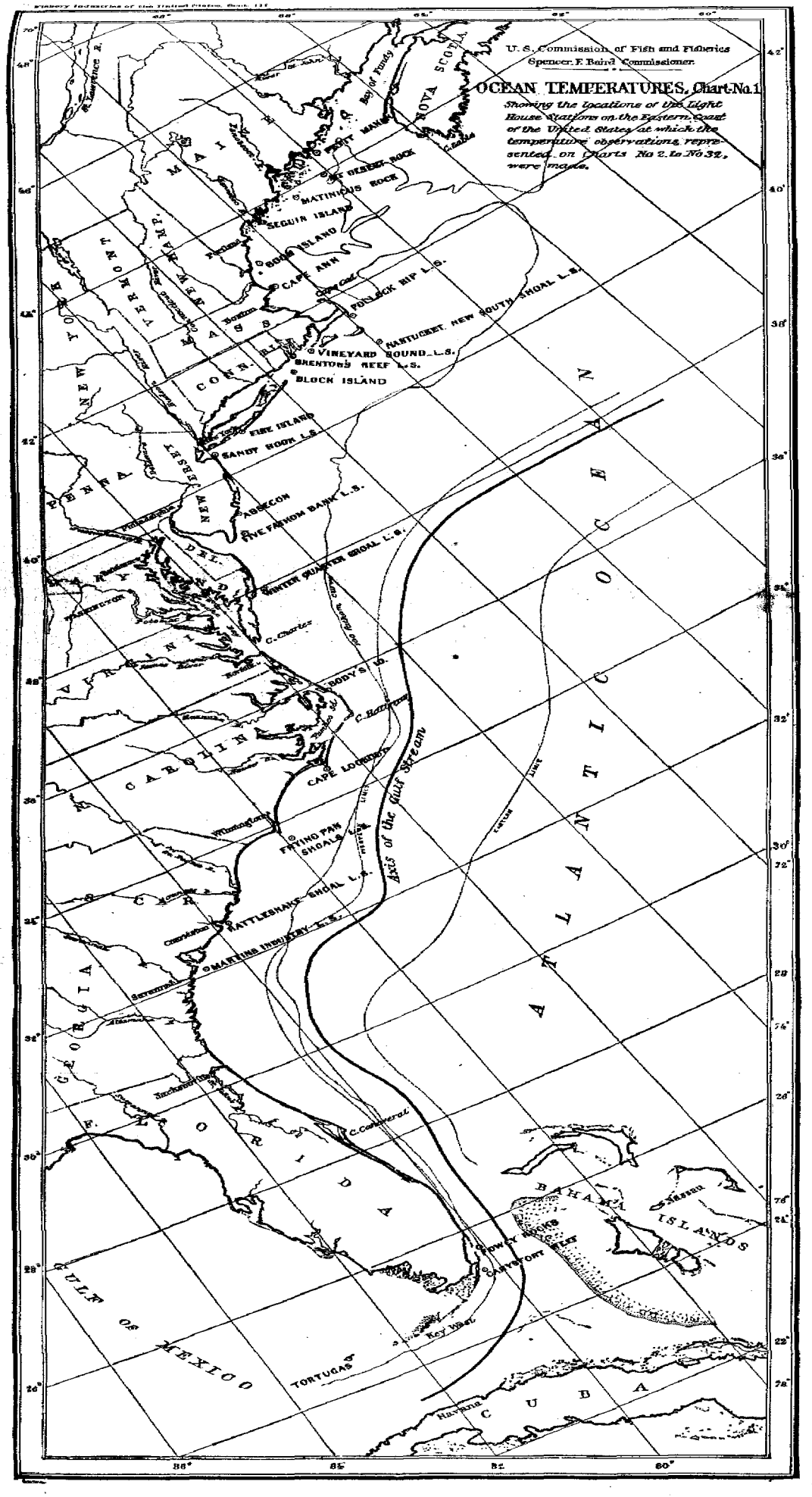

U. S. Commission of Fish and Fisheries
Spencer F. Baird Commissioner.
OCEAN TEMPERATURES, Chart No. 1
Showing the locations of the Light House Stations on the Eastern Coast of the United States at which the temperature observations represented on Charts No 2. to No 32, were made.
NOVA SCOTIA
Bay of Fundy
PETIT MANAN
MT DESERT ROCK
MATINICUS ROCK
SEGUIN ISLAND
BOOM ISLAND
CAPE ANN
POLLOCK RIP L.S.
NANTUCKET NEW SOUTH SHOAL L.S.
VINEYARD SOUND L.S.
BRENTON'S REEF L.S.
BLOCK ISLAND
FIRE ISLAND
SANDY HOOK L.S.
ABSECON
FIVE FATHOM BANK L.S.
WINTER QUARTER SHOAL L.S.
C. Charles
BODY'S I.D.
C. Hatteras
CAPE LOOKOUT
FRYING PAN SHOALS
RATTLESNAKE SHOAL L.S.
MARTINS INDUSTRY L.S.
C. Canaveral
POWEY ROCKS
CARYSFORT REEF
Key West
TORTUGAS
Havana
Nassau
BAHAMA ISLANDS
CUBA
GULF OF MEXICO
ATLANTIC OCEAN
Axis of the Gulf Stream
MAINE
NEW HAMP.
VERMONT
MASS.
CONN.
NEW YORK
NEW JERSEY
PENNA.
DEL.
MARYLAND
VIRGINIA
CAROLINA
S. CAR.
GEORGIA
FLORIDA
Portland
Boston
Philadelphia
Washington
Norfolk
Wilmington
Charleston
Savannah
Jacksonville
Pensacola
St. Lawrence R.
Cape Cod
Cape Sable
Tampico
Pacific Limit
Eastern Limit
70°
68°
66°
64°
62°
60°
48°
46°
44°
42°
40°
38°
36°
34°
32°
30°
28°
26°
24°
22°
78°
76°
74°
72°
70°
68°
66°
64°
62°
60°

Table showing the direction of the winds, by quadrants, for each month of the year, &c.—Continued.

Stations.	September.				October.				November.				December.			
	NE.	SE.	SW.	NW.	NE.	SE.	SW.	NW.	NE.	SE.	SW.	NW.	NE.	SE.	SW.	NW.
Petit Manan, Me	5.5	9.2	10.9	4.3	5.6	8.9	7.4	9.1	6.4	6.3	9.6	7.7	4.3	7.2	7.9	11.6
Mt. Desert Rock, Me	5.5	6.9	10.6	4.1	5.7	7.1	9.8	6.6	6.8	5.7	9.7	7.5	5.3	7.1	8.7	9.6
Matinicus Rock, Me	5.7	6	10.2	5.1	6.1	5.8	10	8.6	6.1	3.7	10.3	9.7	4.5	5.5	8.2	12.3
Seguin Island, Me	7.9	4.7	11.8	4.4	8.6	4.5	11.4	6.1	8.4	1.8	10.1	9	7	2.9	10.7	9.7
Boon Island, Me	10	10.1	6	3.1	11.4	7.3	7.7	4.3	9.7	4.3	9.1	6.8	8.8	4	9.6	8.6
Pollock Rip, Mass	9.4	6.2	8.5	4.5	10.8	4.7	8.3	5.9	6.8	3.1	9.1	10	5.1	4.4	10	10.3
Nantucket N. S. Shoal	10.1	5.3	11.3	3.5	9.3	5.2	9.4	7.6	6.1	2.9	7.2	11.9	4.7	4.6	7.2	13.8
Vineyard Sound light ship, Mass	9.3	4.5	11.3	4.1	10.2	4.1	9.4	6.5	6	1.9	11.1	10.2	5.5	2.3	9.3	13.8
Brenton's Reef, R. I	6	6.3	10.9	4.7	8.1	4.8	9.7	7.1	4.7	2	11	11.6	4.9	2.9	9.4	13.2
Block Island, R. I	9.8	5	11.3	3.9	10.9	4.1	12.1	3.9	5.4	2.7	9.9	9.8	7	3.2	9.7	9.9
Fire Island, N. Y	5.9	4.7	11.5	3.5	7	4.9	7.7	6.9	5.4	1.9	8.3	9.8	7.4	1.8	8.8	8.4
Sandy Hook light-ship, N. Y	7.6	8.8	6.8	5.7	8.6	6.4	5.7	9.5	6	3.9	6.1	13.6	6.5	3.7	5.8	14.6
Absecon Inlet, N. J	10.3	8.2	6.9	4.5	8.6	7.1	6.2	8.7	4.4	4.2	8.9	12.1	3.8	8.9	9.4	13.8
Five-Fathom Bank, N. J	9.4	4.6	11.7	3.8	9	4.2	8.6	7.9	6.3	2.1	9	12.1	4.2	3.2	9.7	12.7
Winter Quarter Shoal, Va	10.6	5.1	10.5	2.8	12	5.3	7.8	4.8	7.5	2.3	9.9	9.8	6.1	4	9.8	9.5
Body's Island, N. C	15.4	6.7	6.8	1.1	15.9	5.	6.2	3.8	8.6	4.4	7.3	9.7	7.5	5.3	9.3	8.6
Cape Lookout, N. C	13.2	6.1	6.5	2.3	13.6	4.2	5.9	6.1	10.2	3.7	4.5	8.9	10.2	4.3	6.6	7.7
Frying Pan Shoals, N. C	13.5	5.1	6.1	1.5	16	4	5.7	3.9	12.5	3.5	4.3	8.3	12	3.2	7.2	7.9
Rattlesnake Shoal, S. C	13.1	10.2	3	2.4	17.7	4.9	4.9	2.7	13.9	4.6	4.6	5.8	11.9	2.4	8.4	5
Martin's Industry Shoal, S. C	15.1	7.1	3.7	3.3	17.8	4.5	4.2	3.8	13.8	3.1	3.9	8.1	10.7	4.1	7.8	6.3
Fowey Rocks, Fla	13.5	9.7	4.4	1.5	17.3	5.7	2.8	4.5	15	7.1	1.4	5.9	12.2	9.2	2.1	6.2
Carysfort Reef, Fla	15.1	8.9	3.6	1.3	16.1	8.1	3.2	3.6	13.7	7.4	2.3	6.4	10.5	11	.7	8.7
Tortugas, Fla	14	10.2	4	1.6	23.2	2.2	2.4	3	21.2	2	.4	6	20	3.3	.2	6.3

EXPLANATION OF OCEAN TEMPERATURE CHART No. 2.

DRY TORTUGAS LIGHT-HOUSE, FLORIDA.

Observer: ROBERT H. THOMPSON.

Location of station.—The Dry Tortugas light-house is built on Loggerhead Key, the westernmost island of the Tortugas Reefs. These reefs are a westerly extension of the Florida Reefs, and are located about 1 degree from Key West. Loggerhead Key is about three-fourths of a mile long, and less than one-fifth as wide. It is situated on the southeasterly side of an elongate bank, bearing the same name, and trending in a northeasterly and southwesterly direction. The bank is about 5 miles long, and has an average width of three-fourths of a mile, inside of the 3-fathom line. The Southwest Channel, with depths of 10 to 12 fathoms, separates Loggerhead Bank from the Bird, Garden and Long Key Bank on the east. Strong tidal currents set through it, running northeast on the flood and southwest on the ebb. The channel between the Tortugas and Cuba is about 90 miles wide and is occupied by the Gulf Stream, the axis of which approaches much nearer the Cuban coast than the Tortugas. The depth of water in this channel exceeds 1,000 fathoms in some places, being greatest in its southern part. The 10-fathom curve passes close by the eastern side of Loggerhead Key, and the 100-fathom curve is distant only about 20 miles to the southward.

Geographical position of the light-house.—Latitude, 24° 38′ 04″ N.; longitude, 82° 55′ 42″ W.

Depth of water.—The depth of water where the observations were taken is 5 feet at mean low tide.

Range of temperature.—Air, 21°.5 (67° to 88°.5); surface, 20°.5 (65°.5 to 86°).

The depth of water where the observations were taken is probably too little, and the locality too much sheltered to afford satisfactory results respecting the temperature of the open waters surrounding the Keys. That such is the case will appear evident on comparing the temperature chart for the Tortugas with those for Carysfort Reef and Fowey Rocks. On the first mentioned, the more direct influence of the air upon the water temperature is made apparent by the manner in which each fluctuation in the curves of air temperature is repeated in the curves of water temperature. At the two more northern stations, although the depths are no greater, the curves of water temperature present fewer angles, probably due to the more open exposure of the places of observation.

The range of temperature given above is for 1881, that year having afforded the greatest extremes in temperature of any plotted. There is comparatively little difference between the air and surface temperatures at any period, and great uniformity in the curves of surface temperature during the summer and early fall months of all the years excepting 1884, in which year both the air and surface temperatures were constantly from 3 to 10 degrees lower between April and the middle of October. The collateral observations fail to explain the cause of this variation, the records for direction and force of the winds showing that essentially the same conditions in those particulars prevailed during 1884 and 1885, though both of those years differed more or less from the three preceding ones.

Between March 21 and April 10, 1881, and between November 26 and December 6, 1882, the temperature of both the air and water fell far below that for the corresponding periods of other years, affording the lowest observations recorded. The cause of these extreme variations, which are so clearly brought out by the curves of temperature on the chart, may be explained by the fact that during those two periods the winds were almost constantly from the north and northwest, and blowing fresh; the prevailing winds for the months in question are generally northeasterly. Low temperatures were recorded during the same periods at Carysfort Reef and Fowey Rocks, the next stations to the north.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	14.0*	15.1	13.4	11.6	14	9.6	11.4	12.8	14	23.2	21.2	20
Southeast	7.2	7	8.4	10.2	8.2	15.6	10.8	9.4	10.2	2.2	2	3.8
Southwest	2	1.1	2.2	1.8	2.4	2.2	5.2	3.6	4	2.4	.4	.2
Northwest	5.9	4.4	5.6	6	5.2	2	2	4	1.6	3	6	6.8

OCEAN TEMPERATURE CHART No. 2

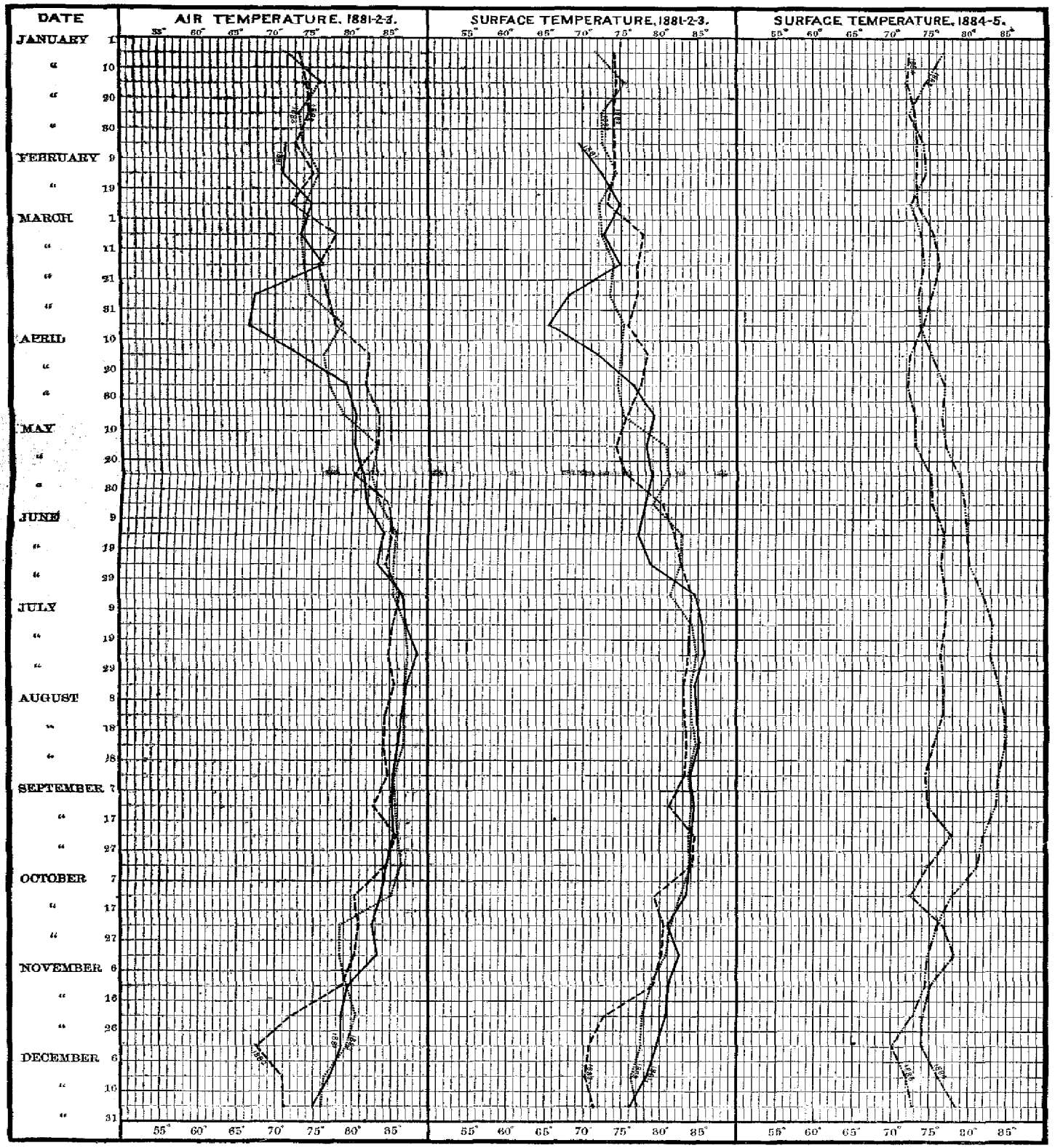
By RICHARD RATHBUN.

Station: Dry Tortugas Light House, Florida.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ... 1883, —·— 1884, —··— 1885.

(ISSUED IN 1886.)



Each vertical interspace represents one degree Fahrenheit, and the fractional parts of a degree are indicated as exactly as possible in the plotting of the curves. Each fifth degree is represented by a slightly heavier line. The transverse interspaces inclosed by the heavier lines represent periods of ten days each, as indicated by the dates on the left-hand side of the plate. The lighter transverse lines, intermediate between the heavier ones, are intended to represent the mean of each ten days, and the curves of temperature are plotted with reference to these lines. The left-hand vertical division is devoted to the air temperatures for 1881, 1882 and 1883, the middle division to the surface water temperatures for the same years, thus permitting of a comparison of the two; and the right-hand division to the water temperatures for 1884 and 1885.

EXPLANATION OF OCEAN TEMPERATURE CHART No. 3.

CARYSFORT REEF LIGHT-HOUSE, FLORIDA.

Observers: EDWARD BELL, F. A. BROST, MARTIN WEATHERFORD.

Location of station.—Carysfort Reef light-house is located on the outer side of Carysfort Reef, in front of Key Largo, and facing the Straits of Florida. It is about 158 miles northeasterly from the Dry Tortugas light-house. The water deepens rapidly from the outer edge of the reef, attaining a depth of 50 fathoms within a distance of about 2 miles. The 100-fathom curve is distant about 7 miles, and the axis of the Gulf Stream about 27 miles.

Geographical position.—Latitude, 25° 13′ 15″ N.; longitude, 80° 12′ 42″ W.

Depth of water.—Three feet.

Range of temperature.—Air, 18°.5 (65°.5 to 84°); surface, 15° (71°.5 to 86°.5).

The temperature is more equable at this station than at the Tortugas, both as regards the air and water. The air temperature is relatively lower throughout the year, the maximum being 4½° lower at Carysfort than at the Tortugas. The curves of surface temperature are more regular, and are very uniform for all the years, apparently indicating that the place at which the observations were taken was well suited for the purpose, although the depth of water was only 3 feet. The maximum surface temperature was practically the same at this station as at the Tortugas, and exceeds the air maximum by 2°.5.

The low temperatures recorded at the Tortugas for March, 1881, and November 26 to December 6, 1882, were also observed at this station, though in a relatively less degree, especially as regards the former period. During the first part of March, 1881, northerly and northwesterly winds prevailed, while during the latter part of the same month the winds were variable. During the ten days ending December 6, 1882, they were mostly from the north and northeast.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	8.4	11	8.6	8.2	11.6	8.8	6.7	9.1	15.1	16.1	13.7	10.5
Southeast	15	7	11.9	12.8	10.1	17.1	17.9	17.2	8.9	8.1	7.4	11
Southwest	2.6	2.2	4.5	3.6	6.4	3.2	4.9	2.3	3.6	3.2	2.3	.7
Northwest	*4.8*	*3*	*5.4*	*5.4*	*2.8*	*.8*	*.9*	*1.9*	*1.3*	*3.6*	*6.4*	*8.7*

OCEAN TEMPERATURE CHART No. 3

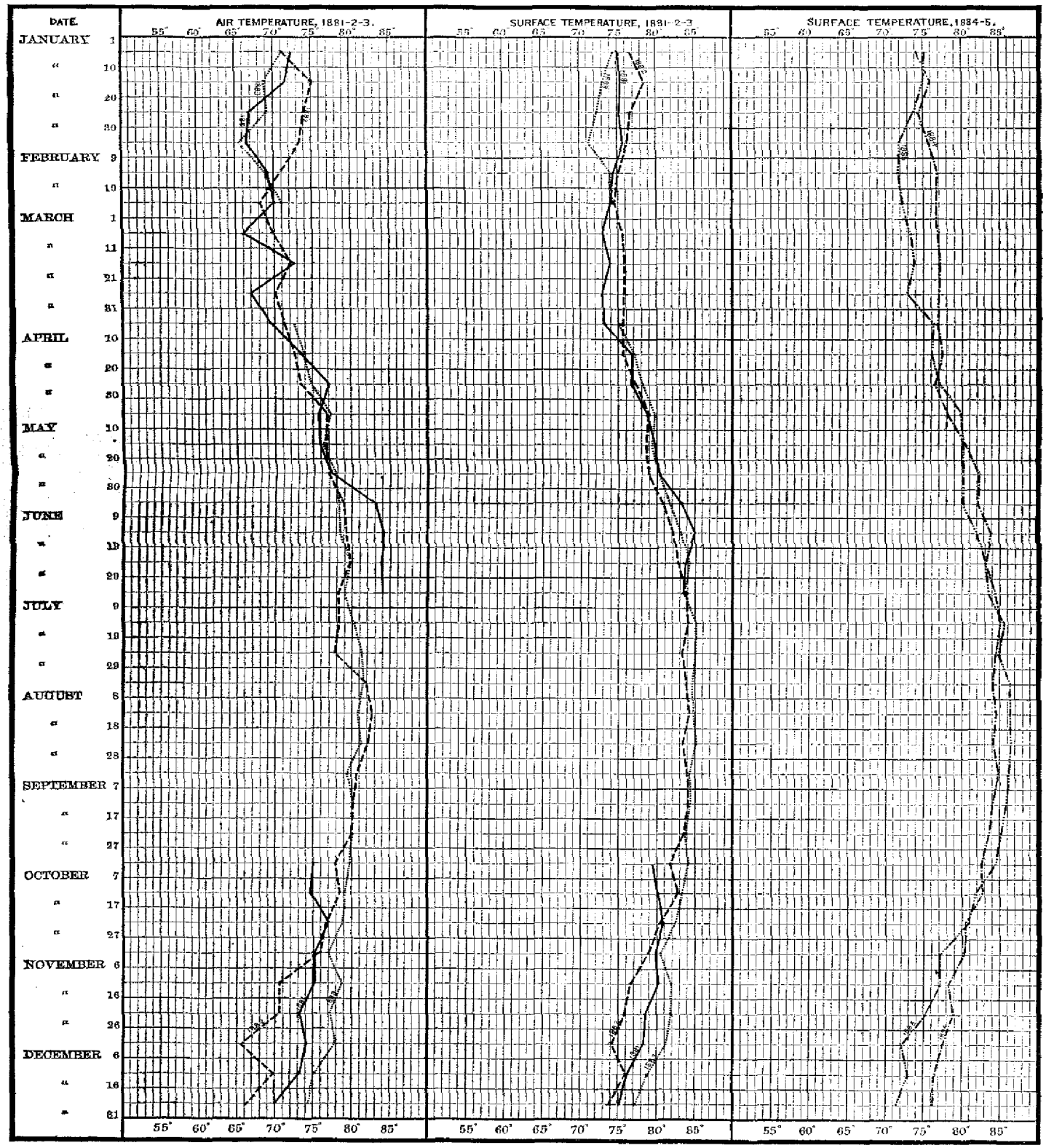
By RICHARD RATHBUN.

Station: Carysfort Reef Light House, Florida.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ... 1883, —.— 1884, —..— 1885.

(Issued in 1886.)



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EXPLANATION OF OCEAN TEMPERATURE CHART No. 4.

FOWEY ROCKS LIGHT-HOUSE, FLORIDA.

Observer: JOHN J. LARNER.

Position.—Fowey Rocks light-house is built on Fowey Rocks, which are located very near the northeastern extremity of the Florida Reefs, about 6 miles southeasterly from Cape Florida, and 23 miles northerly from Carysfort Reef. These rocks are on the western side of the Straits of Florida, in their northern and narrowest portion, sometimes called the Straits of Bemini, the eastern border of which is formed by the northwestern extremity of the Great Bahama Bank. The light-house is situated on the outer edge of the rocks, which lie directly in front of the widest opening to Key Biscayne Bay. Depths of 7 to 16 fathoms occur close to the light; the 100-fathom line is distant only about 2½ miles, and the axis of the Gulf Stream about 24 miles.

Geographical position.—Latitude, 25° 35′ 25″ N.; longitude, 80° 05′ 41″ W.

Depth of water.—Five feet.

Range of temperature.—Air, 18° (68° to 86°); surface, 16°.5 (70° to 86°.5).

There is comparatively little difference between the temperatures at Fowey Rocks and Carysfort Reef, these two stations, located only 23 miles apart, being more closely related than are either of them to the Tortugas. The air temperatures range slightly higher at this station than at Carysfort, but the surface curves correspond very closely throughout each year, the greatest difference at any period being only 2° or 3°. The more prominent irregularities in the surface curves at one station are almost invariably repeated in those of the other at the same period. The angles indicating low temperatures for March, 1881, are more pronounced here than at Carysfort, but those for the last part of 1882 are less marked. The maximum air and surface temperatures at this station are very nearly identical.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	11.6	9.1	8.9	9	11.6	5.3	6.8	6.7	13.5	17.3	15	12.2
Southeast	13.1	10.3	10.5	12.1	11.8	16.9	15.4	16.7	9.7	5.7	7.1	9.2
Southwest	2.9	2.3	4.2	4.5	4.4	5.5	6.4	4.4	4.4	2.8	1.4	2.1
Northwest	3.3	5.9	6.8	3.7	1.9	1.1	1.3	1.6	1.5	4.5	5.9	6.9

OCEAN TEMPERATURE CHART No. 4

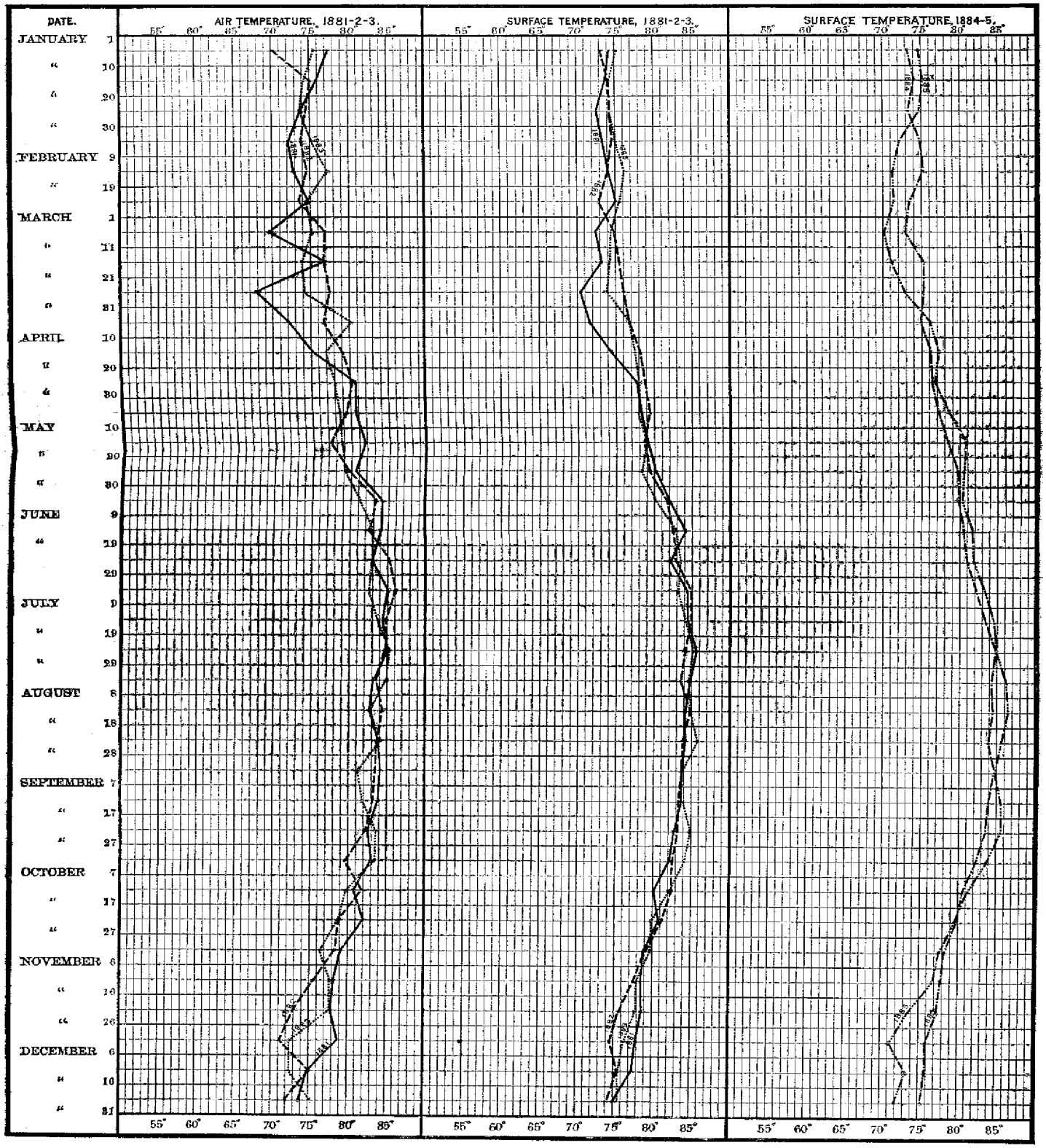
By RICHARD RATHBUN.

Station: Fowey Rocks Light House, Florida.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ····· 1883, —·— 1884, —··— 1885.

(Issued in 1886.)



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EXPLANATION OF OCEAN TEMPERATURE CHART No. 5.

MARTIN'S INDUSTRY LIGHT-SHIP, SOUTH CAROLINA.

Observer: JOHN MASSON.

Position.—This light-ship is located off the entrance to Port Royal Sound, South Carolina, and about 390 miles northerly from Fowey Rocks, Florida. It is anchored about 8½ miles from land, directly in front of Martin's Industry Shoal, from the outer edge of which it is distant a little more than a mile, the depths between ranging from 6½ to 8 fathoms. The 10-fathom curve is distant about 9 miles, the 20-fathom curve about 32 miles, and the 100-fathom curve about 62 miles.

Geographical position.—Latitude, 32° 05′ (31″) N.; longitude, 80° 35′ (07″) W.

Depth of water.—Nine fathoms.

Range of temperature.—Air, 41°.5 (45° to 86°.5); surface, 38° (47° to 85°).

The conditions influencing the temperature at Martin's Industry Shoal are very different from those prevailing at the Florida Reef stations. The range of temperature is very much greater, and the temperature plottings on the chart form much more pronounced curves. The surface curves, although more regular than those for the air, are nearly parallel with them throughout each year, and the difference between the surface and air temperatures are seldom great. The maximum and minimum temperatures are nearly the same for both the air and surface, the latter having a slightly smaller range than the former. The maximum temperatures are about the same here as at Fowey Rocks, and Carysfort Reef, but the minimums are over 20° lower.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	12	10.3	7.6	9.8	11	7.8	7	10.5	15.1	17.8	13.8	10.7
Southeast	4.4	5.5	7.1	7.8	9.9	10.6	7.8	7.5	7.1	4.5	3.1	4.1
Southwest	6.9	6.2	10.3	7.1	7.1	9.4	13.5	8.6	3.7	4.2	3.9	7.8
Northwest	5.3	3.9	5.5	4.4	2.4	1.5	1.4	2.6	3.8	3.8	3.1	6.3

OCEAN TEMPERATURE CHART No. 5

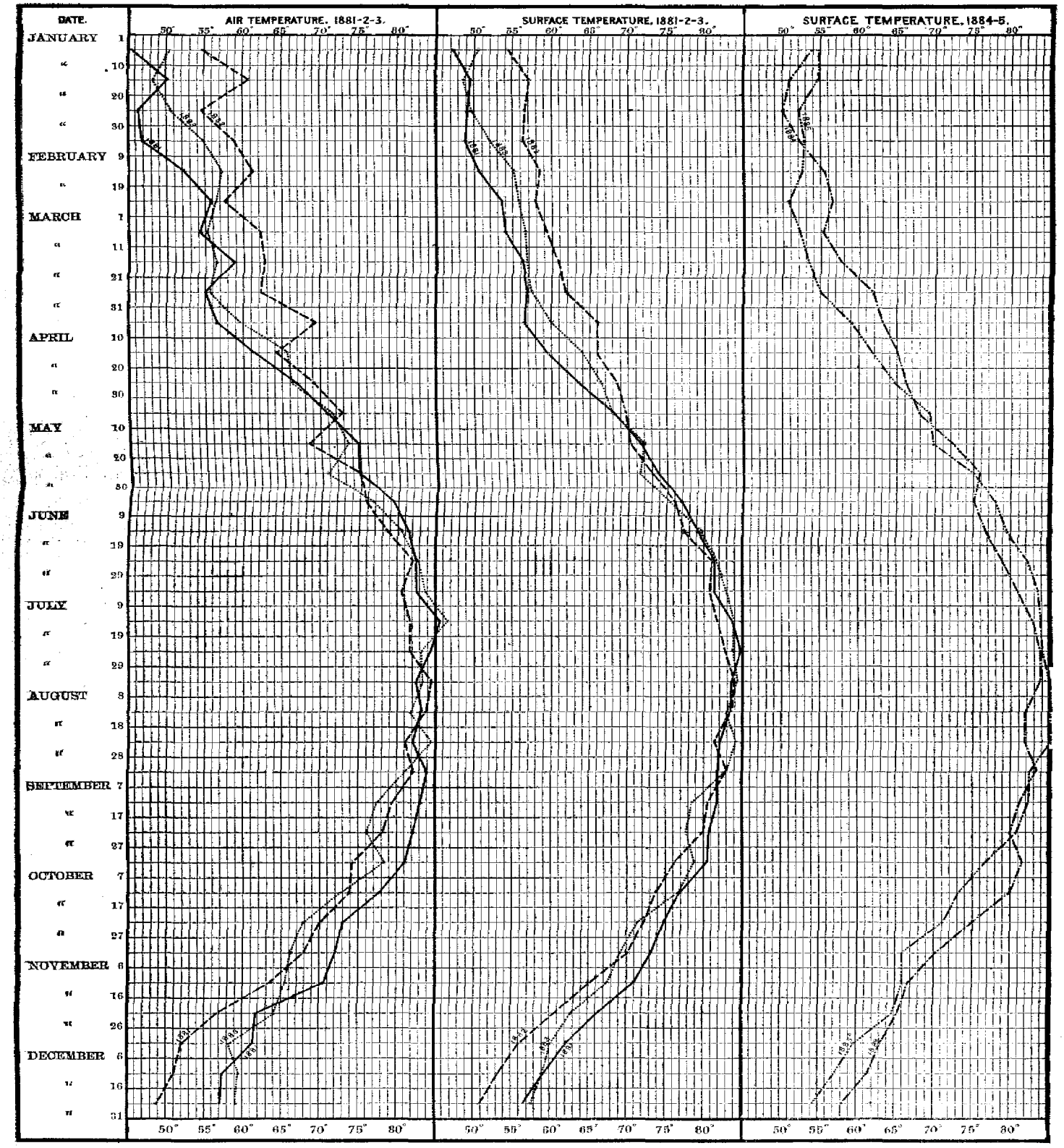
By RICHARD RATHBUN.

Station: Martin's Industry Shoal Light Ship, South Carolina.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ····· 1883, —·— 1884, —··— 1885.

(ISSUED IN 1886.)



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EXPLANATION OF OCEAN TEMPERATURE CHART No. 6.

RATTLESNAKE SHOAL LIGHT-SHIP, SOUTH CAROLINA.

Observer: JOHN McCORMICK.

Position.—Rattlesnake Shoal light-ship is placed just north of the entrance to Charleston Harbor, South Carolina, and about 56 miles northeasterly from Martin's Industry light-ship. It is anchored about 5 miles off shore, and 2 miles off the shoals of the same name, between which and the light-ship there are depths of 4 to 5 fathoms. The 10-fathom curve is distant about 11 miles, the 20-fathom curve about 30 miles, and the 100-fathom curve about 50 miles.

Geographical position.—Latitude, 32° 44′ (00″) N.; longitude, 79° 43′ (40″) W.

Depth of water.—Five fathoms.

Range of temperature.—Air, 41° (45°.5 to 86°.5); surface, 38° (47° to 85°).

The range of temperature at this station is almost precisely the same as at Martin's Industry, there being a difference of only half a degree in the air records. The curves as plotted also agree closely at the two stations, both as regards their general features and their details.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	12.1	11.1	7	9.9	10.6	6.7	6.4	10.9	13.1	17.7	12.9	11.9
Southeast	3	5.8	5.8	6.9	9	8.2	9	8.1	10.2	4.9	4.6	3.4
Southwest	8.5	6.6	13.3	10	8.4	13	14.3	8.3	3	4.9	4.0	8.4
Northwest	5.2	3.1	3.9	2.5	1.6	1.4	.8	1.6	2.4	2.7	5.8	5

OCEAN TEMPERATURE CHART No. 6

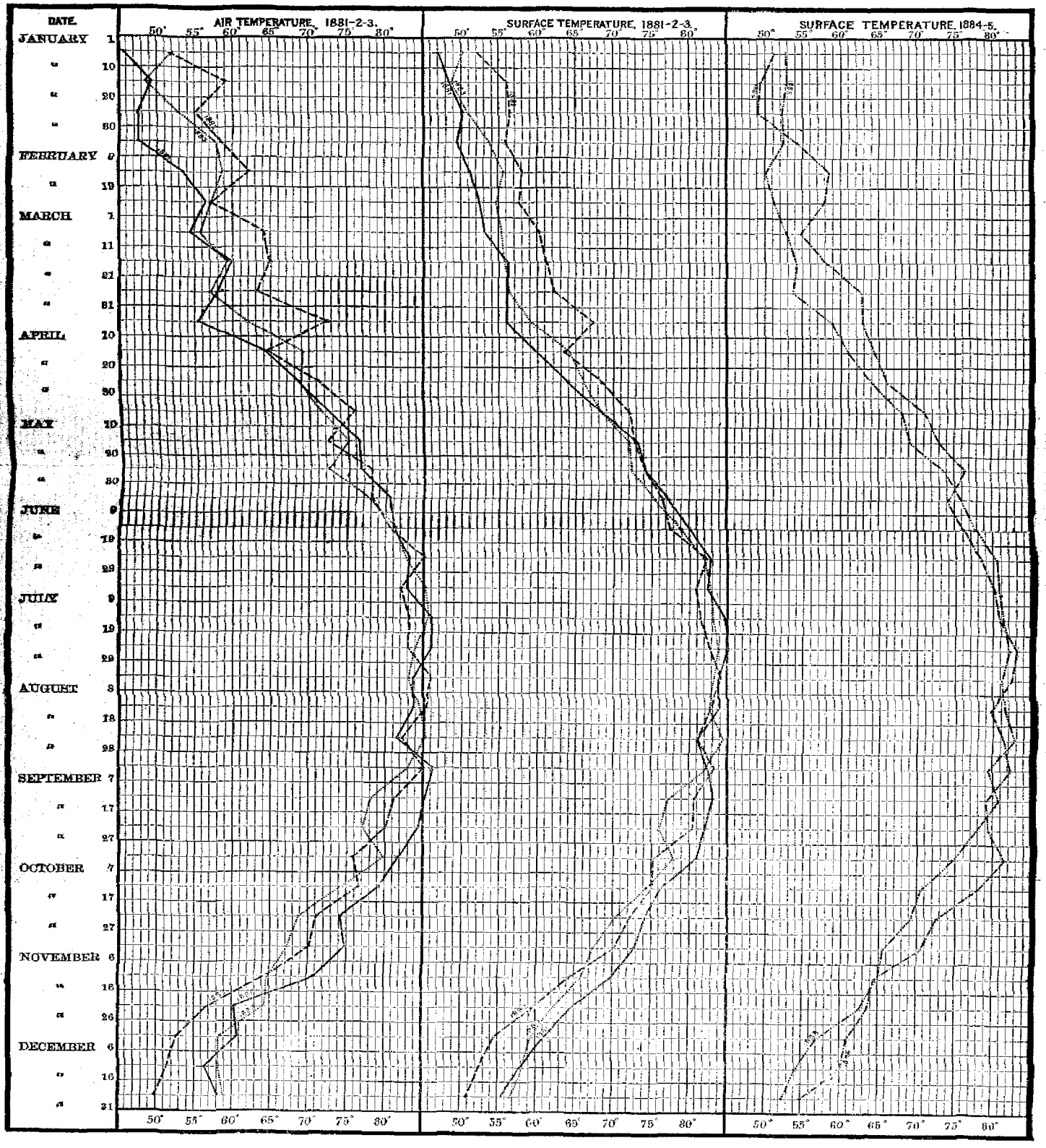
By RICHARD RATHBUN.

Station: Rattlesnake Shoal Light Ship, South Carolina.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ——— 1883, —·— 1884, —·····— 1885.

(Issued in 1886.)



Each vertical interspace represents one degree Fahrenheit, and the fractional parts of a degree are indicated as exactly as possible in the plotting of the curves. Each fifth degree is represented by a slightly heavier line. The transverse interspaces inclosed by the heavier lines represent periods of ten days each, as indicated by the dates on the left-hand side of the plate. The lighter transverse lines, intermediate between the heavier ones, are intended to represent the mean of each ten days, and the curves of temperature are plotted with reference to these lines. The left-hand vertical division is devoted to the air temperatures for 1881, 1882 and 1883, the middle division to the surface water temperatures for the same years, thus permitting of a comparison of the two; and the right-hand division to the water temperatures for 1884 and 1885.

EXPLANATION OF OCEAN TEMPERATURE CHART No. 7.

FRYING PAN SHOALS LIGHT-SHIP, NORTH CAROLINA.

Observers: D. W. MANSON, W. R. WALKER, J. H. DOSHER, J. D. DAVIS, G. D. WALKER, H. SWAN.

Position.—Frying Pan Shoals light-ship is located about 6½ miles from the outer extremity of the main part of Frying Pan Shoals, about 17 miles southeasterly from Cape Fear, North Carolina, and about 108 miles northeasterly from Rattlesnake Shoal light-ship. Within a radius of 3 miles on all sides depths of 6½ to 11 fathoms occur. The 20-fathom curve is distant 21 miles, the 100-fathom curve 36 miles.

Geographical position.—Latitude, 33° 35′ (00″) N.; longitude, 77° 50′ (04″) W.

Depth of water.—Ten to 11 fathoms.

Range of temperature.—Air, 41° (44° to 85°); surface, 33° (49°.5 to 82°.5).

The curves of air temperature do not differ essentially from those of the two preceding stations; the range of temperature is precisely the same, although the maximum and minimum records are each 1½° lower at this station. The surface temperatures, however, have a more limited range by 5°, reaching neither the same maximum nor minimum as at Rattlesnake Shoal.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	13.5	11.3	11	11.2	8.5	9	5.8	10.9	13.5	16	12.5	12
Southeast	2.2	4.5	2.5	2	4.1	8.3	1.5	3.2	5.1	4	3.5	3.2
Southwest	9.6	8.4	10.8	11.2	8.7	15.2	21.1	11.6	6.1	5.7	4.3	7.2
Northwest	5	3.9	5.7	3.9	2.8	1	.7	2.2	1.5	3.9	8.3	7.9

OCEAN TEMPERATURE CHART No. 7

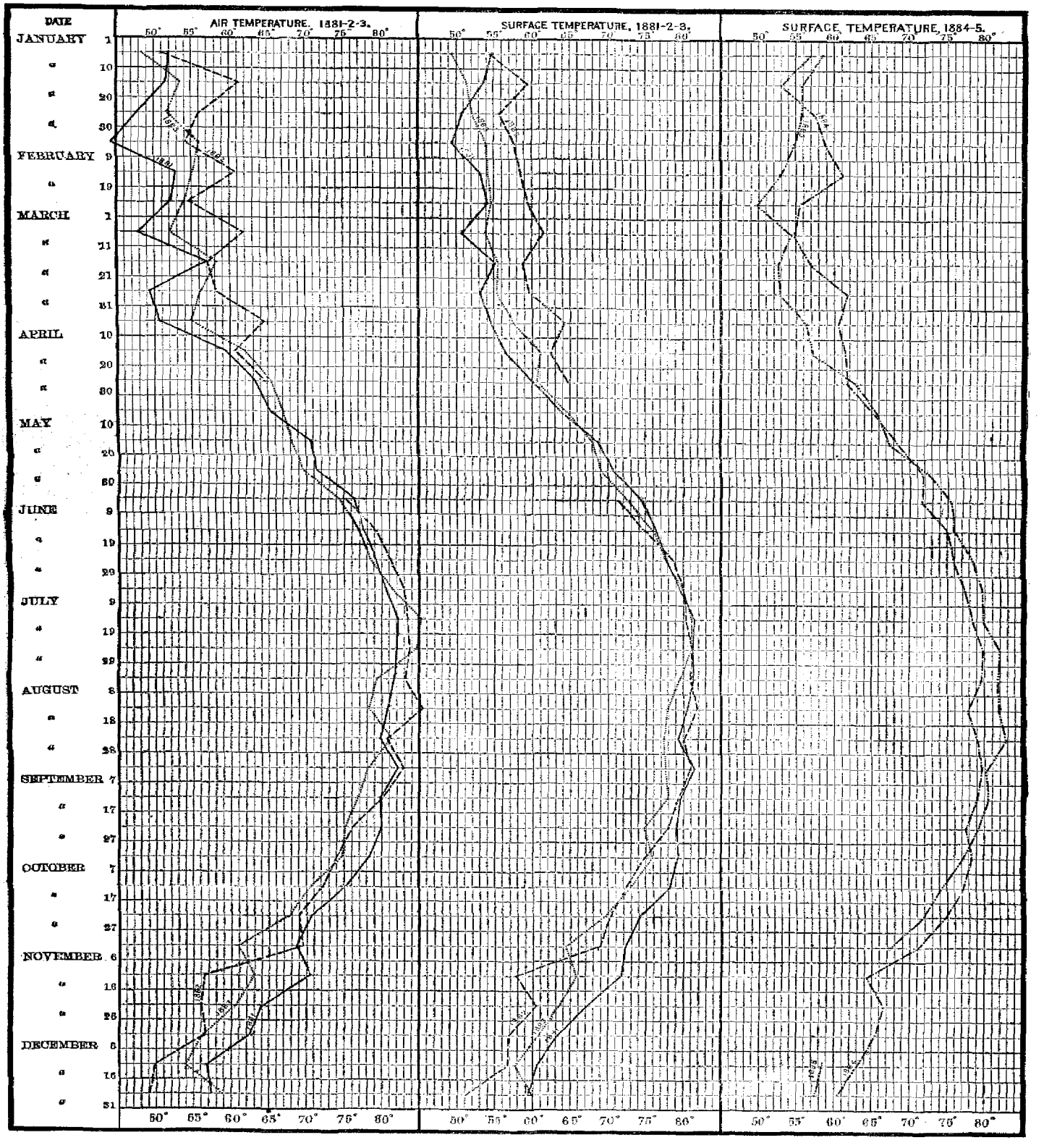
By RICHARD RATHBUN.

Station: Frying Pan Shoals Light Ship, North Carolina.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881. — — — 1882. ····· 1883. —·—·— 1884. —·····— 1885.

(ISSUED IN 1886.)



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EXPLANATION OF OCEAN TEMPERATURE CHART No. 8.

CAPE LOOKOUT LIGHT-HOUSE, NORTH CAROLINA.

Observer: DENARD RUMLEY.

Location of station.—Cape Lookout light-house is situated on the easterly shore, facing the open ocean, about 3 miles north of the extremity of Cape Lookout, North Carolina, and is about 90 miles northeasterly from Frying Pan Shoals light-ship. The sandy shore slopes gradually for about half a mile before a depth of 3 fathoms is reached. The 10-fathom curve is distant about 5 miles, the 20-fathom curve 21 miles, and the 100-fathom curve 35 miles.

Geographical position.—Latitude, 34° 37′ (20″) N.; longitude, 76° 31′ (26″) W.

Depth of water.—One foot.

Range of temperature.—Air, 41° (43° to 84°); surface, 42° (42° to 84°).

The curves of air temperature correspond more or less closely with those of the three preceding stations; the range is precisely the same, and the maximum and minimum records are each but 1 degree lower than at Frying Pan Shoals. It will be observed, however, that the surface curves agree in nearly all their details with those of the air, having essentially the same range, and being much more irregular than at the three preceding light-ships. This is due to the fact that the observations were made in shallow water, close inshore, on a very gradually sloping beach.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	11.5	10.2	8.6	10.8	12.7	9.2	7.3	12.8	13.2	13.6	10.2	10.2
Southeast	2.9	2.7	3.9	3.2	5.2	5.4	3.7	3.9	6.1	4.2	3.7	4.3
Southwest	7.5	9	10	8	10.5	13.9	17.2	10.7	8.5	5.9	4.5	6.6
Northwest	7.7	4.6	6.8	4	1.6	.8	2.1	1.2	2.3	6.1	8.9	7.7

OCEAN TEMPERATURE CHART No. 8

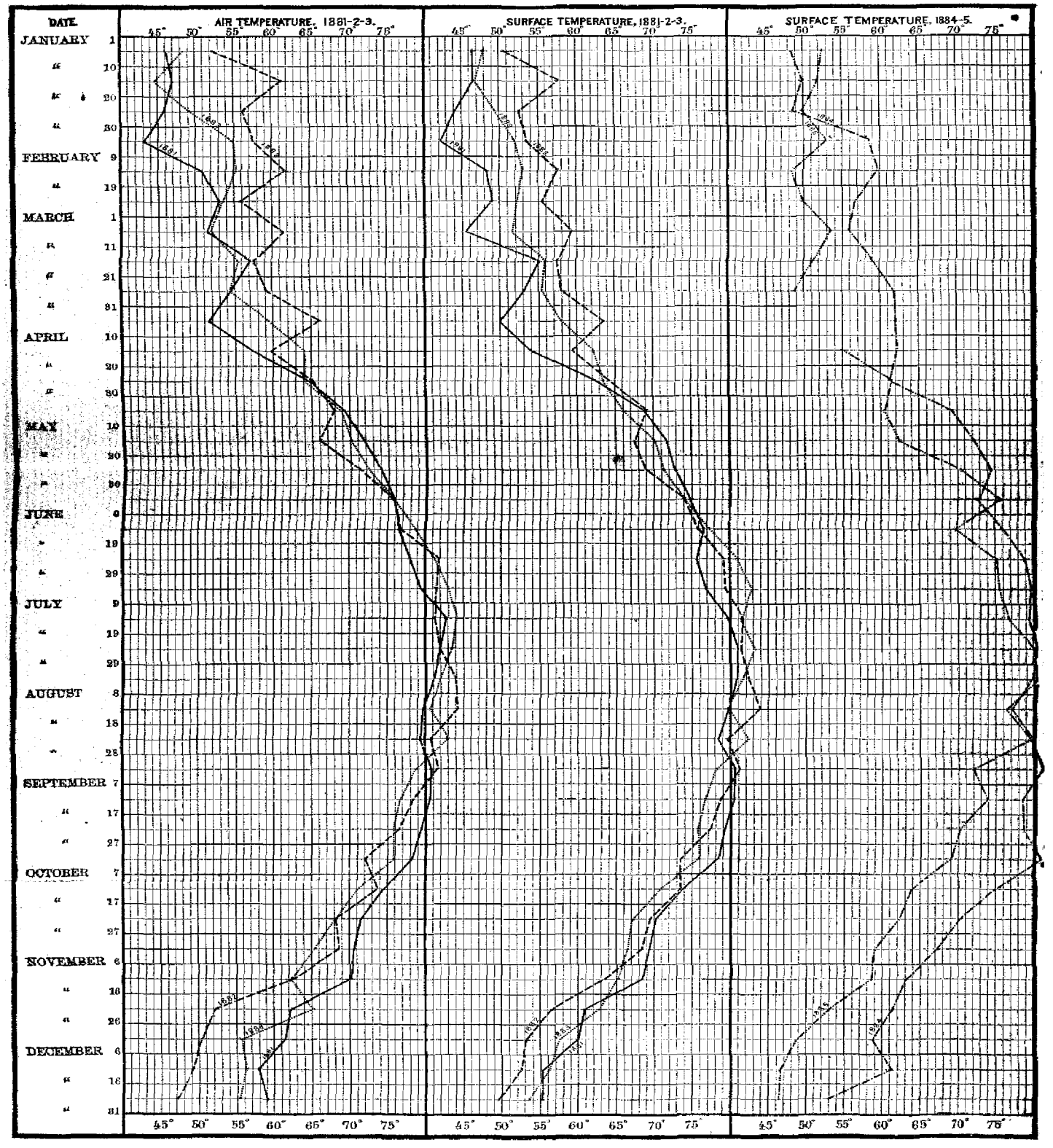
By RICHARD RATHBUN.

Station: Cape Lookout Light House, North Carolina.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES. ——— 1881, — — — 1882, ... 1883, —·— 1884, —··— 1885.

(ISSUED IN 1886.)



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EXPLANATION OF OCEAN TEMPERATURE CHART No. 9.

BODY'S ISLAND LIGHT-HOUSE, NORTH CAROLINA.

Observer: PETER G. GALLOP.

Location of station.—This light-house is situated near the southern end of Body's Island, north of Oregon Inlet, North Carolina, and is about 35½ miles north of Cape Hatteras, and about 86 miles northeasterly from Cape Lookout. The shore is similar to that at Cape Lookout, sandy, and shelving very gradually so as to afford but slight depths of water near land. The 10-fathom curve is distant 2 miles, the 20-fathom curve 24 miles, and the 100-fathom curve 35 miles.

Geographical position.—Latitude, 35° 49′ 07″ N.; longitude, 75° 33′ 49″ W.

Depth of water.—Seven to 9 feet.

Range of temperature.—Air, 64° (27° to 91°); surface, 63° (28° to 91°).

The records for this station show an extraordinary range of temperature. The air and surface curves are almost precisely alike and indicate the same range of temperature for both air and surface, within 1°. The lowest surface temperatures recorded are probably the result of careless reading; the higher ones indicate that the observations were probably made in very shallow and quiet water, directly influenced by the sun's rays during the heat of summer.

The highest mean plotted, 91°, is 2½° higher than the maximum for the air at the Tortugas, and 4° higher than the air maximum for any of the other stations to the south of Body's Island. The surface maximum also exceeds that of any of the more southern stations by 4½°.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of three years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	8.4	8.2	9.6	12.9	14.1	10	9.8	14.7	15.4	15.9	8.6	7.5
Southeast	3.5	5.3	5.1	6	5.6	5.5	5.7	7	6.7	5	4.4	5.3
Southwest	10	6.4	8.9	6.7	9.1	11.5	13.1	7.9	6.8	6.2	7.3	9.3
Northwest	9.1	7.5	7.4	5.2	2.3	1.5	1.9	1.2	1.1	3.8	9.7	8.6

OCEAN TEMPERATURE CHART No. 9

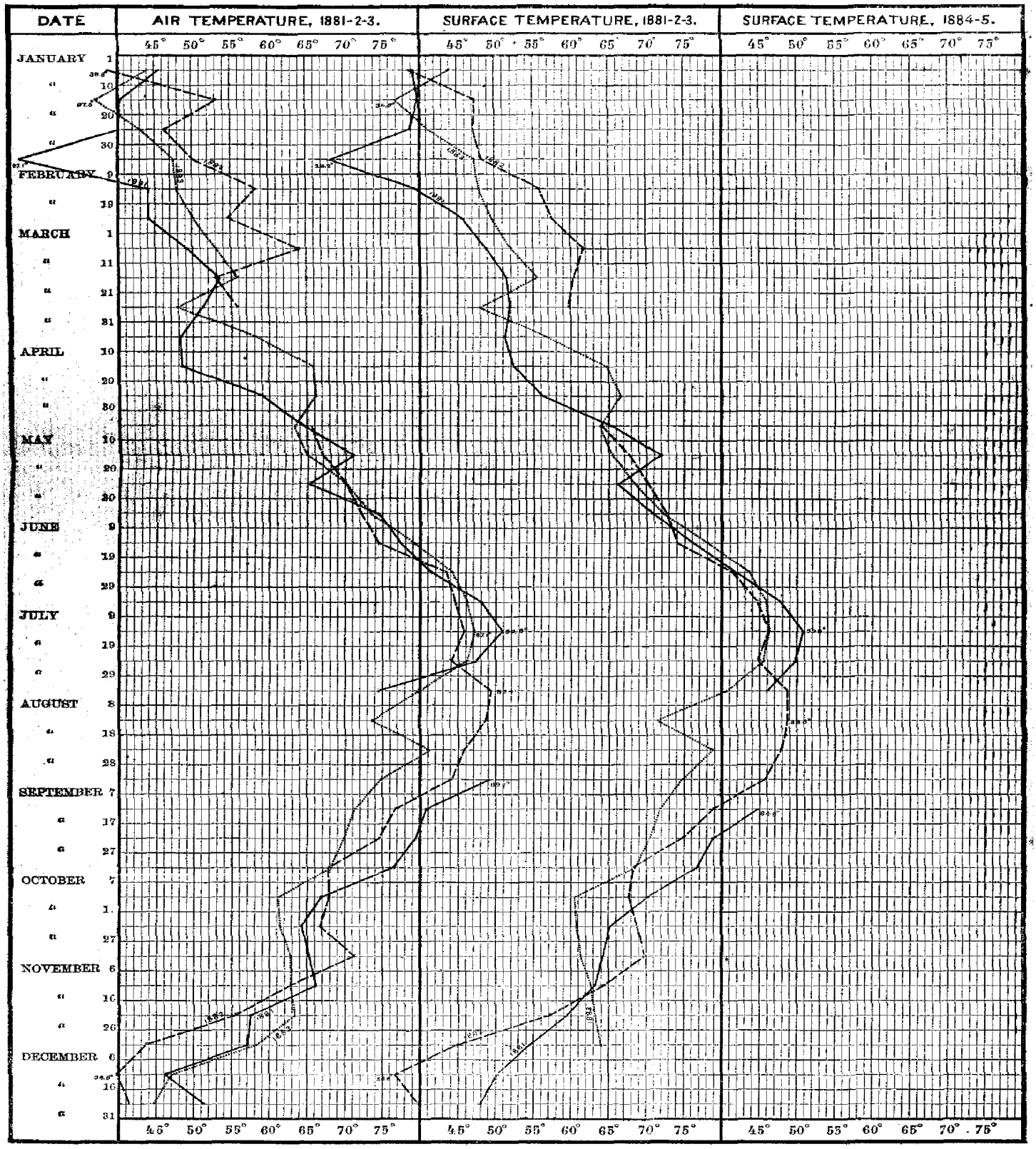
By RICHARD RATHBUN.

Station: Body's Island Light House, North Carolina.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1883, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ····· 1883, —·—·— 1884, —··—··— 1885.

(Issued in 1886.)



Each vertical interspace represents one degree Fahrenheit, and the fractional parts of a degree are indicated as exactly as possible in the plotting of the curves. Each fifth degree is represented by a slightly heavier line. The transverse interspaces inclosed by the heavier lines represent periods of ten days each, as indicated by the dates on the left-hand side of the plate. The lighter transverse lines, intermediate between the heavier ones, are intended to represent the mean of each ten days, and the curves of temperature are plotted with reference to these lines. The left-hand vertical division is devoted to the air temperatures for 1881, 1882 and 1883, the middle division to the surface water temperatures for the same years, thus permitting of a comparison of the two; and the right-hand division to the water temperatures for 1884 and 1885.

EXPLANATION OF OCEAN TEMPERATURE CHART No. 10.

WINTER-QUARTER SHOAL LIGHT-SHIP, VIRGINIA.

Observer: C. LINDEMANN.

Location of station.—This light ship is anchored 2 miles SE. by E. ½ E. from Winter-Quarter Shoal, and 8½ miles off Assateague Island, on the coast of Virginia. It is about midway between Chesapeake Bay and Delaware Bay entrances, and about 128 miles north of Body's Island light. Between the light-ship and the mainland depths of 4 to 10 fathoms occur. The 20-fathom curve is distant about 20 miles, the 100-fathom curve nearly 50 miles.

Geographical position.—Latitude, 37° 57′ (03′) N.; longitude, 75° 05′ (29′) W.

Depth of water.—Ten and one-half fathoms.

Range of temperature (March 1 to January 1).—Air, 48° (33° to 81°); surface, 41° (35°.5 to 76°.5.)

Winter-Quarter Shoal light-ship may be regarded as the southernmost of a third series of stations in which the surface temperature seldom exceeds 75° F., and within the period plotted (March to January) may fall (according to the records) to nearly 35°. The surface curves are somewhat less uniformly parallel with the air curves than at the more southern stations, but the differences are not very marked.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	9.5	7.7	8.1	9.4	11.6	7.5	6.5	12.2	10.6	12	7.5	6.1
Southeast	2.7	4	5.3	5.7	5.6	9.3	5.1	5.4	5.1	5.3	2.3	4
Southwest	8.6	7.8	6.8	6.9	10.8	9.6	14.1	9.5	10.5	7.8	9.9	9.8
Northwest	9.9	7.9	9.9	6	1.9	1.8	2.8	2.2	2.8	4.8	9.8	9.5

OCEAN TEMPERATURE CHART No. 10

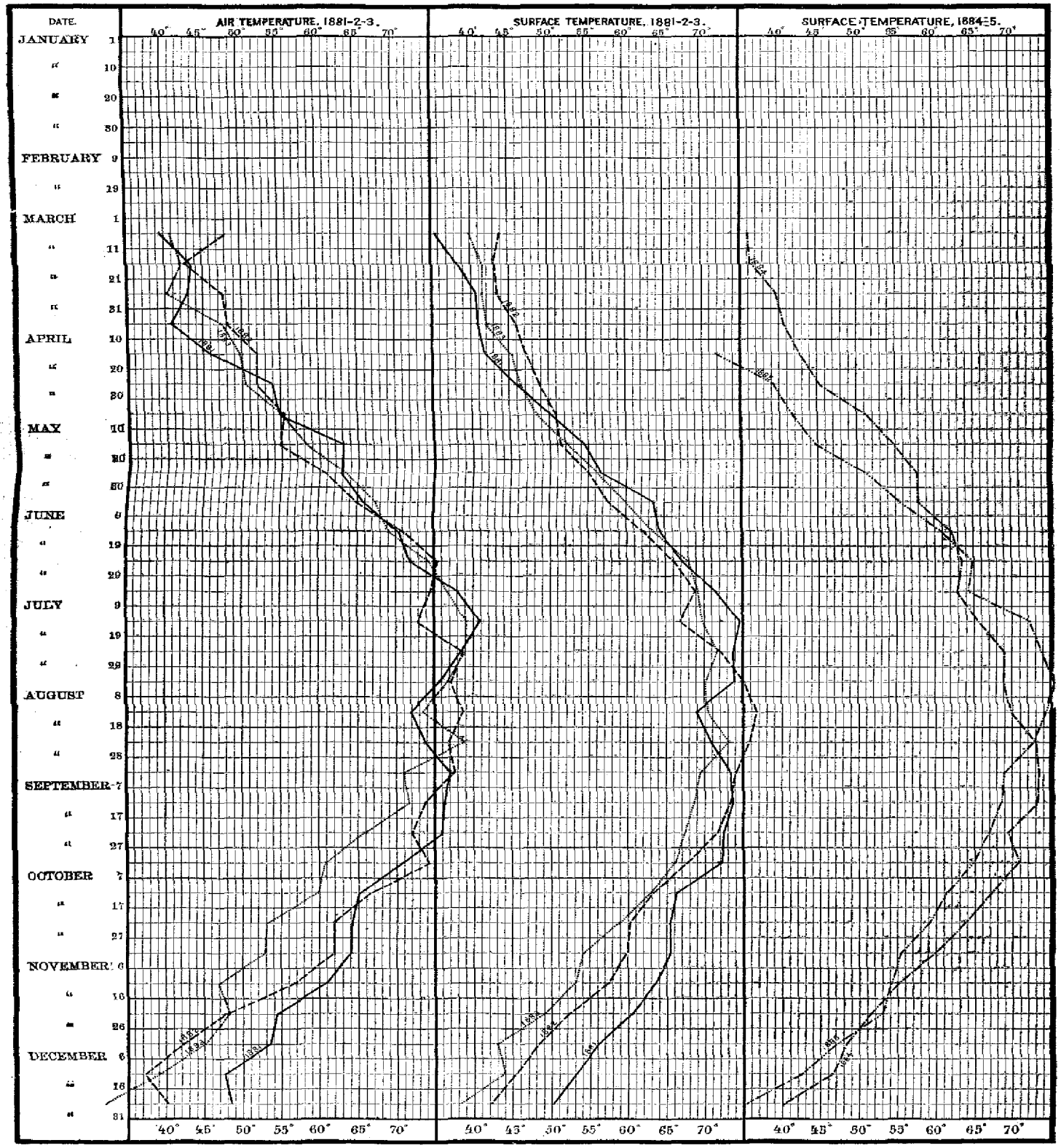
By RICHARD RATHBUN.

Station: Winter Quarter Shoal Light Ship, Virginia.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ...1883, —·—·— 1884, —··—··— 1885.

(ISSUED IN 1886.)



Each vertical interspace represents one degree Fahrenheit, and the fractional parts of a degree are indicated as exactly as possible in the plotting of the curves. Each fifth degree is represented by a slightly heavier line. The transverse interspaces inclosed by the heavier lines represent periods of ten days each, as indicated by the dates on the left-hand side of the plate. The lighter transverse lines, intermediate between the heavier ones, are intended to represent the mean of each ten days, and the curves of temperature are plotted with reference to these lines. The left-hand vertical division is devoted to the air temperatures for 1881, 1882 and 1883, the middle division to the surface water temperatures for the same years, thus permitting of a comparison of the two; and the right-hand division to the water temperatures for 1884 and 1885.

EXPLANATION OF OCEAN TEMPERATURE CHART No. 11.

FIVE-FATHOM BANK LIGHT-SHIP, NEW JERSEY.

Observers: JOHN REEVES, DANIEL MANLOVE, WILLIAM W. SMITH.

Location of station.—This light-ship is located about 14 miles from the nearest part of the New Jersey coast, just east of Cape May, north of the entrance to Delaware Bay, and about 56 miles northeasterly from Winter-Quarter Shoal light-ship. It is anchored about 1½ miles outside of the 10-fathom curve, in a depth of 12 fathoms. The 20-fathom curve is distant 13½ miles, the 100-fathom curve 55 miles.

Geographical position.—Latitude, 38° 48′ (23″) N.; longitude, 74° 36′ (09″) W.

Depth of water.—Twelve fathoms.

Range of temperature (March 1 to January 1).—Air, 47° (36°.5 to 83°.5); surface, 39° (37° to 76°).

The temperatures at this station differ somewhat from those at Winter-Quarter Shoal, and not constantly in the same direction, being sometimes slightly higher, at others slightly lower, during corresponding periods. With a single marked exception, the summer air temperatures average lower here; the surface curves are more nearly like those at Winter Quarter, but do not show so low a minimum in the colder months plotted. An unusually high air temperature was reached between June 19 and 29, 1882, accompanied mainly by southwesterly winds, which are the prevailing winds for that month. This extreme variation is not observable at the neighboring stations, and it apparently had no influence upon the temperature of the water at this place.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	5.2	6.1	6.3	6.8	9	6	5.5	9.3	9.4	9	6.3	4.2
Southeast	1.8	2.9	3.7	5.2	6	7	5.5	5.9	4.6	4.2	2.1	3.2
Southwest	7.8	6.3	6.8	6.6	10	12.9	14.1	10.5	11.7	8.6	9	9.7
Northwest	14.4	11.5	13.4	8.9	5	3.1	4.2	3.8	3.8	7.9	12.1	12.

OCEAN TEMPERATURE CHART No. 11

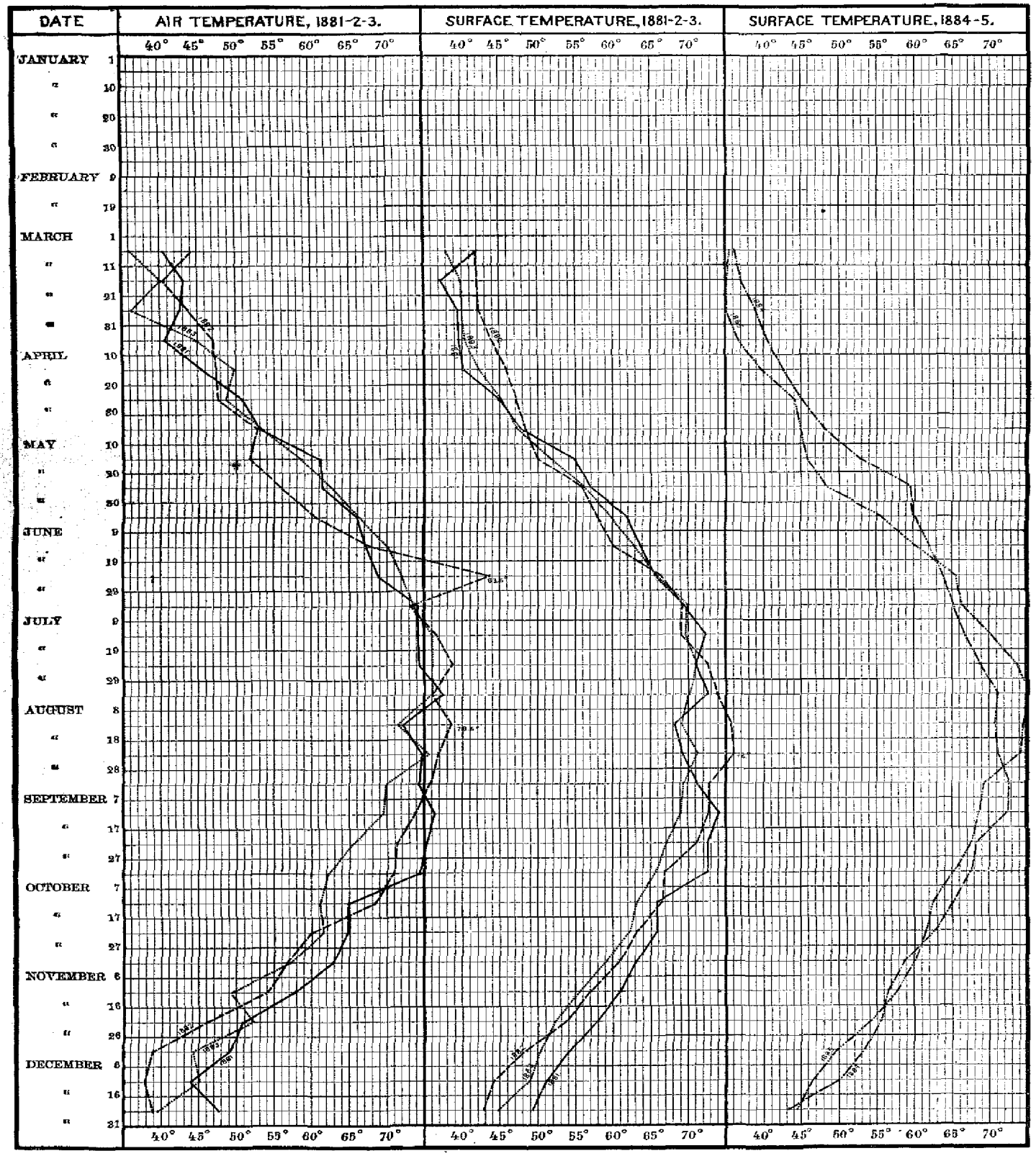
By RICHARD RATHBUN.

Station: Five Fathom Bank Light Ship, New Jersey.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, ——— 1882, ... 1883, —·— 1884, —·— 1885.

(ISSUED IN 1886.)



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EXPLANATION OF OCEAN TEMPERATURE CHART No. 12.

ABSECON LIGHT-HOUSE, NEW JERSEY.

Observer: A. G. WOLF.

Location of station.—Absecon light-house is located on the beach in front of Atlantic City, N. J., and just south of the entrance to Absecon Inlet. It is 34⅔ miles N. by E. ¾ E. of Five Fathom Bank light-ship. The shore in front of the light-house is faced with shoals. The 10-fathom curve is distant 6¼ miles, the 20-fathom curve 34 miles, the 100-fathom curve 70 miles.

Geographical position.—Latitude, 39° 21′ 59″ N.; longitude, 74° 24′ 52″ W.

Depth of water.—Nine to 15 feet.

Range of temperature (March 1 to January 1).—Air, 46°.5 (33° to 79°.5); surface, 45° (34°.5 to 79°.5).

Although located on the shore of an inlet, protected by shoals in front, this station affords more satisfactory results than either Body's Island or Cape Lookout. The ranges of temperature given above are essentially the same for both the air and surface, but if we except the surface curve for 1885, and compare only the air and surface curves for corresponding years, 1881–1883, we find that the maximum for the air exceeds that for the surface by nearly five degrees. The conditions are, therefore, very much the same at Absecon as at Five Fathom Bank, and the surface curves are nearly as regular.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	5.2	7.2	7.8	9.7	10.3	7.9	8.5	9.8	10.3	8.6	4.4	3.8
Southeast	2.8	2.8	4.3	6.7	11.2	12.1	10	9.4	8.2	7.1	4.2	3.9
Southwest	6.9	5.3	6.2	4.9	4.8	6.3	7.5	6.9	6.9	6.2	8.9	9.4
Northwest	16	12.9	12.7	8.5	4.5	2.5	4.6	4.6	4.5	8.7	12.1	13.8

OCEAN TEMPERATURE CHART No. 12

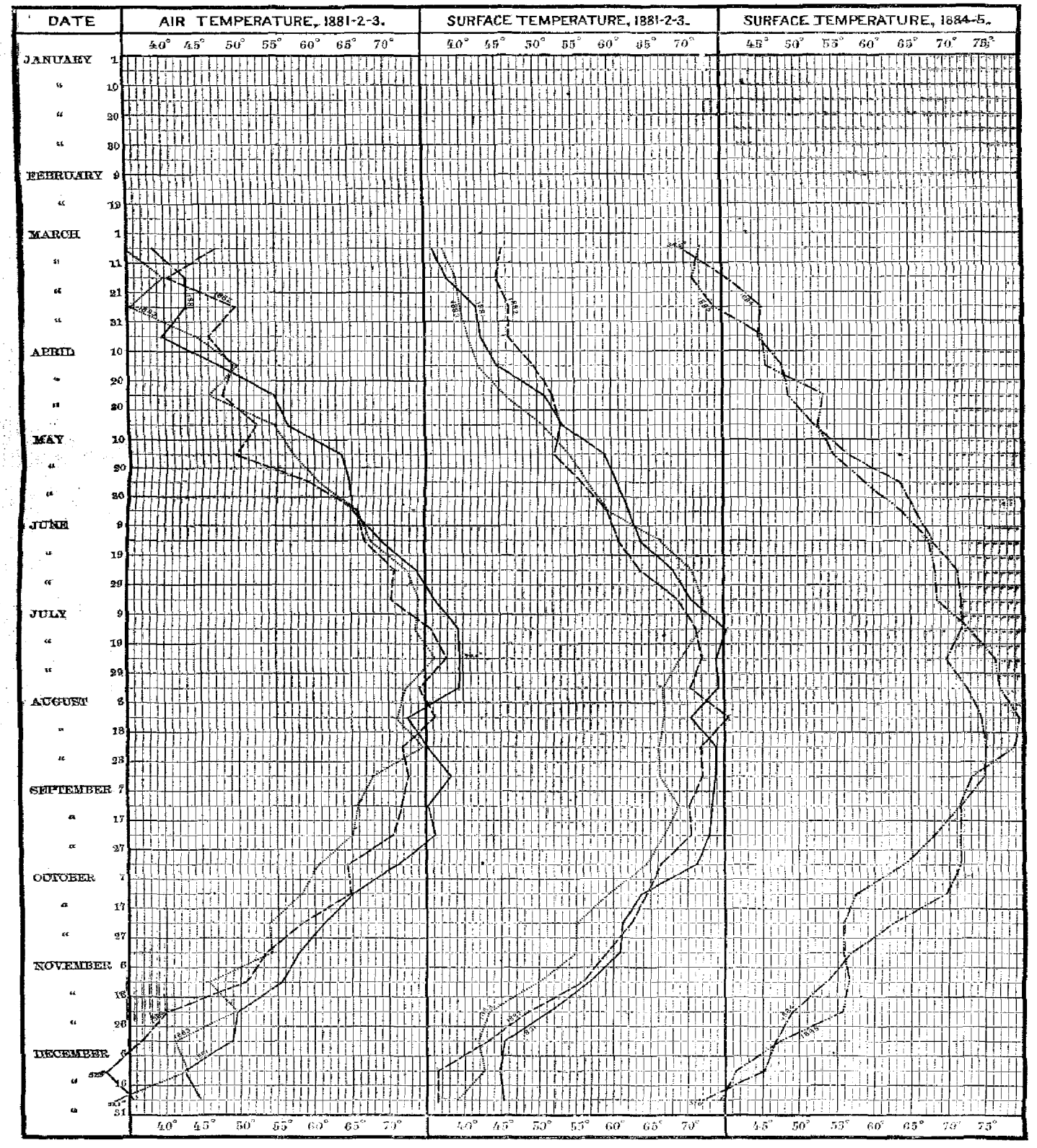
By RICHARD RATHBUN.

Station: Absecon Inlet Light House, New Jersey.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ····· 1883, —·— 1884, —··— 1885.

(Issued in 1886.)



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EXPLANATION OF OCEAN TEMPERATURE CHART No. 13.

SANDY HOOK LIGHT-SHIP, NEW YORK.

Observers: JAMES COSGROVE, R. H. PRITCHARD.

Location of station.—This light-ship is anchored in 14 fathoms of water, off the entrance to New York Bay, 6 miles east of Sandy Hook, N. J., the nearest land, and 8½ miles south of Rockaway Beach, Long Island. It is distant about 70 miles northeasterly from Absecon light. The 15-fathom curve forms a bight extending in towards New York Bay entrance, and reaching nearly to the light-ship, inside of which the depths decrease somewhat rapidly. The 20-fathom curve is distant 16 miles; the 100-fathom curve, 95 miles.

Geographical position.—Latitude, 40° 26′ (12″) N.; longitude, 73° 51′ (42″) W.

Depth of water.—Fourteen fathoms.

Range of temperature (March 1 to January 1).—Air, 50° (31°.5 to 81°.5); surface, 41°.5 (33° to 74°.5).

The range of air temperature is greater than at any of the three preceding stations, but the maximum is two degrees lower than at Five-Fathom Bank, about the same as at Winter Quarter Shoal, and two degrees higher than at Absecon. The maximum surface temperature is slightly lower than at the preceding stations.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	7	6.7	6	5.3	6.4	3.6	3.5	6.6	7.6	8.6	6	6.5
Southeast	3	3.1	4.6	5.5	10.4	11	9.5	8.3	8.8	6.4	3.9	3.7
Southwest	4.9	3.7	3.6	5.7	4.9	7.1	8.3	7.3	6.8	5.7	6.1	5.8
Northwest	15.6	12.6	15	11.5	7	6.7	8.1	7	5.7	9.5	12.6	14.6

OCEAN TEMPERATURE CHART No. 13

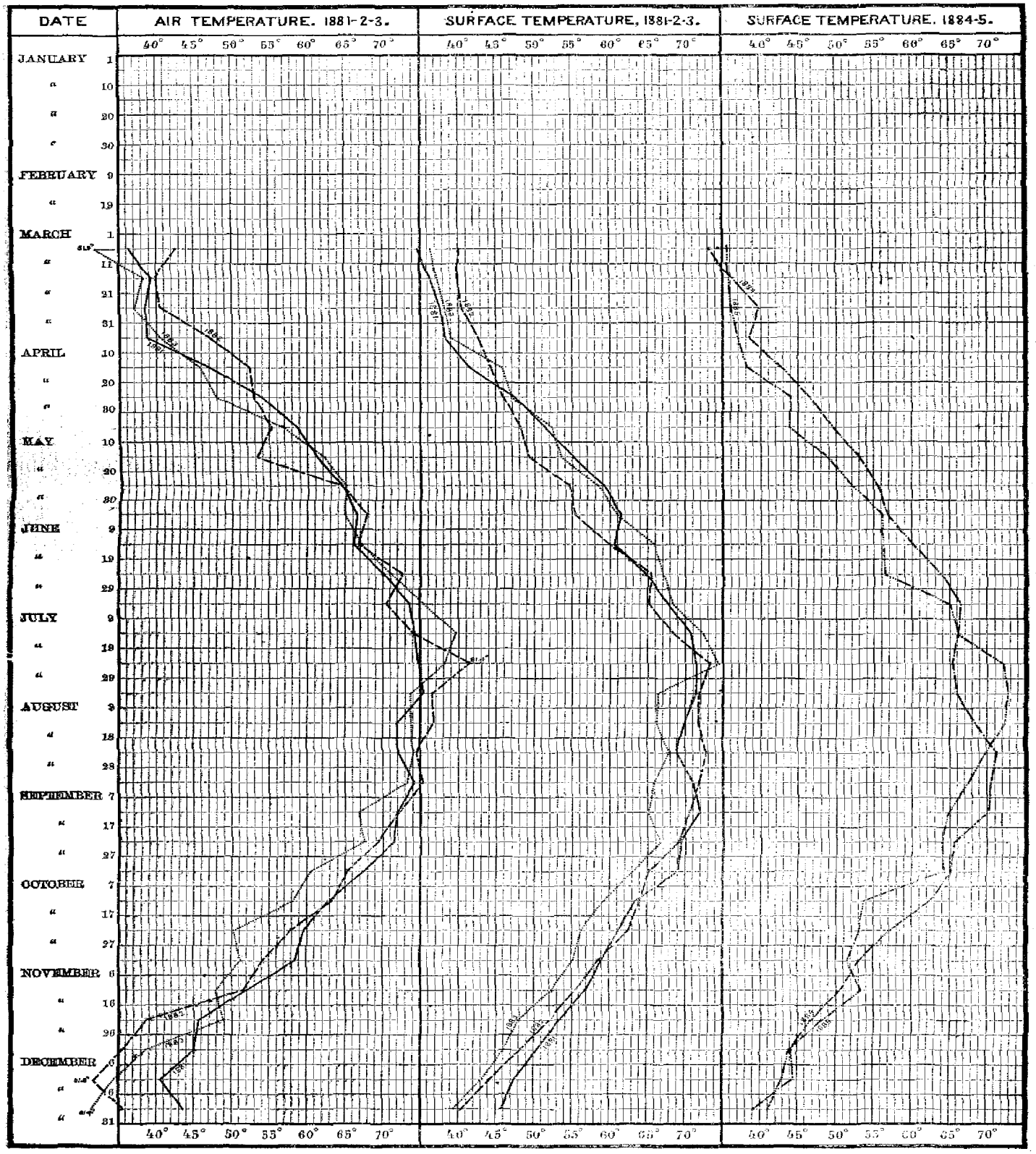
By RICHARD RATHBUN.

Station: Sandy Hook Light Ship, New York.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ····· 1883, ——— 1884, ——— 1885.

(Issued in 1886.)



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EXPLANATION OF OCEAN TEMPERATURE CHART No. 14.

FIRE ISLAND LIGHT-HOUSE, NEW YORK.

Observers: C. A. Blydenburgh, Seth R. Hubbard.

Location of station.—This light-house is situated on the east side of Fire Island Inlet, south side of Long Island, 31 miles E. by N. from Sandy Hook light-ship; and the observations were taken in the narrow entrance to Great South Bay, between Fire Island and Oak Island. The 10-fathom curve is distant 1¼ miles from the outer beach; the 20-fathom curve, 18 miles; the 100 fathom curve, 85 miles.

Geographical position.—Latitude, 40° 37′ 57″ N.; longitude, 73° 13′ 09″ W.

Depth of water.—Three feet.

Range of temperature (March 1 to January 1).—Air, 48°.5 (35° to 83°.5); surface, 40° (33° to 75°).

The observations at this station were probably taken in rapidly running water, as the surface curves are comparatively regular, and the maximum surface temperature is 8° lower than the maximum for the air. In the range of both air and surface temperatures this station agrees most closely with Five-Fathom Bank, the differences being very slight.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	5.8	4.6	5.3	4.5	5	3.3	3.2	5.3	5.9	7	5.4	7.4
Southeast	1.7	4.2	3.8	4.6	8	4.7	4.7	5.5	4.7	4.9	1.9	1.8
Southwest	7.3	6.4	6.6	8.9	8.7	12.7	13.2	12.5	11.5	7.7	8.3	8.8
Northwest	11.6	9.6	10.9	7.6	3.9	3.6	4.9	2.1	3.5	6.9	9.8	8.4

OCEAN TEMPERATURE CHART No. 14

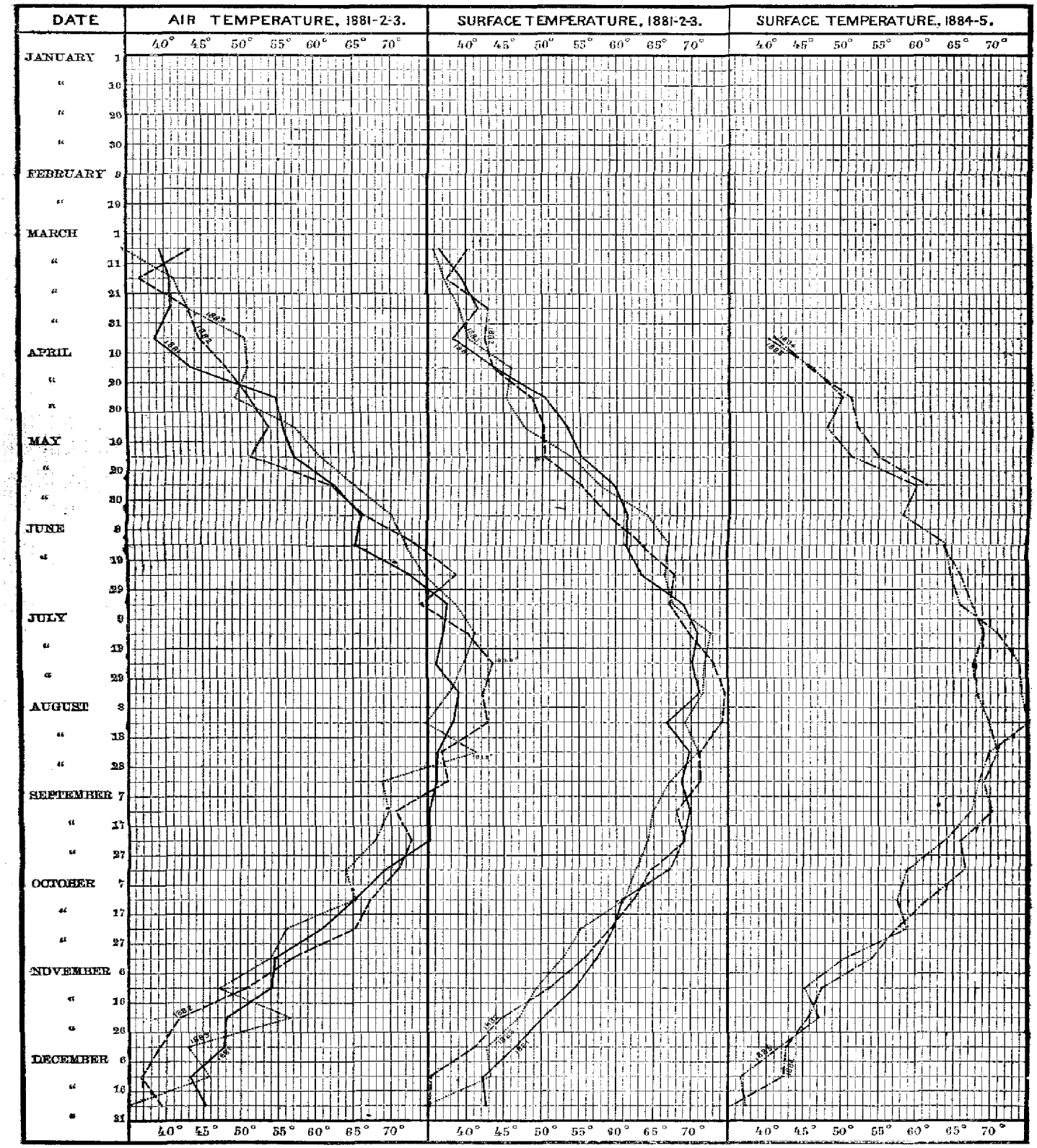
By RICHARD RATHBUN.

Station: Fire Island Light House, New York.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ... 1883, —.— 1884, —..— 1885.

(Issued in 1886.)



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EXPLANATION OF OCEAN TEMPERATURE CHART No. 15.

BLOCK ISLAND SOUTHEAST LIGHT-HOUSE, RHODE ISLAND.

Observer: H. W. CLARK.

Location of station.—This light-house is located on the high bluff at the southeastern extremity of Block Island, and is distant 82 miles northeasterly from Fire Island Light-house, and 78½ miles W. by N. ¼ N. from Nantucket New South Shoal light-ship. The water is very shallow off the southern end of the island, the depths increasing gradually seaward. The 20-fathom curve is distant about 5 miles; the 100-fathom curve, about 70 miles.

Geographical position.—Latitude, 41° 09′ 10″ N., longitude, 71° 33′ 09″ W.

Depth of water.—The observations were taken at the edge of the beach, below the light-house, facing the open sea to the south.

Range of temperature (March 1 to January 1).—Air, 57° (22° to 79°); surface, 41° (29°.5 to 70°.5).

Although the observations were taken from the beach, the surface curves show little direct influence of the air temperature upon the water, and are comparatively regular. The maximum air temperature is about the same as at Absecon, N. J., but the maximum for the surface is four degrees lower than at any of the stations to the west and south.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	6.7	4.8	8.1	8.7	8.9	5.2	4.1	6	9.8	10.9	5.4	7
Southeast	4.3	4.2	2.2	3.5	5.6	4	3.8	4	5	4.1	2.7	2.2
Southwest	7.5	6.2	8.2	11	10.7	16.9	16.7	17.6	11.3	12.1	9.9	9.7
Northwest	12.5	8.8	11.7	6.8	4.6	8.7	4.2	8.2	8.9	8.9	9.8	9.9

OCEAN TEMPERATURE CHART No. 15

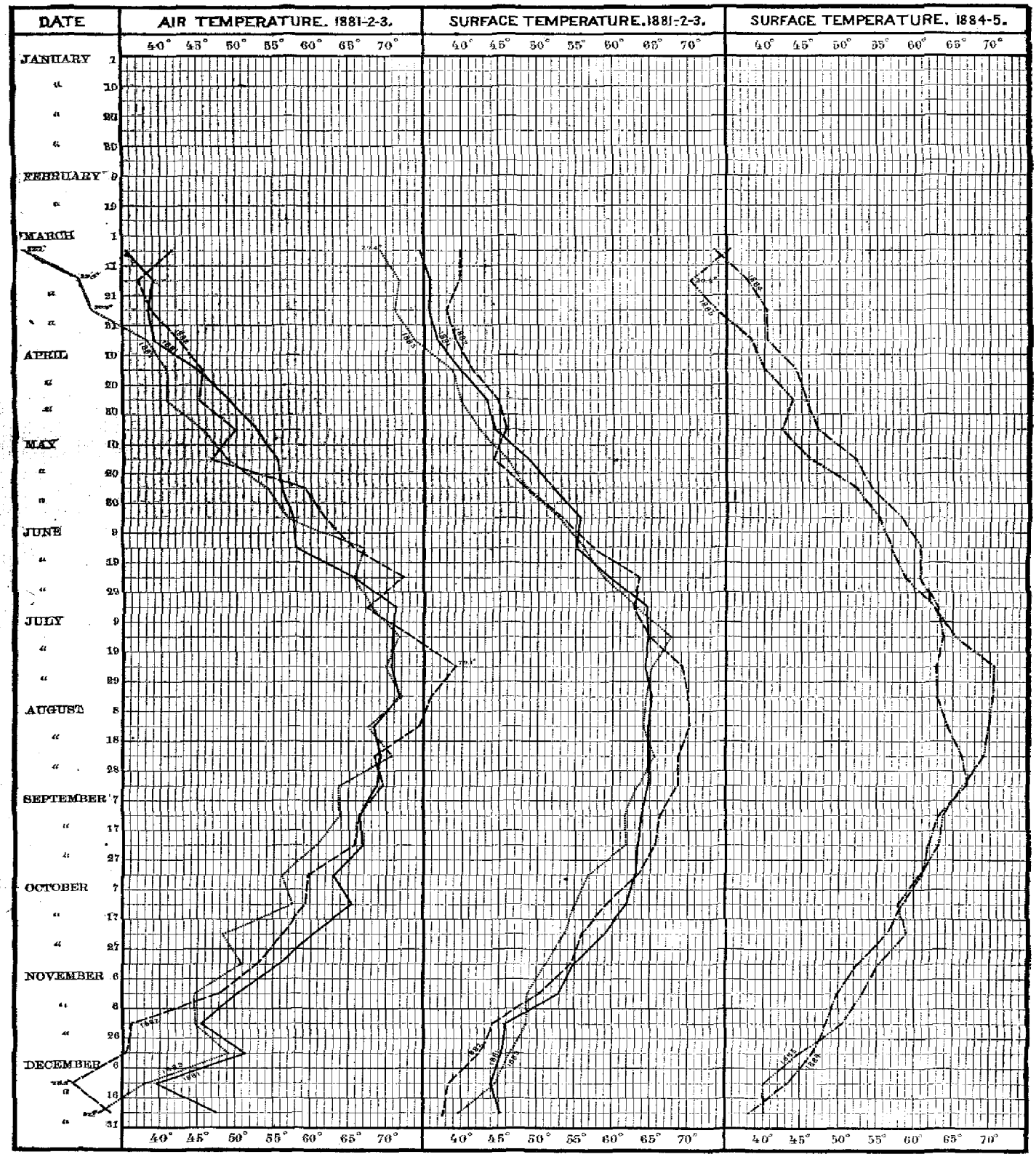
By RICHARD RATHBUN

Station: Block Island S. E. Light House, Rhode Island.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ... 1883, —·— 1884, —··— 1885.

(ISSUED IN 1886.)



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EXPLANATION OF OCEAN TEMPERATURE CHART No. 16.

BRENTON'S REEF LIGHT-SHIP, RHODE ISLAND.

Observer: CHARLES D. MARSH.

Location of station.—This light-ship is located in the middle of the entrance to Narragansett Bay, about 1¾ miles SW. of the southern point of the Island of Rhode Island, and a little over a mile off Brenton's Reef, the depths between ranging from 4½ to 14¾ fathoms. It is 17¾ miles NE. ¾ N. of Block Island southeast light, and faces the open sea to the south, the depths increasing gradually seaward. The 20-fathom curve is distant about 8½ miles; the 100-fathom curve, about 85 miles.

Geographical position.—Latitude, 41° 25′ (52″) N.; longitude, 71° 22′ (36″) W.

Depth of water.—Fourteen and one-half fathoms.

Range of temperature (March 1 to January 1).—Air, 45°.5 (29° to 74°.5); surface, 35° (34° to 69°).

The minimum temperatures are higher, the maximum lower at this station than at Block Island. The maximum surface temperatures, however, show a difference of only 1½° for the two stations. It is probable that the surface observations for Brenton's Reef are the more reliable, having been taken where the water is 14½ fathoms deep.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	4	5	5.5	6.2	7.1	2.7	2.8	4.6	6	8.1	4.7	4.9
Southeast	3	3.3	4.4	4.6	7.6	6.2	6	4.8	5.3	4.8	2	2.9
Southwest	8.7	6.3	6.4	9.6	10.8	15	15.5	15.9	16.9	9.7	11	9.4
Northwest	14	12.1	13.2	8.5	4	3.8	4	4.1	4.7	7.1	11.6	13.2

OCEAN TEMPERATURE CHART No. 16

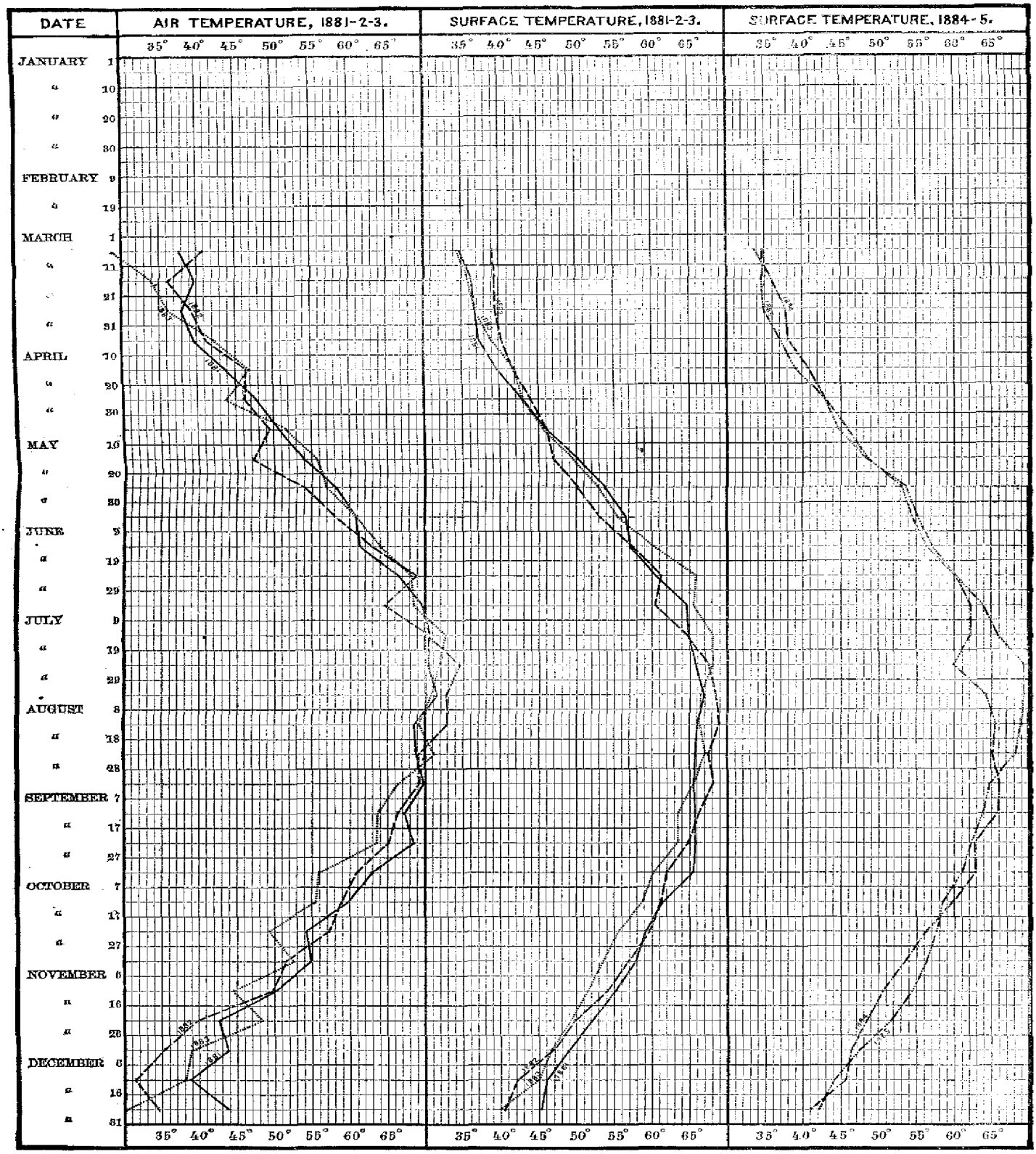
By RICHARD RATHBUN.

Station: Brenton's Reef Light Ship, Rhode Island.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ... 1883, —·— 1884, —··— 1885.

(ISSUED IN 1886.)



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EXPLANATION OF OCEAN TEMPERATURE CHART No. 17.

VINEYARD SOUND LIGHT-SHIP, MASSACHUSETTS.

Observers: WILLIAM H. DOANE, A. H. BRAY.

Location of station.—The Vineyard Sound, or "Sow and Pigs" light-ship, as it was formerly called, is anchored 1 mile to the southwestward of Sow and Pigs Reef, and 2½ miles SW. by W. of the light on Cuttyhunk Island, the southernmost of the Elizabeth Group. It is situated 17¼ miles E. by S. ¼ S. of Brenton's Reef light-ship, and on the western side of the southern entrance to Vineyard Sound. Within a radius of a mile the depths range from 4½ to 16½ fathoms. The 20-fathom curve is distant about 6 miles; the 100-fathom curve, about 80 miles.

Geographical position.—Latitude, 41° 23′ (02″) N.; longitude, 70° 59′ (01″) W.

Depth of water.—Fifteen fathoms.

Range of temperature (March 1 to January 1).—Air, 43° (28°.5 to 71°.5); surface, 37° (31° to 68°).

The temperatures for the colder months were evidently more carefully read here than at most of the northern stations, and the curves have been plotted on the chart for the entire year. In reckoning the ranges of temperature, however, January and February have been omitted to facilitate comparisons with the neighboring stations. Compared with Brenton's Reef, the maximum air record is 3° lower, the maximum surface only 1° lower, indicating closely corresponding conditions.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	5.8	6.5	6.8	6.9	8.6	4.8	4.4	6.3	9.3	10.2	6	5.5
Southeast	2.4	4.5	4.3	3.6	5.8	5.5	5.3	5.4	4.5	4.1	1.9	2.2
Southwest	8.6	5.3	7.8	10.7	12.3	16.3	16	14.8	11.3	9.4	11.1	9.3
Northwest	13.8	10.2	11.7	6.8	3	2.9	3.6	2.1	4.1	6.5	10.2	12.8

OCEAN TEMPERATURE CHART No. 17

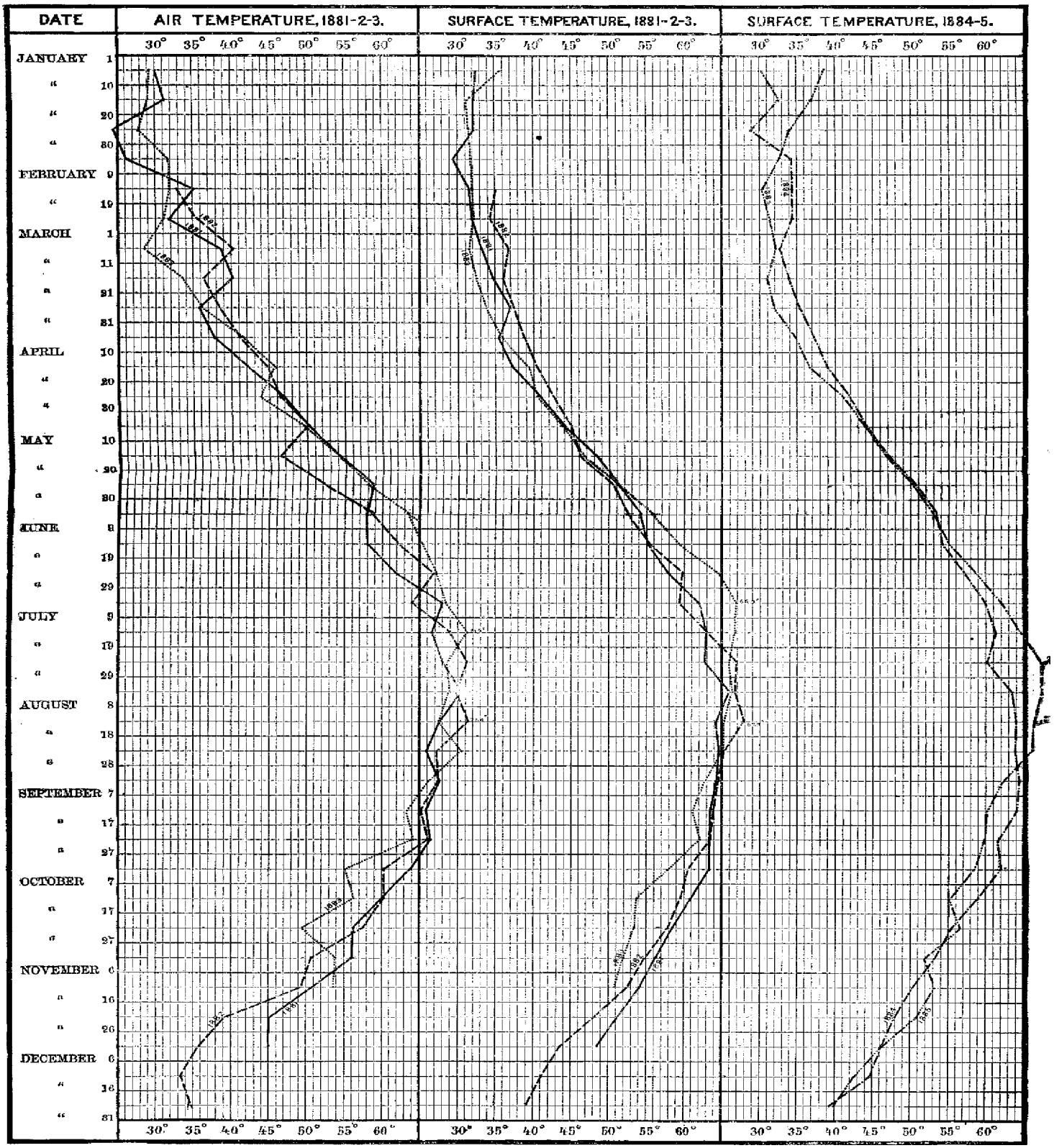
By RICHARD RATHBUN.

Station: Vineyard Sound Light Ship, Massachusetts.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ... 1883, —·— 1884, —··— 1885.

(ISSUED IN 1886.)



Each vertical interspace represents one degree Fahrenheit, and the fractional parts of a degree are indicated as exactly as possible in the plotting of the curves. Each fifth degree is represented by a slightly heavier line. The transverse interspaces inclosed by the heavier lines represent periods of ten days each, as indicated by the dates on the left-hand side of the plate. The lighter transverse lines, intermediate between the heavier ones, are intended to represent the mean of each ten days, and the curves of temperature are plotted with reference to these lines. The left-hand vertical division is devoted to the air temperatures for 1881, 1882, and 1883, the middle division to the surface water temperatures for the same years, thus permitting of a comparison of the two; and the right-hand division to the water temperatures for 1884 and 1885.

EXPLANATION OF OCEAN TEMPERATURE CHART No. 18.

NANTUCKET NEW SOUTH SHOAL LIGHT-SHIP.

Observers: T. S. JAMES, A. J. SANDSBURG, ISAAC HAMBLEN.

Location of station.—Nantucket (or Davis') New South Shoal light-ship is placed at the southern end of Nantucket Shoals, about 3 miles SSE. of the shoalest part of Davis' New South Shoal, and 21 miles SE. of Nantucket Island, the nearest land. It is distant from Vineyard Sound light-ship about 58 miles in a southeasterly direction. In the immediate vicinity the depths range from 11 to 18 fathoms. The water deepens gradually seaward, attaining a depth of 30 fathoms at distances of 22 to 25 miles; the 100-fathom curve is distant about 60 miles.

Geographical position.—Latitude, 40° 54′ (51″) N.; longitude, 69° 49′ (26″) W.

Depth of water.—Sixteen to 18 fathoms.

Range of temperature (12 months).—Air, 43° (26° to 69°); surface, 28°.5 (33°.5 to 62°).

The position of this light-ship, over 20 miles from the nearest land, and in the course of those schools of surface fish that pass around or through the Nantucket Shoals in their migrations, especially fits it as a permanent station for temperature and other observations bearing upon the coast fisheries. The temperature of the surface water is more equable here than at any of the preceding stations north of the Florida Reefs, but the maximum surface temperature at Nantucket New South Shoal is 8° lower than the minimum at Fowey Rocks. The comparatively slight range of temperature throughout the year has made it possible to utilize the winter temperatures, all of which have been plotted on the chart.

The range of air temperature from March 1 to January 1 is 40° (29° to 69°), nearly the same as at Vineyard Sound light-ship, the maximum being 2½° lower at New South Shoal than at Vineyard Sound. The lowest air records for the winter months also differ only 2° at these two stations. The maximum surface temperature at New South Shoal is, however, 6° lower than at Vineyard Sound, and the minimum between March and January, about 3° higher. The range of surface temperature is, therefore, considerably less at New South Shoal.

Table showing the direction of the wind, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	4.8	4.1	5	7.3	9.4	5.2	4.1	8.1	10.1	9.3	6.1	4.7
Southeast	4.4	4.2	4.5	3.6	5.1	3.9	5.4	4.6	5.3	5.2	2.9	4.6
Southwest	7.1	5.7	5.8	8.2	9.9	14.8	13	10.5	11.3	9.4	7.2	7.2
Northwest	13.7	12.6	13.8	8.8	4	2.2	2.1	3.9	3.5	7.6	11.9	13.8

OCEAN TEMPERATURE CHART No. 18

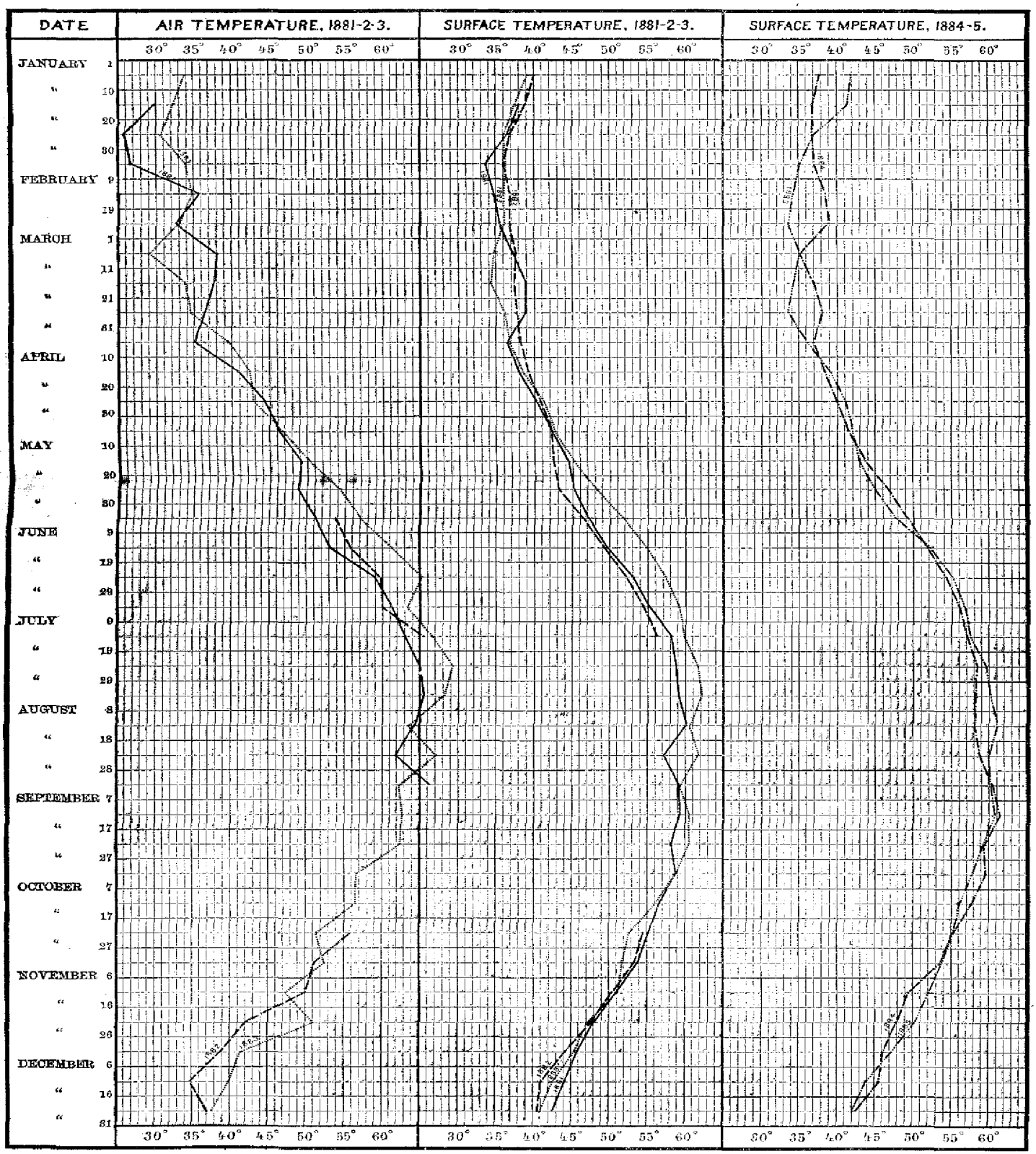
By RICHARD RATHBUN.

Station: Nantucket New South Shoal Light Ship.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ····· 1883, —·— 1884, —··— 1885.

(ISSUED IN 1886.)



Each vertical interspace represents one degree Fahrenheit, and the fractional parts of a degree are indicated as exactly as possible in the plotting of the curves. Each fifth degree is represented by a slightly heavier line. The transverse interspaces inclosed by the heavier lines represent periods of ten days each as indicated by the dates on the left-hand side of the plate. The lighter transverse lines intermediate between the heavier ones, are intended to represent the mean of each ten days, and the curves of temperature are plotted with reference to these lines. The left-hand vertical division is devoted to the air temperatures for 1881, 1882 and 1883, the middle division to the surface water temperatures for the same years, thus permitting of a comparison of the two; and the right-hand division to the water temperatures for 1884 and 1885.

EXPLANATION OF OCEAN TEMPERATURE CHART No. 19.

POLLOCK RIP LIGHT-SHIP, MASSACHUSETTS.

Observers: WILLIAM HAFFARDS, JAMES F. KELLY, JOSEPH ALLEN, JR.

Location of station.—This light-ship is located in the northeastern entrance to Nantucket or Vineyard Sound, and 3¼ miles SE. by E. ½ E. from Monomoy Point light-house, at the southeastern extremity of Cape Cod. It is 1¼ miles distant from Pollock Rip Shoal proper, which lies between it and Monomoy Island, and is surrounded on nearly all sides, at different distances, by small shoals or groups of shoals. There is, however, no land to the northeast, east, or southeast of it. It is anchored in a depth of 5 fathoms, and the depths about it range from 4 to 7 fathoms. The bottom in this region consists of sand and gravel. Nantucket New South Shoal light-ship is about 26 miles nearly south.

Geographical position.—Latitude, 41° 32′ (27″) N.; longitude, 69° 55′ (15″) W.

Depth of water.—Five to 7 fathoms.

Range of temperature (March 1 to January 1).—Air, 39° (27° to 66°); surface, 30°.5 (32° to 62°.5).

The curves of surface temperature are more irregular and less uniform than at the three or four preceding stations, and in many cases the variations do not appear to be due to the influence of the air. They may be caused in part by the currents flowing through the numerous passageways between the surrounding shoals. The ranges of temperature correspond closely with the same at Nantucket New South Shoal, the maximum air temperature being 3° lower at this station, but the maximum and minimum for the surface are almost precisely alike at both. The maximum surface temperature at Pollock Rip, located at the eastern entrance to Vineyard Sound, is 5½° lower than at Vineyard Sound light-ship, at the southwestern entrance to the same body of water.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	4.5	5.4	5.7	6.8	5.9	4.3	4	6.7	9.4	10.8	8.8	5.1
Southeast	5.3	3.9	4.1	4.1	5.1	5.9	6	5.7	6.2	4.7	3.1	4.4
Southwest	7.7	8	10	10.5	9.9	14.6	15.8	12.2	8.5	8.3	9.1	10
Northwest	13.4	10.7	10.7	7.6	4.2	4	3.3	3.5	4.5	5.9	10	10.1

OCEAN TEMPERATURE CHART No. 19

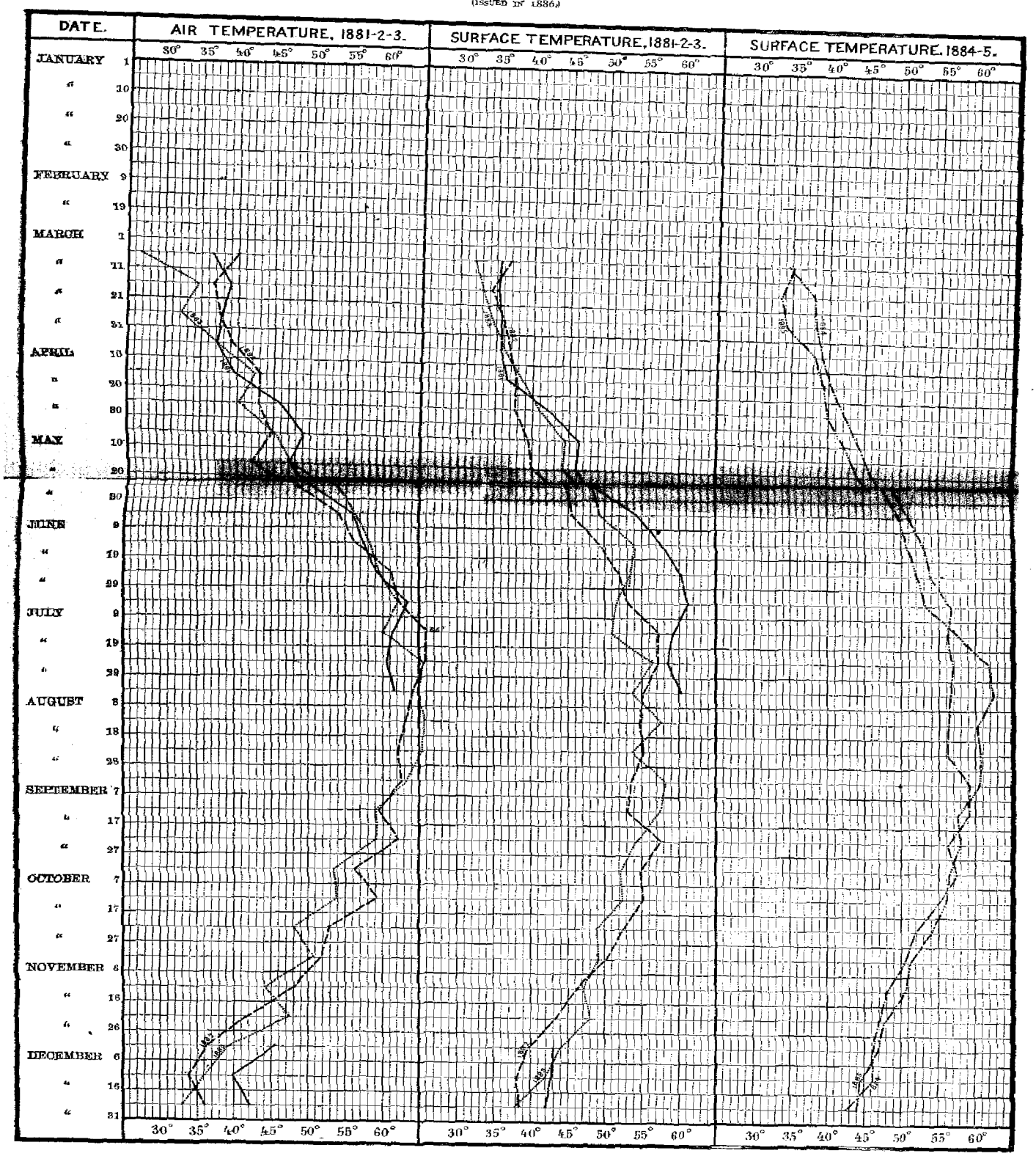
By RICHARD RATHBUN.

Station: Pollock Rip Light Ship, Massachusetts.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ... 1883, —·— 1884 —··— 1885.

(ISSUED IN 1886.)



Each vertical interspace represents one degree Fahrenheit, and the fractional parts of a degree are indicated as exactly as possible in the plotting of the curves. Each fifth degree is represented by a slightly heavier line. The transverse interspaces inclosed by the heavier lines represent periods of ten days each, as indicated by the dates on the left-hand side of the plate. The lighter transverse lines, intermediate between the heavier ones, are intended to represent the mean of each ten days, and the curves of temperature are plotted with reference to these lines. The left-hand vertical division is devoted to the air temperatures for 1881 1882 and 1883, the middle division to the surface water temperatures for the same years, thus permitting of a comparison of the two; and the right-hand division to the water temperatures for 1884 and 1885.

EXPLANATION OF OCEAN TEMPERATURE CHART No. 20.

THATCHER'S ISLAND LIGHTS, MASSACHUSETTS.

Observers: E. C. Goss, O. B. Cole, G. Liebmann, of the U. S. Signal Service.

Location of station.—The Cape Ann lights are located on Thatcher's Island, about three-fourths of a mile off the eastern extremity of Cape Ann, both being on the outer side of the island. There are several rocky ledges in front of the island, but otherwise depths of 3½ to 24 fathoms occur within a distance of 1 mile. A depth of 60 fathoms is reached 5½ miles to the eastward. Thatcher's Island is about 73 miles northwesterly from Pollock Rip light-ship.

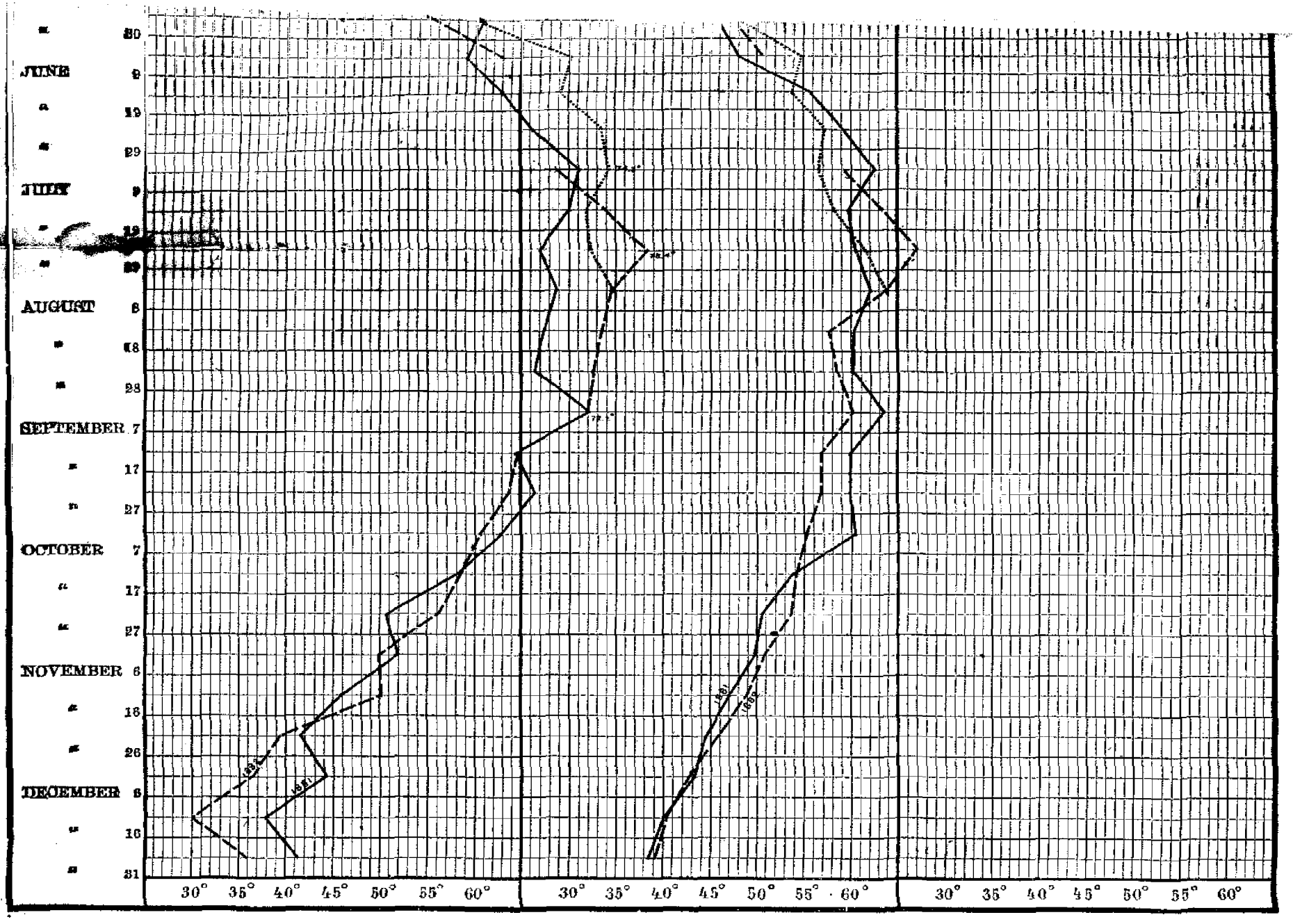
Geographical position.—The northern light is located in latitude 42° 38′ 21″ N.; longitude, 70° 34′ 31″ W.

Depth of water.—Seven feet.

Range of temperature (twelve months).—Air, 48°.5 (30° to 78°.5); surface, 32° (35° to 67°).

The observations at this station were taken by trained observers of the Signal Service, and the winter records, although covering only two years, are presumably accurate, and have been plotted. Observations were continued through only three years, and there are many gaps within that period, which is very unfortunate, considering the important geographical position of the station. Only one observation was taken daily, at 2 p. m. The surface curves are very irregular, and in many cases, especially during the warmer months, indicate direct atmospheric influence, from the similarity of the variations in both the air and surface curves. There is not always, however, a strict correspondence in the relative positions of the curves in different years, the air curve from May to July, 1883, being from 2° to 10° higher than the air curve for the same months in 1881, while the surface curve for a part of the same period, in 1883, is from 2° to 6° lower than in 1881. During the colder months the surface curves are very regular.

The maximum air temperature is higher at Thatcher's Island than at any of the preceding stations as far south as Block Island, with which latter this station corresponds approximately. In surface temperatures Thatcher's Island agrees most closely with Vineyard Sound and Brenton's Reef light-ships, but it is probable that the higher surface temperatures of Thatcher's Island are due to the observations having been taken in a sheltered place.



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OCEAN TEMPERATURE CHART No. 20

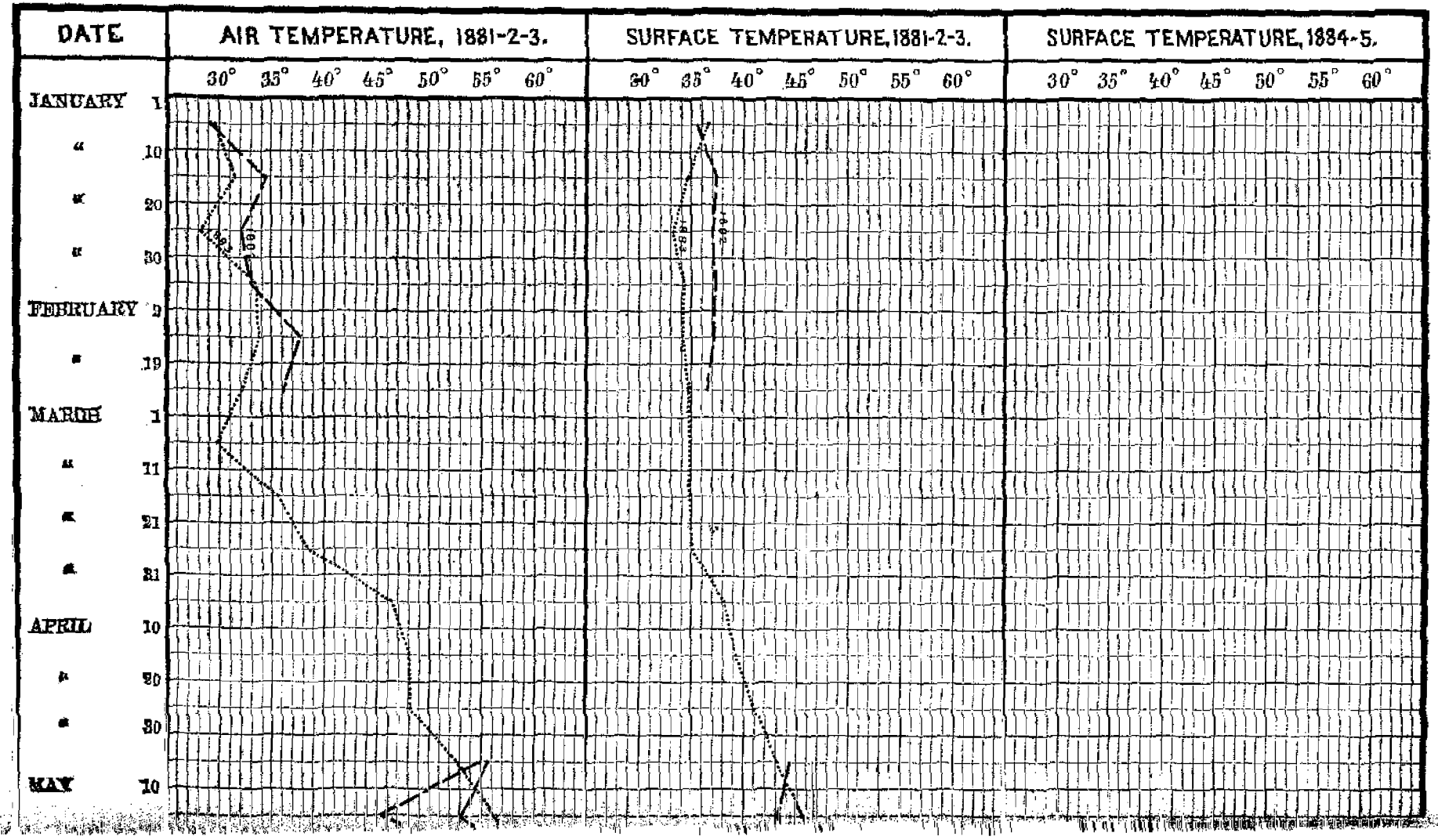
By RICHARD RATHBUN.

Station: Thatcher's Island Lights, Massachusetts.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1883, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ····· 1883, —·— 1884, —··— 1885.

(Issued in 1886.)



EXPLANATION OF OCEAN TEMPERATURE CHART No. 21.

BOON ISLAND LIGHT-HOUSE, MAINE.

Observer: ALFRED J. LEAVITT.

Location of station.—Boon Island is a small, low, rocky island, off York Harbor, Maine, and 5⅝ miles from Cape Neddick, the nearest part of the mainland. From Thatcher's Island it is distant about 35 miles, in a northerly direction. Within a radius of 1 mile depths of 5½ to 25 fathoms occur, and a depth of 60 fathoms is reached at a distance of about 6¼ miles to the eastward and southeastward.

Geographical position of the light-house.—Latitude, 43° 07′ 17″ N.; longitude, 70° 28′ 37″ W.

Depth of water.—Nine fathoms.

Range of temperature (March 1 to January 1).—Air, 51° (22°.5 to 73°.5); surface, 29° (33° to 62°).

This station affords the highest maximum surface temperature of any of the stations located in the northern part of the Gulf of Maine. This maximum is 5° lower than at Thatcher's Island, but agrees exactly with the surface maximums at Pollock Rip and Nantucket New South Shoal. The maximum for the air is, however, somewhat higher at Boon Island than at the two light-ships mentioned. The surface curves are more irregular than at the other stations in the Gulf of Maine. It is necessary to explain, however, that the surface observations were not taken with any regularity at this station, omissions of several days, sometimes as many as five or six days, occurring in a majority of the ten-day periods. The omissions are much less frequent during the summer than the winter months. It is impossible to calculate to what extent the results may be vitiated by this fact.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	7.8	9	9.3	9.1	9.9	5.3	5.8	7.5	10	11.4	9.7	8.8
Southeast	3.2	3.6	5.9	8.8	13	13.3	12.9	10	10.1	7.3	4.3	4
Southwest	9	7.2	5.5	3.9	4.5	5.6	7.7	10.5	6	7.7	9.1	9.6
Northwest	10.9	6.4	10.5	8	3.2	4.8	3.8	2.6	3.1	4.2	6.8	8.6

OCEAN TEMPERATURE CHART No. 21

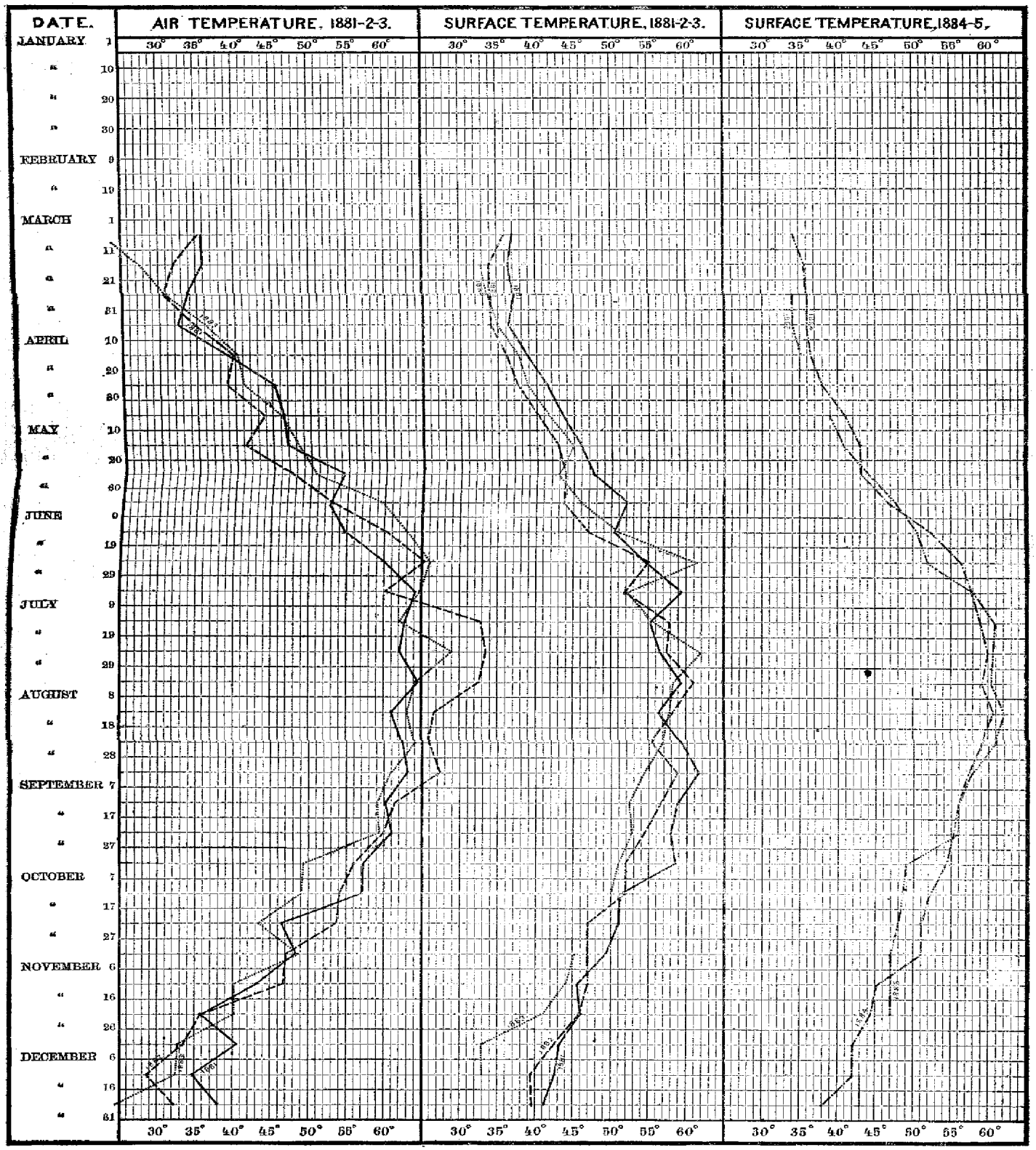
By RICHARD RATHBUN.

Station: Boon Island Light House, Maine.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881. — — — 1882, ... 1883, —·— 1884, —··— 1885.

(Issued in 1886.)



Each vertical interspace represents one degree Fahrenheit, and the fractional parts of a degree are indicated as exactly as possible in the plotting of the curves. Each fifth degree is represented by a slightly heavier line. The transverse interspaces inclosed by the heavier lines represent periods of ten days each, as indicated by the dates on the left-hand side of the plate. The lighter transverse lines, intermediate between the heavier ones, are intended to represent the mean of each ten days, and the curves of temperature are plotted with reference to these lines. The left-hand vertical division is devoted to the air temperatures for 1881, 1882 and 1883, the middle division to the surface water temperatures for the same years, thus permitting of a comparison of the two; and the right-hand division to the water temperatures for 1884 and 1885.

EXPLANATION OF OCEAN TEMPERATURE CHART No. 22.

SEGUIN ISLAND LIGHT-HOUSE, MAINE.

Observer: THOMAS DAY.

Location of station.—Seguin Island is a small rocky island with precipitous shores, located about 2¼ miles off the nearest part of the mainland, on the east side of the entrance to Kennebec River, and about 47 miles northeasterly from Boon Island. Between Seguin Island and the shoals bordering the adjacent mainland depths of 3½ to 9 fathoms occur, and off the island a depth of 40 fathoms is reached within a distance of 3¼ miles. The light is placed on the western side of the island where the water is from 6 to 8 fathoms deep close inshore.

Geographical position.—Latitude, 43° 42′ 26″ N.; longitude, 69° 45′ 32″ W.

Depth of water.—Six fathoms.

Range of temperature (March 1 to January 1).—Air, 46°.5 (24° to 70°.5); surface, 25° (33° to 58°).

This station has a shorter range of temperature for both the air and surface than Boon Island. The maximum air temperature is 3°, the maximum surface temperature 4°, lower than at Boon Island. Both the air and surface curves are more regular than at the preceding station, and more uniform for all the years.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	7.4	7.6	9	6.5	9.3	4.9	3.9	4.9	7.9	8.6	8.4	7
Southeast	2.1	3.1	4.3	5.4	8.8	6.8	7.4	7.5	4.7	4.5	1.8	2.9
Southwest	9.5	7.8	8	8.6	3.2	13.8	15.6	14.2	11.8	12.4	10.1	10.7
Northwest	11.6	8.8	9.2	8.6	2.9	3.4	3.2	3.4	4.4	6.1	9	9.7

OCEAN TEMPERATURE CHART No. 22

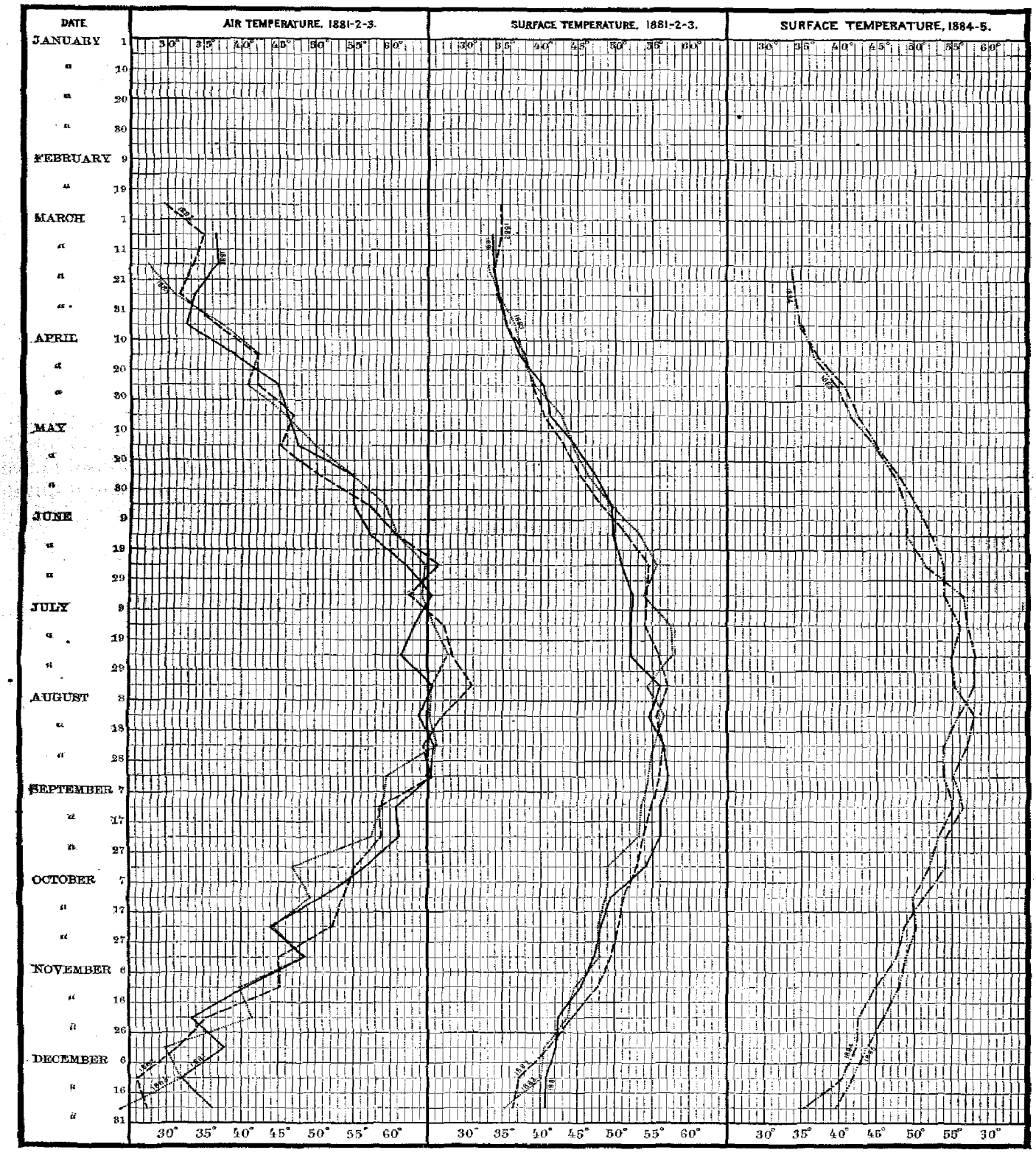
By RICHARD RATHBUN.

Station: Seguin Island Light House, Maine.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1882 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881. — — — 1882, ····· 1883, —·— 1884 —··— 1885.

(Issued in 1886.)



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EXPLANATION OF OCEAN TEMPERATURE CHART No. 23.

MATINICUS ROCK LIGHT-HOUSE, MAINE.

Observer: WILLIAM G. GRANT.

Location of station—Matinicus Rock is a bare, rocky islet, about 80 miles easterly from Seguin Island, and about 14 miles south of Vinal Haven Island, at the mouth of Penobscot Bay, the nearest large piece of land. It is about 2¾ miles SE. of Ragged Island, which is close to Matinicus Island and between the latter and Matinicus Rock. Within a radius of a mile the water deepens rapidly from 4 to 45 fathoms.

Geographical position.—Latitude, 43° 47′ 01″ N.; longitude, 68° 51′ 20″ W.

Depth of water.—Six to 12 fathoms.

Range of temperature (March 1 to January 1).—Air, 42° (23° to 65°); surface, 21°.5 (32°.5 to 54°).

Matinicus Rock and Mount Desert Rock present the shortest range of surface temperature of any of the stations north of the Florida Reefs, being 7° shorter than at Nantucket New South Shoal light-ship. The surface and air maximums for Matinicus Rock are also the lowest of any recorded. The surface curves are very regular and uniform from year to year. Unfortunately, there are nearly as many omissions in the surface records for this station as for Boon Island, but they are seldom frequent except during the colder months.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	3.7	4.6	5.3	6.3	6.6	2.7	2.4	3.7	5.7	6.1	6.1	4.5
Southeast	4.8	4.9	4.8	4.8	9.6	8.5	9.4	7.3	6	5.8	3.7	5.5
Southwest	9.1	6.4	7.4	8	9.2	12.8	13.9	12.9	10.2	10	10.3	8.2
Northwest	12.9	11.7	13.5	7.9	4.3	4.4	2.9	3.4	5.1	8.6	9.7	12.3

OCEAN TEMPERATURE CHART No. 23

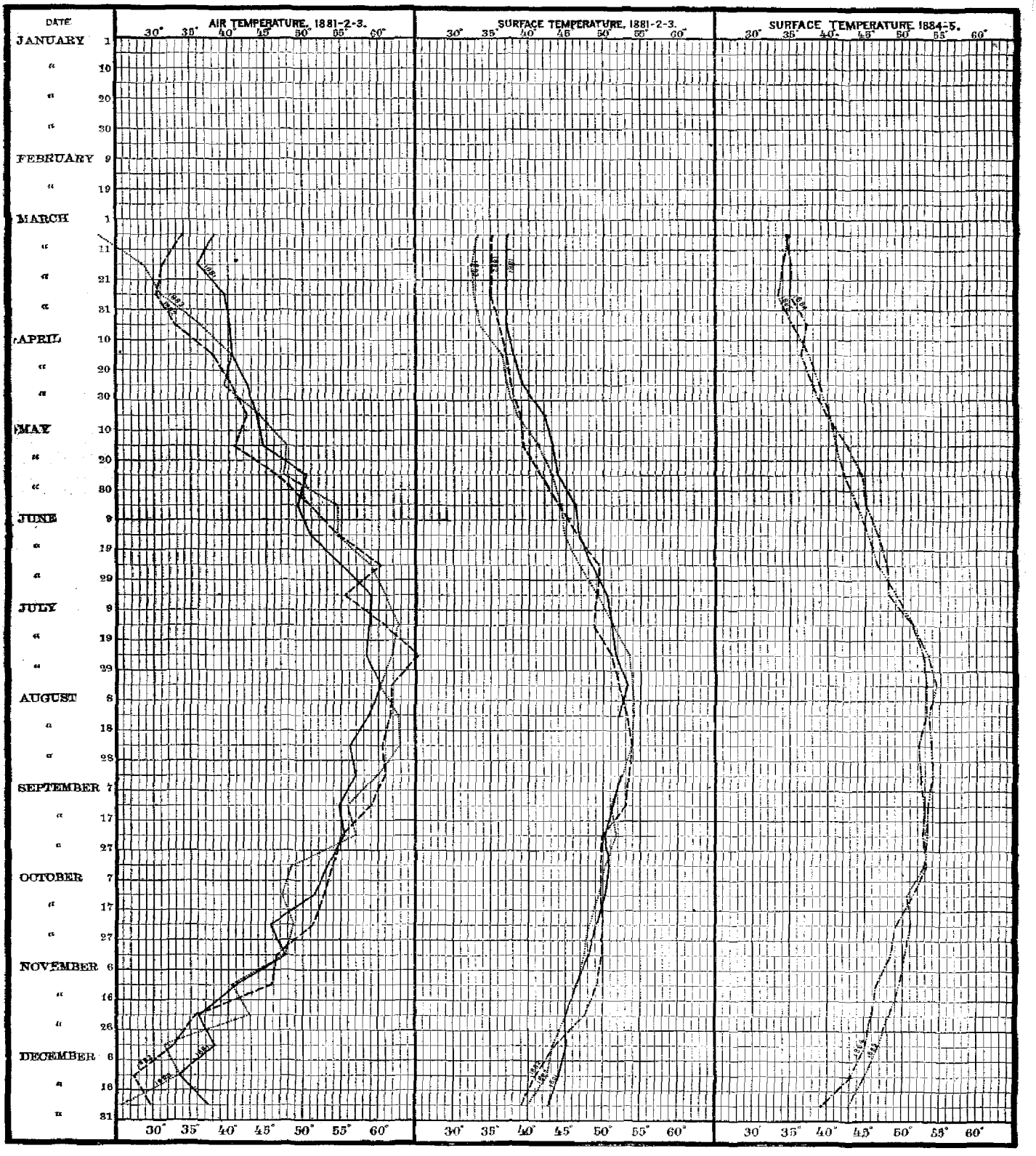
By RICHARD RATHBUN.

Station: Matinicus Rock Light House, Maine.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ... 1883, —·— 1884, —··— 1885.

(ISSUED IN 1886)



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EXPLANATION OF OCEAN TEMPERATURE CHART No. 24.

MOUNT DESERT ROCK LIGHT-HOUSE, MAINE.

Observers: AMOS B. NEWMAN, JAMES A. MORRIS, THOMAS MILAN.

Location of station.—Mount Desert Rock is a small, barren islet, 34 miles E. ¾ N. from Matinicus Rock, and about 18 miles off Mount Desert Island. The rock is surrounded with deep water, the depths ranging from 50 to 95 fathoms within a radius of 5 miles.

Geographical position.—Latitude, 43° 58′ 05″ N.; longitude, 68° 07′ 44″ W.

Depth of water.—Two to 10 fathoms.

Range of temperature (March 1 to January 1).—Air, 50° (25°.5 to 75°.5); surface, 21°.5 (33° to 54°.5).

This station presents the same surface range as Matinicus Rock, with practically the same maximum and minimum temperatures, but the surface curves are less regular and not uniform for all the years (especially from 1881 to 1883, inclusive), sometimes showing differences of 10° to 12° in corresponding periods. The maximum air temperature is 2° higher than at any other station in the Gulf of Maine, excepting Thatcher's Island, Brenton's Reef light-ship being the first station to the south with which it corresponds closely in this respect. The maximum air temperature at Matinicus Rock, the nearest station to the west, is 10° lower than at Mount Desert Rock. Excluding, however, the year 1883, in which the summer temperature was far above those of the two previous years, the maximum air temperature of this station would be only 68°.5.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	4.0	5.6	7.2	5.4	7.1	2.5	1.7	3	5.5	5.7	6.8	5.3
Southeast	4.5	4.9	6.8	5.3	8.3	8.9	9.9	7.3	6.9	7.1	5.7	7.1
Southwest	8.5	8	7.1	10.1	10.9	13.3	14.3	14	10.6	9.8	9.7	8.7
Northwest	12.9	9.4	9.6	7	3	3	2	3.1	4.1	6.6	7.5	9.6

OCEAN TEMPERATURE CHART No. 24

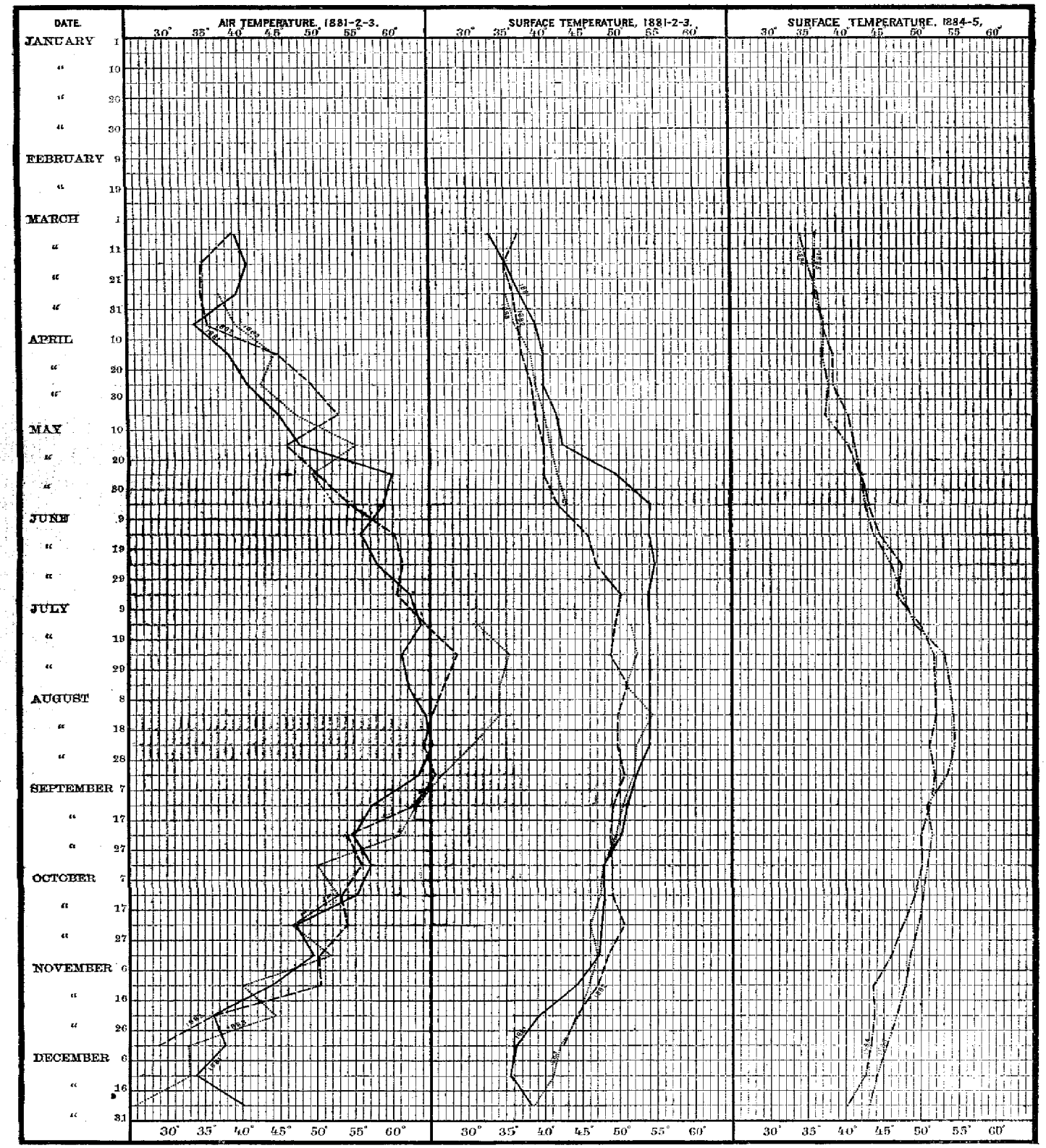
By RICHARD RATHBUN.

Station: Mount Desert Rock Light House, Maine.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, —·—·— 1882, ····· 1883, —·— 1884, —··— 1885.

(ISSUED IN 1886.)



Each vertical interspace represents one degree Fahrenheit, and the fractional parts of a degree are indicated as exactly as possible in the plotting of the curves. Each fifth degree is represented by a slightly heavier line. The transverse interspaces inclosed by the heavier lines represent periods of ten days each, as indicated by the dates on the left-hand side of the plate. The lighter transverse lines, intermediate between the heavier ones, are intended to represent the mean of each ten days, and the curves of temperature are plotted with reference to these lines. The left-hand vertical division is devoted to the air temperatures for 1881, 1882 and 1883, the middle division to the surface water temperatures for the same years, thus permitting of a comparison of the two; and the right-hand division to the water temperatures for 1884 and 1885.

EXPLANATION OF OCEAN TEMPERATURE CHART No. 25.

PETIT MANAN LIGHT-HOUSE, MAINE.

Observer: GEORGE L. UPTON.

Location of station.—Petit Manan light-house is located on the southernmost of a group of low, rocky islets, known, collectively, as Petit Manan Island. These islets are situated off the western entrance to Pigeon Hill Bay, near Gouldsborough, Me., and are distant about 2 miles from the nearest point of the mainland. They are immediately surrounded by ledges and shoals, but within a distance of 8 miles to the southward depths of 60 fathoms occur. The light is 27 miles NE. ¾ N. from Mount Desert Rock light-house.

Geographical position.—Latitude, 44° 22′ 03″ N.; longitude, 67° 51′ 51″ W.

Depth of water.—Eight to 15 fathoms.

Range of temperature (March 1 to January 1).—Air, 50° (20° to 70°); surface, 27°.5 (31° to 58°.5).

The range of air temperature is the same as at Mount Desert Rock, but with the maximum and minimum temperatures each 5½ degrees lower. Excluding the year 1883, the maximums of air temperature would be nearly the same at both places. The surface maximum is 4 degrees higher at this station. The surface curves for 1881 to 1883, inclusive, are fully as irregular as at Mount Desert Rock, and there is the same lack of uniformity between the different years, but the variations do not in any way correspond at the two stations, and the conditions by which they were produced were evidently not common to both. There is much greater correspondence between the years 1884 and 1885.

Table showing the direction of the winds, by quadrants, for each month of the year, being the means of five years' observations.

Quadrant.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
Northeast	5.5	5	8.6	6.8	8.5	3.7	3	3.8	5.5	5.6	6.4	4.3
Southeast	3.6	6	6	5.7	10.5	11.1	14.3	13.6	9.2	8.9	6.3	7.2
Southwest	9.5	7.3	9.2	10.7	8.4	11.8	11.4	11.3	10.9	7.4	9.6	7.9
Northwest	12.4	9.9	7.2	6.8	3.6	3.4	1.8	2.3	4.3	9.1	7.7	11.6

OCEAN TEMPERATURE CHART No. 25

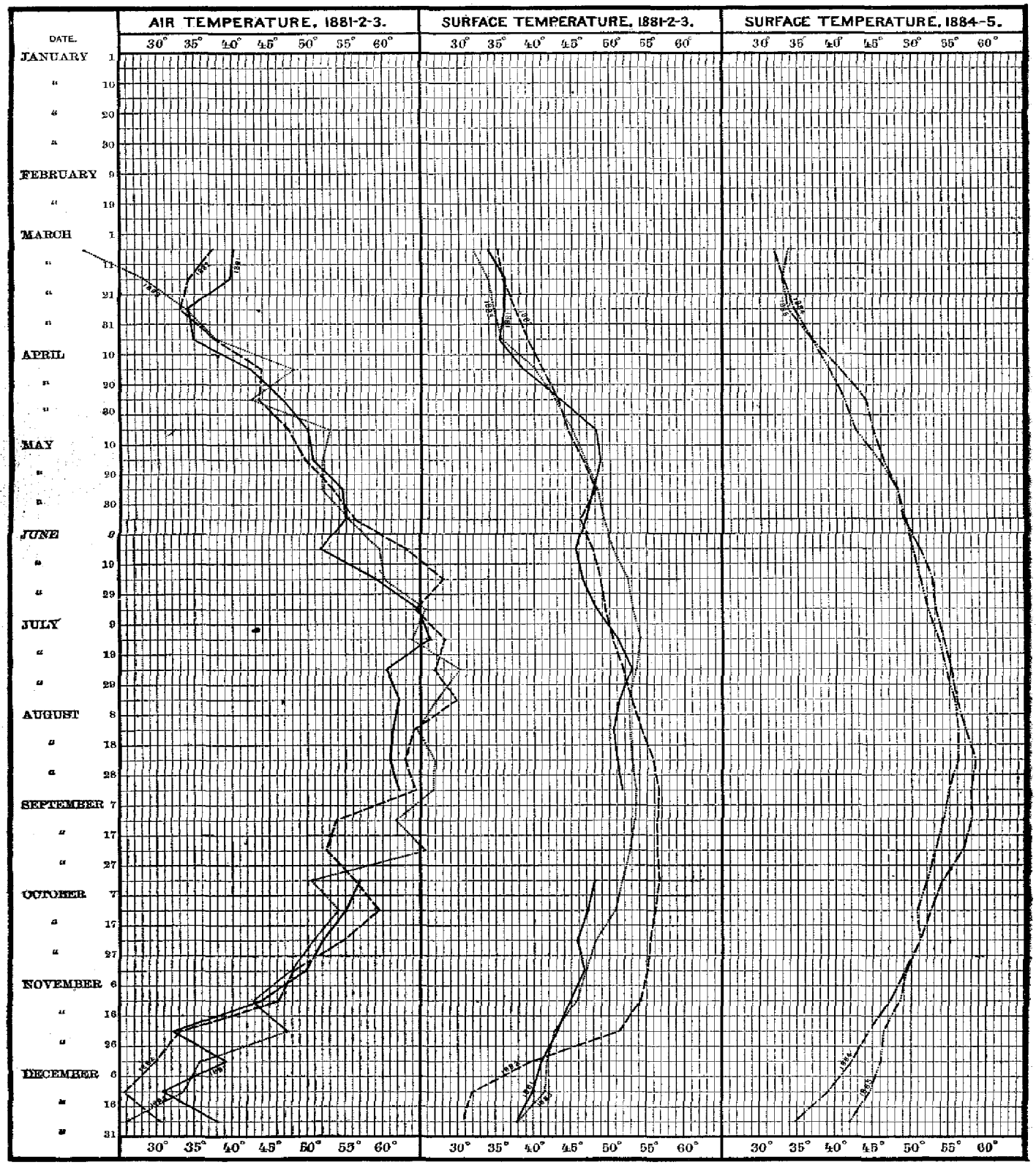
By RICHARD RATHBUN.

Station: Petit Manan Light House, Maine.

Representing, by means of curves, the temperature of the air from 1881 to 1883, inclusive, and of the water at the surface from 1881 to 1885, inclusive, reduced to means of ten days.

EXPLANATION OF THE CURVES: ——— 1881, — — — 1882, ... 1883, —·— 1884, —·····— 1885.

(ISSUED IN 1886.)



Each vertical interspace represents one degree Fahrenheit, and the fractional parts of a degree are indicated as exactly as possible in the plotting of the curves. Each fifth degree is represented by a slightly heavier line. The transverse interspaces inclosed by the heavier lines represent periods of ten days each, as indicated by the dates on the left-hand side of the plate. The lighter transverse lines, intermediate between the heavier ones, are intended to represent the mean of each ten days, and the curves of temperature are plotted with reference to these lines. The left-hand vertical division is devoted to the air temperatures for 1881, 1882 and 1883, the middle division to the surface water temperatures for the same years, thus permitting of a comparison of the two; and the right-hand division to the water temperatures for 1884 and 1885.

EXPLANATION OF OCEAN TEMPERATURE CHART No. 26.

Isothermal lines connecting the series of light-house stations on the eastern coast of the United States, represented on Chart No. 1, constructed for every 5° of temperature, Fahrenheit, from 40° to 80°, inclusive, for the year 1881.

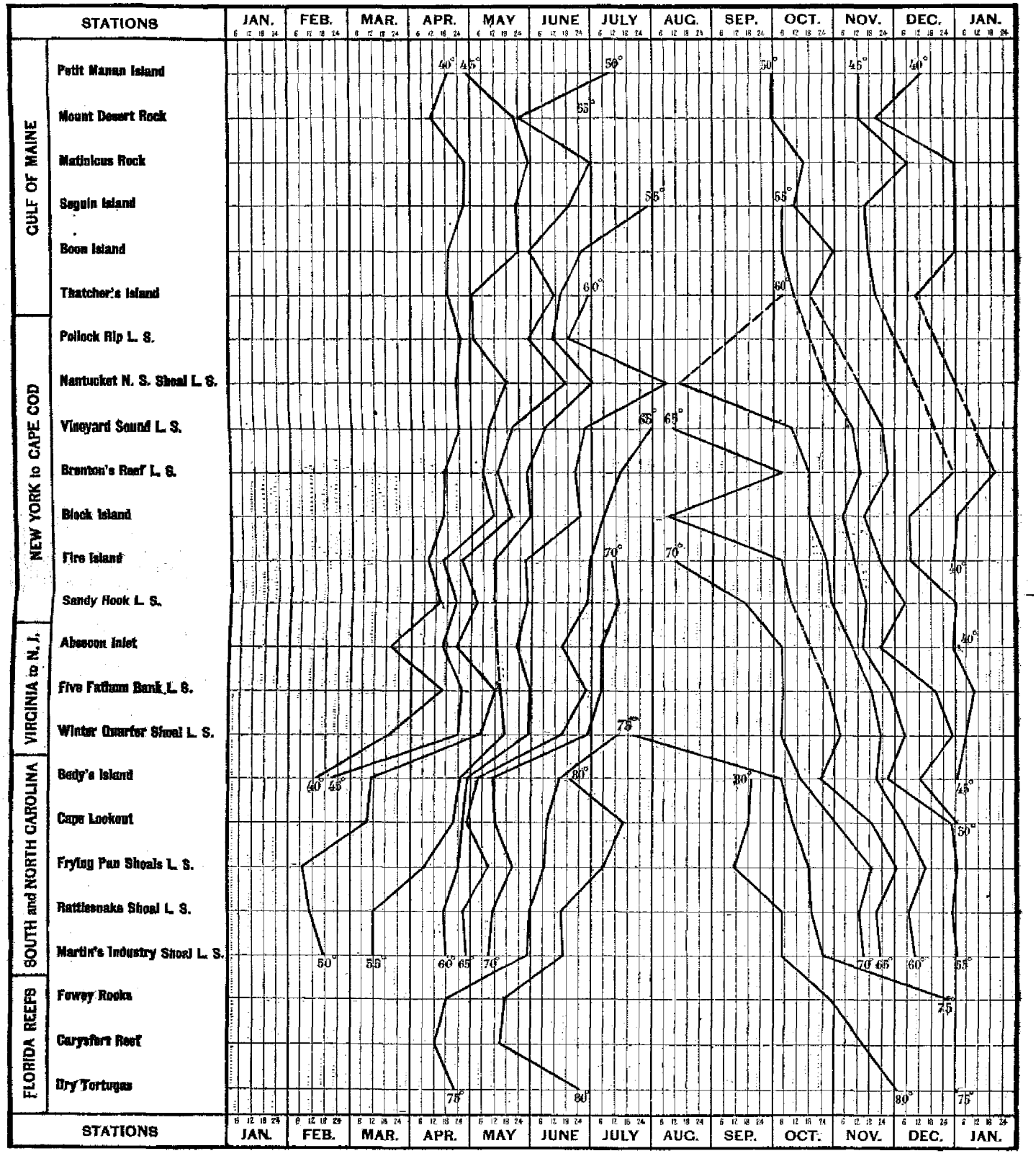
A temperature of 55° was reached at Mount Desert Rock between June 24 and 30, but otherwise the isotherms of 55° extend north only to Seguin Island. At Nantucket New South Shoal, 60° was recorded continuously for eight days only, or from August 7 to 14. Two very short periods of higher temperature than 75° occurred at Absecon Inlet (July 14 to 20, September 30 to October 24), but the isotherms of 75° begin regularly at Winter Quarter Shoal, where the interval between the two lines is only eight days (July 13-20). During the period of falling temperature, the isotherm of 40° extends south continuously within the year to Fire Island, although at Pollock Rip, Nantucket New South Shoal, and Vineyard Sound observations are lacking for that temperature. At Sandy Hook the isotherm of 40° was not reached until February, 1882, while at Five Fathom Bank and Winter Quarter Shoal the temperature remained above 40° during the entire winter of 1881 and 1882. The isotherm of 50° extends south only to Cape Lookout in the same winter, but in the early part of 1881 it reached to Martin's Industry. At the Tortugas the temperature fell below 70° during a short period just prior to February 8, and again between March 20 and April 15.

OCEAN TEMPERATURE CHART No. 26

By RICHARD RATHBUN.

Isothermal lines connecting the series of Light House Stations represented on Chart No. 1, constructed for every five degrees of temperature, Fahrenheit, from 40 degrees to 80 degrees, inclusive, for the year 1881.

(ISSUED IN 1886.)



This chart is divided vertically into thirteen months in order to include the first month of the following year. Each month is further divided, by the lighter lines, into periods of six days each, except in the case of those months having fewer or more days than 30, when the last division of the month may equal four, five, or seven days. The 1st, 6th, 12th, 18th, 24th and last days of the month fall on the vertical lines. The transverse lines represent the stations from which they extend. A complete break in the isothermal line opposite any station generally indicates that the temperature did not reach the isotherm at that station during the year. A line consisting of dashes denotes a lack of observations for the corresponding station.

EXPLANATION OF OCEAN TEMPERATURE CHART No. 27.

Isothermal lines connecting the series of light-house stations on the eastern coast of the United States represented on Chart No. 1, constructed for every 5° of temperature, Fahrenheit, from 40° to 80°, inclusive, for the year 1882.

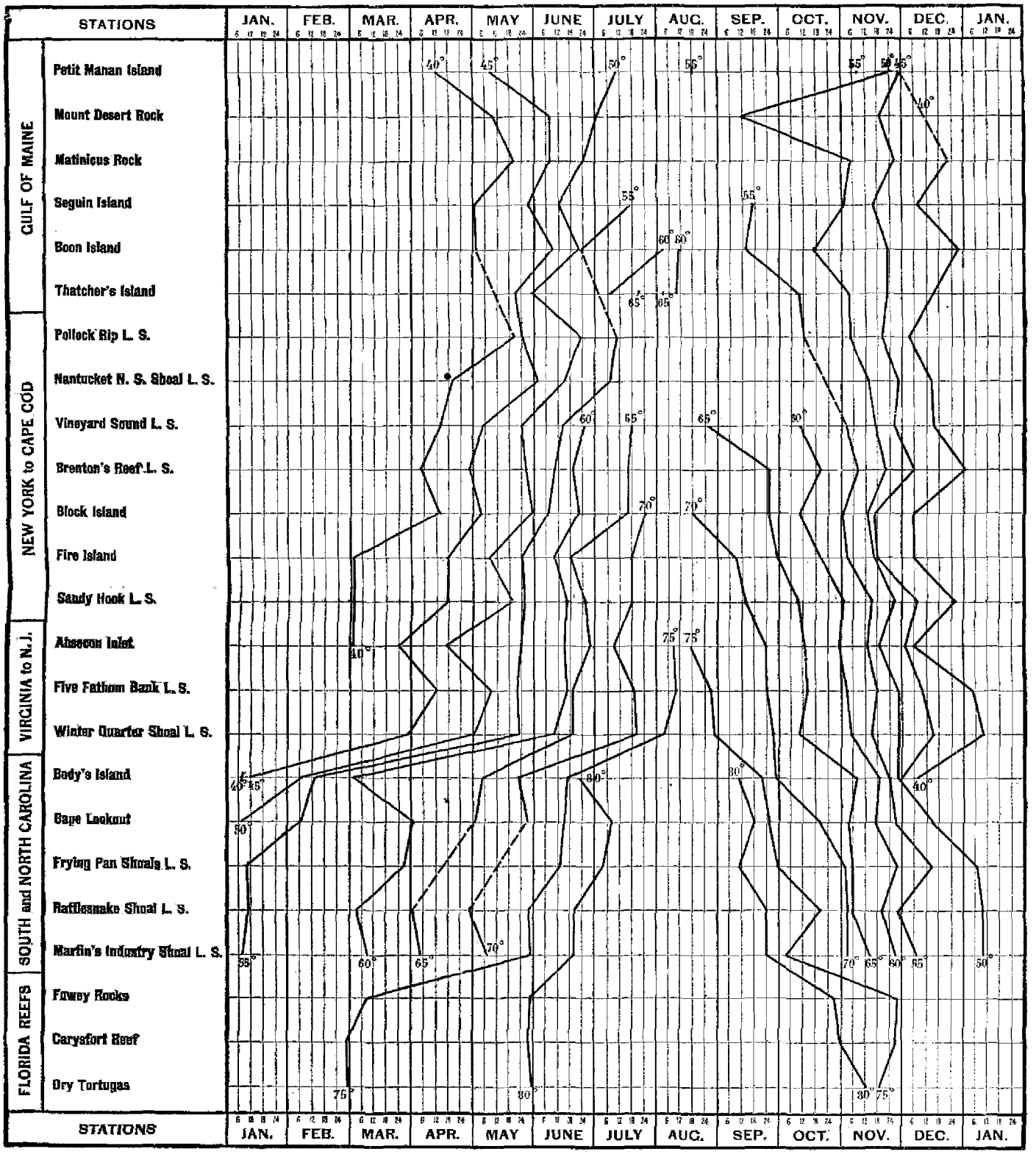
The isotherm of 40° extends south continuously in the spring only as far as Absecon Inlet; during the period of falling temperature, however, the isotherm of that value extends to Body's Island. Higher temperatures than 55° were recorded at Petit Manan, from August 18 to November 8, but the isotherms of 55° begin at Seguin Island. The isotherm of 60° appeared at Boon Island and Thatcher's Island, but not elsewhere north of Vineyard Sound, although the record is incomplete for Nantucket New South Shoal. The isotherms of 65° extend north continuously to Vineyard Sound, and the same temperature was also recorded at Thatcher's Island. At the Tortugas, the temperature was below 75° between May 9 and 21, and below 80° between October 8 and 14.

OCEAN TEMPERATURE CHART No. 27

By RICHARD RATHBUN.

Isothermal lines connecting the series of Light House Stations represented on Chart No. 1, constructed for every five degrees of temperature, Fahrenheit, from 40 degrees to 80 degrees, inclusive, for the year 1882.

(ISSUED IN 1886.)



This chart is divided vertically into thirteen months in order to include the first month of the following year. Each month is further divided, by the lighter lines, into periods of six days each, except in the case of those months having fewer or more days than 30, when the last division of the month may equal four, five, or seven days. The 1st, 6th, 12th, 18th, 24th and last days of the month fall on the vertical lines. The transverse lines represent the stations from which they extend. A complete break in the isothermal line opposite any station generally indicates that the temperature did not reach the isotherm at that station during the year. A line consisting of dashes denotes a lack of observations for the corresponding station.

EXPLANATION OF OCEAN TEMPERATURE CHART No. 28.

Isothermal lines connecting the series of light-house stations on the eastern coast of the United States, represented on Chart No. 1, constructed for every 5° of temperature, Fahrenheit, from 40° to 80°, inclusive, for the year 1883.

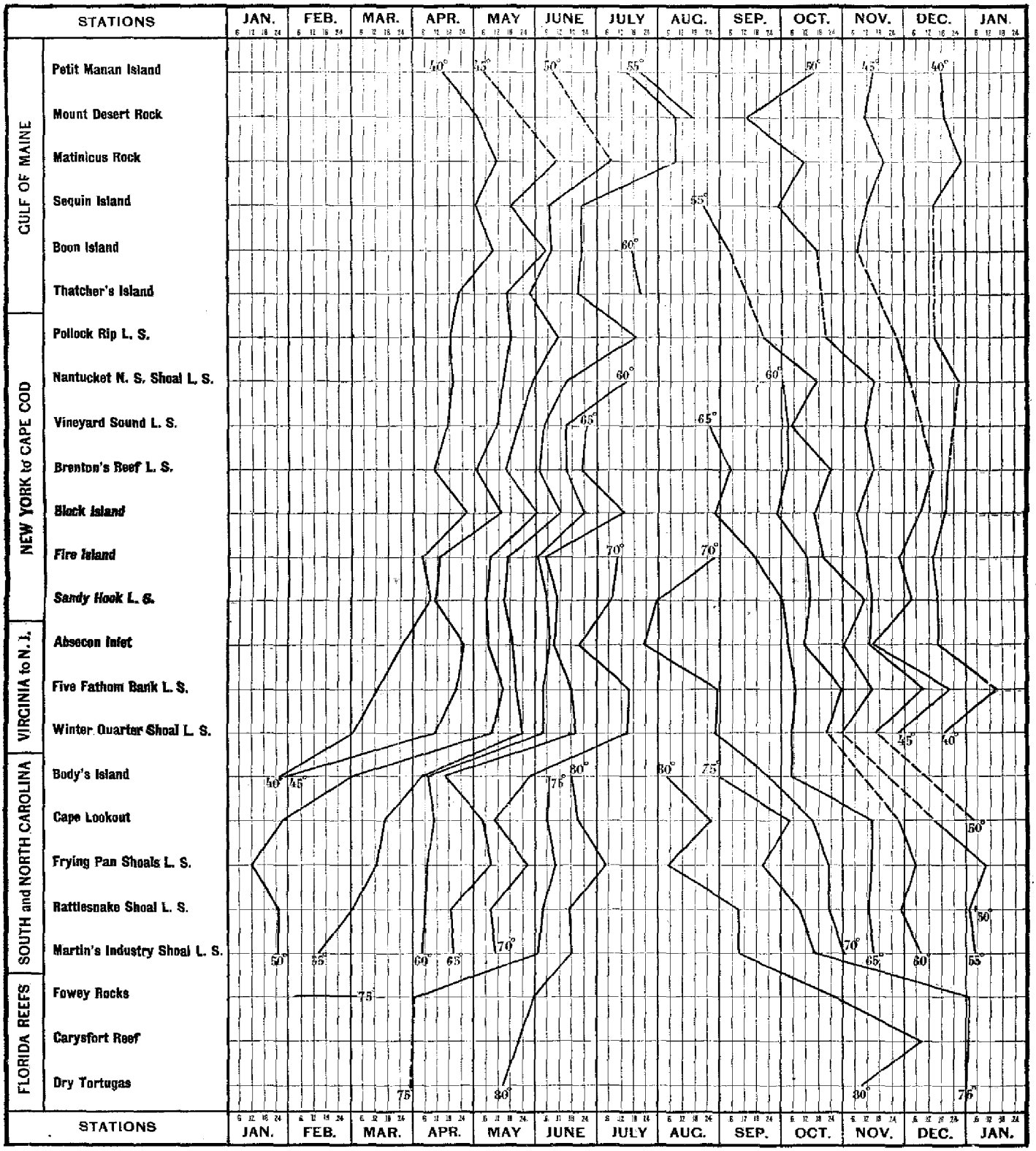
The two isotherms of 55° follow one another closely at Petit Manan and Mount Desert Rock; at Matinicus Rock the same temperature was recorded for two or three days, beginning August 9, and this point has been included in the first isotherm of 55°. At Boon Island the isotherm of 60° was reached July 17 (that temperature, however, continuing only until July 31), and at Thatcher's Island July 21, with no corresponding observations during the period of falling temperature; at Pollock Rip temperatures of 60° were occasionally recorded, but only for a day or two at a time. At Fowey Rocks the temperature was above 75° from February 3 to March 3, after which there was a period of lower temperature, continuing until April 1. At the Tortugas the temperatures of 75° and 80° were not continuous between the dates on which the isotherms of 75° and 80° are plotted.

OCEAN TEMPERATURE CHART No. 28

By RICHARD RATHBUN.

Isothermal lines connecting the series of Light House Stations represented on Chart No. 1, constructed for every five degrees of temperature, Fahrenheit, from 40 degrees to 80 degrees, inclusive, for the year 1883.

(ISSUED IN 1886.)



This chart is divided vertically into thirteen months in order to include the first month of the following year. Each month is further divided, by the lighter lines, into periods of six days each, except in the case of those months having fewer or more days than 30, when the last division of the month may equal four, five, or seven days. The 1st, 6th, 12th, 18th, 24th and last days of the month fall on the vertical lines. The *transverse lines represent the stations from which they extend. A complete break in the isothermal line opposite any station generally indicates* that the temperature did not reach the isotherm at that station during the year. A line consisting of dashes denotes a lack of observations for the corresponding station.

EXPLANATION OF OCEAN TEMPERATURE CHART No. 29.

Isothermal lines connecting the series of light-house stations on the eastern coast of the United States, represented on Chart No. 1, constructed for every 5° of temperature, Fahrenheit, from 40° to 80°, inclusive, for the year 1884.

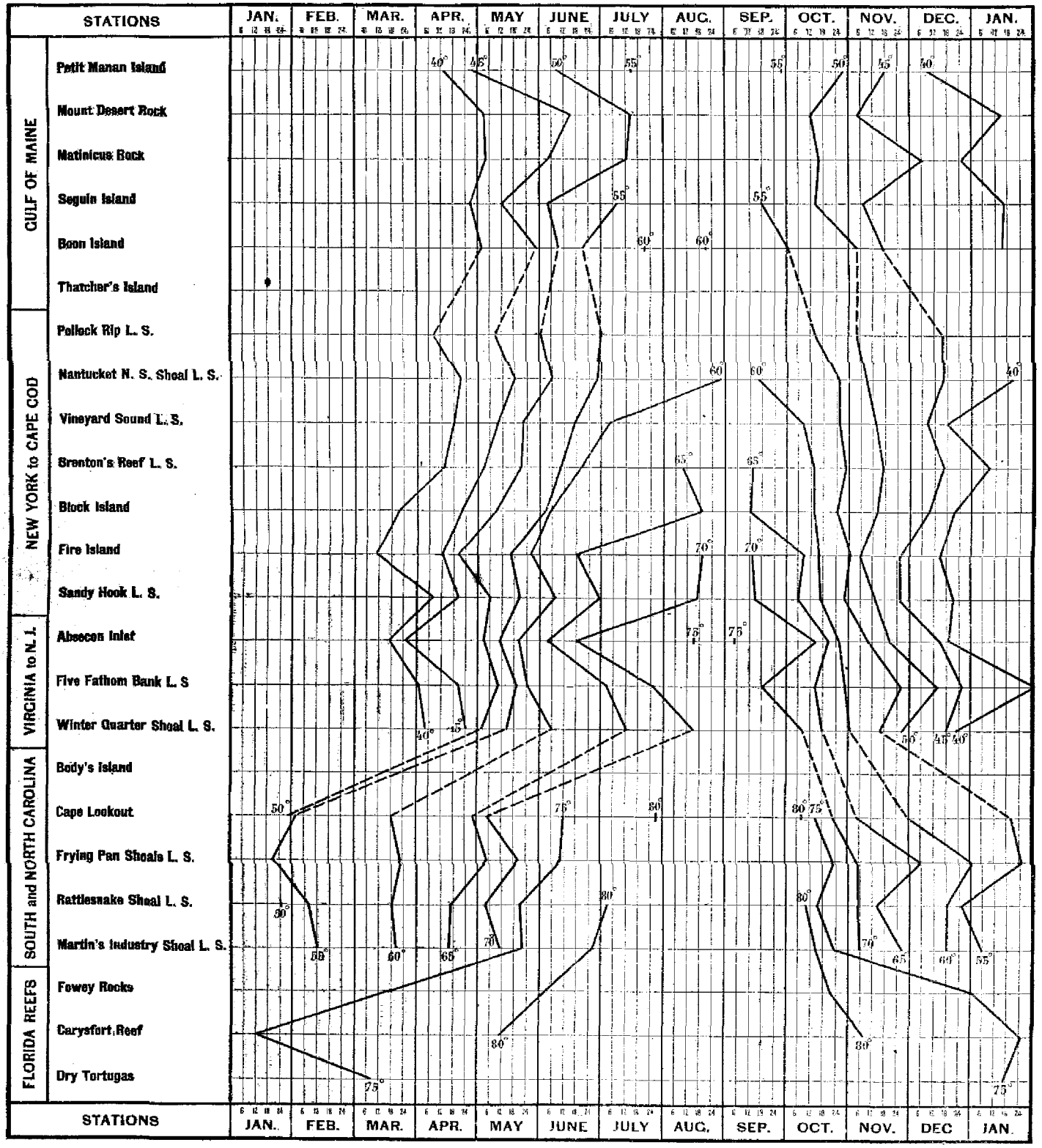
Higher temperatures than 55° were recorded at Petit Manan, but not at Mount Desert Rock and Matinicus Rock. The isotherm of 60° extends north continuously only to Nantucket New South Shoal, but the same temperature was recorded at Boon Island. Breaks of a similar character also occur in the isotherms of 75° and 80° at the southern stations. The temperature fell below 75° at the Tortugas several times during the year and reached 80° only between October 24 and 29.

OCEAN TEMPERATURE CHART No. 29

By RICHARD RATHBUN.

Isothermal lines connecting the series of Light House Stations represented on Chart No. 1, constructed for every five degrees of temperature, Fahrenheit, from 40 degrees to 80 degrees, inclusive, for the year 1884.

(ISSUED IN 1886.)



This chart is divided vertically into thirteen months in order to include the first month of the following year. Each month is further divided, by the lighter lines, into periods of six days each, except in the case of those months having fewer or more days than 30, when the last division of the month may equal four, five, or seven days. The 1st, 6th, 12th, 18th, 24th and last days of the month fall on the vertical lines. The transverse lines represent the stations from which they extend. A complete break in the isothermal line opposite any station generally indicates that the temperature did not reach the isotherm at that station during the year. A line consisting of dashes denotes a lack of observations for the corresponding station.

EXPLANATION OF OCEAN TEMPERATURE CHART No. 30.

Isothermal lines connecting the series of light-house stations on the eastern coast of the United States, represented on Chart No. 1, constructed for every 5° of temperature, Fahrenheit, from 40° to 80°, inclusive, for the year 1885.

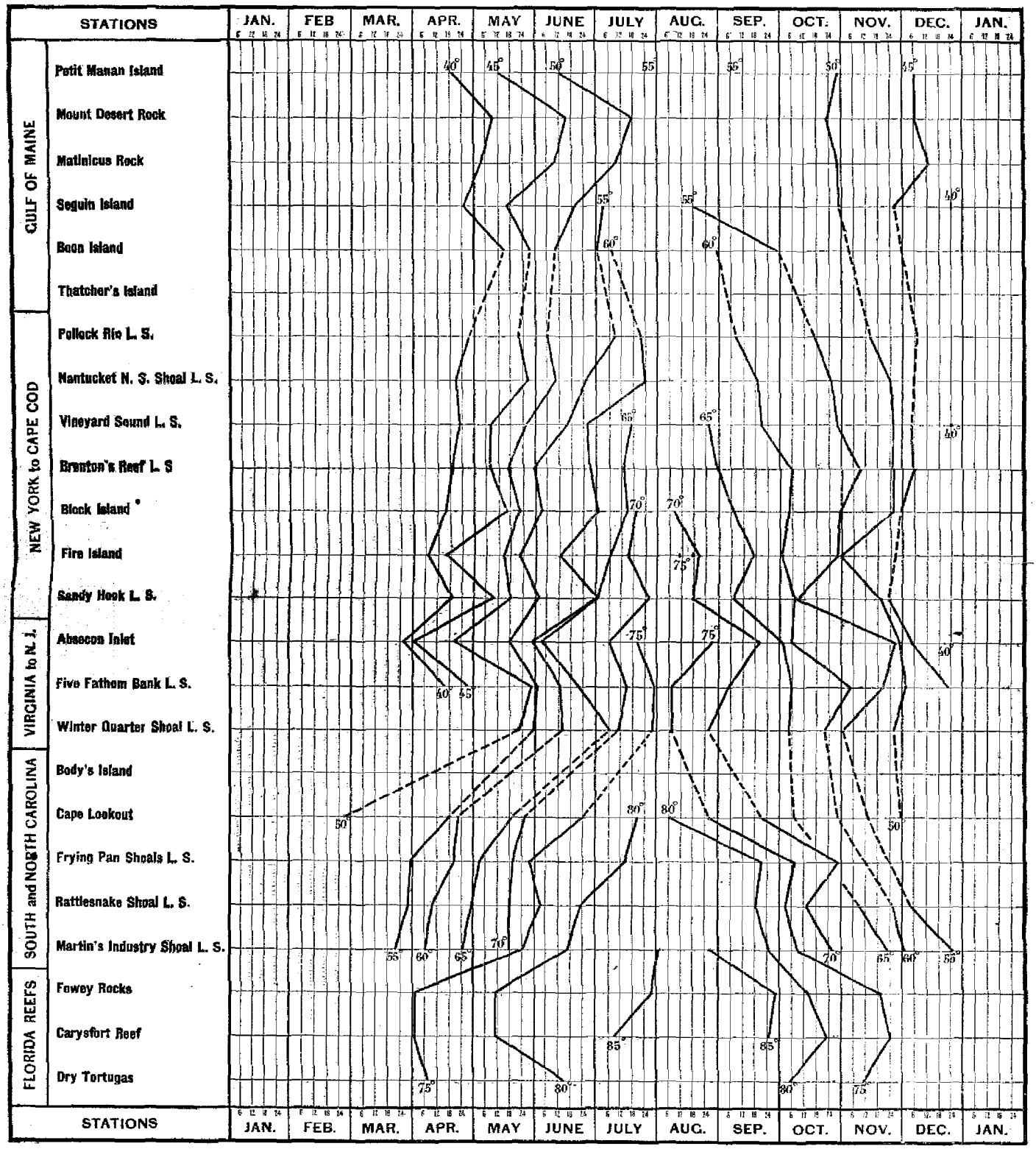
At the time this chart was prepared, the temperature records for 1886 were not available, and it was, therefore, impossible to plot the isotherm of 40° during the period of falling temperature, excepting for those stations at which that temperature was reached in December. As in most previous years, higher temperatures than 55° were recorded at Petit Manan, although the isotherms of 55° extended north continuously only as far as Seguin Island.

OCEAN TEMPERATURE CHART No. 30

By RICHARD RATHBUN.

Isothermal lines connecting the series of Light House Stations represented on Chart No. 1, constructed for every five degrees of temperature, Fahrenheit, from 40 degrees to 80 degrees, inclusive, for the year 1885.

(ISSUED IN 1886.)



This chart is divided vertically into thirteen months in order to include the first month of the following year. Each month is further divided, by the lighter lines, into periods of six days each, except in the case of those months having fewer or more days than 30, when the last division of the month may equal four, five, or seven days. The 1st, 6th, 12th, 18th, 24th and last days of the month fall on the vertical lines. The transverse lines represent the stations from which they extend. A complete break in the isothermal line opposite any station generally indicates that the temperature did not reach the isotherm at that station during the year. A line consisting of dashes denotes a lack of observations for the corresponding station.

EXPLANATION OF OCEAN TEMPERATURE CHART No. 31.

Isothermal lines connecting the series of light-house stations on the eastern coast of the United States, represented on Chart No. 1, constructed for every 5° of temperature, Fahrenheit, from 40° to 80°, inclusive, being the means of five years' observations, from 1881 to 1885, inclusive.

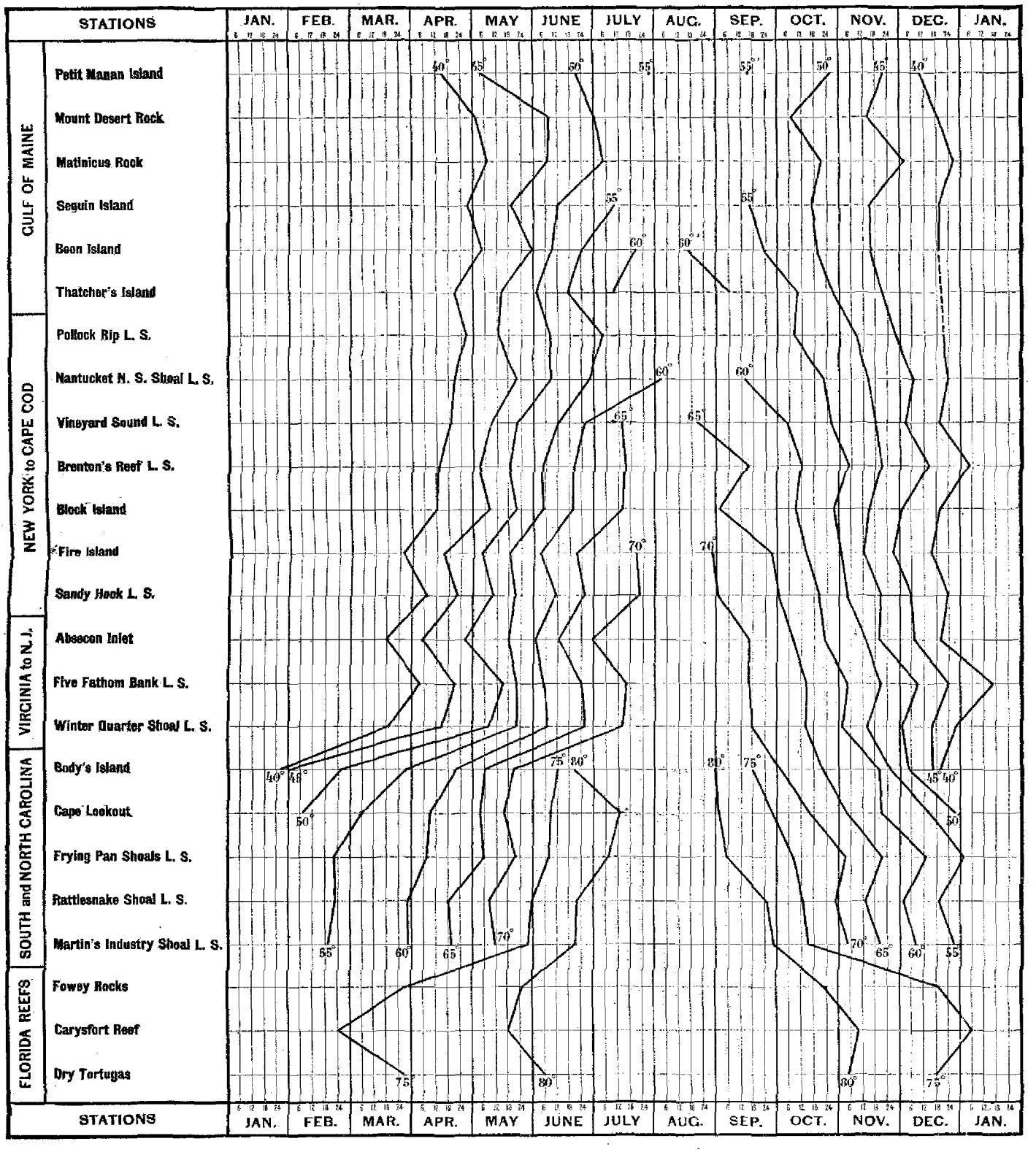
Most of the plottings on this chart are reductions of the observations of five years, but in some cases they represent a shorter period, though seldom less than four years, and never less than three years. The exact number of observations in each case may be determined by reference to the five preceding charts (Nos. 26–30) on which the isotherms for each year are separately shown. At Thatcher's Island, Massachusetts, no records were kept after the summer of 1883, and at Body's Island, Virginia, observations ceased to be taken after October of the same year. At none of the other stations, however, do serious breaks in the records occur, and there are seldom more than one or two omissions at any station.

OCEAN TEMPERATURE CHART No. 31

By RICHARD RATHBUN.

Isothermal lines connecting the series of Light House Stations represented on Chart No. 1, constructed for every five degrees of temperature, Fahrenheit, from 40 degrees to 80 degrees, being the means of five years observations, from 1881 to 1885, inclusive.

(ISSUED IN 1886.)



This chart is divided vertically into thirteen months in order to include the first month of the following year. Each month is further divided, by the lighter lines, into periods of six days each, except in the case of those months having fewer or more days than 30, when the last division of the month may equal four, five, or seven days. The 1st, 6th, 12th, 18th, 24th and last days of the month fall on the vertical lines. The *transverse lines represent* the stations from which they extend. A complete break in the isothermal line opposite any station generally indicates that the temperature did not reach the isotherm at that station during the year. A line consisting of dashes denotes a lack of observations for the corresponding station.

EXPLANATION OF OCEAN TEMPERATURE CHART No. 32.

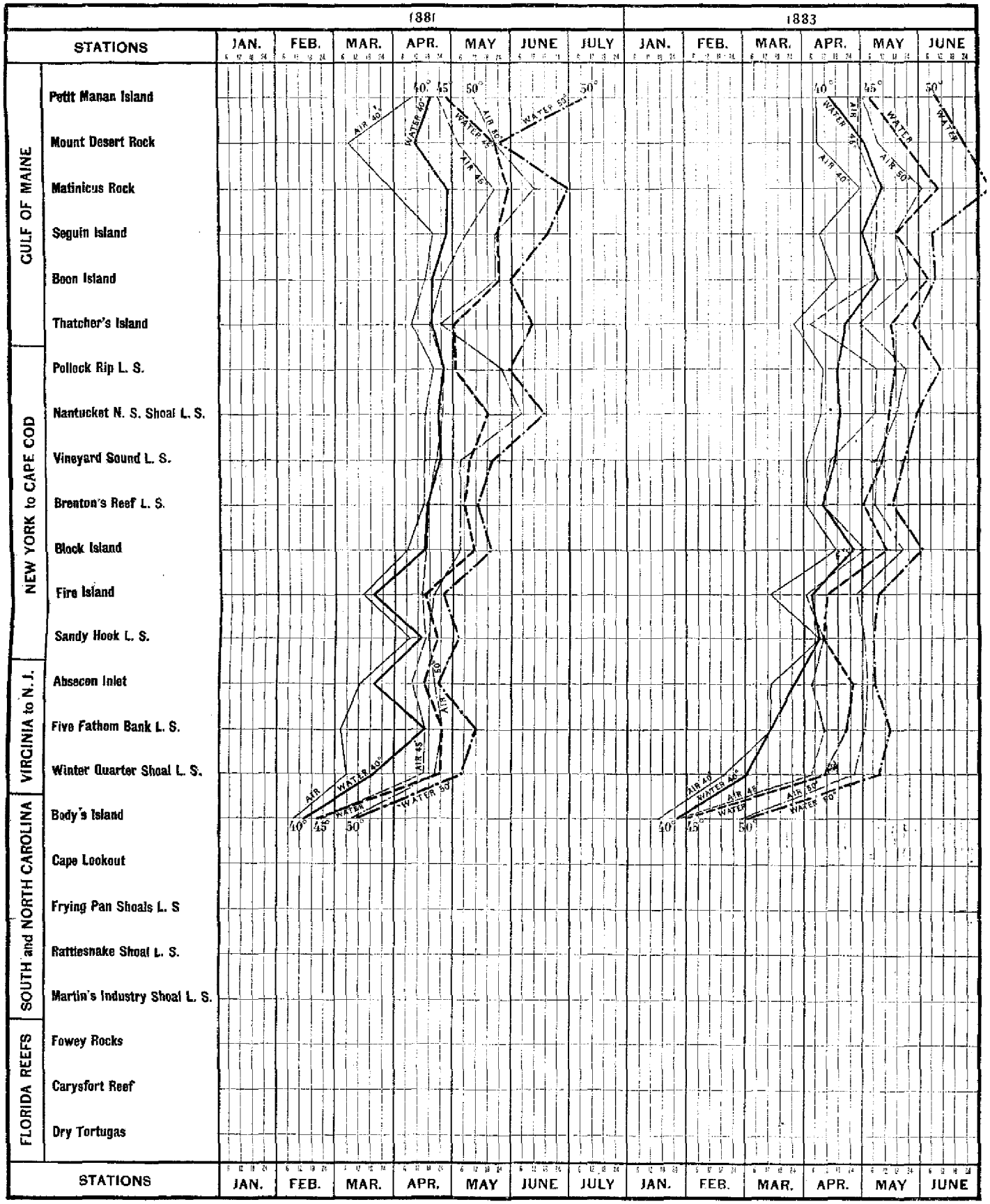
The air and surface isotherms of 40°, 45°, and 50°, Fahrenheit, at the light-house stations of the eastern coast of the United States, during the years 1881 and 1883.

This chart has been prepared to permit of a comparison of the surface with the air isotherms at the several light-houses and light-ships now under consideration. It has been noticed by previous observers that, in certain localities, the rise and fall in the surface temperatures maintain a nearly constant relation to the rise and fall in the air temperatures at the same place. For example, the surface temperatures of 40°, 45°, and 50° may follow the air temperatures of the same value at more or less regular intervals, and the length of these intervals may be sufficiently uniform to permit of a prediction of the surface temperature several days in advance, with approximate accuracy. Such predictions would be of great practical value in determining the time when schools of those fishes that regulate their migrations by the surface temperature of the water might be expected at certain fishing grounds. It is very probable, for example, that the spring migrations of mackerel and menhaden are regulated mainly, if not entirely, by changes of surface temperature.

The writer has made many plottings of the air and surface isotherms conjointly, without discovering a constant ratio at any of the stations. The two sets of isotherms shown on the accompanying chart are presented as illustrations of the variations that occur.

OCEAN TEMPERATURE CHART No. 32

By RICHARD RATHBUN.

The Air and Surface Isotherms of 40, 45 and 50 degrees, Fahrenheit, at the Light House Stations of the Eastern Coast of the United States, during the years 1881 and 1883.

(ISSUED IN 1886.)