CHAPTER 11

COAST AND GEODETIC SURVEY DATA — AN AID TO THE COASTAL ENGINEER

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INTRODUCTION

I am grateful for the opportunity to participate in this timely Institute and to present to this distinguished group of engineers and scientists something of the work of the Bureau, which I am privileged to head, insofar as that work relates to the problems of coastal engineering.

In its long career of surveying and chartering the coastal waters of the United States and possessions, a career which dates back to the early part of the nineteenth century, the work of the Coast and Geodetic Survey has been associated with the problems of the coastal engineer. Its successive hydrographic and topographic surveys of the coastal regions furnish basic data for the study of changes in the coastline and adjacent underwater topography and the means to arrest these changes; its tide and current surveys provide the fundamental data necessary in the design of waterfront structures and in harbor improvement; and its geodetic control surveys provide an accurate base for the preliminary study and final construction plans for large-scale improvement projects. To a lesser extent the geomagnetic and seismologic data of the Bureau have also been used by the coastal engineer (Fig. 1).

These and other data comprise a vast reservoir of precise facts concerning the coastal regions of our country. We are constantly adding to this storehouse of knowledge, both qualitatively and quantitatively, through improvements in instruments and techniques. In the field of hydrographic surveying, for example, the development of electronic methods for depth measurement and position fixing has made it feasible to survey large sections of our coastal waters with a completeness of detail and position accuracy comparable to that usually obtainable on a ground topographic survey. This was not possible with the older methods of wire sounding and celestial observation.

In this discussion, I should like to describe briefly the nature of our activities, the kind of data we accumulate, and the criteria by which such data should be evaluated.

BUREAU ACTIVITIES RELATED TO COASTAL ENGINEERING

TOPOGRAPHIC SURVEYS

Of primary importance in problems involving coastal engineering is a knowledge of the location, nature, and form of our sea coasts. Topographic surveys provide this information. Since land features are an essential part of marine charts, the Bureau has been making topographic surveys almost from the very beginning of its work. Scales of topographic surveys are usually 1-20,000 or larger (1-10,000 or 1-5,000), depending upon the importance of the area and the extent of detail to be shown.

Previous to 1922 all topographic surveys were made from the ground using the planetable method. Among ground surveying methods this was probably the most superior for mapping purposes. The terrain was mapped as the surveyor saw it, and no notes were required to be kept for after-plotting in the office. This method made the survey available, as it progressed, for immediate use by hydrographic parties. Some 5,000 surveys were made by this method. Since 1922 an increasing use has been made of aerial photographs. Ground topographic methods are rapidly giving way to the more economical and more expeditious method of aerial photogrammetry. Field inspection of photographs and manuscript maps provides identification of doubtful detail on the photographs, such as the location of the high-water line along a sandy beach, and for the special needs of the hydrographic parties.

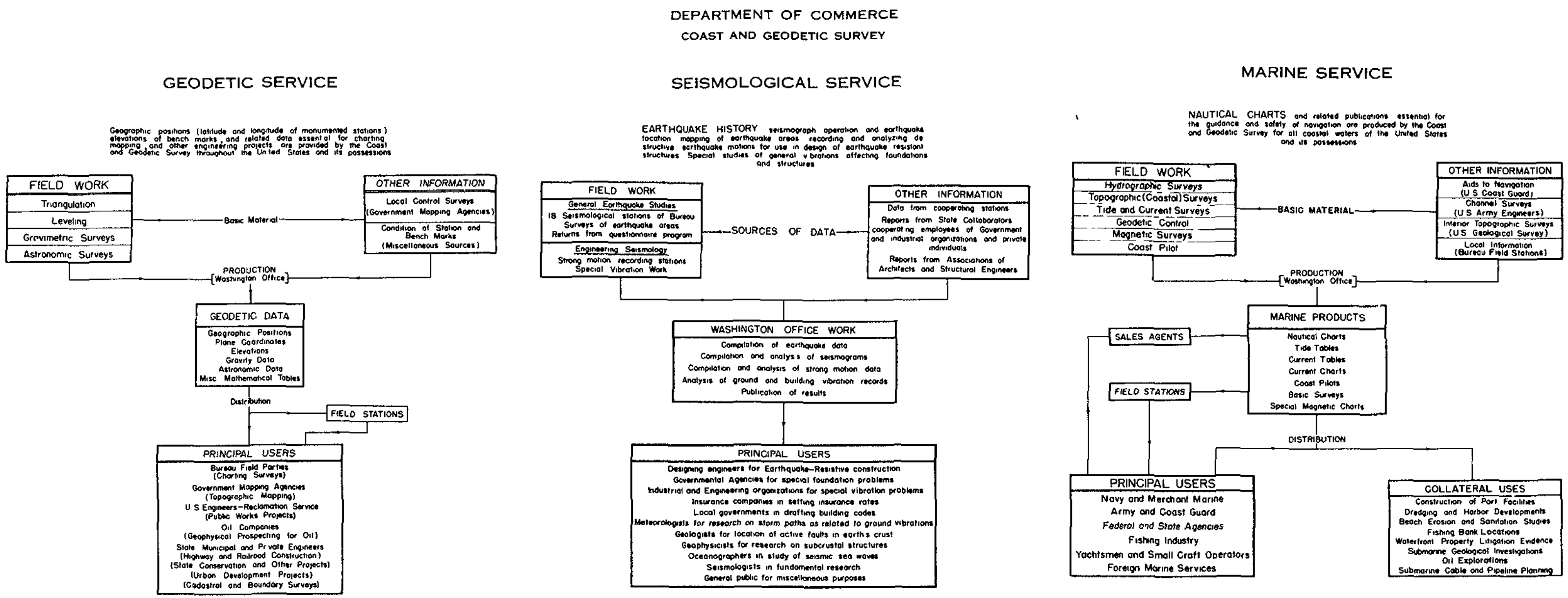


Fig. 1. Types of services available by the Coast and Geodetic Survey.

For its photogrammetric work the Coast Survey has designed a special nine-lens camera, together with transforming, rectifying, and stereoplotting equipment. At an elevation of 14,000 feet, approximately 125 square miles are photographed in a single exposure. To cover the same area with single-lens photographs at the same scale would require twenty exposures.

The high water line. The most significant feature on a topographic survey of the coast is the shoreline It is the dividing line between land and water. On Coast and Geodetic Survey charts it closely approximates the mean high-water line. The topographer attempts to locate this line on his survey as accurately as is consistent with the methods used and the purpose for which the survey is intended.

The true mean high-water line is the intersection of the plane of mean high water with the shore. The identity of this line on the ground for purposes of fixing property boundaries can be determined accurately by means of levels run from established bench marks. The line can also be identified on aerial photographs taken at the time of mean high water. For charting, such precise methods have not been found necessary, and the topographer usually identifies the mean high-water line from distinctive lines of drift, compactness of sand, and other physical appearances of the beach. His judgment is the basis for the location of the line on our topographic surveys.

(Accuracy of determination.) The closeness with which the line can be identified depends upon the character of the shore. On a rocky or steep-to beach, the identification would be accurate because a short horizontal distance is covered or exposed during the rise or fall of the tide. On gently sloping beaches, the estimation of the high-water line is necessarily approximate, and the line is seldom located with greater accuracy than within 10 feet of its true position. The many predetermined triangulation points within the area of a topographic survey provide a constant check on the work and no large errors can accumulate.

High-water line in tidal marshes, etc. In areas of marsh grass, mangrove, or other similar marine vegetation, where the shoreline is generally obscured, the surveyor makes no attempt to locate the actual mean high-water line, but rather a line that marks the outer or seaward edge of the marsh or marine vegetation, because to the navigator this is the visible shoreline. The true mean high-water line in such areas is generally a meandering line located somewhere between the outer edge of the vegetation and the fast land inshore. Under certain stages of marsh development, the whole of the marsh area may be precisely at mean high water, but from the topographic survey alone, no inference can be drawn regarding the position of the mean high-water line. Other collateral information is usually necessary, such as the contemporary hydrographic survey of the area.

The low water line. Another feature on coastal topographic surveys that is important to the coastal engineer is the low-water line -- symbolized by a series of dots. A word of caution is necessary regarding the use of this line from topographic surveys. From the survey alone, there is no evidence that the line is the true low-water line. During a large part of the time when the topographer is at work the low-water line is covered and it is impossible for him to locate it by measurement. The low-water line on our topographic surveys is a sketched line and does not represent a definite plane of reference. For charting purposes, the line is developed from the hydrographic survey, supplemented wherever necessary with information from the topographic survey.

HYDROGRAPHIC SURVEYS

Hydrographic surveying, as applied to the work of the Coast Survey, consists essentially of measuring depths -- this is, taking soundings -- and determining the definite locations of the depths even though their positions may be out of sight of land. Besides their value for charting, hydrographic surveys provide the coastal engineer with information on the underwater slope immediately adjacent to the shore. Successive surveys reveal whether there has been a steepening or flattening of the shore and throw light on probable future changes.

In the offshore areas the measurement of great depths can now be obtained in a matter of seconds, making it possible to take thousands of soundings in areas where formerly only a few scattered ones were economically feasible. This is greatly augmenting our knowledge of the ocean floor which not only contributes to the safety of navigation but provides important data for use in several of the earth sciences.

Modern methods. During the century and a quarter that we have been engaged in charting work, many changes have taken place in the methods of hydrographic surveying, each change resulting in an accumulation of more accurate and more detailed information. The most significant of these changes occurred during the periods following the two World Wars. The measurement of ocean depths by handlead and wire gave way to echo sounding, which is a measurement of the time a sound echo takes to return from the bottom beneath the vessel. The uncertain methods of position determination, such as dead reckoning and celestial observation, have been supplanted by electronic methods for measuring distances to known points previously determined.

(Echo sounding.) Modern echo-sounding equipment, designed for use in small launches, furnishes detailed information on depths of water close to the beach. The continuous profiles traced by graphic recorders show characteristic patterns of the underwater topography and details which were frequently missed by the older handlead-and-line method of sounding. An interesting example of underwater topography was disclosed recently in a hydrographic survey in San Francisco Bay off one of the beaches. A distinctive saw-tooth pattern closely resembling sand wave forms was disclosed by the fathogram. Another fathogram survey of an inshore area in the Gulf of Mexico revealed a narrow along-shore ridge with a depth of 6 feet of water over it. This hitherto unknown ridge occurred between inshore and offshore depths of 12 feet.

The fathograms of echo-sounding equipment also show quite clearly, under certain conditions, layers of silt or other loosely distributed sediment overlaying the substrata, such as are commonly found in bays, lakes, or estuaries.

Experience has shown that the most effective method of surveying an inshore area, where the bottom slopes gradually, is by a system of sounding lines parallel to the beach, with an occasional cross check line. The first line of soundings is run as close to the high-water line as practicable. The next lines are closely spaced and do not exceed 50 meters. This interval is increased as the survey progresses offshore. Our operations are planned to take advantage of periods of high tide and calm weather which afford the best conditions for inshore sounding.

(Shoran and E.P.I.) For position fixing in hydrographic surveying we have developed two electronic systems. One is Shoran, or Short Range Navigation, which is an adaptation of a method used by the Air Forces during World War II for strategic bombing. Shoran constitutes no new principle in hydrographic surveying, but it does apply a new and effective method for measuring distances from control points. Shoran does the job quickly, accurately, and under adverse weather conditions. Shoran is based on the fact that radio waves travel through the atmosphere at a very nearly constant velocity of approximately 186,000 miles per sec. Success of the method is due to the accomplishment of electronic engineers in devising means for accurate measurement of the remarkably small time intervals involved in the travel of electromagnetic waves to a target and back. In the familiar radar, dependence is placed upon the reflection of radio waves from natural objects encountered. Shoran strengthens and specializes this principle by use of responding radio stations set up at known points, which return intensified signals. Distances can be read to hundredths or even thousandths of a mile. Two such distances are measured simultaneously and thereby determine the position of the survey ship. Shoran will measure distances with a probable error of about 8 meters in a single measurement.

The radio frequencies used in Shoran are in the ultra-high-frequency bands and are of the order of 250 megacycles per sec. The range of the system is limited to line-of-sight distances. With a normal installation, control is possible over an area extending 50 to 75 miles from the ground stations. We have used Shoran successfully off the Atlantic coast and in Alaskan waters off the western Aleutians during the past 5 years.

Because of the line-of-sight limitation of Shoran, the Coast and Geodetic Survey developed an Electronic Position Indicator (E.P.I.) for use beyond the limits of Shoran. E.P.I. utilizes very low frequencies of the order of 2 megacycles per sec. which can be detected for great distances because they follow the curvature of the earth. The principles of position fixing with E.P.I. are essentially the same as with Shoran. The range of E.P.I. does not depend on elevation and therefore the system can be used with control stations of relatively low height. Distances close to 300 miles have been measured in the Gulf of Mexico. The over-all accuracy of the system is about 75 meters and is independent of distance from the control station.

(Accuracy of echo soundings.) Questions often arise as to the accuracy of the new methods of hydrographic surveying. With respect to depth measurement, it can be stated that, insofar as the equipment is concerned, the visual type of echo sounder, known as the "Dorsey No. 3," which was developed by the Coast and Geodetic Survey, has a probable reading accuracy of 1/10 ft. for soundings of 100 fathoms and less. The graphic recorder type of echo sounder using supersonic frequencies (up to 25 kilocycles per second) gives good results for depths of from 3 ft. under the keel to greater than 4,000 fathoms. The accuracy of these instruments is about 1:1,000 on the expanded shoal scales and about 1:100 on the compressed deep-water scales.

Echo-sounding instruments are usually calibrated for a velocity of 4,800 ft. per sec., whereas the velocity of sound in the different oceans varies from 4,500 to 5,100 ft. per sec. Depths read on the instrument must therefore be corrected for this difference, which constitutes perhaps the greatest single factor affecting the accuracy of an echo sounder. Inasmuch as velocity is dependent upon the temperature, salinity, and depth of the water and as these factors vary both seasonally and regionally, our specifications call for a determination of these physical characteristics with such frequency that the resulting depths will not be in error by more than 1 percent of the true depth. Thus, a sounding of 100 ft. should be correct within 1 ft., and a 1,000-ft. sounding within 10 ft.

It is of interest to note that, in the early period of echo sounding, the standard of comparison was the leadline or wire, and echo soundings were frequently corrected from comparisons made with these standards. With improvements in the time-measuring device and in operational techniques, greater accuracy was gradually achieved. Today echo soundings are considered more accurate than the old standard of comparison, since they are not subject to the inherent and uncontrollable errors and difficulties associated with the leadline and wire.

(Low-water line on hydrographic surveys.) On hydrographic surveys the line of zero soundings, generally called the low-water line, represents the line where the plane or datum adopted for the soundings intersects the shore. On the Atlantic coast the reference plane is mean low water, while on the Pacific coast it is mean lower low-water. Soundings obtained inshore of the zero line would be shown as minus depths on the survey, indicating that the area is exposed at low water.

In general an attempt is made to fully develop the low-water line on our hydrographic surveys wherever tidal conditions permit. This is not always possible, particularly along an exposed coast, such as large portions of the California shoreline. Many of our surveys therefore do not show a continuous low water line. For charting purposes low-water in such cases is represented by an interpolated line based on the high-water line on the topographic survey and the inshore soundings on the hydrographic survey. In using such information for purposes other than charting, the engineer should keep in mind the accuracy limitations imposed by the survey methods used. The low-water line is located by methods adequate for purposes of navigation. To accurately delimit the line for fixing property boundaries would require, as in the case of the high-water line on topographic surveys, running lines of levels from established bench marks or using an aerial photographic method.

(Character of sea bottom from hydrographic surveys.) The determination of the character of the sea bottom -- that is, its consistency, color, and classification-- is an essential part of every hydrographic survey. Although only the immediate top layers of the bottom are sampled, the value of such information to the mariner for choosing an anchorage, to the fisherman for avoiding types of bottom likely to damage his equipment, to the engineer engaged in dredging operations or in underwater construction, and in a limited sense to the student of the earth sciences, is recognized and our field parties are given detailed instruction for gathering such data.

The frequency with which data on bottom characteristics are obtained depends upon the nature of the area and the method of survey. In harbors, anchorages, and channels and on shoals and banks the coverage is generally more complete. Along the open coasts and in large bays, where tests have indicated that a sameness of bottom material is to be expected, fewer samples are taken.

The character of the bottom is determined either by "feel" or by bringing up a sample for examination with the leadline or with a special snapper device. No samples are retained as a permanent record, except by pre-arrangement with a scientific institution or a commercial establishment. The basis for the classification of sediments is the size of the particles composing them. No mechanical analysis is used for typing a sediment. An estimation of its dimensions is made by eye, and classification is based on an available table covering the range from "ooze" to "boulder." Standard abbreviations have been adopted on our survey sheets and charts for indicating the character of the sea bottom; for example "hrd SShP" denotes "hard sand, shells, pebbles." The adjective part of the characteristic is shown with lower-case letters and the noun part with capitals. An appropriate legend covering abbreviations is included on our nautical charts. Because of their larger scale, many more bottom characteristics appear on our survey sheets than are shown on the published charts.

HORIZONTAL CONTROL SURVEYS

It was recognized at an early period in the history of the Coast Survey that an undertaking of such vast magnitude could not be attacked as a problem in ordinary surveying. To be of lasting value, the shape and size of the earth must be taken into account, and accurate latitudes, longitudes, and azimuths determined from astronomic observations and from triangulation. This was the method adopted at the beginning of our work. The great network of horizontal control which has since been established along our coasts and in the interior of the country forms a rigid geodetic framework for all our surveys and charts (Fig. 2).

A network of monumented points. To span the continent from coast to coast and from north to south, widely spaced arcs of triangulation were first established. This gave a preliminary framework. Intermediate arcs, spaced 40 to 60 miles apart, provided control for boundary determinations and general purposes of the various States. The next logical step has been followed in the last decade and work has begun on filling in the areas between these arcs. There are now 115,000 miles of arcs of first- and second-order triangulation in the United States, and monumented stations have been established at an average of about 10 miles along the various arcs. Monumented stations are also placed at 4-mile intervals along the main highways in agricultural areas with closer spacing in metropolitan areas and along the coasts. In addition, a large number of prominent objects, such as water tanks, church spires, cupolas, chimneys, etc., have been located in connection with the triangulation, making a total of about 150,000 stations for which geographic positions (that is, latitude and longitude) have been determined. To facilitate the use of the triangulation stations by local surveyors and engineers, a nearby azimuth mark is established which gives directional control and avoids the need of establishing a true meridian line.

Although great strides have been made by the Bureau in establishing this basic network of control for the country, our job is far from completed. Our concept of adequacy is continually changing, as it necessarily must, with the ever-widening needs of commerce and industry. Our present policy is to provide for at least one triangulation station in each 7-1/2-minute quadrangle map. To coordinate local urban surveys, at least one Federal base line is measured in metropolitan areas of 100,000 population or over.

Development of the North American 1927 datum. All the horizontal control work of the Coast and Geodetic Survey, with few exceptions, is now referenced to a single geodetic datum, the North American 1927 Datum. This is a fact of great practical significance to the engineer who uses the horizontal control data of the

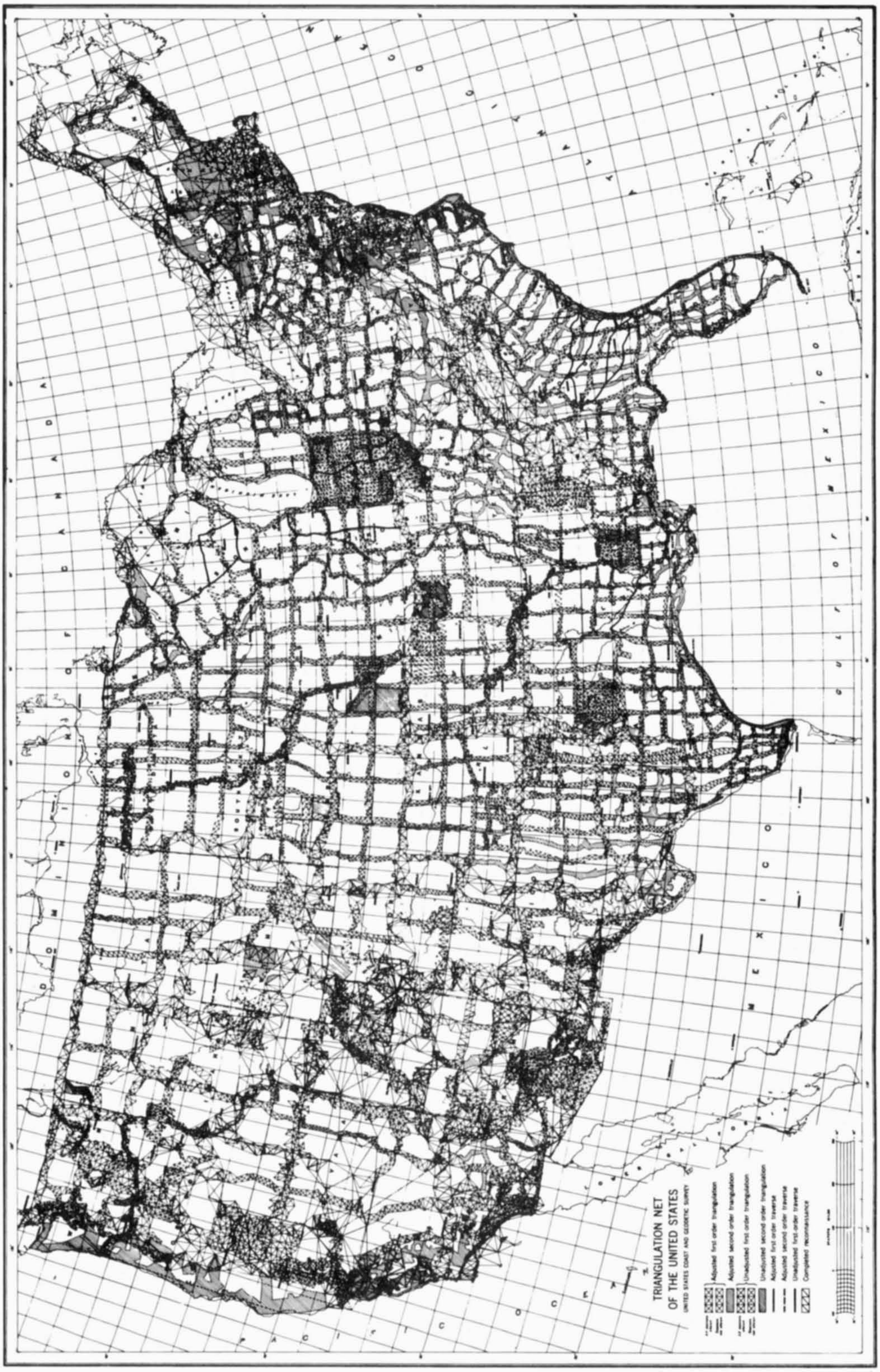


Fig. 2. Triangulation network of the United States

Bureau or the surveys based on such control. But it is important to remember that this was not always the case.

The horizontal control surveys of the United States were begun during the early part of the nineteenth century and existed at first as separate surveys, each based on one or more astronomical determinations of latitude, longitude, and azimuth. Examples of such detached surveys were the early triangulation in New England and along the Atlantic coast; a detached portion of the transcontinental arc centered on St. Louis, and another portion of the same arc in the Rocky Mountain region; and three separate surveys in California, in the vicinities of San Francisco, Santa Barbara Channel, and San Diego. With the lapse of time these separate pieces of triangulation were expanded until they joined and difficulties immediately arose. The positions of common points computed from different triangulation schemes were found to differ by varying amounts, because each scheme was based on its own astronomic determinations, and such determinations are affected by the irregular distribution of masses in the earth's crust.

In any engineering or scientific undertaking involving a large area, such as the United States, it is essential that full coordination and correlation be obtained of the surveys, maps, and charts of the area. A depth along the coast or a point on shore can have but one latitude and longitude, which should be the same on every map or chart on which such feature appears. This can be accomplished only by establishing a single geodetic datum for the area, that is, by having the position of a single point in the country as the initial or datum to which all other stations are referred. This became possible about 1900, when the transcontinental arc was completed which joined all the detached portions into one continuous triangulation.

On March 13, 1901, a single datum was adopted by the Bureau and was named the United States Standard Datum. This datum corresponded to the one in use in the New England States, and hence did not change the latitudes and longitudes of triangulation stations in that area. In 1913, Canada and Mexico adopted this datum and its designation was changed to North American Datum to reflect its international character. The two datums are, however, identical.

As the triangulation of the country expanded and the principal arcs were completed it became necessary to make a unified adjustment of the whole network, first the western half -- begun in 1927 -- and later the eastern half. This new adjustment assigned new values to all points except station Meades Ranch, which was held fixed. The new datum was called the North American 1927 Datum.

The engineer who uses surveys or charts made prior to the adoption of the North American 1927 Datum must keep in mind this development of a single geodetic datum. From the standpoint of datums the greatest differences in the geographic positions of triangulation stations occurred with the adoption of the United States Standard Datum.

Accuracy of horizontal control. Control surveys are classified as nearly as possible according to the accuracy of the resulting lengths and azimuths of the lines. Since the absolute errors of these quantities cannot be ascertained, indirect gages must be used. For triangulation, the principal criterion is whether the discrepancy between a measured length of a base line and its computed length, as carried through the network from the next preceding base, is less than a certain fraction of the measured length. For first-order work, the computed length must agree on an average within 1 part in 75,000 or about 1 ft. in 14 miles. Base lines are measured in both directions and are generally from 4 to 8 miles long with a probable error for the mean of the two measurements averaging about 1 in 2,000,000.

Another important indirect gage of the accuracy of the final results of triangulation is the average closure of the triangles. To insure adequate agreement among the component parts of the triangulation, basic criteria have been adopted for the observations. For first-order work, the requirements are an average triangle closure not in excess of 1 sec.

State plane coordinates. The results of the triangulation of the Coast and Geodetic Survey are expressed in terms of geographic coordinates -- that is, latitude and longitude. Such coordinates are most convenient where extensive areas

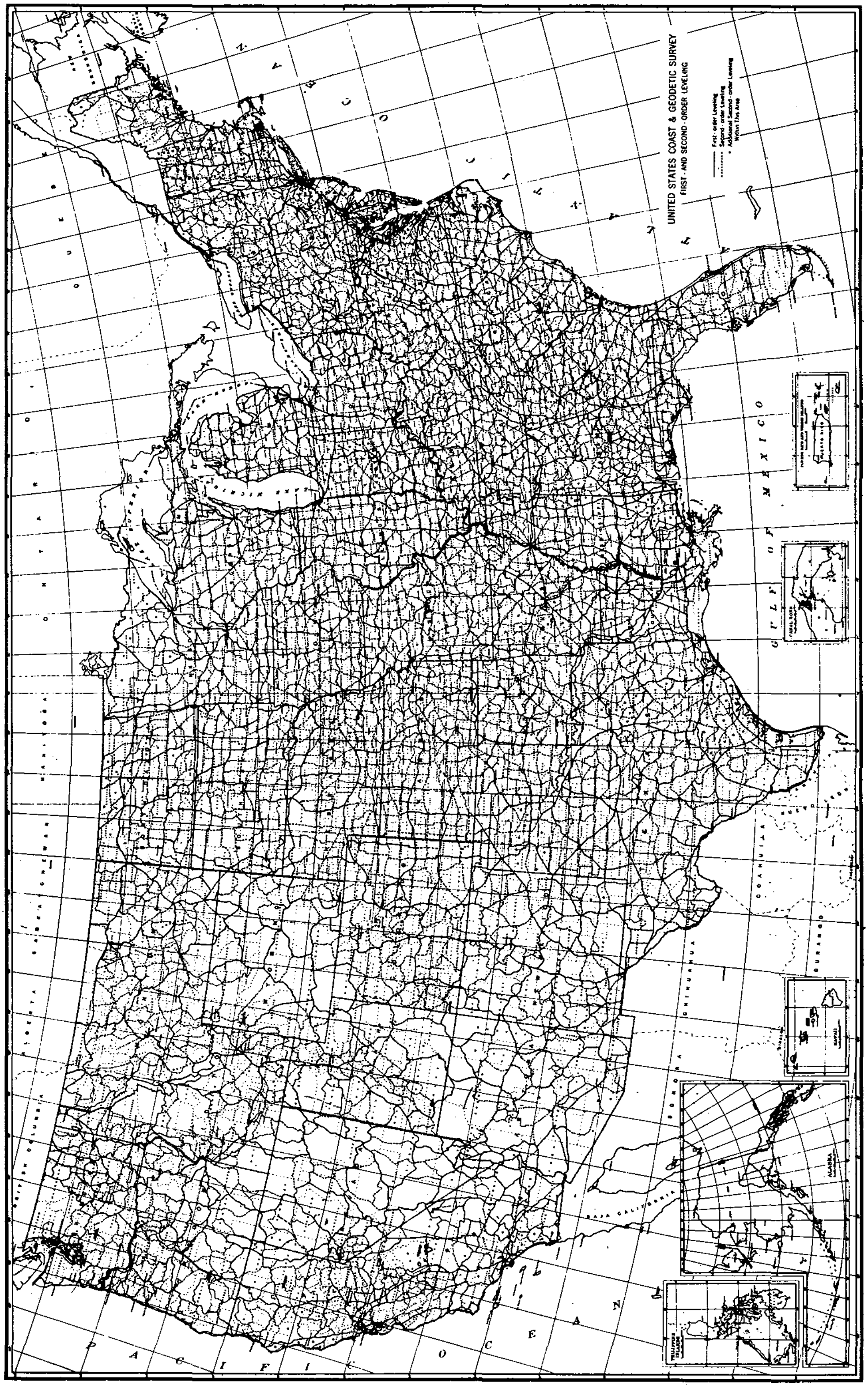


Fig. 3. Precise leveling lines of the United States

are involved. They constitute a universal system, all points of which are directly related. We have recognized, however, that engineers and surveyors, unfamiliar with the computational methods involved, hesitate to use geographic coordinates for surveys of smaller areas, such as those performed within a state, county, or city. Considering the desirability of having all surveys tied into the Federal network of geodetic control, the Coast Survey in 1933 devised systems of plane coordinates for each state and developed the formulas for the transformation of geographic coordinates to their corresponding X and Y values. By these systems, points on the earth's surface are mathematically projected upon a surface which can be developed into a plane. Surveys between such points can then be treated as though the work were accomplished on a plane instead of a spheroidal surface.

In the practical field use of State Coordinates, the engineer needs only the plane coordinates of the triangulation stations and the plane azimuth to an azimuth mark within the area covered by his survey. These data are sufficient for him to run and adjust his traverse, using the ordinary methods of plane surveying, and obtain an accuracy of not less than 1 part in 10,000, without any corrections for scale error. The local engineer may bring his computations to geodetic accuracy, if such refinement should be desired, because the State Coordinate Systems are based on definite systems of projections with definite scale corrections.

VERTICAL CONTROL SURVEYS

In providing for the vertical control of the country, the Coast and Geodetic Survey followed a program starting with widely spaced lines 100 miles apart, later supplemented by lines spaced at 50-mile intervals (Fig. 3). At the present time, we are providing area leveling with lines spaced 6 miles apart connected to the wider spaced lines in a consistent network of levels. Bench marks are set at 1-mile intervals along each line. For convenience in running and in the subsequent use of bench marks, the lines of leveling usually follow the routes of highways and railroads. There are now more than 370,000 miles of first- and second-order leveling in the United States and upward of 275,000 established bench marks.

First-order leveling represents the most exact method of determining elevations. Lines are run in both directions and the two runnings must be such that in a 100-mile circuit the error of closure will on an average be only slightly over an inch.

Sea level datum of 1929. The reference datum for elevations in the vertical control network is MEAN SEA LEVEL. Originally, the leveling was extended from a tide station at Sandy Hook, N.J., to furnish accurate vertical control for the transcontinental arc of triangulation following approximately the 39th parallel. As the net expanded and new circuits developed with additional sea level connections, it was found desirable to make adjustments in the elevations. The first adjustment was made in 1899, with partial readjustments in 1903, 1907, and 1912. A complete readjustment of the network was made in 1929, in which sea level was held fixed as observed at 26 tide stations, 5 in Canada and 21 in the United States. Elevations in this adjustment are referred to as being based on the "Sea Level Datum of 1929."

TIDAL SURVEYS

The tidal work of the Coast and Geodetic Survey had its origin in the need for reducing to a common level, or datum plane, soundings taken at different stages of the tide during hydrographic surveys, so that nautical charts would show all depths referred to a uniform datum. The further needs of the mariner were met with the publication of tide tables giving the predicted times and heights of the tide annually in advance. Within recent years the needs of the engineer have been given consideration, and in 1922 systematic tide and current surveys were begun of all the important harbors.

Engineering aspects of tides. Tidal observations are of particular interest to the coastal engineer. The rise and fall of the tide is a continuing phenomenon and varies from day to day and from place to place. Thus, at New York the mean range is about 4.5 ft. while the maximum range may be 7 ft. At the Atlantic entrance to the Panama Canal the range is less than a foot while at the Pacific entrance it averages 12.5 ft. On the other hand, at Anchorage, Alaska, a rise and fall of approximately 35 ft. may be encountered on certain days.

Tides also differ in the character of the rise and fall. At New York, for example, there are two tides a day of approximately equal range; at San Francisco there are two tides a day of unequal range; and at Pensacola, there is but one tide a day.

These and other aspects of the tidal phenomenon are matters which the coastal engineer must take into account in planning or designing waterfront structures.

The accumulated tide records of the Coast and Geodetic Survey furnish the fundamental data required in the establishment or datum planes based on tidal definition; in the prediction of tides; in the determination of mean and extreme ranges of tide; and in the study of changes in the plane of mean sea level and its correlative coastal stability.

Primary tide stations. Although tidal constants and tidal datum planes may be established (within certain limits of accuracy) from observations extending over a month or a year, for geodetic and scientific purposes continuous observations for a period of 19 years are required. This takes into account all changes due to astronomic causes and tends to balance out the disturbing effects of wind and weather.

For the collection of tidal data, the Bureau has in operation some 80 primary stations at coastal ports where automatic tide-gage installations provide continuous graphic records of the rise and fall of the tide over a long period of years. Most of the basic data are obtained from this source. In addition, short-period observations are obtained in connection with our hydrographic operations or for some other purpose. By means of simultaneous observations with primary stations, short-period observations may be converted to long-period means with an accuracy closely approximating the 19-year cycle.

(The 1924-1942 epoch.) Long-period observations indicate a slow secular change in sea level. Therefore, in defining tidal datums, it is necessary to identify them with a particular 19-year group. To make datums comparable at all localities the same group of years must be used. In the Coast and Geodetic Survey the 1924-1942 epoch has been adopted for datum plane reference.

(Changes in sea level.) Long series of tidal measurements furnish the only quantitative data for the study of changes in sea level and the important geophysical problem of coastal stability, that is, whether any given coastal region is rising or sinking relative to the sea. For example, along the Atlantic coast of the United States, investigations indicate that in the last 20 years mean sea level has risen, or the land has subsided, about 0.3 ft.; while on the Pacific coast sea level has risen about 0.1 ft. On the other hand, at Skagway, Alaska, observations over the last 40 years show a fall in sea level of over 2 ft.

Determination of datum planes. Besides the datum of mean sea level, which is used for the vertical control surveys of the country, other datums are established from tide observations for use in our hydrographic surveys and nautical charts, and for other purposes.

(Chart datums.) Chart datums are selected primarily for their practical utility to the navigator and depend upon the characteristics of the tide in a given area. The aim is to provide the mariner with as wide a margin of safety in navigating his vessel as will be consistent with prevailing conditions. From the standpoint of navigation, the critical part of the tidal cycle is at the time of low water. At this time depths in a channel or over a shoal area are at a minimum. If a datum higher than low water were to be used as a reference plane, depths shown on the nautical charts would be greater than actually exist at the time of low water. This might result in giving the mariner a false sense of security, particularly in areas where the controlling depth approaches the draft of his vessel. Another practical advantage of a low-water datum is that tidal corrections given in the Tide Tables, which the mariner uses in conjunction with the chart to find the depth at a specified time and place, will be mostly additive values. It is for these reasons that low-water datums have been adopted for the nautical charts of the Coast and Geodetic Survey.

But even low-water datums differ on the different coasts of the United States, depending upon the prevailing type of tide. On the Atlantic coast, for example, the tide is of the semidaily type, with two tides a day of approximately equal range. Successive low waters differ but slightly and the adopted chart datum is MEAN LOW WATER, which is the mean of all the low waters in a given area. On the Pacific coast, the tide is of the mixed type, with two tides each day of unequal range. Successive low waters exhibit a marked inequality and the datum of MEAN LOWER LOW WATER is used, which is the mean of all the lower of the two low waters each day.

The advantages of using a mean lower-low-water datum over a mean low-water datum for Pacific coast charts are similar to those described above for low-water datums. The important thing to keep in mind is that the selection was dictated by the practical needs of navigation. Its use should be so appraised.

In order that datum planes once derived may be preserved for future use, they are referenced as so many feet below bench marks established in the vicinities of tide stations. This makes the recovery of datum planes a simple matter, so long as the bench marks are maintained.

Tidal surveys of important harbors. In some areas a need has developed for more detailed tidal information than is provided by the nearest primary stations and those stations established in connection with hydrographic surveying. To supplement these sources special tide surveys have been made in selected areas. Numerous tide-gage installations, at carefully selected sites, are required in most coastal harbors, or in any system of tidal waterways, to determine the varying times and heights of high and low waters at critical points. The first of such systematic surveys was begun in New York Harbor in 1922.

Prediction of tides. Mention has been made of the use of the Coast and Geodetic Survey Tide Tables for navigational purposes. These tables, which give the daily predictions of the times and heights of the tide at the important ports of the world, can also serve the coastal engineer who may wish to know in advance the height of the tide that may be expected at a given time and place.

To predict the tides for any given port, tidal observations must first be obtained to determine the characteristics of the tide at that port. From these data, predictions can then be made for any date in the future. Tide prediction is a complicated mathematical process; however, the work has been greatly simplified through the design and use in the Bureau of a tide predicting machine which can reproduce the tide in nature by solving equations involving as many as 37 variables. Tide Tables are published by the Bureau approximately 6 months in advance.

(Accuracy of tide tables.) To test the accuracy of the Tide Tables, comparisons have been made for different ports between predicted tides and observed tides. These tests indicate that, under normal weather conditions, the predicted tides closely approximate the actual tides. At Los Angeles, for example, where the tide is of the mixed type with a mean range of 3.8 feet, a full year of comparisons showed that 90 percent of the predicted times of high and low waters agreed within 5 minutes of the observed times; 98 percent of the predicted heights agreed within half a foot of the observed heights; and 59 percent agreed within one-tenth foot.

TIDAL CURRENT SURVEYS

Observations of the strength and direction of tidal currents along our coasts and in tidal waterways have been made by the Coast and Geodetic Survey in connection with hydrographic operations and as special surveys, as an aid to navigation. Currents must also be considered by the engineer engaged in the maintenance and improvement of channels and harbors, in marine construction and improvement of beaches, and in the problem of sewage disposal.

Comprehensive tidal current surveys have been made of our more important harbors and waterways. In recent years current observations have been greatly expedited by the Bureau's development of the Roberts Radio Current Meter, which not only measures the velocity and direction of the current but transmits the data by radio to a central receiving station. As many as eight meters can be operated simultaneously in an area.

Tidal current data are used in the Current Tables published by the Bureau annually in advance. The tables give daily predictions of the times of slack water and the times and velocities of strength of flood and ebb currents for numerous places along our coasts and in our waterways.

AVAILABILITY OF COAST AND GEODETIC SURVEY DATA

An important part of the work of the Coast and Geodetic Survey is the dissemination of its technical information, which is meticulously collected, analyzed, and compiled, and made available to the public in the form of charts, maps, and printed publications. Although our nautical and aeronautical charts and related publications are well known to mariners and aviators, we frequently find that much of the fundamental data on which these products are based is unknown to those dealing with engineering and scientific problems.

Some of these data, of special interest to the coastal engineer, and the forms in which they are available are described in the balance of this paper. Illustrative samples of indexes and other forms of available data are included at the end.

TOPOGRAPHY AND HYDROGRAPHY

Copies of field surveys. Photographic copies of field topographic and hydrographic surveys are available at the nominal cost of reproduction. Detailed topographic and hydrographic surveys have been made since 1834 of most of the coastline of the United States and Alaska and of our island possessions. Along some portions of our coast, surveys have been repeated at periodic intervals.

Most of the topographic surveys compiled from aerial photographs are published as lithographic prints. Planimetric maps show nearly all interior topographic features except contours and elevations. More than 1,000 planimetric maps are now available which cover the greater part of the Atlantic coast and extensive areas of the Gulf and Pacific coasts.

Notwithstanding their accuracy limitations, as already explained, these surveys nevertheless represent an authentic historical record of the evolution of our coastline and the underwater features, useful in the study of beach erosion and protection and for other engineering purposes. The scales are large enough (usually 1:10,000 and 1:20,000) to provide the engineer with a background of information from which a quantitative appraisal can be made of changes.

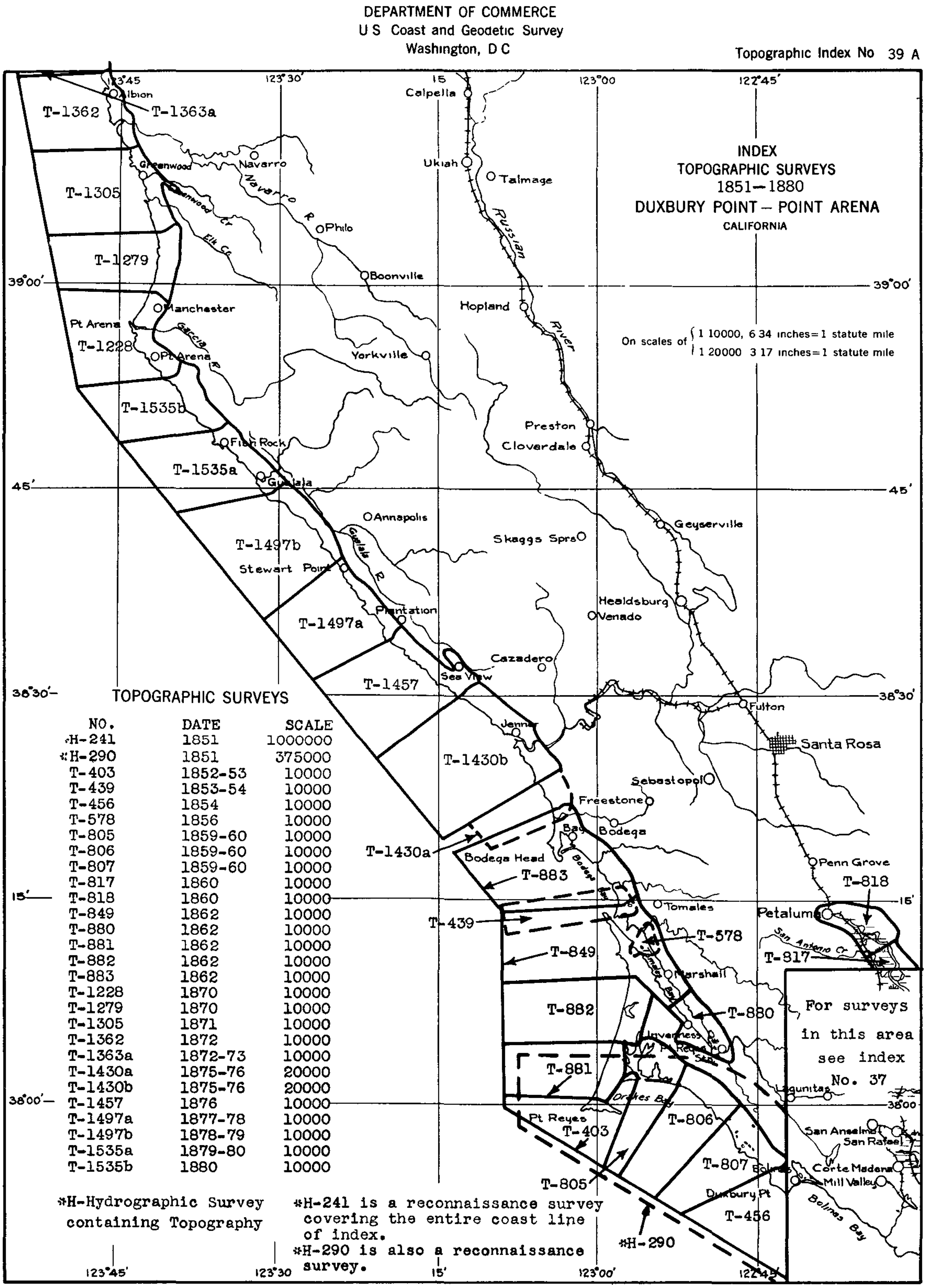
An important by-product value of our topographic and hydrographic surveys is their use in waterfront boundary disputes where the seaward limit of property is defined by the high- or low-water line. Our early surveys may be very informative in cases where it is important to determine, as of a specific date, whether a coastal strip was exposed, or covered with water, at high tide.

A cautionary note must be sounded, however, regarding the use of original field surveys made at different periods. Because different geodetic datums were used at various periods in the history of the Bureau, surveys must be brought to the same datum before an accurate comparison can be made of shorelines or other data. Copies of old surveys furnished from the Washington Office usually show at least one projection intersection based on the North American 1927 Datum.

Survey indexes. Index maps -- showing the date, area covered, and scale of each survey -- are available for the planetable and planimetric surveys along the Atlantic, Gulf, and Pacific coasts, and for the hydrographic surveys along the Atlantic and Gulf coasts (Figs. 4 - 9, inclusive). They are furnished on request without cost.

CONTROL SURVEY DATA

State index maps. Index maps are available showing the triangulation and leveling accomplished in each state. The scales of the maps are large enough (1:650,000) to show graphically the locations of the individual stations and bench marks. On the leveling map the lines are numbered and the engineer desiring information on any particular level line can refer to the line by its number.



NO.	DATE	SCALE
*H-241	1851	1000000
*H-290	1851	375000
T-403	1852-53	10000
T-439	1853-54	10000
T-456	1854	10000
T-578	1856	10000
T-805	1859-60	10000
T-806	1859-60	10000
T-807	1859-60	10000
T-817	1860	10000
T-818	1860	10000
T-849	1862	10000
T-880	1862	10000
T-881	1862	10000
T-882	1862	10000
T-883	1862	10000
T-1228	1870	10000
T-1279	1870	10000
T-1305	1871	10000
T-1362	1872	10000
T-1363a	1872-73	10000
T-1430a	1875-76	20000
T-1430b	1875-76	20000
T-1457	1876	10000
T-1497a	1877-78	10000
T-1497b	1878-79	10000
T-1535a	1879-80	10000
T-1535b	1880	10000

Fig. 4

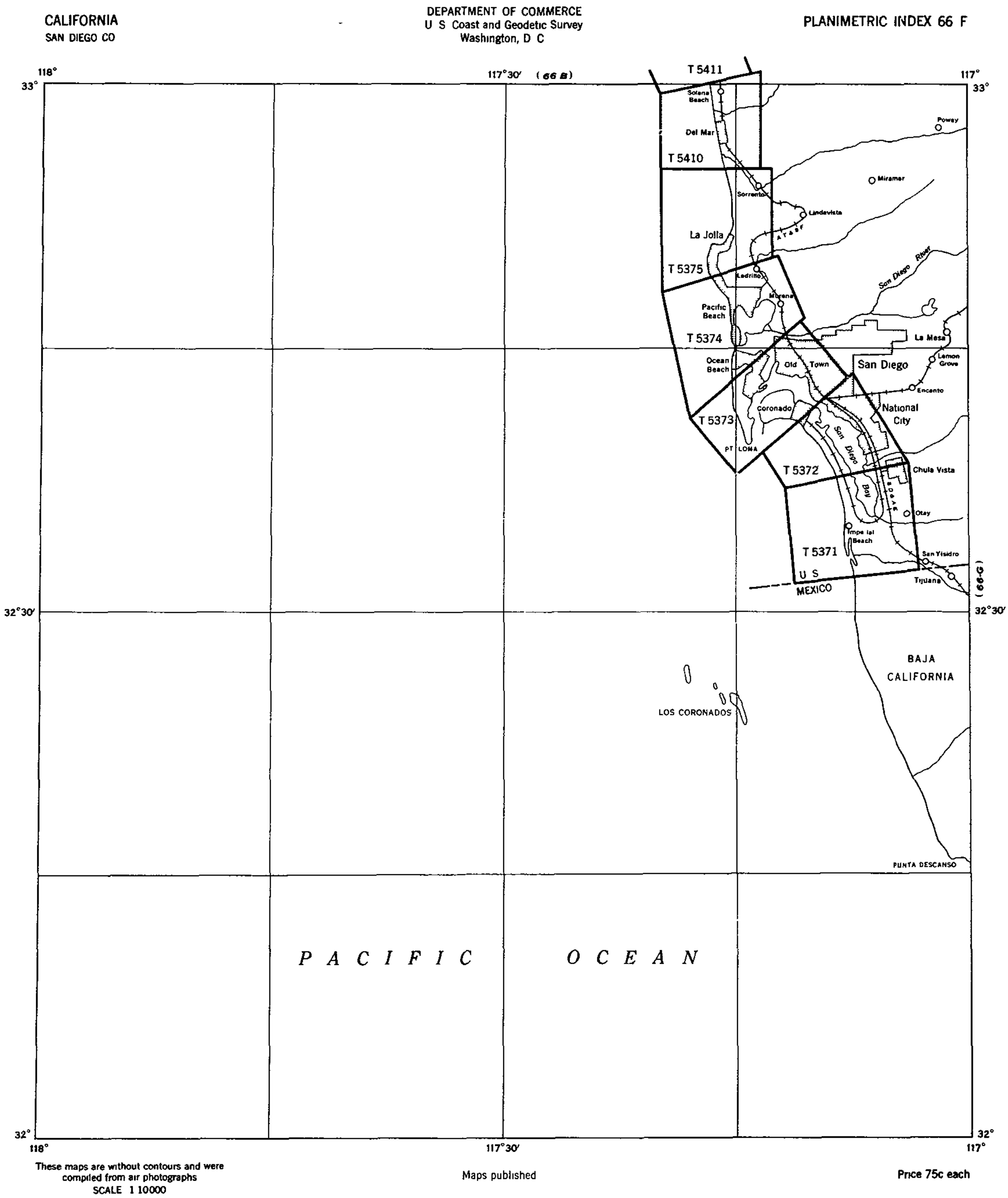

CALIFORNIA
SAN DIEGO CO
DEPARTMENT OF COMMERCE
U S Coast and Geodetic Survey
Washington, D C
PLANIMETRIC INDEX 66 F
118°
33°
117°30′ (66 B)
117°
T 5411
Solana Beach
Del Mar
T 5410
Poway
Miramar
Sorrento
Linda Vista
La Jolla
T 5375
San Diego River
Pacific Beach
T 5374
La Mesa
Lemon Grove
Ocean Beach
Old Town
San Diego
Encanto
Coronado
National City
T 5373
PT LOMA
San Diego Bay
T 5372
Chula Vista
Otay
Imperial Beach
T 5371
San Ysidro
U S
MEXICO
Tijuana
(66-G)
32°30′
BAJA CALIFORNIA
LOS CORONADOS
PUNTA DESCANSO
P A C I F I C O C E A N
32°
118°
117°30′
117°
These maps are without contours and were compiled from air photographs
SCALE 1 10000
Maps published
Price 75c each

Fig. 5

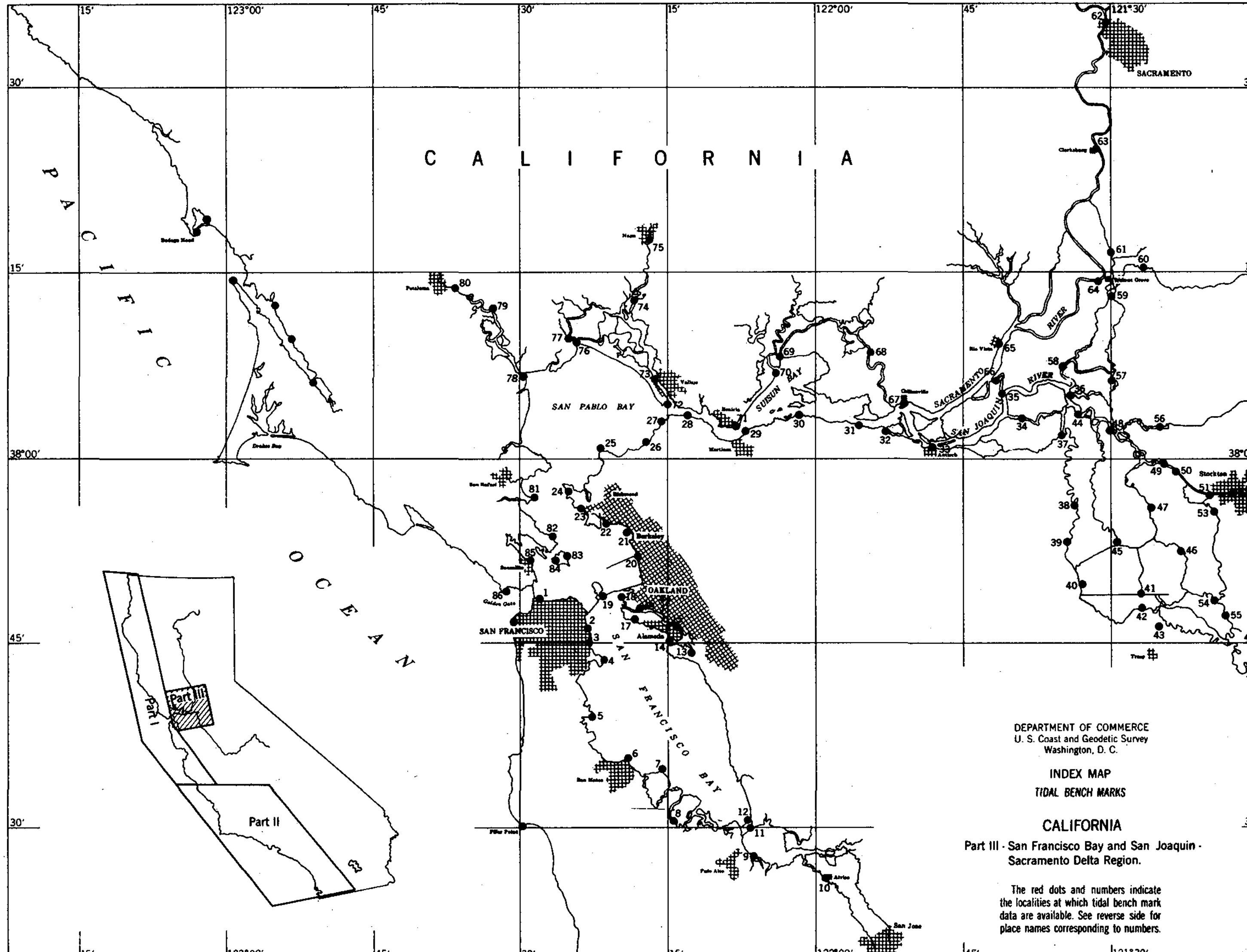

CALIFORNIA
PACIFIC
OCEAN
SAN PABLO BAY
SUISUN BAY
SAN FRANCISCO BAY
SACRAMENTO RIVER
SAN JOAQUIN RIVER
SACRAMENTO
SAN FRANCISCO
OAKLAND
Alameda
Berkeley
Richmond
Vallejo
Benicia
Martinez
Antioch
Stockton
Napa
Petaluma
San Rafael
Sausalito
Golden Gate
Bodega Head
Drakes Bay
San Mateo
Palo Alto
Alviso
San Jose
Pillar Point
Rio Vista
Collinsville
Clarksburg
Walnut Grove
Tracy
Part I
Part II
Part III
123°00′
122°00′
121°30′
38°00′
DEPARTMENT OF COMMERCE
U. S. Coast and Geodetic Survey
Washington, D. C.
INDEX MAP
TIDAL BENCH MARKS
CALIFORNIA
Part III - San Francisco Bay and San Joaquin - Sacramento Delta Region.
The red dots and numbers indicate the localities at which tidal bench mark data are available. See reverse side for place names corresponding to numbers.
B-3458-11 ++
OVER
FEBRUARY 1950

Fig. 6

INDEX MAP NUMBER (see reverse side)	NAME	INDEX MAP NUMBER (see reverse side)	NAME
1	Presidio, San Francisco	44	Prisoners Point, Venice Island
2	Rincon Point, San Francisco	45	Borden Highway Bridge, Middle R
3	Potrero Point, San Francisco	46	Union I Highway Br , Middle R
4	Hunters Point (Point Avisadero)	47	Holt, Whiskey Slough
5	Point San Bruno	48	Ward Cut, Ward Island
6	San Mateo (U S M S School)	49	Blackslough Landing
7	San Mateo Bridge	50	Eldorado Pump, San Joaquin R
8	Smith Slough, San Francisco Bay	51	Jacobs Road, San Joaquin River
9	Palo Alto Yacht Harbor	52	Stockton, San Joaquin River
10	Alviso, Alviso Slough	53	Borden Highway Bridge, San Joaquin River
11	So Pac RR Bridge, Dumbarton Point	54	Junction, Old & San Joaquin Rivers
12	Dumbarton Highway Bridge	55	Mossdale Bridge, San Joaquin R
13	Oakland Municipal Airport	56	Bishop Cut, Disappointment Slough
14	Alameda (Electric Light Plant)	57	Terminous, Mokelumne River
15	Oakland (Park Street Bridge)	58	Georgiana Slough Entrance
16	Oakland (Inner Harbor)	59	New Hope Bridge, Mokelumne R
17	Alameda (Naval Air Station)	60	Benson Ferry Bridge, Mokelumne R
18	Oakland Mole (7th St), Oakland	61	Snodgrass Slough (Highway Bridge)
19	Yerba Buena & Treasure Islands	62	Sacramento, Sacramento River
20	Berkeley	63	Clarksburg, Sacramento River
21	Point Isabel	64	Walnut Grove, Sacramento River
22	Richmond (Inner Harbor)	65	Rio Vista, Sacramento River
23	Point Richmond	66	Three Mile Slough Entr , Sacramento River
24	Point Orient & Point San Pablo	67	Collinsville, Sacramento River
25	Pinole Point, San Pablo Bay	68	Meins Landing, Montezuma Slough
26	Hercules, Refugio Landing	69	Montezuma Slough Entrance
27	Selby, Carquinez Strait	70	Suisun Echo Board, Suisun Bay
28	Crockett, Carquinez Strait	71	Benicia, Carquinez Strait
29	Suisun Point and Vicinity	72	Carquinez Strait Lighthouse and Vicinity
30	Port Chicago, Suisun Bay	73	Mare I Naval Shipyard & Vallejo
31	Mallard Ferry Wharf Suisun Bay	74	Brazos Drawbridge, Napa River
32	Pittsburg, New York Slough	75	Napa, Napa River
33	Antioch, San Joaquin River	76	Sonoma Creek Entrance
34	Webb Ferry, Webb Tract, False R	77	Tubbs I Wharf, Sonoma Creek
35	Three Mile Slough Entr , San Joaquin R	78	Petaluma Creek Entrance
36	Bouldin Island, Potato Slough	79	Lakeville, Petaluma Creek
37	Franks Tract Pump, Sand Mound Slough	80	Upper or Quarry Drawbridge, Petaluma Creek
38	Orwood, Old River	81	Point San Quentin and Vicinity
39	Borden Highway Bridge, Old River	82	California City
40	Clifton Court Ferry, Old River	83	Angel Island (East Garrison)
41	Grant Line Bridge, Union Island	84	Angel Island (West Garrison)
42	Naglee Bridge Old River	85	Sausalito and Vicinity
43	Holly Sugar Refinery, Sugar Cut	86	Point Bonita, Golden Gate

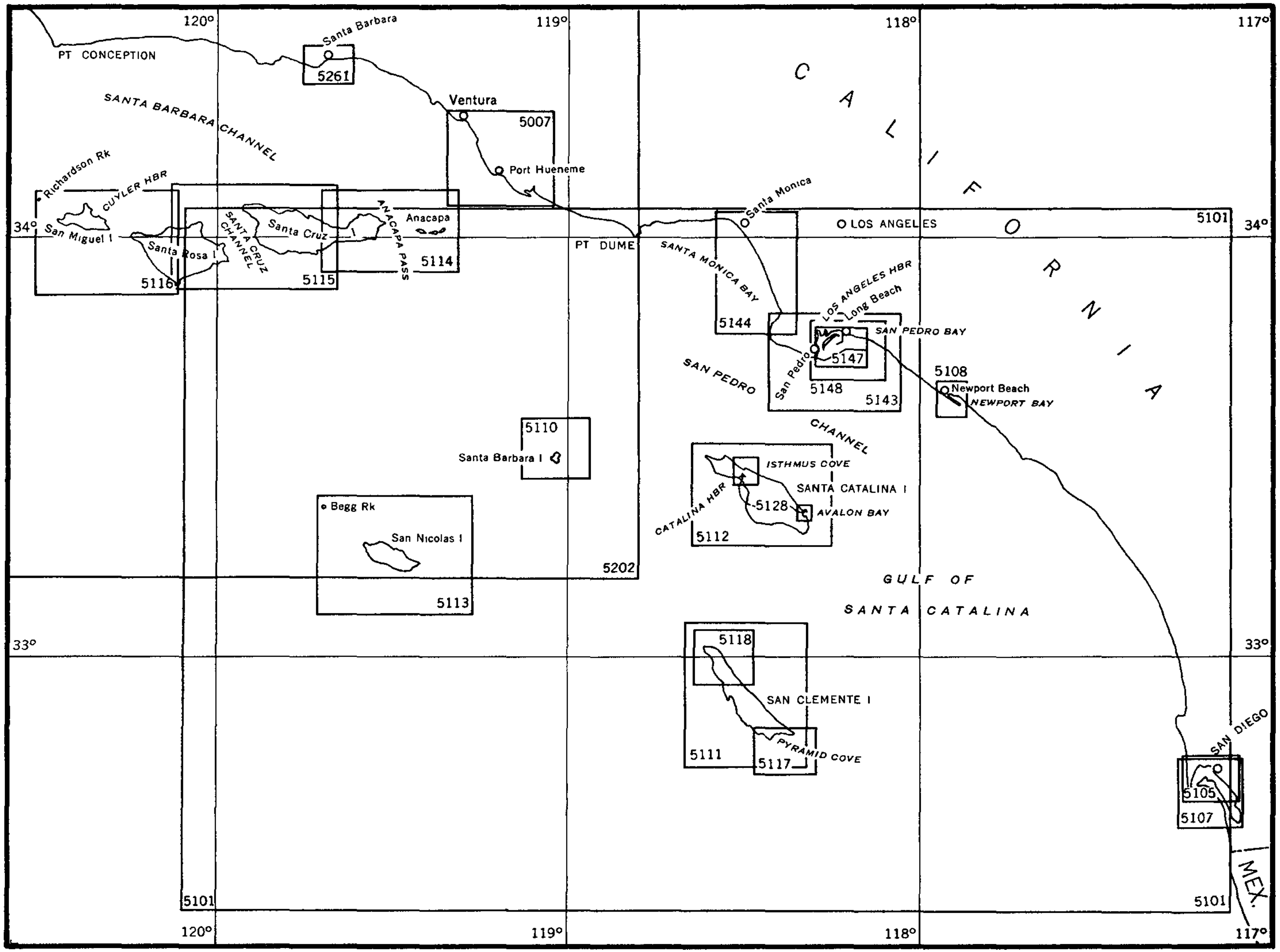
NOTE Unnumbered red dots on the index map on the reverse side indicate nearest tidal bench mark locations along the Northern California Coast

Tidal bench mark locations in the State of California are shown on three index maps, as follows
- Part I - Northern California
- Part II - Southern California
- Part III - San Francisco Bay and San Joaquin - Sacramento Delta Region

Tidal bench mark data are available for the above locations and may be obtained by writing to the Director, U S Coast and Geodetic Survey, Washington 25, D C **In requesting these data, please refer to both the index map numbers and the names of the particular localities in which you are interested**

GENERAL, COAST AND HARBOR CHARTS - PACIFIC COAST

SAN DIEGO TO POINT CONCEPTION, CALIFORNIA



COAST AND GEODETIC SURVEY DATA — AN AID TO THE COASTAL ENGINEER

U. S. Department of Commerce
Coast and Geodetic Survey
Washington, D C

Diagram No 17
SEPT 1949

Fig. 7

GENERAL, COAST AND HARBOR CHARTS—PACIFIC COAST
SAN DIEGO TO POINT CONCEPTION, CALIFORNIA

No.	Price	Title	State	Scale	Size of border (inches)	Edition Date
		GENERAL CHARTS				
5101	$0 75	San Diego to Santa Rosa Island	California	1 234,270	32×48	Jan 1947
5202	75	Point Dume to Purisima Point	"	1:232,188	31×46	Dec. 1940
		HARBOR CHARTS				
5007	25	Pt. Mugu to Ventura	California	1 40,000	25×28	May 1941
		Ventura		1 20,000		
		Port Hueneme		1 10,000		
5105	.75	North San Diego Bay	"	1 12,000	33×44	Oct. 1947
5107	75	San Diego Bay	"	1 20,000	33×37	Jan. 1948
5108	75	Newport Bay	"	1 10,000	28×37	Aug 1940
5110	75	Santa Barbara Island	"	1 20,000	32×37	Mar 1935
5111	75	San Clemente Island	"	1.40,000	33×39	Feb 1946
5112	75	Santa Catalina Island	"	1 40,000	27×38	Feb 1945
5113	75	San Nicolas Island	"	1 40,000	31×41	Oct. 1944
5114	50	Anacapa Passage	"	1 40,000	22×37	July 1945
		Prisoners Harbor		1·20,000		
5115	75	Santa Cruz Channel	"	1 40,000	28×42	Aug. 1945
5116	75	San Miguel Passage	"	1 40,000	28×39	Nov 1945
		Cuyler Harbor		1 20,000		
5117	75	Pyramid Cove and approaches, San Clemente Island	"	1 15,000	33×44	Apr 1938
5118	50	San Clemente Island—Northern Part	"	1 20,000	30×32	May 1940
		Wilson Cove		1 5,000		
5128	25	Catalina Harbor, Isthmus Cove and Avalon Bay, Santa Catalina Island	"	1 10,000	22×27	Oct. 1935
5143	50	Los Angeles Harbor and vicinity	"	1.40,000	25×37	June 1947
5144	50	Santa Monica Bay	"	1 40,000	22×34	Feb 1948
5147	75	Los Angeles and Long Beach Harbors	"	1 12,000	33×45	Oct. 1943
5148	75	San Pedro Bay	"	1.18,000	29×45	July 1945
5261	25	Santa Barbara	"	1.20,000	20×27	July 1939

U. S. Department of Commerce
Coast and Geodetic Survey
Washington, D C

Diagram No 14
APR 1950

CHARTS OF THE ATLANTIC INTRACOASTAL WATERWAY

NORFOLK TO KEY WEST

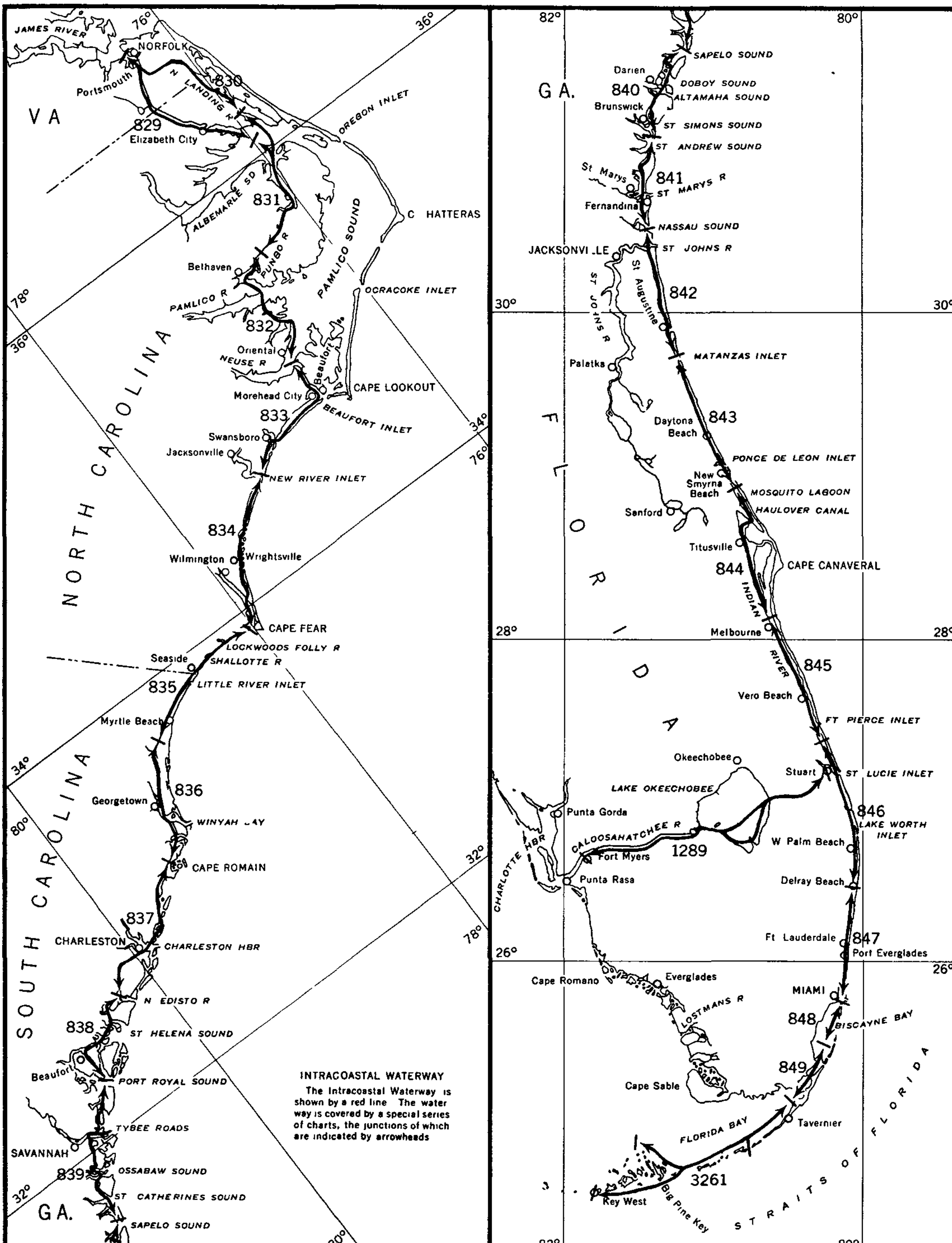


Fig. 8

CHARTS COVERING THE ATLANTIC INTRACOASTAL WATERWAY (INSIDE ROUTE)—NEW YORK TO KEY WEST

Arranged in order of progression southward

NEW YORK TO NORFOLK

No.	Price	Title	Scale	Size of border (inches)	Edition Date
		The following coast and harbor charts, listed with others on pp 4 to 7 inclusive are relisted here as those best suited for this section of the route			
369	$0 75	New York Harbor, N Y and N J	1 40,000	34×43	Feb 1947
1215	75	Approaches to New York—Fire Island Light to Sea Girt Light, N Y and N J	1 80,000	33×41	Feb 1947
825	25	Manasquan Inlet to Little Egg Harbor, N J	1 40,000	22×34	July 1946
826	25	Little Egg Harbor to Longport, N J	1 40,000	22×34	June 1949
827	25	Longport to Cape May, N J	1 40,000	22×34	Oct 1943
1218	75	Delaware Bay, N J and Del	1 80,000	31×37	Jan 1942
294	75	Delaware River—Smyrna River to Wilmington, N J and Del	1 40,000	29×45	Sept 1943
570	50	Chesapeake and Delaware Canal, Md and Del	1 20,000	22×34	Feb 1947
1226	75	Chesapeake Bay—Sandy Point to Head of Bay, Md	1 80,000	34×38	Aug 1942
1225	75	Chesapeake Bay—Cove Point to Sandy Point, Md	1 80,000	35×38	May 1943
1224	75	Chesapeake Bay—Smith Point to Cove Point, Md and Va	1 80,000	30×41	Feb 1947
1223	75	Chesapeake Bay—Wolf Trap to Smith Point, Va	1 80,000	31×39	July 1943
1222	75	Chesapeake Bay Entrance, Va	1 80,000	33×43	Dec 1946

NORFOLK TO KEY WEST

No	Price	Title	Approximate Scale	Size of border (inches)	Date
		The following series of Atlantic Intracoastal Waterway (Inside Route) charts shows the route in strips of convenient widths, with 3 strips to each sheet			
829	$0 25	Dismal Swamp Canal—Norfolk to Albemarle Sound, Va and N C	1 40,000	22×34	May 1938
830	25	Norfolk to North River, Va and N C	1 40,000	22×34	Feb 1943
831	25	North River to Alligator River-Pungo River Canal, N C	1 40,000	22×34	Feb 1943
832	25	Alligator River-Pungo River Canal to Neuse River, N C	1 40,000	22×34	Jan 1938
833	25	Neuse River to New River Inlet, N C	1 40,000	22×34	June 1946
834	25	New River Inlet to Southport, N C	1 40,000	22×34	Sept 1942
835	25	Southport to Socastee Cr , N C and S C	1 40,000	22×34	Jan 1943
836	25	Socastee Cr to McClellanville, S C	1 40,000	22×34	Aug 1942
837	25	McClellanville to Wadmalaw River, S C	1 40,000	22×34	Oct 1942
838	25	Wadmalaw River to Port Royal Sound, S C	1 40,000	22×34	Oct 1942
839	25	Port Royal Sound to Johnson Creek, S C and Ga	1 40,000	22×34	Apr 1943
840	25	Johnson Creek to Brunswick River, Ga	1 40,000	22×34	July 1942
841	25	Brunswick River to Nassau Sound, Ga and Fla	1 40,000	22×34	Mar 1943
842	25	Nassau Sound to Matanzas Inlet, Fla	1 40,000	22×34	July 1941
843	25	Matanzas Inlet to Mosquito Lagoon, Fla	1 40,000	22×34	Nov 1938
844	25	Mosquito Lagoon to Eau Gallie, Fla	1 40,000	22×34	May 1942
845	25	Eau Gallie to Walton, Fla	1 40,000	22×34	June 1938
846	25	Walton to Delray Beach, Fla	1 40,000	22×34	Jan 1943
847	25	Delray Beach to Miami, Fla	1 40,000	22×34	Mar 1943
848	25	Miami to Elliott Key, Fla	1 40,000	23×34	Oct 1939
849	25	Elliott Key to Florida Bay, Fla	1 40,000	22×34	Oct 1939
3261	25	Barnes Sound to Key West, Fla	1 80,000	22×34	July 1941
1289	75	Okeechobee Waterway including Lake Okeechobee	1 80,000	33×46	Mar 1949

The following charts are recommended to supplement the special Atlantic Intracoastal Waterway series For diagrams see pages 6 to 10 inclusive

- 291 Lake Worth Inlet and Palm Beach, Fla
- 419 Ocracoke Inlet and part of Core Sound, N C
- 420 Beaufort Inlet and part of Core Sound, N C
- 440 Savannah River and Wassaw Sound, S C and Ga
- 447 St Simon Sound, Brunswick Harbor and Turtle River, Ga
- 448 St Andrew Sound, Ga
- 452 Norfolk Harbor and Elizabeth River, Va
- 453 Fernandina Harbor, Ga and Fla
- 491 Charleston Harbor Entrance, S C
- 538 Neuse River and Upper Part of Bay River, N C
- 546 Port Everglades, Fla
- 547 Miami Harbor, Fla
- 571 Port Royal Sound and inland passages, S C
- 573 Ossabaw Sound and St Catherines Sound, Ga
- 574 Sapelo and Doboy Sounds, Ga
- 575 Altamaha Sound, Ga
- 577 Fernandina to Jacksonville, Fla
- 582 Fort Pierce Harbor, Fla
- 584 Key West Harbor and approaches, Fla
- 777 New River, N C
- 787 Winyah Bay, S C
- 792 Stono and North Edisto Rivers, S C
- 793 St Helena Sound, S C
- 794 Parts of Coosaw and Broad Rivers, S C
- 795 Shark River, Manasquan River and Bay Head Harbor, N J

DEPARTMENT OF COMMERCE
U. S. Coast and Geodetic Survey
Washington, D. C.

Hydrographic Index No. 66 J

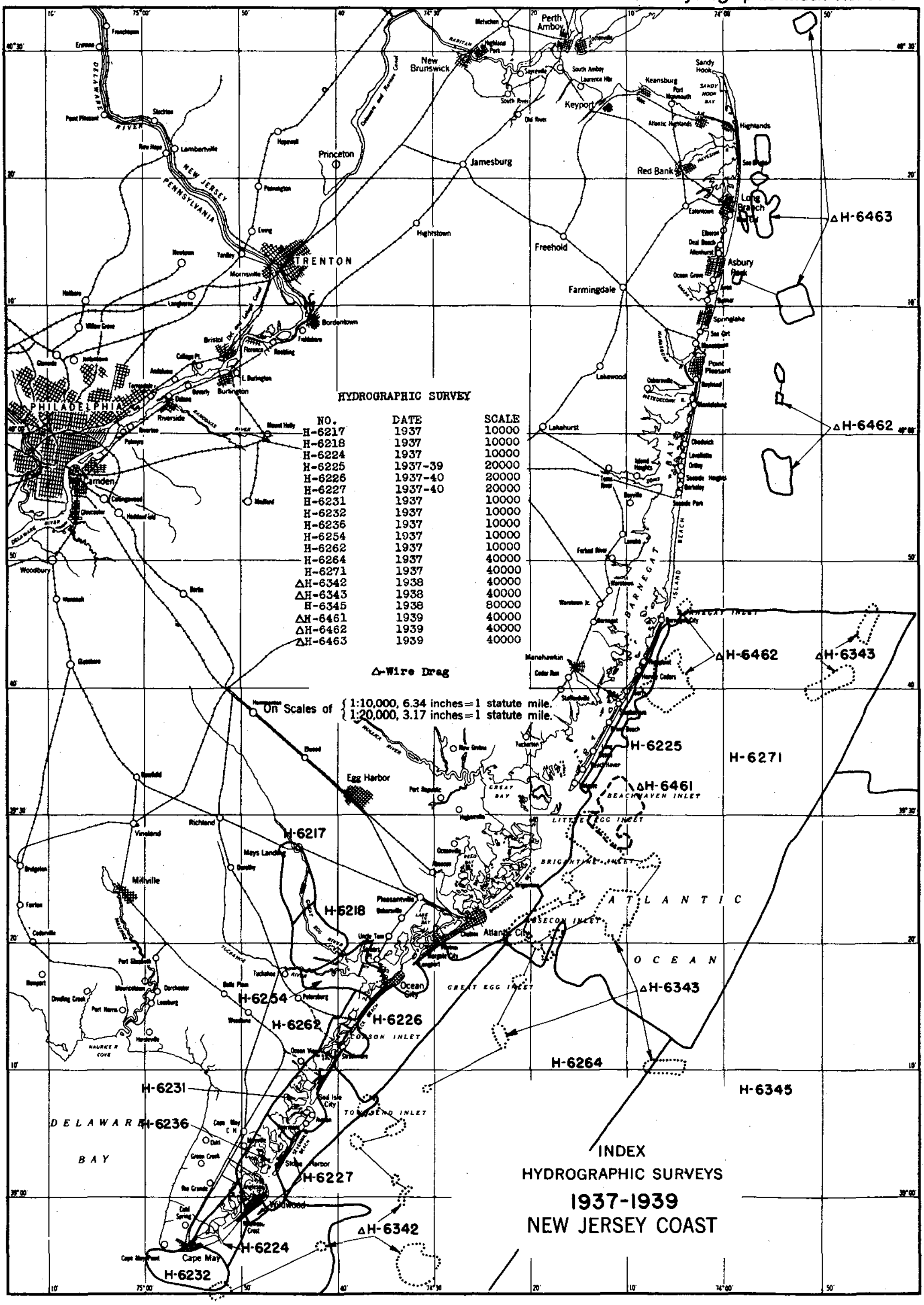


Fig. 9

Triangulation and leveling data. Triangulation and leveling data are issued in several series in loose-leaf form. One series gives the latitudes and longitudes of the established triangulation stations and the lengths and azimuths of the lines to contiguous stations; another the descriptions of the stations; and a third the plane coordinates of the stations, together with the grid azimuths to adjacent stations. Descriptions and elevations of bench marks are given in a fourth series.

TIDES AND CURRENTS

Tidal bench mark data. Tidal bench mark data are available for each tide station. These include the elevations of the bench marks above the basic hydrographic datum; the date and length of the tidal series; and a table showing the relations between the basic datum and other tidal planes in general use, for conversion of elevations to any of these planes. Heights of observed or estimated highest and lowest tides are also given. In addition, special index maps are prepared for each coastal state showing, by place name and number, the localities for which tidal bench mark data are available. Where spirit level connections have been made between the tidal bench marks and the geodetic bench marks of the vertical control survey net, information can be furnished on the relationship between the hydrographic datum and sea level datum.

Tidal current charts. For many areas, where comprehensive current surveys have been made, TIDAL CURRENT CHARTS are published showing graphically, by a set of 12 charts, the direction and velocity of the tidal current for each hour of the tidal cycle.

COMPILED CHARTS

The nautical charts of the Coast and Geodetic Survey are compiled from the basic topographic and hydrographic surveys of the Bureau, supplemented by data from the Corps of Engineers, Coast Guard, Harbor Boards, and other agencies.

Charts are published on different scales to meet the various needs of navigation. They are revised frequently to reflect the many natural and man-made changes that are constantly taking place along our coasts.

Surveys and charts. In using charts for purposes other than navigation, the distinction between a survey and a chart must be kept in mind. Perhaps the principal distinction is that the former, whether hydrographic or topographic, shows the condition as of a specific date and is the result of a field examination. A chart, on the other hand, is the result of an office study and compilation, is usually on a much smaller scale than the field survey, and may show information obtained over a long period of time.

(Dates on charts.) Many misconceptions have grown up regarding the import of our published charts, particularly with reference to the publication dates shown. The significance of the several dates on Coast and Geodetic Survey nautical charts should be understood by all who have occasion to use them.

When a new nautical chart is printed, the date (month and year) and edition number are given in the publication note, which is placed in a central position in the lower margin of the chart. This date is known as the PUBLICATION DATE, and remains unchanged until a new edition is printed, when the date and edition number are changed. A new edition is printed when it becomes necessary to chart important corrections too numerous to be applied by hand.

An additional printing of a chart which includes any change in any portion of the chart is designated as a new print and the year, month, and day are noted in the lower left margin of the chart. This date is known as the NEW PRINT DATE. For each new print an additional date is added. New prints include corrections which generally are not of sufficient importance to require a new edition.

One other date appears on nautical charts which it is well to keep in mind. This is the CORRECTION DATE. It is a stamped date placed in the lower right margin of the chart and represents the date to which all essential changes for lights, buoys, beacons, recently reported dangers, and other critical information have been corrected.

The user of a chart should therefore not be misled by the edition or printing dates on a chart. These dates bear no relationship necessarily to the date when the survey was made or when certain material was obtained. If the precise date pertaining to any section of the chart is required, recourse must be had to the original material from which the chart was compiled.

HOW TO OBTAIN DATA

Nautical charts and related publications (Coast Pilots, Tide Tables, Current Tables, Tidal Current Charts) of the Coast and Geodetic Survey can be purchased at its Washington Office and field offices (Fig. 10) and from authorized sales

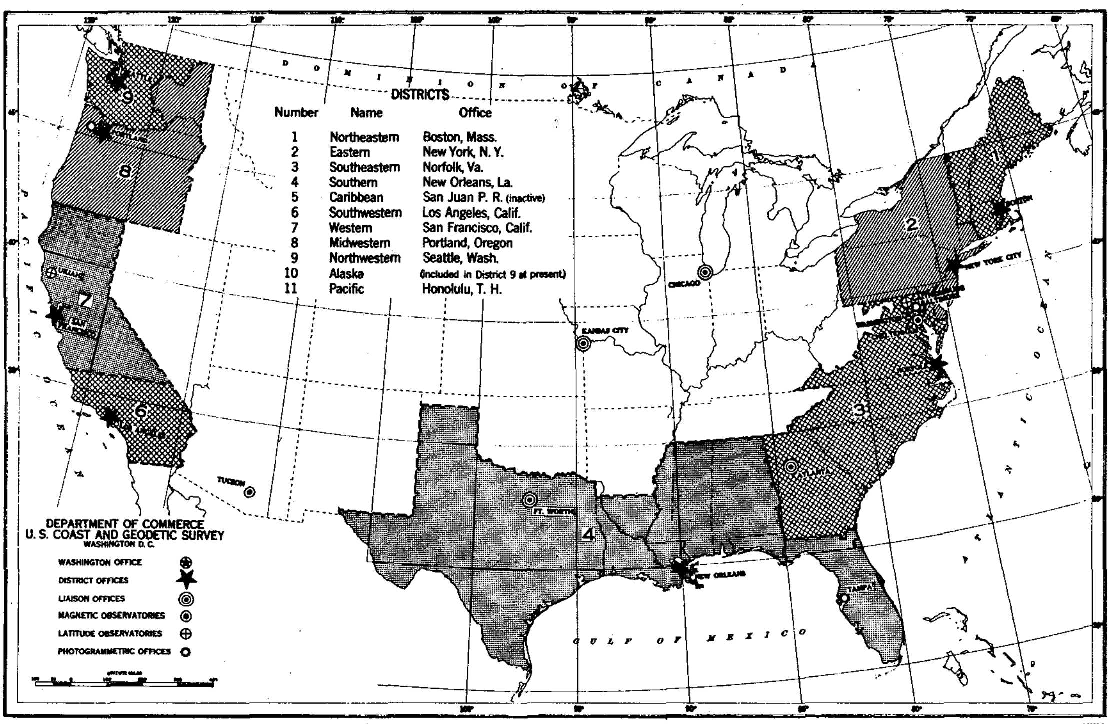


Fig. 10

agencies at the principal seaports of the United States and possessions. These offices and agencies are listed in the Catalog of Nautical Charts published by the Bureau. Copies of field surveys, planimetric maps, triangulation and leveling data, bench mark data, and information on temperature and density of sea water are also obtainable from the Washington Office. Other printed publications, such as manuals, are obtainable on a sales basis from the Superintendent of Documents, Government Printing Office at Washington, D.C.

CONCLUSION

In conclusion, I would like to say that it is my hope that out of this brief presentation will come a better understanding and a wider use on the part of engineers of the results of our activities. The Coast and Geodetic Survey has an important interest in the problems of the coastal engineer. Our surveys are uncovering new and interesting facts about the coastal regions. We are pleased to make these available to all who have occasion to use them.