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COAST AND GEODETIC SURVEY
R. S. PATTON, Director

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JAN 17 1930
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ANNUAL REPORT

OF THE

DIRECTOR, UNITED STATES COAST AND GEODETIC SURVEY

TO THE

SECRETARY OF COMMERCE

FOR THE

FISCAL YEAR ENDED JUNE 30, 1929

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National Oceanic and Atmospheric Administration

Annual Report of the Superintendent of the Coast Survey

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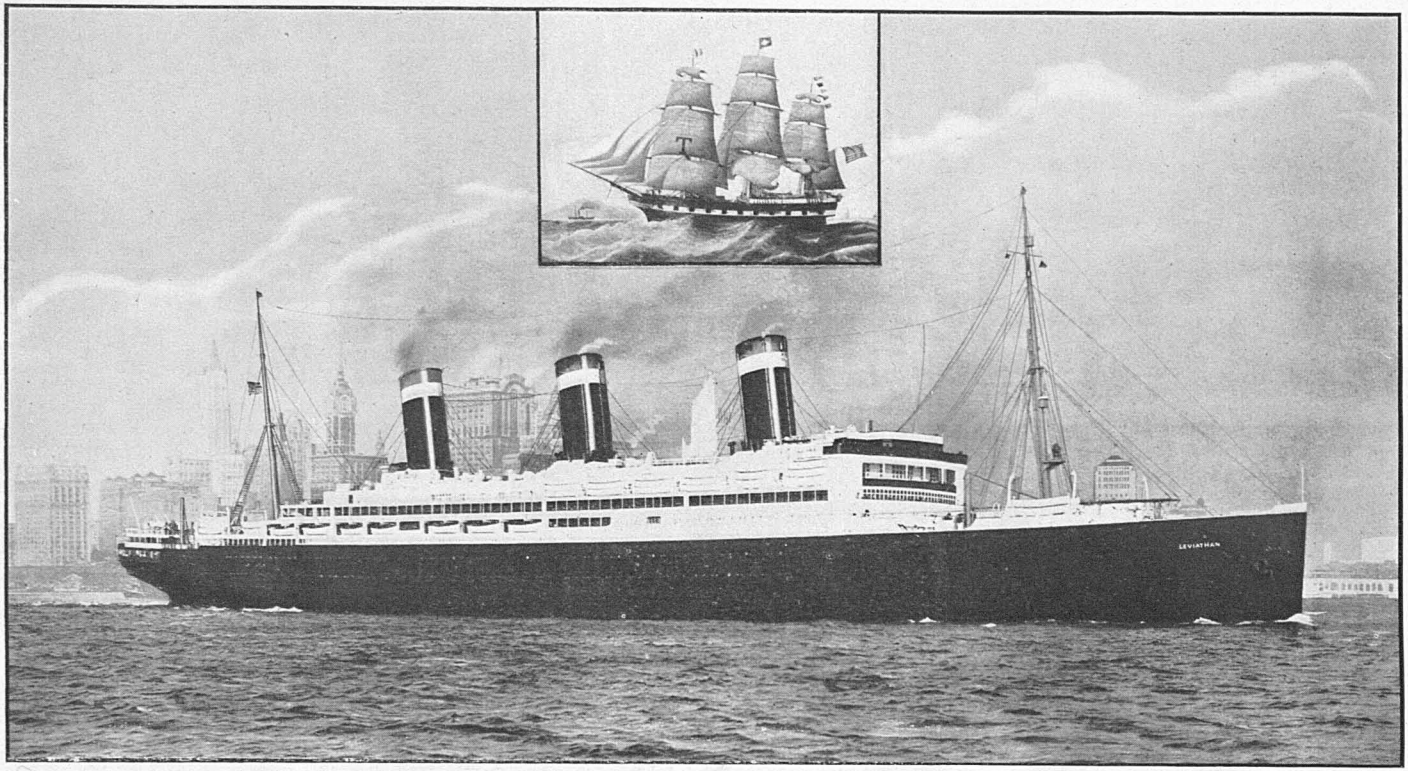

The "Leviathan" and (insert on same scale) the White Diamond liner "Anglo American," a famous trans-Atlantic passenger ship of 1848

The remarkable increase in the size and speed of ships during the past century has been accompanied by a corresponding growth in the demands upon the Coast and Geodetic Survey for additional information on nautical charts and for their extension seaward.

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REPORT OF THE DIRECTOR
UNITED STATES COAST AND GEODETIC SURVEY

DEPARTMENT OF COMMERCE,
COAST AND GEODETIC SURVEY,
Washington, July 1, 1929.

The honorable the SECRETARY OF COMMERCE.

DEAR MR. SECRETARY: There is transmitted herewith my first annual report. This report is for the fiscal year ended June 30, 1929, and is the ninety-eighth annual report of this bureau.

INTRODUCTION

With the ending of the past fiscal year the Coast and Geodetic Survey completed the thirteenth year of its second century of active existence. In most respects the results of the year have been very satisfactory. The demands upon the bureau for the many and varied services that it renders—demands that have increased to a notable extent during recent years—continued without abatement. As a result of a constant effort to increase our output by the development of more economical methods and more efficient equipment, real progress along the line of internal improvements was made. The results obtained by the use of several new and remarkable methods and instruments, described in the 1928 annual report of the bureau, have fully justified our estimate of their value.

Especially gratifying has been the evidence accumulated through the year not only of the increasing use by the public of the numerous products of the bureau but also of the spreading realization, even on the part of those who receive only indirect benefits, of the value and essential nature of the services that we furnish.

The importance of our charts and other nautical publications, being an indispensable part of the navigator's equipment, naturally has been recognized from the first. The value to engineers and scientists of the results of other operations, such as the bureau's geodetic work and its tide, current, magnetic, and seismologic investigations, has not been so well known. To bring these products, and the many ways in which they may be used to advantage, to the attention of the general public, and thereby to increase the return on its investment in this particular branch of our Government, has been the object of a determined campaign for a number of years. Our efforts along this line are producing definite and excellent results.

Certain present unsatisfactory conditions relative to compensation of personnel, both on the active and retired lists, which, of

course, do not affect this bureau alone, have been mentioned in previous reports. While there has been no material improvement during the past year, there have been a number of indications that the urgent need for relief in this respect is well recognized. I am hopeful that the present situation will be remedied by more liberal legislation in the near future.

From another point of view the record of the year is less favorable for it has brought home with increasing force the realization that this organization, due to insufficient personnel and operating facilities, is unable in all respects to provide the complete and adequate service that is essential to navigators, engineers, and others.

It is a congenial and easy task, in a report of this nature, to recite the accomplishments in which we may perhaps take justifiable pride. To mention our deficiencies, even though they result from causes beyond our control, is not so pleasant. I would, however, feel guilty of a serious neglect of duty if I failed to bring to your attention the condition of the bureau in this respect.

The Coast and Geodetic Survey is charged by law with a number of specific duties. Some of our products are vital to the safety of our Navy and merchant marine and have a very distinct bearing on the economical aspects of water transportation. Others have a definite dollars and cents value to the engineering and allied professions. If our resources are insufficient to enable us fully to meet the needs of those whom we serve, the result is a direct economic loss that must continue until relief is obtained.

In this report I shall, therefore, endeavor to set forth as clearly and concisely as possible, not only the progress of the bureau in performing its duties but also the extent to which it has failed to meet its obligations, the reasons therefor, and the steps that appear necessary in order to remedy present conditions.

Before taking up these matters, however, I can not refrain from mentioning the grievous loss suffered by the bureau in the death, on April 9, 1929, of Col. E. Lester Jones, director of the bureau since 1915. In his death the members of this organization feel that our country has lost an outstanding executive and that they, personally, have been deprived of a capable and trusted leader whose faith in this service and devotion to its ideals afforded a constant source of inspiration.

Part I.—FUNCTIONS OF THE BUREAU, ITS PROGRESS AND NEEDS

PRIMARY FUNCTIONS OF THE BUREAU

In order to carry on its work efficiently and economically the organization of the Coast and Geodetic Survey consists of a number of divisions, each charged with the accomplishment of one or more classes of work. The duties of these divisions are in many respects so different in character that it is necessary, in order to prepare a comprehensive report, to consider each almost as a separate entity and to treat of its progress under a separate heading. The thought has occurred to me that this arrangement, although seemingly necessary, may have a tendency to create the impression that this branch of the Government, while performing several important duties, is engaged in a number of unrelated operations and must in the very nature of things be unbusinesslike and cumbersome.

To correct any impression of this nature that may exist, I believe that it is desirable to begin this report with a brief outline of the organization of the bureau with the idea of defining its primary functions and of indicating the relation between the different branches of its work.

The Coast and Geodetic Survey was organized 113 years ago for the purpose of surveying the coast and harbors of the United States, including adjacent shoals. From a small beginning the scope of its operations has grown with our country until it now operates throughout the vast extent of the United States and its off-lying Territories.

The results of our coastal surveys are published, for the guidance of navigation and the protection of life and property at sea, on about 700 different charts which constitute the basic product of the bureau. I take it for granted that there is no need to point out or emphasize the importance of coastal charts to any nation that depends on water transportation for any part of its prosperity.

The greater part of the information shown on these charts is obtained by extensive hydrographic and topographic surveys and the accuracy and adequacy of such surveys in any region are, therefore, an index of the condition of the charts of that region.

The first surveys of any navigable waters for purposes of chart construction are designed to meet immediate needs and such future requirements as can be anticipated. In many cases, however, surveys that had these qualities are found, after a period of years, to be entirely inadequate for the new needs that have developed during that time. There are also extensive stretches of our coasts where charts may become inaccurate on account of changes in the depths of navigable areas and in the configuration of channels, due to natural causes or improvements by man. Such conditions can be remedied only by repeating or supplementing the original surveys.

There is also a considerable amount of information required by mariners that can not be shown conveniently on charts. This includes sailing directions and data relative to port facilities, weather conditions, radio service, and similar subjects. To supply this information all maritime nations issue volumes called Pilots. The Coast and Geodetic Survey publishes 12 Pilot volumes for the coasts under the jurisdiction of the United States and 3 Inside Route Pilots for our inland waterways. Material for these Pilots is collected in connection with hydrographic surveying operations and by special parties.

The geodetic work of the bureau has for its principal object the establishment of a great number of stations, distributed along our coasts and throughout the interior, which provide a foundation or framework for practically all charting and mapping operations. These are divided into two general classes—stations, the positions of which, with relation to each other and on the surface of the earth, are determined; and bench marks, the elevations of which are known.

It has long been recognized that geodetic control is absolutely essential to the satisfactory execution of extensive mapping projects and to the proper location of the boundaries of political subdivisions and of private property; also that the operations required to establish this control provide data indispensable to certain lines of scientific investigation. During recent years there has been an increasing realization of the value of geodetic control in many engineering and industrial operations such as highway location, hydroelectric power development, drainage and irrigation projects, and flood control.

As is the case with the majority of maps, a nautical chart, especially if it extends over more than a very few miles of coast or is one of a number of charts covering an extensive stretch of coast, must be based on a rigid control system that forms a backbone for the entire series. It is considered that one of the outstanding indications of the ability of Ferdinand R. Hassler, first superintendent of this service, is that he recognized this fact and insisted on the performance of operations that would produce the results desired—a procedure for which neither this bureau nor any other map-making organization has ever been able to find a satisfactory substitute.

Just as the first coastal work of the bureau, back in 1816, began with a trigonometric survey to locate control points, so must its present-day hydrographic and topographic operations be preceded by a similar geodetic operation, called triangulation. Without this control the bureau would be unable properly to plot a single sounding, landmark, or aid to navigation on any of its charts.

When, as a result of the growth of our country from a narrow band of States along the Atlantic coast, it became necessary to extend geodetic control inland, the work was not delegated in a haphazard manner to the first bureau that came to mind. It was assigned to an organization that from the first had been carrying on similar operations as a necessary part of its duty and was the only agency equipped with the trained personnel and suitable instruments required for the work.

The necessity for tidal observations as a part of any coastal survey is fairly obvious. Charted soundings must show the depths at some definite stage of the tide adopted as a uniform plane of ref-

erence. This being the case, the bureau's tidal investigations serve two purposes with respect to chart production; first, they provide data for the establishment of the reference plane and for the reduction of all soundings to that plane; second, they enable the bureau to compile annual tables of predicted tides by means of which the mariner can time the movements of his ship to take advantage of the tide or, by using the tables in conjunction with his chart, can ascertain the actual depths at any time. This information is of great importance nowadays when the drafts of a large number of ships are but little less, and are sometimes greater, than the low-water depths of the channels which they must navigate.

The degree of safety and facility with which a ship may be handled in restricted waters and its running time between ports are often affected to a considerable extent by tidal currents. With the increase in size of ships and the growing importance of economy in their operation, it has been necessary in late years for the bureau greatly to extend the scope of its current investigations which are carried on in connection with tidal observations. Outside the bureau the results of these operations are of great value in harbor-improvement work, sewage disposal, and similar projects.

The magnetic surveys of the bureau are carried on for the primary purpose of providing the data relative to magnetic variation that are shown on all charts and airway maps and are essential to the accurate use of the mariner's compass. The results are equally necessary for land surveying and for many branches of scientific research.

The activities mentioned above are all essential branches of chart and map production work. That the results, once they are available, are valuable and increasingly useful in many other lines of endeavor is certainly a desirable condition but should not be allowed to obscure the fundamental purpose for which they are obtained.

These operations are carried on and supervised to a certain extent by separate divisions of the bureau for the following reasons: Results that come in from the field require a very considerable amount of office work to put them in final form for use. The expeditious accomplishment of this work requires the services of mathematicians, cartographers, and others who are specialists in the various branches of office work. The operations themselves are generally of such a nature that in the field, if a certain part of the work is done with extreme accuracy, the remainder may be accomplished by less precise methods. The first class of work is best carried on under the supervision of the divisions concerned, but there is no further specialization in field work. The field officers of the bureau are competent to perform all classes of work, and it is the usual procedure for each party to execute all field operations required for chart compilation.

The bureau has recently engaged in two other activities. One of these is airway mapping. In addition to being directly in line with our other charting operations, the assignment of this duty to the bureau is simply a case of utilizing trained personnel and a modern map-making plant to turn out additional work with no great increase in overhead expenses. The necessity for this work is obvious.

The other activity is seismology, or earthquake investigation. This was delegated to the bureau for the reason that the work required is admirably adapted, both in the field and office, for prosecution in

conjunction with our magnetic surveys and, like airway mapping, can be carried on with only a moderate increase in operating expenses. We are not carrying on this work alone, but rather are cooperating with a number of other agencies by obtaining certain fundamental data required by all. The collective results can not fail to have beneficial effects with respect to public safety.

PROGRESS AND SUFFICIENCY OF SERVICE

The various classes of operations are discussed below in order to picture in a general way the progress of the bureau in accomplishing its duties, to point out the factors that have contributed to that progress, and to indicate the extent to which we are meeting the demand for our products. Details concerning operations in the field and office are given in subsequent parts of this report.

HYDROGRAPHIC AND TOPOGRAPHIC WORK

During the past year hydrographic and topographic surveying operations were carried on extensively along the coasts of the United States, in Alaska, and in the Hawaiian and Philippine Islands. The greater part of this work was on large projects that were adopted and started before the beginning of the year.

An important accomplishment on the Atlantic coast is the completion of surveys in the vicinity of Cape Canaveral, Fla., in connection with a general resurvey of the South Atlantic coast in progress for a number of years. This section, on account of exposed location and the existence of several off-lying shoals, is one of the difficult parts of the project. An interesting feature of work elsewhere on the east coast is the completion of a wire-drag examination of an area off Portsmouth, N. H., to be used for deep-submergence tests of submarines. To accomplish this survey it was necessary to set the drag to a depth over three times as great as has been used heretofore, which required the development of special apparatus and methods of operation.

The very satisfactory rate of progress of Pacific coast surveys that has been made possible during recent years by the use of modern ships equipped with echo-sounding instruments and apparatus for radio-acoustic position finding, as described in the 1928 report of this bureau, was more than maintained. Each party surveyed a greater area than in any previous year. Over 75 per cent of the Pacific coast of the United States has now been adequately surveyed for present needs.

Operations in southwestern Alaskan waters were greatly facilitated by the use, for the first time in Alaska, of the radio-acoustic method of position finding. As an example of the efficacy of this method may be cited the fact that one of our ships, working off Prince William Sound, was able to run over 700 miles of sounding lines during one week of thick weather that would have entirely prevented work with methods previously available. Surveys in the Hawaiian and Philippine Islands were expedited by the use of echo-sounding instruments with which all ships operating in those waters are equipped.

Taken altogether the accomplishments in this branch of our work during the past year constitute a record, as far as this bureau is concerned, for quantity output of high-grade work.

Research work for the purposes of developing new methods and appliances was carried on both in the field and office. Experiments were made with a new type of echo-sounding apparatus for use in shallow water and a new instrument was devised for increasing the accuracy of deep-water measurements by this method. All field officers stationed in Washington were given a course of instruction in the use of echo-sounding and radio-acoustic apparatus.

In connection with its Coast Pilot work the bureau compiled a new publication containing tables of distances between United States ports. This volume lists over 400 ports and points on inland waterways and is intended to supplement the Coast Pilot series by providing a convenient means for ascertaining navigable distances between the ports of the United States and its off-lying Territories.

Condition of surveys.—During the past decade steady progress has been made toward increasing the output of surveying parties and reducing the unit cost of work. This has been accomplished by the use of modern ships, improvements in methods and apparatus, and careful planning of work in order to reduce the cost of starting projects and to coordinate the efforts of the various parties.

Since 1916, the last normal pre-war year, the area surveyed per year has more than doubled; unit costs have been cut nearly in half.

These internal improvements have enabled the bureau to meet, to a considerable extent but not entirely, a very great increase in the demand for new charts and for additional information on existing charts.

Surveys on the Pacific coast, in general, are keeping pace with the need for charts and probably can be completed as rapidly as conditions require. A similar situation exists in southeastern Alaska. Conditions in western Alaska are not so satisfactory as the demand for surveys and new charts exceeds our ability to provide them. It is believed, however, that the situation is not critical and can be corrected within a few years by a reasonable addition to the facilities that now exist or have been authorized.

In the Hawaiian Islands the bureau is nearly keeping up with the need for surveys and should have the situation well in hand in the near future. A considerable amount of work remains to be done in the Philippine Archipelago, but the need is not urgent, as we are not behind in supplying the demand for new charts. Porto Rico and the American Virgin Islands have been fully surveyed. It appears that no additional work in this region will be required for some time except for the purpose of charting any harbor improvements that may be made.

As a general rule the nature of the coasts mentioned above is such that resurveys will not be required for many years. The exceptions are a number of rivers, bays, and entrance bars that form a very small percentage of the total area.

On the Atlantic and Gulf coasts the situation is entirely different; for here the bureau is far behind in meeting the need for new surveys and the adequate charts that result therefrom.

This vast extent of coast line has a length of about 3,500 miles along its general trend and is so broken by bays, indentations, points, and off-lying islands that the actual shore line measures about 18,000 miles. Backing a large part of these coasts are important inland waterways navigated by thousands of small vessels and motor boats.

Notwithstanding the fact that surveys have been made at one time or another along the entire extent of our eastern seaboard, not over one-third of this region is adequately surveyed at the present time. A large proportion of the inland waterways requires examinations that can not even be considered with present resources.

There are two principal reasons for this condition; one is the great change that has taken place in the requirements of navigation. Early surveys were made to meet the needs of light-draft sailing vessels that worked their way leisurely into a small number of ports. Nowadays there are scores of important harbors to and into which swift, deep-draft steamers must proceed by the shortest possible routes regardless of conditions of weather and visibility. This development has been responsible for a steadily increasing demand for surveys in greater detail and for the extension seaward of such surveys.

The other reason is the fact that by far the greater part of the eastern seaboard (practically all of the coast south of New York) is subject to constant change, necessitating resurveys from time to time in order to provide accurate charts.

Additional facilities required.—For many years the facilities of this bureau on the east coast have been entirely inadequate to cope with the conditions outlined above. As a general rule, surveys in any one locality have been made at the expense of other regions where the need for work, while urgent, was not quite so acute.

We now have three ships for this work; all converted yachts obtained from the Navy when it disbanded its war-time auxiliary fleet. None of these is entirely suitable for surveying operations and only one is fit for offshore work in exposed localities. A new ship now under construction will soon be available partially to relieve the situation, but there is urgent need for two additional ships with personnel and operating funds; one for work on the outside coast and the other for surveys of inland waterways.

With a fleet of this size the charts of the Atlantic and Gulf coasts can, within a reasonable time, be brought up to the excellent standard that is being maintained elsewhere. Otherwise the prospects for any rapid improvement in present conditions are discouraging.

CHART PRODUCTION

The various office processes involved in chart production begin with a careful review and verification of field sheets and records. The data obtained from these and from numerous other sources are next correlated and combined in the form of a chart drawing. A tabulation made a few years ago listed 469 field sheets and records of various kinds that were used in the compilation of a single chart.

The chart is then engraved on copper or on glass negatives, transferred to a printing plate, and printed on a high-speed lithographic

press. Finally each chart must be corrected by hand for changes that occur between dates of printing and issue. During the past year over 1,000,000 hand corrections were required.

Our chart-production force has several other duties, including preparation of the weekly Notice to Mariners in collaboration with the Bureau of Lighthouses, the custody of thousands of original survey sheets, and the preparation and issue of copies of these sheets The latter activity is growing rapidly. Because of their marked accuracy in comparison with contemporaneous surveys the earlier sheets are frequently the only means of obtaining an authentic portrayal of conditions existing at certain times in the past and consequently have been found of great value in deciding property lines and in solving various engineering problems.

During the past fiscal year the activities mentioned above have been carried on with increasing volume. A larger number of charts was distributed than in any other year since the war. Other accomplishments include an investigation relative to slope corrections to echo soundings and the development of a mechanical method of transferring correction work to the printing plate that will result in a considerable saving of time.

Airway mapping.—The program of airway mapping and progress to the end of the fiscal year are shown on the diagram facing page 41 of this report. This work is beginning to show a trait common to other branches of our operations—namely, that we are confronted by a constantly growing demand so that our greatest possible progress falls far short of requirements.

The original program contemplated only the production of strip maps of established airways. It now appears necessary to extend this to include sectional aeronautical maps of the United States. This necessity arises from the fact that about 80 per cent of the present annual flight mileage is away from the regular airways. Work is now in progress on the first of these sectional maps.

Internal improvements.—In order that the results of surveying operations may be published with the least possible delay it is important that the time required for chart construction be reduced to the greatest practicable extent. To accomplish this and to meet the need for expansion, every effort has been made in recent years to develop a smooth-working and efficient office organization to handle this work. The various improvements that have been made are too technical and elaborate to be described here; their efficacy is shown by the results attained.

Since 1916 our productive capacity has more than doubled; the average time to complete each new chart is now less than one-half that required in 1920. In this connection a noteworthy record was made during the past year by our engraving section. In 1920 the average elapsed time required to engrave a new chart on copper was over 27 months. During the fiscal year 1929, 12 new charts, more than in any recent previous year, were engraved in an average elapsed time of 4.9 months. The need for greatly increasing the issue of charts has been met by a complete transition from copperplate printing to offset lithographic printing.

Additional personnel required.—It is obvious that there is a very close relation between the amount of chart-production work that

must be accomplished and the volume of survey material coming in from the field. The present condition of the bureau in this respect is shown graphically on the opposite page.

Special attention is invited to the disparity between the increase in surveys received and the increase in our chart force since 1916. A considerable part of this discrepancy has been made up by internal improvements as mentioned above but it is too large for complete compensation in this manner. As a result, unfinished work is, and has been for some years, piling up. This condition affects every branch of chart production. Surveys frequently must wait their turn for a longer period than is required to convert them into charts once they can be taken up; some projects must be postponed indefinitely; back orders of important charts, indicating the difference between supply and demand, fluctuate but are always present to some extent.

With our present force the current program of airway mapping will require about 15 years for completion. The immediate needs of aerial navigation, and it is unthinkable that they will not increase greatly in the future, indicate that this program should be completed in one-quarter of the above time.

The present situation can be remedied only by an increase in personnel. Seven additional employees are required in the airway mapping section. Throughout the other branches of our chart-production force 14 additional employees are needed. Such an addition would provide a force 13 per cent greater than at present, 54 per cent larger than in 1916, and capable of handling expeditiously a volume of incoming material over 100 per cent greater than in 1916.

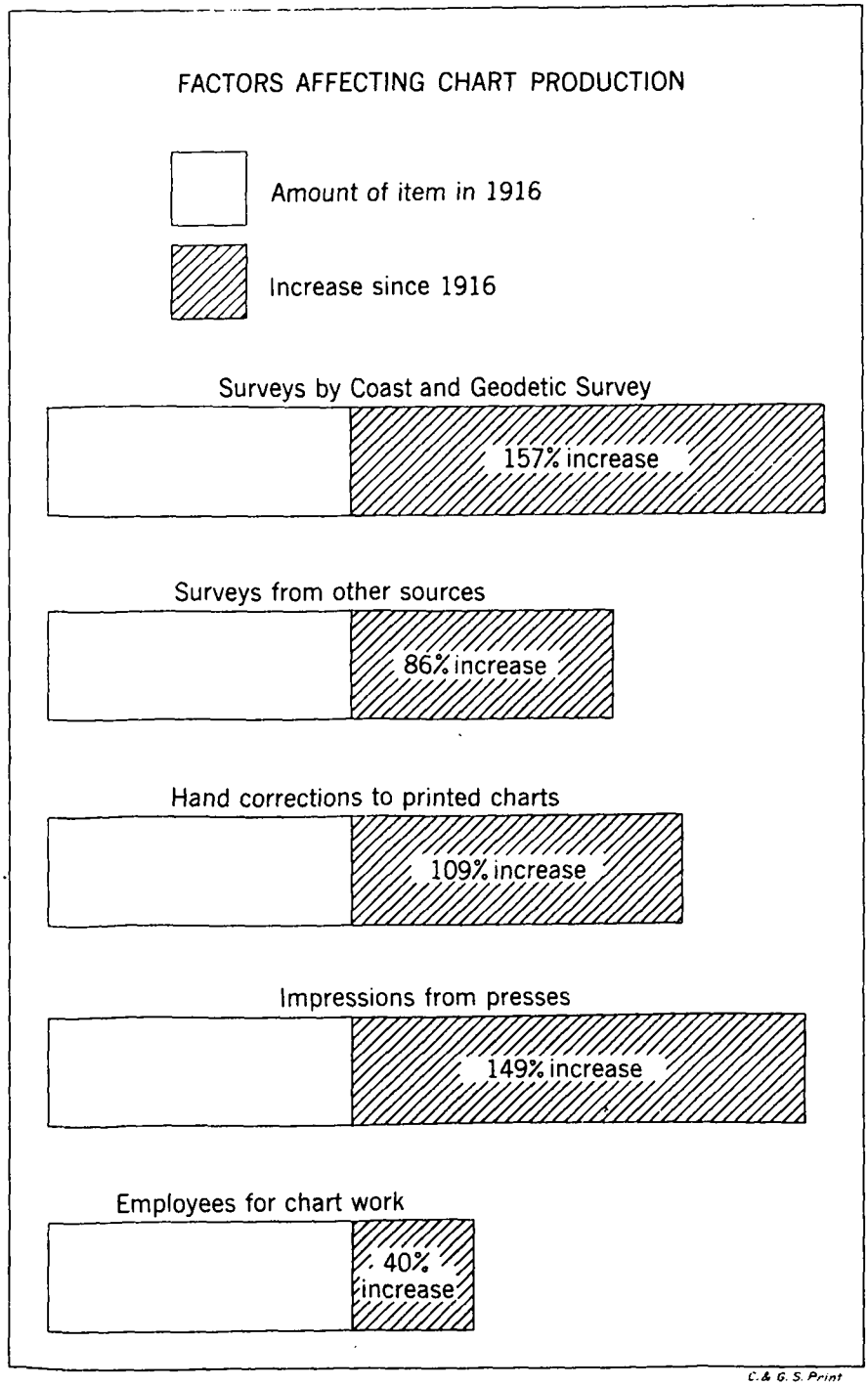
The need for additional personnel for chart-production work has been mentioned in the annual reports of this bureau for several years past; it grows more acute every year. It is believed that this need, on account of its urgency and moderation, deserves the most careful consideration.

CONTROL SURVEYS

In order properly to distribute control stations of known latitude and longitude throughout the United States, a number of belts or arcs of triangulation must be extended across the country. Some of these run north and south, others east and west, and a few in an oblique direction, so that they cross each other and form a triangulation net covering the entire country. In a similar manner a network of level lines provides bench marks of known elevation. In addition to serving the interior, these nets are necessary for the proper tying together of charts of the east and west coasts of the continental United States and of Alaskan waters; also for correlating these charts with maps of the interior.

In providing a triangulation net it eventually becomes necessary to adjust it in a single unit in order that unavoidable discrepancies where two arcs join may be distributed over the entire system. This has been accomplished for the western half of the country.

During the past fiscal year the funds available for geodetic work were devoted largely to supplying missing arcs that are required for the adjustment of the net over the eastern United States. Within


FACTORS AFFECTING CHART PRODUCTION
Amount of item in 1916
Increase since 1916
Surveys by Coast and Geodetic Survey
157% increase
Surveys from other sources
86% increase
Hand corrections to printed charts
109% increase
Impressions from presses
149% increase
Employees for chart work
40% increase

C. & G. S. Print

the limits of our resources excellent progress was made in this work and several necessary arcs or parts thereof were completed. In addition, a triangulation arc in California, required for cooperative earthquake investigation, was about three-fourths completed. Other accomplishments include the completion of a number of lines of first-order leveling and the maintenance of the variation of latitude station at Ukiah, Calif.

Notable office operations were the completion of adjustment of the triangulation in the Hawaiian Islands and the isostatic reduction for 49 gravity stations at which observations were made during the cruise of the United States submarine *S-41*. The results were furnished to Doctor Meinesz, of the Dutch Geodetic Commission, under whose supervision the observations were made. An extensive investigation was also made for the purpose of adjusting the combined level nets of the United States and Canada.

Increase in efficiency.—Internal progress in this branch of our work during recent years is fully comparable with our advance in other lines. Since 1916 annual mileage of triangulation has increased over 60 per cent; unit costs for this work have been reduced to about 45 per cent of the 1916 figure. This increased efficiency has been made possible by stabilization of personnel, better transportation facilities, and improvements in instruments, equipment, and methods.

Control surveys should be expedited.—The situation in this country with regard to geodetic surveys is not satisfactory. The high quality of the work that has been done and the efficiency with which it has been executed are recognized throughout the civilized world. Unquestionably, however, it is not being carried on toward completion at the rate required to meet the need for the data it provides. Only 43 per cent of the area of the United States is covered by topographic maps and of this area probably not over one-half is accurately mapped because of obsolescence and the more exacting requirements of the map user of to-day. Control surveys are the first step toward remedying this condition.

A growing realization on the part of the public that this work should be accelerated is evidenced by resolutions urging greater progress adopted by such representative engineering and scientific organizations as the American Society of Civil Engineers and the American Geophysical Union; also by the testimony of numerous State officials and private individuals.

A prominent citizen of one of our western States, in a recent communication, cites the following uses in his State for control surveys and for accurate maps based thereon: Geological investigations, compilation of rainfall and snowfall data vitally important to irrigation and power projects, study of forest conditions, soil surveys, highway development, and forest-fire control. He deplores the lack of adequate control surveys in his State but is frank enough to admit that many other States are facing the same situation.

It is difficult to estimate the full value to engineering and industrial enterprises of maps based on accurate control. In highway construction alone, however, it is probable that the saving, due to selection of the shortest practicable routes, that would result from the availability of a standard topographic map would be sufficient to pay the entire cost of completing the map. This is not hard to

understand when we consider that a highway of the best type costs from $30,000 to $40,000 per mile while the cost of a topographic map is not over $50 per square mile.

The requirements of this country for control surveys have been studied extensively by the various map-making organizations of our Government. As a result it is generally agreed that the size of the meshes of the triangulation and level nets should be reduced to such an extent that no point in the United States will be more than 25 miles from a control station. With present resources the completion of this program will require from 40 to 50 years. Under existing conditions it is safe to say that in any 5-year period the economic waste due to lack of this control will exceed the total cost of the project.

Undoubtedly the progress of control surveys should be expedited materially by increasing to a reasonable extent the facilities of this bureau for carrying on this work both in the field and office.

TIDE AND CURRENT SURVEYS

The tidal work of the bureau is well standardized. In general, it consists of the maintenance of a number of primary tide stations distributed along our coasts to which are referred observations obtained at numerous secondary stations. The data obtained from all of these are used for the compilation of tables of predicted tides, published annually in advance, and for other purposes. To meet a gradual increase in the demand for tidal information it is necessary, from time to time, to establish new primary stations. During the past decade this increase has averaged about one new station per year.

During the past fiscal year 21 primary stations were maintained. Several of these were operated in cooperation with other organizations, this bureau contributing the instruments required and receiving the records without other expense. Observations from secondary stations included a large number of short-period observations obtained by the various field parties of the bureau and through the cooperation of other organizations.

Every tide station is connected with several permanent bench marks at a known elevation with respect to such datum planes as mean low water and mean sea level. These marks are of great value to engineers for many purposes, including investigation of the permanence of our coast line and of improvements along the coasts on which many millions of dollars have been expended. There have been so many requests for information regarding these marks that it has been considered desirable to publish the data in printed form. Publications for six States have been issued and others are being prepared.

The current investigations of the bureau consist chiefly of systematic and comprehensive surveys of harbors and larger indentations. Surveys have been completed of New York, San Francisco, Boston, and Portsmouth Harbors, southeastern Alaska, Delaware Bay, and Chesapeake Bay. The current survey of the latter bay was concluded during the past fiscal year and work was then started in Long Island Sound.

The results of these surveys are published in tables of predicted currents and in special publications relating to individual localities. The instant demand for this information is ample evidence of the desirability of extending the work. A recent publication is a volume of current charts for New York Harbor. From the best information available it was estimated that the first edition would last something over one year. It was sold out in three months.

Additional personnel required.—The present need for this class of work in the field can be cared for with our present appropriations. Office work, however, is falling behind chiefly on account of increased work incident to the extension of our current surveys. There is need for two or three additional mathematicians in order that the results of our field work may be handled without undue delay.

The nature of tide and current work, both in the field and office, is such that automatic or semiautomatic instruments can be used to a considerable extent and work can, therefore, be carried on at a very nominal cost. For this reason a small investment for additional personnel will yield large returns.

TERRESTRIAL MAGNETISM AND SEISMOLOGY

During the past fiscal year the five magnetic observatories of the bureau were continued in operation and observations were obtained at 96 stations in the field. The latter include several points in the interior of Alaska never before reached for this purpose. New methods which facilitate observations have been adopted at several observatories. Other operations include cooperative observations at Duke University, Durham, N. C., and special auroral observations at Sitka, Alaska.

Some progress was made in the office toward the publication of results of observations, but this work was limited to a considerable extent by insufficient personnel. Special attention was given to the maintenance of contact with the many organizations throughout the world which are engaged in magnetic work. Cooperation with the Navy Department and the Carnegie Institution of Washington was especially satisfactory.

Seismological observations were obtained at Tucson, Ariz., and Sitka, Alaska, throughout the year and at San Juan, P. R., up to the time of the September, 1928, hurricane which damaged the observatory buildings to a considerable extent. Cooperative stations were maintained at the Universities of Chicago and Hawaii. Noteworthy progress was made in the organization of volunteer observers for the collection of reports on certain effects of earthquakes.

A feature of the service that is provided in this class of work is the early determination of positions of earthquakes through reports from observatories and cooperative organizations. This information has been found so valuable that, at the request of Great Britain, it is now being transmitted to Europe as a part of the meteorological messages of the Weather Bureau.

Additional requirements.—In order properly to carry on both the magnetic and the seismological work in the field a slight increase in observatory personnel, several small buildings, and a few improved

instruments are required. Our most urgent need, however, is for additional personnel in the office.

Public service in these fields is measured almost entirely by the information available in published form. Through a determined effort and by neglecting a part of the work, basic needs have been met; that is, information has been supplied for chart and airway map production and data have been furnished to some extent for other purposes, such as investigation of radio transmission and search for oil and minerals.

On the other hand, there have been serious failures of accomplishment. There is a demand for magnetic information in convenient form throughout the United States; this has been prepared for only about one-quarter of the country. Long delays in the publication of observatory results are especially serious but are unavoidable. The quarterly seismological report, which is fundamental in all earthquake investigations, is several years in arrears. Our present office force is engaged in a desperate struggle with this accumulation of material.

While the volume of accumulated material is large, the increase in personnel required to remedy the situation is extremely moderate. The services of only four additional scientists and one clerk will result in a great increase in efficiency and will enable us to issue a great amount of valuable information, the publication of which has been delayed for a period far too long.

INSTRUMENTS

Practically all of the operations of this bureau are of such a nature that the quantity and quality of the results attained depend to a considerable extent on the availability of adequate, and in many cases highly specialized, instrumental equipment. For this reason the instrument division of the bureau has always played an important part in its work.

During recent years this division has made a remarkable record in the development of new instruments and in improving those already in use. Many of these achievements have been mentioned in previous reports of the bureau. Among the accomplishments of the past fiscal year are the following:

1. Development of a portable engine-driven sounding machine for use in hydrographic launches. A standard machine of this nature has been badly needed for some time and its use undoubtedly will further increase the efficiency of our inshore hydrographic work.

2. Redesign of the depth-registering sheaves used with sounding machines for deep-sea sounding. The new sheave has a more rugged registering device which is easier to read and operate than the old register.

3. Design and construction of a special dividing machine for level rods. With this machine rods can be graduated with a degree of accuracy much higher than was formerly possible. Experiments indicate that, with rods graduated in this manner, changes can be made in the details of first-order leveling operations that will speed up the work from 10 to 15 per cent.

An adequate instrument division is essential to the work of this bureau for both practical and economic reasons. In the first place we often require special instruments in limited quantity, the development of which by private firms is exceedingly difficult. In this respect our instrument division has an immense advantage through its close contact with our field force which provides an exact knowledge of the purpose for which the instrument is required, as well as the conditions under which it is to be used, and also affords unlimited opportunity for tests in the field until the apparatus is finally perfected.

Futhermore, the development by private firms of special instruments for which the demand is small is usually an extremely costly proposition. We have had extensive experience along this line. Our records show many cases where the bureau has obtained estimates for such work, found them so high as to be far beyond its resources, and has then constructed the instruments in its own shops. Actual costs from 50 to 100 per cent less than those estimated by private firms have been the general rule; savings much greater are not uncommon.

In this and in previous reports has been mentioned the great improvement in field work due to the development of radio acoustic position finding. After a bid of $4,000 for one unit of this apparatus had been received, it was constructed in our shops at a total cost of $449.98.

When a number of instruments are required and one has been perfected and is available as a model, procurement at reasonable prices from private firms is usually practicable.

Additional instrument makers required.—The operations of our instrument division, as is the case with the majority of our office divisions, are hampered by insufficient personnel. Another common characteristic is that the increase required is so small in comparison with its ultimate value, as indicated above, that an extensive argument in its favor hardly seems necessary. In order properly to maintain and repair our stock of instruments and to develop a number of improved instruments that are badly needed, five additional instrument makers and mechanics are required.

CHANGE IN HEADQUARTERS OF THE BUREAU

The prospective use, for the construction of an office building for the House of Representatives, of the site formerly occupied by the Coast and Geodetic Survey at 205 New Jersey Avenue SE., necessitated a change in the bureau's Washington headquarters during the past fiscal year. For this purpose, pending the completion of the new building for the Department of Commerce, the Public Buildings Commission authorized the rental of the 7-story building at 119 D Street NE.

The moving of the bureau was completed during the early part of June, 1929. Our work was necessarily retarded to a considerable extent, but the ground lost is gradually being regained. The hearty cooperation of the employees of the bureau in increasing production prior to moving, their assistance in the moving operations, and their zealous efforts toward resumption of work, are worthy of the highest praise.

NEEDS OF THE BUREAU

The remarkable industrial and commercial growth of this country since the World War has been responsible for a great increase in the demand for all of the various services rendered by this bureau. To meet such an increase only two methods are available; first, to secure a greater return on every dollar expended, by rigid economy and by intensive effort toward greater output through internal improvements; second, to utilize additional facilities obtained by means of increased appropriations.

Application of the first method to the fullest possible extent before resorting to the second is dictated not only by the necessity for national economy but also by the first principles of good business management.

The extent to which the bureau has used the first method has been recorded in the preceding paragraphs. The fact that the results mentioned have been obtained without assistance in the form of larger appropriations may require a word of explanation. It is true that the appropriations for this service are greater than they were a few years ago, in 1923, for example. The increase, however, has been solely for the purpose of providing additional compensation for employees in accordance with general legislation affecting large groups throughout the Government service of which our personnel is an exceedingly small part. Excluding this item, the funds provided for the annual operating expenses of this bureau have decreased $55,000 since 1923.

The foregoing statement also indicates the extent to which the bureau is behind in its work and the increase in facilities required to remedy this situation. There is little likelihood that the work in arrears can be made up through further increase in efficiency. Internal progress undoubtedly will continue but necessarily at a diminished rate not sufficient to keep up with a constantly growing demand. In this connection it should be borne in mind that a large part of our progress in recent years is due to radical improvements that practically have revolutionized methods and apparatus in use with only minor changes for a century or more. They are not an everyday occurrence.

For several years this bureau has devoted unremitting effort toward the reorganization and modernization of its functions. The results have enabled it to meet a very large part of the additional demand for its products. I believe that the improvements of the last decade constitute a record in which any organization might take pride. At any rate it is one on which this bureau is willing to stand squarely in an appeal for the increase in facilities that is now required to enable us completely to accomplish our duties.

I feel that our request for additional resources is especially reasonable in that a large increase in appropriations is not required. A little help properly distributed throughout the various branches of our work will enable us to catch up and keep abreast of our national progress instead of struggling along and falling constantly further behind. The largest item is the need for new ships on the Atlantic coast. This expenditure, however, would be distributed through

several years and the cost of the ships is small when spread through the years of their usefulness.

Undoubtedly our most imperative requirement is for additions to our office force to enable it to handle accumulated and incoming material. By all means let us put a roof on our house before we build an addition. In so doing, however, it is my earnest hope that the urgent needs of the bureau along other lines will not be overlooked.

Taken altogether, the additional facilities that we require are moderate. The cost will be small with relation to the total appropriations of the bureau; insignificant when compared with the value of the results to a large part of our population.

Part II.—IN THE FIELD

HYDROGRAPHIC AND TOPOGRAPHIC WORK

During the fiscal year 1929 hydrographic, topographic, and control surveys were made on various sections of the Atlantic and Pacific coasts, along the Alaska coast, in the Hawaiian Islands, and in the Philippines. To perform these surveys, which comprised 38 separate projects, 25 different survey units were employed.

A summary of the surveys accomplished or in progress at the close of the year is given below:

Atlantic coast.—At the beginning of the fiscal year the survey ship *Lydonia* was engaged on a resurvey of the southern part of the coast of Maine. New surveys were carried northward from Portsmouth, N. H., to Portland, Me. A wire-drag party completed the sweeping of a trial course for deep submergency tests of submarines in the vicinity of Portsmouth, N. H. A resurvey of Gloucester Harbor and the Annisquam River, Mass., was completed. Revision surveys were made at Newburyport and Hampton, Mass., and at Edgartown, Oak Bluffs, Gardiners Bay, and Jamaica Bay, N. Y. Revision of the Potomac River triangulation was completed. The survey ships *Ranger* and *Natoma* made new surveys in the entrance of the Delaware River and in the vicinity of Five-Fathom Bank. An original survey of the Cooper River from Charleston, S. C., to the Seaboard Air Line bridge was completed. On the Florida coast topographic, hydrographic, and control surveys were carried southward from the vicinity of Ponce de Leon Inlet to Cape Canaveral by the party on the survey ship *Lydonia*. The ships *Ranger* and *Natoma* completed similar surveys from Jupiter Inlet southward to Hillsboro Lighthouse, and in addition the party on the *Natoma* developed the shoals off Cape Canaveral. Control surveys for the reduction of air photographs were made along the Florida coast in connection with other operations. Examinations were made by the party on the *Ranger* of several reported shoals between Hillsboro Lighthouse and Miami, and revised the triangulation in a portion of Biscayne Bay. On the west coast of Florida surveys of San Carlos Bay and the Caloosahatchee River were completed by the party on the survey ship *Hydrographer*. This party also completed the triangulation and traverse necessary to control the air photographs between San Carlos Bay and Cape Sable. A revision survey of Mobile, Ala., water front was made.

Pacific coast.—On the Washington coast a shore party had started control and topographic surveys preparatory to taking up hydro-

graphic work between Cape Elizabeth and Cape Flattery. Chart revision work was done in the vicinity of Seattle.

On the Oregon coast the survey ship *Pioneer* completed the project on which it had started during the latter part of the previous fiscal year, namely, a complete topographic and hydrographic survey of the coast from Cape Foulweather to Cape Arago. This work extended approximately 60 miles offshore. Inshore work was done by the launch party from Cape Blanco southward to Cape Sebastian.

On the California coast the survey ship *Discoverer* completed the project it had started during the latter part of the previous fiscal year, namely, a complete topographic and hydrographic survey of the coast from Cape Sebastian southward to Crescent City. The offshore hydrography was carried southward to Redding Rock and extended approximately 60 miles offshore. During the latter part of the fiscal year this party started on a similar project which extended southward from Cape Mendocino to Point Reyes. At the end of the year the work had been carried to the vicinity of Point Arena. A launch party engaged on inshore hydrographic and topographic surveys had completed work from Crescent City southward to Mussel Point. Near the end of the fiscal year the survey vessel *Pioneer* started on a new project which extends from Point Reyes to Point Sur. Considerable revision work was done in San Francisco and vicinity.

Alaska.—In southwest Alaska the party on the survey ship *Surveyor* completed a large offshore area southwest of Montague Island. This work extended offshore to Portlock Bank. Surveys were also made by this party in the approaches to Ressurrection Bay and in Harris and Two Arm Bays. A survey made in Sitkalidak Strait, Kodiak Island, by a subparty of the *Surveyor* disclosed a passage which shortens the steamer track of vessels approaching Port Hobron from the westward by approximately 40 miles. At the end of the fiscal year the party on the *Surveyor* had taken up work on the north and west coast of Kodiak Island and was engaged on surveys in Shelikof Strait and in Uganik, Uyak, Zachar, and Alitak Bays. While working at this project the party dragged the area where the steamer *Aleutian* was wrecked and disproved the existence of an uncharted rock in that locality.

Hawaiian Islands.—At the end of the fiscal year the survey ship *Guide* had practically completed the survey of the inlets, shoals, banks, and adjacent waters which extend westward from Niihau Island to French Frigate Shoals. During the winter season this vessel surveyed a large area west and northwest of the island of Hawaii and made detailed surveys of the landings at Honokaa and Kukuihaele on the north coast of the island. A revision survey of Kahului Harbor on the north coast of Maui Island was also made by this party.

Philippines.—The survey ships *Pathfinder*, *Fathomer*, and *Marinduque* were employed throughout the year on surveys in Balintang Channel, Lyzon Strait; on the east coast of Luzon, in the vicinity of Casiguran Sound; in the Sulu Archipelago, in the vicinity of Tawi Tawi Island; and on the south coast of Mindanao, in the vicinity of Davao and Dumanquilis Bay.

Hydrography, topography, and triangulation (second and third order) performed during year

Locality	Hydrography			Topography		Triangulation (second and third order)		
	Miles of sounding lines	Area in square miles	Number of soundings	Length of shore line surveyed in miles	Area surveyed in square miles	Length of scheme in miles	Area covered in square miles	Number of geographic positions determined
Coast of Maine	2,616	461	33,344			32	317	10
Isles of Shoals, Me	WD 45	WD 26						
Gloucester Harbor, Mass	190	3	12,092	6	24	7	12	31
Newburyport, Marthas Vineyard and Gardiners Bay, Mass., and N. Y	492	31	23,874	38	6	65	168	31
Jamaica Bay, N. Y	29	13	6,663	74	15			
Cape May, N. J	1,934	126	40,701	10	30	19	20	8
Delaware Bay	1,225	69	25,511					
Potomac River, Md. and Va						46	108	100
Cape Lookout, N. C	188	11	1,618	7				
Cooper River, S. C	300	7	16,178	90	12	26	21	59
Cape Canaveral, Fla	3,989	2,624	52,036	65		27	151	32
West Palm Beach and Cape Canaveral, Fla	1,262	144	18,197			39	6	25
Lake Worth to Hillsboro, Fla	1,398	216	29,463	38	10	45	60	28
Cape Sable to San Carlos Bay	1,156	41	38,987	11	3	40	150	74
West coast Florida (air photo reduction)				150	773			
La Jolla, Calif	114	7	2,261	9	5			
San Francisco Bay, Calif	15	1	1,506	44	21	20	20	9
Point Reyes, Calif	202	26	3,226	7	3	35	86	39
Shelter Cove to Point Arena, Calif	2,807	4,133	16,684	74	21	14	18	18
Crescent City to Mussel Point, Calif	307	42	6,200	52	72			
Cape Sebastian to Trinidad Head, Calif. and Oreg	6,837	5,600	54,074	114	83			
Coquille River to Cape Sebastian, Oreg	598	94	9,738	58	65			
Cape Foulweather to Cape Arago, Oreg	6,978	4,665	42,743	74	31			
Behm Canal, Alaska						78	136	68
Keku Strait and Wrangell Narrows, Alaska	738	17	51,691	48	17	30	28	87
Taku Inlet, Alaska						26	75	17
Kruzoff Island and Peril Strait, Alaska	860	124	9,986	110	130	68	615	21
	WD 32	WD 18	WD 11					
Southwest Alaska	5,857	3,552	42,196	239	212	88	434	157
Hawaiian Islands	15,755	33,795	85,340	36	4		260	44
North of Luzon and Mindanao, P. I	6,026	7,655	34,099	108	135	69	1,405	15
East coast Luzon and Mindanao, P. I	5,411	3,233	44,713	104	115	77	1,000	6
Sulu and Mindanao, P. I	6,830	493	143,385	160	75	27	75	17
Total	74,481	67,227	846,517	1,726	1,862	878	5,165	891

GEODETIC WORK

	Length of scheme	Area covered
	Miles	*Sq. mi.*
Triangulation, first-order:		
Maine, Augusta to international boundary	80	2,700
Pennsylvania and Ohio, Pittsburgh arc	85	1,100
Ohio, Columbus arc	225	2,500
Kentucky, Owingsville to Virginia-Tennessee boundary	120	2,850
Kentucky, Bardstown to Berea	65	1,000
Kentucky, Owingsville to Portsmouth, Ohio	50	600
Iowa, Missouri, and Arkansas, ninety-third meridian arc	420	5,400
Missouri, Springfield to Van Buren	95	1,600
California, Newport Beach to Bear Lake	60	1,100
Total	1,200	18,850
Triangulation, second-order: California, Redding to Humboldt Bay	85	2,400
Base line, first-order: Ohio, Burghill	5.8	-------
Reconnaissance, first-order triangulation:		
New York and Pennsylvania, Buffalo, N. Y., to Canton, Pa	150	1,200
Kentucky, Berea to Portsmouth, Ohio	110	1,600
Arkansas, Danville to Missouri boundary	120	1,800
Missouri, Springfield to Charleston	190	2,700
Arkansas, Louisiana, and Texas, ninety-fourth meridian arc	310	3,000
Louisiana, Mississippi, and Alabama, Shreveport to union base	390	4,100
Georgia and Alabama, Atlanta to Montgomery	200	2,200
Reconnaissance, first-order triangulation—Continued		
Missouri, Kentucky, Arkansas, and Tennessee, Cairo to Memphis	145	1,600
Arkansas, Mississippi, and Louisiana, Memphis to Natchez	270	1,700
Mississippi and Louisiana, Natchez to New Orleans	180	1,300
California, Newport Beach to Lucerne Valley	90	1,600
Total	2,155	22,800
Leveling, first-order:		
Montrose, Colo., to Farmington, N. Mex	148	-------
Farmington to Shiprock, N. Mex	30	-------
Alexandria, Va	3	-------
Tucumcari to Taylor Springs, N. Mex	103	-------
Greenup to Jackson, Ky	128	-------
Somerset to Glasgow Junction, Ky	102	-------
Monett, Mo., to Memphis, Tenn. (part of line), 362—40=322	322	-------
Covington to Richmond, Va	257	-------
Balcony Falls to Harpers Ferry, W. Va	185	-------
Washington, D. C	1	-------
Taylor Springs, N. Mex., to Pueblo, Colo. (part of line)	14	-------
Total	1,290.3	-------
Summary:		
First-order triangulation	1,200	18,850
Second-order triangulation	85	2,400
First-order base line	5.8	-------
First-order triangulation, reconnaissance	2,155	22,800
First-order leveling	1,290.3	-------

For several years the funds available for geodetic work have been devoted largely to the extension of the first-order triangulation net of the country. This has been done with a view to supplying those missing arcs that are needed in the adjustment of the net in order that final or standard geographic positions can be furnished those desiring the data. The time comes in the conduct of the geodetic work of a nation when the network of arcs of triangulation must be adjusted in a single unit and those unavoidable discrepancies where two arcs join must be distributed over the net according to the best mathematical methods. This has already been accomplished for the western half of this country. The eastern border of that net is an arc of triangulation which extends from Canada to Mexico, approximately along the ninety-eighth meridian. During the fiscal years 1930 and 1931, even if no increase in appropriations for the geodetic work is made, additional arcs for the eastern half of the country will be executed.

Triangulation during the past fiscal year has been extended from central Iowa along approximately the ninety-third meridian south to central Arkansas, with a spur line from that arc running eastward for 100 miles from Springfield, Mo. That arc of triangulation which extends from the vicinity of Martinsburg, W. Va., northward via Pittsburgh, Pa., to the Lake Survey triangulation in northeastern Ohio was completed. Part of that arc was executed in the previous fiscal year. An arc of triangulation was begun in the vicinity of Sandusky, Ohio, and carried southward to a point about 60 miles north of Portsmouth, Ohio, during the first half of the fiscal year. Late in the fiscal year this work was resumed and it is expected that it will be completed very early in July, 1929. An arc of triangulation was begun in the summer of 1928 in Maine and was completed in June, 1929. The work had to be discontinued in the fall of 1928 because of unfavorable atmospheric conditions.

An arc of triangulation for the study of earth movements in California was begun during the early part of the fiscal year in southern California. This arc will run between Newport Beach and Lucerne Valley. About three-fourths of that arc were completed during the fiscal year. The remainder will be executed in the early part of the fiscal year 1930. The location of the arc was decided on by officials of this bureau in consultation with members of the committee on seismology of the Carnegie Institution of Washington. By executing arcs of triangulation over regions subject to earthquakes in the past, and the location of many triangulation stations which are well monumented, one is able by making new observations in the future to determine whether the ground has undergone strain in horizontal direction and its extent. If an earthquake should occur in this region, the reobservation of the angles of triangles would enable one to determine the amount of movement at different places and to determine the distance from the actual fault resulting from the earthquake that movement has occurred. This work, which is considered to be of prime importance for the study of earthquakes, is in its infancy, and it is believed that exact knowledge of the behavior of an earthquake may have a large influence on the practical affairs of our people.

First-order levels were run between Republic, in western Missouri, along the St. Louis-San Francisco Railway to Memphis, Tenn. A line was run from Montrose, Colo., to Farmington, N. Mex., and another from Tucumcari to Taylor Springs, N. Mex. Two lines of first-order leveling aggregating 230 miles were run in Kentucky. In Virginia levels were run from Covington to Richmond along the Chesapeake & Ohio Railroad and from Glasgow Junction to Harpers Ferry along the Norfolk & Western, Baltimore & Ohio, and the Southern Railways. The latter work was executed at the request of the United States Geological Survey which furnished the funds for the field expenses.

A party of the Coast and Geodetic Survey was engaged during the first five months of the fiscal year in determining astronomic longitudes and latitudes and occasionally azimuths at triangulation stations in Iowa, Minnesota, Wisconsin, and Illinois. The astronomic data secured are essential to the adjustment of the triangulation of the eastern half of the country.

The variation of latitude station at Ukiah, Calif., has been kept in operation during the fiscal year and the record of observations furnished to Prof. H. Kimura, president of the International Commission on the Variation of Latitude. The Ukiah work was done in cooperation with the Governments of Japan and Italy and with officials of the International Astronomical Union and the Iternational Geodetic and Geophysical Union.

MAGNETIC AND SEISMOLOGICAL WORK

Magnetic stations occupied during the fiscal year ended June 30, 1929

Alabama	2	Ohio	8
Alaska	14	Pennsylvania	3
Florida	5	South Carolina	5
Georgia	14	South Dakota	1
Indiana	2	Tennessee	3
Kansas	3	Texas	8
Kentucky	4	Virginia	10
Louisiana	2	West Virginia	3
Mississippi	3		
Nebraska	5	Total	96
North Carolina	1		

As shown in the table the principal magnetic work has been in the section of the country lying eastward of a line from southern Texas to western Pennsylvania, an area in the northwest, and in the interior of Alaska. In the latter survey observations were made at points never hitherto reached for this purpose.

Continuous recording of the magnetic elements was in progress at five magnetic observatories. The hurricane destroyed several buildings at San Juan, P. R., but fortunately not those containing the essential magnetic instruments, and these have been kept in operation. New methods which facilitate observations have been put in effect at a number of observatories. Cooperative magnetic observations were carried on at Duke University, Durham, N. C. Special auroral observations were made at Sitka.

Seismology.—Instrumental observations have been made at Tucson, Sitka, at the cooperative stations at the University of Hawaii and the University of Chicago, and at the San Juan Observatory up to the time of the hurricane. No observations have been made in Porto Rico since that time. Several new seismographs have been tested at Cheltenham, which is used primarily for this purpose.

The collection of reports on the visible and felt effects of earthquakes as made by volunteer observers is becoming better organized. The inspector in charge of the field station at San Francisco has done important work in organizing the collection of reports in the Pacific coast region.

TIDE AND CURRENT WORK

In addition to numerous short series of tide observations along the coasts of the United States and possessions in connection with hydrographic surveys, tide observations were continued at primary tide stations of the bureau for the purposes of furnishing general tidal control for hydrographic surveys in the various regions represented and for the determination of tidal datum planes.

Primary tide stations

Portland, Me.
Portsmouth, N. H. (cooperative).
Boston, Mass.
Fort Hamilton, N. Y.
New York, N. Y.
Atlantic City, N. J.
Philadelphia, Pa.
Annapolis, Md. (cooperative).
Baltimore, Md.
Hampton Roads, Va. (cooperative).
Charleston, S. C.
Mayport, Fla. (cooperative).
Daytona Beach, Fla.
Key West, Fla.
Pensacola, Fla.
Galveston, Tex.
San Diego, Calif. (cooperative).
La Jolla, Calif.
Los Angeles, Calif. (cooperative).
San Francisco, Calif.
Astoria, Oreg.
Seattle, Wash.
Valdez, Alaska.
Ketchikan, Alaska.
Seward, Alaska.
Honolulu, Hawaii (cooperative).
Hilo, Hawaii (cooperative).

Within the past few years considerable saving has been made in the appropriation for tides and currents in establishing primary tide stations in cooperation with other organizations having personnel in the immediate localities in which the tide observations are desired. Of the 27 primary tide stations 8 are cooperative, or more than 25 per cent of all. These cooperative tide stations are maintained and operated at practically no additional cost to the Government, and the records are forwarded to this bureau for our permanent files.

Tide observations, secondary stations.—In addition to the primary tide stations, short series of tides are observed by hydrographic parties either with standard or with portable tide gages. Tides were observed at 67 stations, with a total of 17 years and 7.9 months.

Staff observations.—In addition to the primary and secondary stations, tides were observed on plain tide staffs, for hydrographic purposes, and were recorded in books. Tides were observed on plain staff gages at 41 stations, with a total of 4 years and 0.3 months.

Tide observations, outside sources.—Tide records were received from sources outside this bureau from 28 tide stations, totaling 17 years and 9.2 months of records. These records are in addition to the cooperative primary tide stations.

Summary of tide records received

	Stations	Years	Months
Eastern coast	80	18	5.9
Gulf of Mexico coast	10	4	4.3
Pacific coast	29	10	5.8
Alaskan coast	15	3	10.5
Outlying territory	18	54	11.9
Total	152	92	2.4

Current observations.—Short series of currents were observed as listed below:

Summary of current observations

	Stations	Year	Months
Short series	186	1	9.8

In continuing the program of tide and current surveys of important harbors, Chesapeake Bay and tributaries were completed during the fiscal year. Because of the wide extent of the waterways comprising this system two field seasons were necessary, the upper part of the bay being surveyed in the fiscal year 1928 and the lower in 1929. During the past fiscal year 106 current stations and 23 tide stations were observed during this survey. The results have been tabulated and reduced and the manuscript for a publication on tides and currents in Chesapeake Bay and tributaries is nearing completion and will be sent to the printer early in the present fiscal year. In the last month of the fiscal year 1929 a tide and current survey of Long Island Sound and tributaries was begun. This will be completed during the fiscal year 1930.

At Fort Hamilton, N. Y., the tide station which had been in operation for about a year and a half was discontinued on December 31, 1928, the series derived furnishing the observation required.

The tide station at Valdez, Alaska, which was in operation for several years, was discontinued October 4, 1928, the observations obtained being sufficient for the purpose for which this station was established.

A portable automatic tide gage has been loaned to the Florida Railroad & Navigation Corporation for the purpose of securing a series of tidal observations on the west coast of Florida, the records to become the property of the Coast and Geodetic Survey. This gage is operated at no cost to the survey.

Through a cooperative arrangement between this survey and the Chamber of Commerce of Cordova, Alaska, a series of tide observations is being obtained at that place.

At the request of the city of Fort Lauderdale, Fla., a portable automatic tide gage has been established at that place to be operated for a period of about a year.

In order to furnish data in connection with a lawsuit to which the Government is a party, two portable automatic tide gages were maintained during the month of February in the vicinity of Bennings Bridge, D. C., in cooperation with the United States Army Engineers. Members of the division were called upon to testify in court as expert witnesses in connection with this case.

In addition to the tide records, temperature and density observations—frequently requested by operators of cold-storage plants, by fishing concerns, and by investigators of the ravages of pile-boring *ilmnoria*—were made at all primary tide stations at no increase of cost to the Government. Short series of these observations were also made at all current stations occupied in the current survey of Chesapeake Bay and tributaries.

The following cooperation was given the Coast and Geodetic Survey in tidal work during the year:

The primary tide station at Annapolis, Md., which is operated cooperatively by this bureau and the Naval Academy was put into operation on August 7, 1928. Aside from serving as a primary tide station, it is also to be used for the purpose of instructing the midshipmen in tidal work.

The Navy cooperated in the operation of tide stations at the Portsmouth (N. H.) Navy Yard, San Diego, Calif., and at the naval operating base, Hampton Roads, Va.

The chief hydrographer, Canal Zone, furnished tide observations for the full year at two tide stations in the Canal Zone.

The city of Los Angeles and the Territory of Hawaii are cooperating in the maintenance and operation of tide stations at Los Angeles, Hilo, and Honolulu, respectively.

Capt. G. St. Maur Stocker, Swatow, China, is furnishing the records from a series of tide observations being obtained at the entrance to Swatow Harbor.

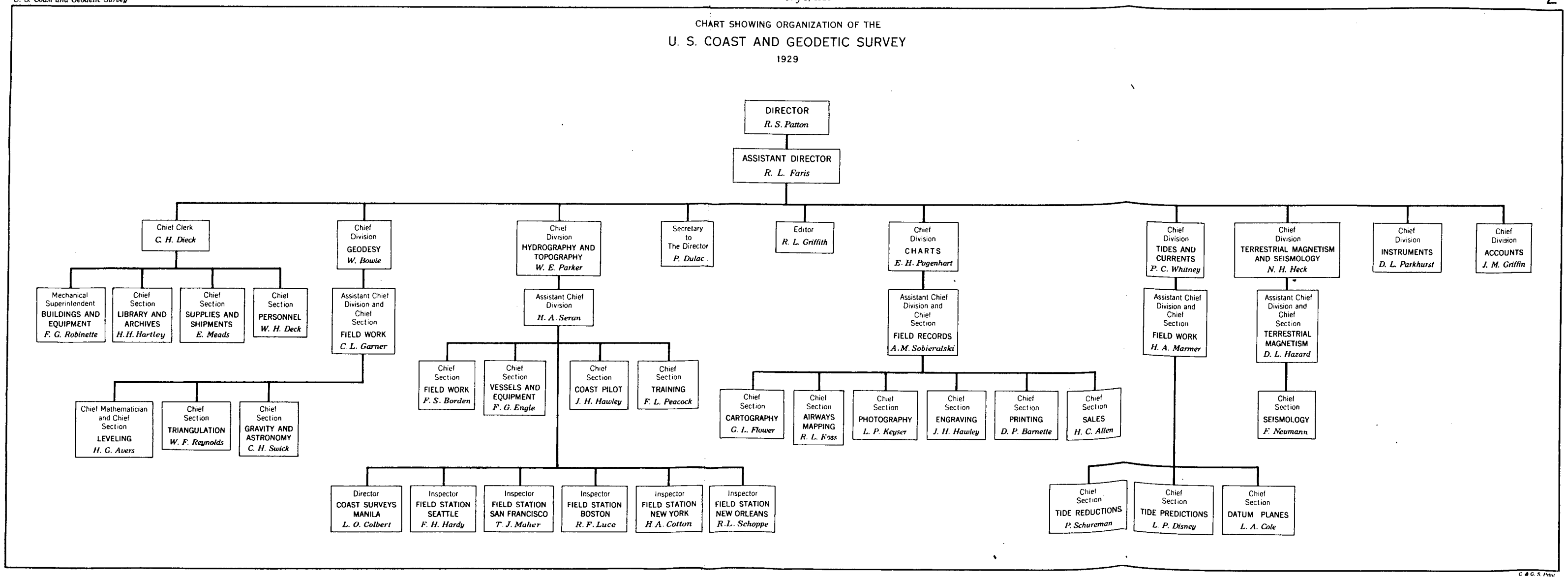
During the fiscal year the following primary tide stations were visited and levels run between tide staffs and bench marks:

Portland, Me.
Portsmouth, N. H.
New York, N. Y.
Baltimore, Md.
Annapolis, Md.
Charleston, S. C.
Mayport, Fla.
Jacksonville, Fla.
Daytona Beach, Fla.
Key West, Fla.
Everglades, Fla.
Astoria, Oreg.
Seattle, Wash.
Ketchikan, Alaska.
Cordova, Alaska.
Valdez, Alaska.
Seward, Alaska.
Honolulu, Hawaii.

CHART SHOWING ORGANIZATION OF THE

U. S. COAST AND GEODETIC SURVEY

1929



Part III.—THE WASHINGTON OFFICE

The organization of the Washington office of the bureau is presented by the organization chart opposite. The accomplishments during the fiscal year by divisions and sections follow.

CHIEF CLERK

The principal duties of this division are the care, custody, and upkeep of the building occupied by the bureau; the supervision of the expenditures for office expenses, including the purchase of supplies for the office and to some extent for the field; the care of most of the original records of the field surveys, as well as the library of printed publications; the general supervision of all matters relating to the personnel work, including reports of leaves of absence; the custody and accounting for the receipts from the sale of charts, publication, etc.; and the direction of the employees engaged in the care, maintenance and protection of the buildings occupied by the bureau in the District of Columbia.

In the library and archieves 109 hydrographic and 87 topographic sheets, each representing new surveys made by the bureau, were received. Other additions were blue prints (mostly showing surveys made by Army Engineers), 616; maps, 3,253; charts, 2,346; field, office, and observatory records, 3,913; photographs and negatives, 171; prints, 400; lantern slides, 156; books, 467.

The total number of permanent and temporary employees in the office and field forces, which includes commissioned officers and all employees appointed through civil-service certification, is: Office force, 221; field force, 199; total, 420. These figures do not include the persons engaged as rodmen, chainmen, heliotropers, and others in the field parties nor any enlisted men on vessels.

The statistics in regard to leave of absence during the calendar year are: Annual leave, 7,459 days; sick leave, 1,829 days; without-pay leave, 285 days; accrued leave, 3,264 days. While the number of employees naturally varied on account of resignations and vacancies, calculated on the number actually in the service on June 30, 1929, as a basis of computation, the average annual leave taken during the year by each employee was approximately 17.37 days and sick leave 4.35 days.

The receipts from the sale of charts and nautical publications prepared by the bureau amounted to $65,545.42. The funds realized from the sale of old property, work done, and miscellaneous sources amounted to $4,707.63.

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY

The work performed by the administrative and other officers of this division stationed at the Washington office is quite diversified. It consists of the preparation of plans and instructions for field surveys, the supervision of field work, and the examination of the records

of field parties. These officers prepare plans and specifications for new vessels and for hydrographic surveying equipment. They also supervise repairs and upkeep of the vessels. Research work is carried on in connection with new surveying methods and appliances. During the past year experiments were made on a new type of echo-sounding apparatus for use in shallow water and a new instrument was devised for getting more accurate measurement of deep water by means of echo sounding. A course of instruction was carried out in the division for the education of field officers in the use of echo-sounding apparatus and sound ranging. All field officers stationed in Washington took this course of instruction.

The preparation of manuscript for coast pilots and inside route pilots was performed by the coast pilot section of the division from information obtained by an officer of the division who made a thorough field inspection of the area covered by the coast pilot. This section compiled during the year a publication containing tables for ascertaining navigable distances between the ports of the United States ports to a number of foreign ports. This publication lists over 400 ports and points on inland waterways and is intended to supplement the series of coast pilots by providing a convenient means for ascertaining navigable distances between the ports of the United States and its offlying territories.

DIVISION OF GEODESY

The following important pieces of work were completed during the year or were in progress at the end of the fiscal year:

Computation and adjustment of the following pieces of triangulation.—

1. Readjustment of the first-order triangulation west of the ninety-eighth meridian. Main scheme and intersection points completed.
2. Southeast Alaska: Main scheme completed and partly prepared for publication.
3. Territory of Hawaii: Adjustment completed and manuscript of publication sent to the printer.
4. Readjustment of the first-order triangulation net east of the ninety-eighth meridian. Preliminary work only.

Computation of leveling.—About 1,800 miles of leveling located in New Mexico, Kentucky, Tennessee, Virginia, West Virginia, and Colorado.

Computation of the following astronomic and gravity work.—

1. Azimuths: 37 stations in the United States, Alaska, and Hawaiian Islands.
2. Longitudes: 19 stations in the United States. Work was also done in preparing for publication the world longitude determinations made by this bureau in 1926.
3. Longitudes: 11 stations in the United States.
4. Laplace azimuths: Computation of true geodetic azimuths at 19 Laplace stations.
5. Isostatic reductions: Computation of the reduction for topography and isostatic compensation at 49 sea stations determined in fall of 1928 by cooperation of the United States Navy, Carnegie Institution of Washington, and Dr. F. A. Vening Meinesz. Also same computations for 3 stations in Hawaiian Islands.
6. Gravity computations: Computation of 3 stations in Hawaiian Islands and of various standardizations and experimental work at Washington, D. C.

Investigations were carried on during the year in the following subjects: Interior of the earth, lunar theory, variation of latitude, California earthquakes, and tidal friction.

The following publications were issued by the division during the fiscal year:

Special Publication 140, Manual of First-Order Leveling.
Special Publication 145, Manual of Second and Third Order Triangulation and Traverse.
Special Publication 151, Comparison of Old and New Triangulation in California.
Special Publication 153, Conformal Projection of the Sphere Within a Square.
Special Publication 156, Triangulation in the Hawaiian Islands (in press).
Special Publication 77, Precise Leveling in Texas (revised edition).
Serial 257, Geodetic Surveys—Methods, Instruments, and Purposes (revised edition).

DIVISION OF CHARTS

The printing and distribution of charts increased by more than 7,000 copies during the year. This is approximately the normal annual increase that has been continuing for the past 15 years. The sale of tide tables and current tables is the largest we have ever had. These are substantial evidences of growth. There are many indications that during the coming year this volume will be exceeded.

There is a persistent demand from various sources for charts of localities not previously published. Charts of several rivers and comparatively shoal areas heretofore considered unimportant for navigation but now coming into importance on account of the phenomenal increase in the number of motor boats are on our program. The addition of a new chart to the number on issue requires not only the work of compilation and preparation of plates but also continuous correction, year after year, work which is already taxing the capacity of the division. This demand for charts of new areas must be met to the best of our ability and between 1925 and 1929, 31 new charts have been added to the list on issue.

Photographic copies of original survey sheets are quite extensively used in the study of important engineering projects as base maps for local improvements and assessments and as evidence in litigation involving valuable property rights. These records are highly valuable, judging by the number of complimentary letters received.

The progress in airway mapping has fallen behind the increasing demand for airway charts. The production of strip maps is being curtailed to permit undertaking general flying maps which will eliminate considerable duplication caused by overlapping strips.

Accomplishments for the year.—There were 13 new nautical charts produced and 10 new editions of existing charts; 3 airway strip maps published, 5 reprinted, and 5 nearing completion. All existing charts were kept up to date and weekly Notices to Mariners prepared for publication.

Below is given a 5-year comparative statement showing the total number of nautical charts on issue, the new charts constructed, and new editions issued during the year; also the cancellations of obsolete charts. On account of very extensive corrections several of the 84 new editions listed for 1929 required practically as much work as a new chart.

	1925	1926	1927	1928	1929
Current charts on issue	679	687	691	702	710
New charts	13	10	16	18	13
New editions	114	97	94	74	84
Charts canceled	8	2	12	7	5

The charting program for 1930 includes 13 new nautical charts, 5 charts to be reconstructed, 9 new airway strip maps, 2 sectional charts of a series that will eventually cover the entire country. The work of first importance will be keeping existing charts up to date.

DIVISION OF TERRESTRIAL MAGNETISM AND SEISMOLOGY

The principal accomplishments have been:

1. The resumption of preparation of magnetic observatory results for publication. Progress has been made though the amount is unsatisfactory. Further improvements in methods have been made.
2. Preparation of the field results for publication. This has been kept practically up to date.
3. Preparation of the magnetic tables and charts for 1925 was completed. This publication should meet the need for which it is prepared for many years.
4. Progress has been made in the preparation of magnetic information by groups of States. A volume covering the area from Delaware to Tennessee was practically completed and the necessary maps compiled.
5. A program of development of instruments and methods with study of the underlying theory has been an important activity. There have been improvements in the standard methods and new materials and apparatus have been adopted for solving the problems as they have become available.
6. Attention has been given to some of the major problems relating to the earth's magnetism, and a special effort has been made to keep in touch with all the various organizations throughout the earth which are now very actively attacking this problem. Special mention should be made of cooperation with the Navy Department and the Carnegie Institution of Washington.

SEISMOLOGY

Only a partially successful effort has been made to put the available information into finished form. The delay in the issue of our quarterly seismological report has become quite serious but in so far as other observatories are concerned their needs have been met by advance information from our observatories. Immediate determination of position of earthquakes through reports from cooperative organizations and observatories has proved so valuable that upon request from Great Britain the service has included transmission of earthquake information to Europe as part of the meteorological messages of the Weather Bureau. Advice and information has been furnished to those contemplating the installation of instruments and other various activities related to the earthquake problem.

DIVISION OF TIDES AND CURRENTS

Owing to the increased calls for tide and current data and because of the additional data obtained from the current and tide surveys the work in the office of the division of tides and currents has increased considerably in the past few years, without a commensurate increase in the personnel.

Upon the completion of a tide and current survey, one of which is made in a different harbor each summer, the observations are reduced and the manuscripts for special publications on the tides and currents in these harbors are prepared for printing in the next fiscal year. The survey of Chesapeake Bay and tributaries was completed early in the past year and manuscript is now being prepared for publication.

These comprehensive tide and current surveys were begun in 1922, and to the present time the following special publications, dealing with tides and currents in the respective harbors, have been issued:

Currents and tides in harbors

No. 111. New York Harbor, 1925.	No. 127. Southeast Alaska, 1927.
No. 115. San Francisco Harbor, 1925.	No. 142. Boston Harbor, 1928.
No. 123. Delaware Bay, 1926.	No. 150. Portsmouth Harbor, 1929.

Special Publication 148, Tidal Bench Marks, State of New Jersey, received from the printer during the fiscal year, is part of a series containing descriptions and elevations of tidal bench marks along the coasts of the United States. The following are publications of this series issued to the present time:

Tidal bench mark publication

No. 83. New York, 1922.	No. 141. California, 1928.
No. 119. District of Columbia, 1925.	No. 148. New Jersey, 1929.
No. 128. Rhode Island, 1926.	No. 155. Massachusetts (in press).
No. 136. Connecticut, 1927.	

Special Publication 154, Instructions, Primary Tide Stations, which was prepared as a supplement to Special Publication 139, was sent to the printer in January, 1929. This publication contains instructions pertaining to the operation of a primary tide station and the prelminary reduction of the records.

Two new publications that were issued during the fiscal year, Tide Table, Boston Harbor and Vicinity, and Tidal Current Charts, New York Harbor, have been well received by the public, the unexpected demand for the current charts necessitating a reprint within a few months of the original issue. This publication gives by means of a set of 12 charts the direction and velocity of the current at various localities throughout New York Harbor. In addition to this information, the complete set of charts presents a comprehensive view of the tidal-current movement for the harbor as a whole. At the present time we have insistent demands for similar publications for San Francisco Bay, Boston Harbor, and Chesapeake Bay, where current surveys have already been made and observational data are available.

The predictions of tides and currents are made and the manuscript submitted to the printer each year in time to have all the tables for any calendar year ready for issue by July 1 of the preceding calendar year. Predictions of currents for the current tables for the calendar year 1931 were begun October 30, 1928, and completed November 30, 1928. Tide predictions for the tide tables for the calendar year 1931 were begun November 30, 1928, and completed January 22, 1929.

The following table, showing the issue of the tide tables for each fiscal year for the 10-year period 1920–1929, is indicative of the demand for the tables:

Fiscal year	United States and Foreign Ports Tide Tables	Atlantic Coast Tide Tables	Pacific Coast Tide Tables	New York Harbor Tide Table	Boston Harbor Tide Tables	Total
1920	3,469	5,357	16,061			24,887
1921	3,577	5,678	14,957			24,212
1922	3,067	5,704	14,902			23,673
1923	2,479	5,440	15,054			22,973
1924	2,509	7,097	15,234			24,840
1925	2,218	6,727	15,849			24,794
1926	2,730	6,707	15,347			24,784
1927	2,692	6,934	15,911			25,537
1928	2,377	7,281	17,009	1,992		28,619
1929	3,257	7,276	16,896	952	1,461	29,486

The following table shows the number of copies of the current tables issued for the fiscal years 1923 to 1929, separate current tables having been issued in 1923 for the first time:

Fiscal year	Atlantic Coast Current Tables	Pacific Coast Current Tables	Total	Fiscal year	Atlantic Coast Current Tables	Pacific Coast Current Tables	Total
1923	2,029	1,786	3,815	1927	3,722	2,311	6,033
1924	3,124	2,002	5,126	1928	3,614	2,501	6,115
1925	2,452	2,474	4,926	1929	3,492	4,040	7,532
1926	3,014	1,763	4,777				

The United States and Foreign Ports Tide Tables for 1929 contain daily predictions for 88 reference stations and tidal differences and constants for 3,775 subordinate stations. One additional reference station, Aberdeen, Grays Harbor, Wash., was included in the 1930 edition.

In accordance with a cooperative arrangement for the exchange of tidal predictions, daily predictions for the annual tide tables are now exchanged between the Coast and Geodetic Survey and the following organizations: British Admiralty, 19 stations; Canadian Hydrographic Office, 4 stations; Deutsche Seewarte, Germany, 6 stations; and Service Hydrographique, France, 4 stations.

The production of tide and current tables has been systematized and a high degree of efficiency attained. Only nominal improvements can now be hoped for along these lines, as the present conditions are such that any further speeding up must result in loss of accuracy.

DIVISION OF ACCOUNTS

For the fiscal year 1929 the regular appropriations for the Coast and Geodetic Survey amounted to $2,445,127. This amount was further increased to $2,527,627 by deficiency acts, transfers from other departments, etc. The actual disbursements during the fiscal year amounted to $2,587,862.02. This amount does not represent the actual expenses of the bureau for the fiscal year 1929, as included therein are disbursement on account of previous fiscal years.

During the year from 30 to 50 chiefs of party have disbursed funds in the field, operating throughout the entire United States and its possessions. These chiefs of party are financed by advances made to them through this division, and their accounts are in turn rendered to this division for credit to their account of advances. They are then included in the accounts of the disbursing agent, and are transmitted to the General Accounting Office for final settlement.

The primary object for these chiefs of party being in the field is the accomplishment of surveying work, and it is, and has been, the continued endeavor of this division to simplify the accounting work in every possible manner in order that a maximum of effort may be devoted by these chiefs of party to their surveying work. The majority of these officers have no permanent station, their work being migratory. The accounting work is necessarily accomplished at night after completing the day's work in the field, and under the most difficult conditions, as, for instance, by lamplight in a small tent with only the crudest facilities.

INSTRUMENT DIVISION

The development, procurement, modification, and servicing of the surveying instruments used by the field parties and observatories of this bureau in its work of geodetic, hydrographic, magnetic, tidal surveys, and other activities is the function of the bureau's instrument division. This division also records all material transfers to, from, and between field parties and the Washington office, and accounts for material at the bureau's headquarters. It is also the function of this division to design such special instruments and equipment as may be needed, to prepare drawings and specifications, and to construct sample instruments. It is also frequently necessary for this organization to design and build special machines to perform some of the highly accurate and special work which is occasioned by the construction of the various precision instruments which the bureau uses.

These various functions were carried on during the past year, and a number of new instruments and improvements were made, the more important being:

Precise level rod.—We have steadily improved the level rod both in its construction and in the method of dividing it. We have been able to develop a rod which will be of longer life, and so stable that there will not be appreciable changes in length due to usage. By the designing and constructing in our own shop of a special dividing machine we have been able to graduate these rods with a much higher degree of accuracy, and calibration is now carried one decimal place farther than was formerly possible. By means of this machine all rods are practically alike and we are experimenting, with, I understand, very favorable results, with a change in the method of conducting the leveling work whereby it is not necessary to reverse the positions of the forward and rear rods with each set-up, and the preliminary tests show a speeding up of from 10 to 15 per cent.

Second-order theodolite.—This instrument, whose design was referred to in last year's report, has been under construction during

the year and is virtually completed. A notable improvement in its design has been made in the introduction of ball bearings into the micrometer microscopes, which renders them extremely sensitive and makes them adjustable and practically free from the effects of wear. An important element of such microscopes is the reversibility of the micrometer screw. The introduction of ball bearings renders the operating parts so lacking in friction that movement is virtually instantaneous in either direction on rotation of the screw. This will result in speedier and more accurate observation.

Engine-driven sounding machine.—A new portable, air-cooled, gasoline engine-driven sounding machine has been developed for launch work and is now under field test. This machine is quite light, very powerful, and its entire control is in one hand of the operator. This machine will enable shallow soundings to be conducted with much greater ease and rapidity than where the hand sounding machine is used.

Registering sheave.—The registering sheave used by this bureau in deep-sea sounding was redesigned to incorporate a more rugged and more easily read and operated registering device, and a number of these instruments were placed in the field for testing purposes.

A new type of automatic time switch for the control of signal lamps, to eliminate the constant need of an attendant, was designed and built during the year. This switch makes use of a drop of mercury sealed into a glass tube properly mounted on suitable metal parts, connected with a clock. This type of switch will not be affected by moisture, temperature, or dirt, nor is there any tendency for the tarnishing of contacts, as in the case of some of the switches previously used. A quantity of these switches is being used during the present season.

Efforts are continually being made to improve the quality and accuracy of the instruments, and to reduce their cost by the use of improved materials and methods of construction. Every effort is made to reduce the operating expense of the shops by the introduction of labor-saving machinery, and by adding suitable apparatus for testing incoming instruments and materials.

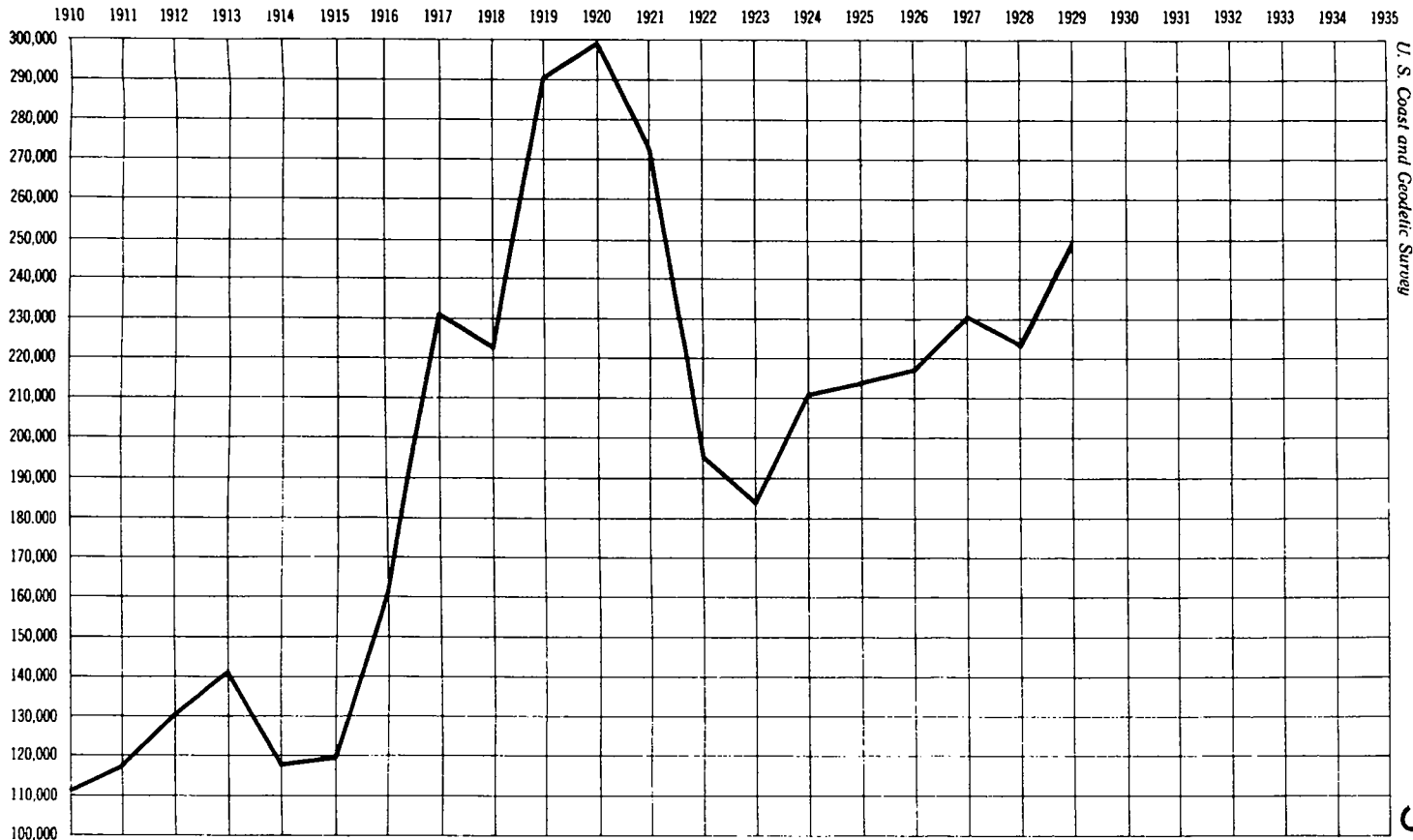
NEW CHARTS

925. Port Arroyo, south coast of Porto Rico. April, 1929. Scale, 1:20,000; 20 by 26 inches. Price, 25 cents. Soundings are in feet and give the depths at mean low water. Surveyed by the Coast and Geodetic Survey in 1927 supplemented by older surveys.

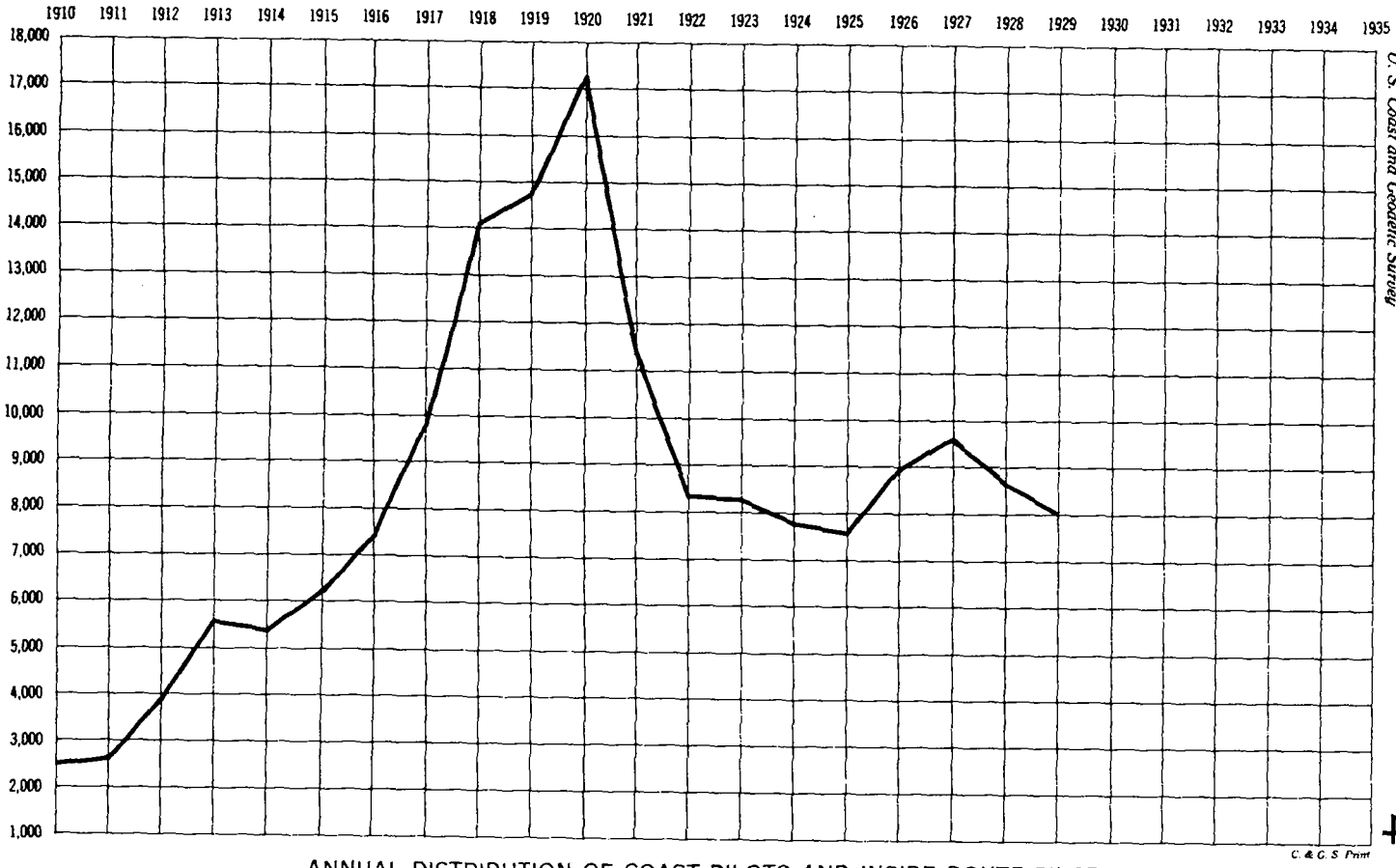
1237. Little River Inlet to Winyah Bay Entrance, S. C. January, 1929. Scale, 1:80,000; 32 by 42 inches. Price, 75 cents. This is one of the new series of coast charts constructed on the Mercator projection and oriented with the Meridian. Soundings are in feet and give the depths at mean low water. This chart supersedes charts 151 and 152 of the old series.

1238. Winyah Bay Entrance to Charleston Lightship, S. C. December, 1928. Scale, 1:80,000; 32 by 42 inches. Price, 75 cents. This is one of the new series of coast charts constructed on the Mercator projection and oriented with the meridian. The soundings are in feet and give depths below the plane of mean low water. It replaces chart 153 of the old series.

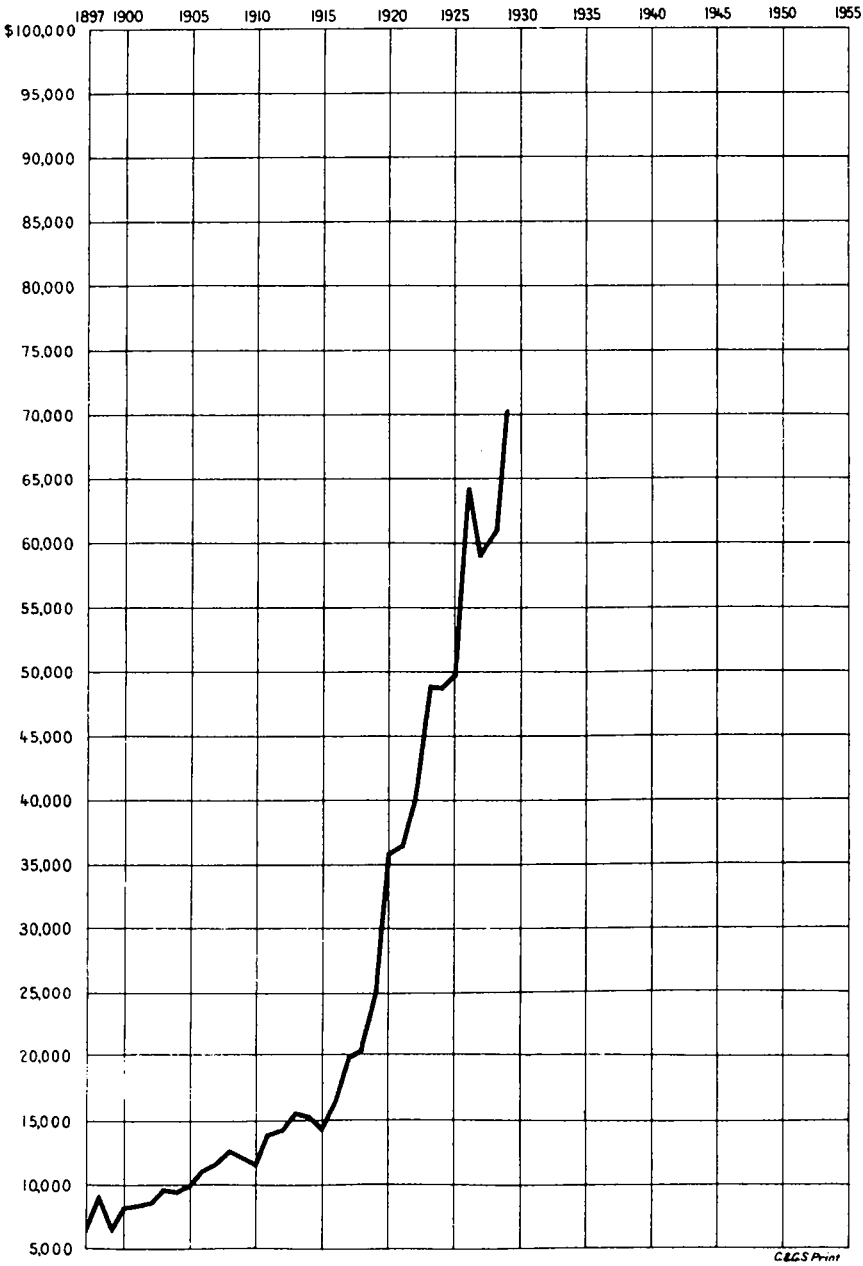
4123. Kealakekua Bay to Honaumau Bay, Hawaii. July, 1928. Scale, 1:10,000; 25 by 34 inches. Price, 50 cents. Chart shows the results of surveys made in 1927–28. Soundings are in fathoms at mean lower low water.



ISSUE OF CHARTS FROM 1910 TO 1929



ANNUAL DISTRIBUTION OF COAST PILOTS AND INSIDE ROUTE PILOTS



RECEIPTS FROM SALE OF CHARTS AND NAUTICAL BOOKS
1897 TO 1929

4190. United States Possessions in the Samoan Islands, South Pacific Ocean. February, 1929; 32 by 39 inches. Price 75 cents. The chart shows a small scale plan of the Samoan Islands, plans of Rose Island and Swains Island, a plan of the Manua Islands on a scale of 1/80,000, a plan of Tutuila Island on a scale of 1/60,000, and a plan of Page Pago Harbor on a scale of 1/150,000. Soundings are given in fathoms and the heights in feet.

4205. Batan Islands, P. I. March, 1929. Scale, 1:100,000; 29 by 41 inches. Price, 75 cents. Chart shows complete information for coastwise navigation from surveys to 1928. Soundings in fathoms at mean lower low water.

6406. Port Ludlow, Wash. September, 1928. Scale, 1:10,000; 23 by 36 inches. Price, 25 cents. Chart shows the result of a survey made in 1927. Soundings and heights in feet.

6407. Tacoma Harbor, Wash. March, 1929. Scale, 1:15,000; 26 by 36 inches. Price, 50 cents. Chart replaces 6451. It is on a larger scale and extends farther to the north and west and shows the results of surveys made by the Coast and Geodetic Survey and the United States Engineers up to March, 1928, with additions to topography from other sources. Soundings in feet at mean lower low water.

8173. Southern Entrance to Sumner Strait, southeast Alaska. March, 1929. Scale, 1:40,000; 31 by 43 inches. Price, 75 cents. This is one of the series of charts on a scale of 1:40,000 covering the west coast of southeast Alaska. Soundings in fathoms at mean lower low water.

8248. Salisbury Sound and Peril Strait to Emmons Island, southeast Alaska. August, 1928. Scale, 1:40,000; 32 by 34 inches. Price, 75 cents. This is on the Mercator projection and supersedes chart 8282, which was on the Polyconic projection. It extends farther to the westward than 8282, giving more sea room off the entrance to Salisbury Sound.

8258. Cape Edward to Lisianski Strait, west coast of Chichagof Island, southeast Alaska. December, 1928. Scale, 1:40,000; 23 by 30 inches. Price, 25 cents. This is one of the series of charts on a scale of 1:40,000 covering the west coast of southeast Alaska and shows the results of surveys made in 1926. Soundings are in fathoms at mean lower low water.

8271. Tebenkof Bay, Chatham Strait, southeast Alaska. January, 1929. Scale, 1:40,000; 25 by 27 inches. Price, 25 cents. This chart shows the results of surveys made in 1926. The soundings are in fathoms at mean lower low water.

8505. Lituya Bay, south coast of Alaska. February, 1929. Scale, 1:20,000; 24 by 34 inches. Price, 50 cents. Soundings are in fathoms and give the depths at mean lower low water as determined by a survey made in 1926.

Part IV.—DISTRIBUTION OF PARTIES DURING THE FISCAL YEAR ENDED JUNE 30, 1929

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY

Abbreviations used: L=length in statute miles; A=area, square statute miles; P=number of geographical positions; M=miles of sounding lines; S=number of soundings; W. D.=wire drag; sta.=stations; mag.=magnetic]

Locality and operations	Persons conducting operations
Maine, Isles of Shoals-Portland: Triangulation; L32, A317, P10; hydrography, M2,616, A461, S33,344; Mag. sta. 4.	Ship Lydonia, July 1-Oct. 22, Lt. G. C. Mattison. comdg.; Lt. E. W. Eickelberg, exec.; Lt. (J. G.) E. B. Roberts; Lt. (J. G.) J. H. Service; Lt. (J. G.) H. A. Paton; Lt. (J. G.) E. R. McCarthy; R. A. Philleo, D. O., to Sept. 22; M. G. Ricketts, D. O.; C. N Conover, ch. engr.; H. G. Dorsey, sr. elec. engr., to July 14.
Maine and New Hampshire, off Isles of Shoals: Hydrography, wire drag, M45, A26.	Wire-drag party, July 1-Aug. 8, Lt. C. K. Green, in charge; Lt. (J. G.) H. E. Finnegan; Lt. (J. G.) C. F. Ehlers; R. C. Bolstad, D. O., F. E. Okeson, mate.
Massachusetts, Gloucester Harbor: Triangulation, L7, A12, P31; topography, L6, A24; hydrography, M190, A3, S12,092; tide sta., 4; mag. sta., 3.	Shore party, July 1-Oct. 31, Lt. R. P. Eyman, in charge; Lt. (J. G.) L. C. Johnson.
Massachusetts and New York, Newburyport, Marthas Vineyard, and Gardiners Bay: Triangulation, L65, A168, P31; topography, L38, A6; hydrography, M492, A31, S23,874; tide sta., 5; mag. sta., 1.	Launch Ogden, Aug. 9-Dec. 23, Lt. C. K. Green, in charge; Lt. (J. G.) H. E. Finnegan, to Dec. 10, (acting chief of party Aug. 9-28); Lt. (J. G.) C. F. Ehlers, to Dec. 7; F. E. Okeson, mate, to Nov. 7.
New York, Jamaica Bay: Topography, L74, A15; hydrography, M229, A13, S6,663; tide sta., 5; current sta., 3.	Shore party, Aug. 21-Dec. 22, Lt. C. D. Meaney, in charge; R. C. Bolstead, D. O., to Dec. 8.
New Jersey, Cape May: Triangulation, L19, A20, P3; topography, L10, A30; hydrography, M1,934, A126,S40,701; tide sta., 1.	Ship Ranger, July 1-Oct. 31, Lt. R. L. Schoppe, comdg.; Lt. (J. G.) B. H. Rigg, exec.; Lt. (J. G.) W. M. Gibson; Ensign G. E. Morris, jr.; C. A. George, D. O., to Aug. 15; H. F. Garber, D. O., from Aug. 24; F. L. Chamberlin, ch. engr.; R. C. Overton, mate.
New Jersey, entrance Delaware Bay: Hydrography, M1,225, A69, S25,511; tide sta., 1.	Ship Natoma, Aug. 1-Oct. 25, Lt. J. Senior, comdg.; Lt. (J. G.) J. C. Bose, exec., from Aug. 16; Ensign W. J. Chovan; Ensign W. R. Porter, from Aug. 7; Ensign J. M. Baker, to Aug. 16; J. N. Jones, D. O., from Aug. 14; A. Silva, ch. engr.
Maryland and Virginia, Potomac River, Cockpit Pt.-Alexandria: Triangulation, L19, A70, P19; azimuth sta., 2; base measure, L 0.84.	Launch Mikawe, Apr. 2-June 8, Lt. F. L. Peacock, in charge; Lt. (J. G.) E. B. Latham; Ensign C. A. Schanck, to May 3.
Maryland and Virginia, Potomac River, Lower Cedar Point-Alexandria: Triangulation, L27, A38, P81.	Shore party, July 1-Oct. 18, Lt. (J. G.) Charles Pierce.
Virginia, Chesapeake Bay: Coast Pilot revision.	Lt. G. D. Cowie, in charge.
North Carolina, Cape Lookout Shoals: Topography, L7; hydrography, M188, A11, S1,618, tide sta., 1.	Ship Natoma, July 1-20, Lt. J. Senior, comdg; Lt. (J. G.) J. C. Bose, exec.; Lt. (J. G.) C. R. Bush; Ensign W. J. Chovan; Ensign J. M. Baker; A. Silva, ch. engr.
South Carolina, Cooper River and vicinity Charleston: Triangulation, L26, A21, P59; topography, L90, A12; hydrography, M390, A7, S16,178; tide sta., 5.	Launch Elsie III, July 1-Jan. 29, Lt. (J. G.) R. F. A. Studds, in charge; Ensign W. R. Porter, to Aug. 6; Ensign L. W. Swanson; R. A. Earle, D. O., Aug. 18-Jan. 18.
Florida, vicinity Cape Canaveral: Triangulation, L27, A151, P32; topography, L65; hydrography, M3,989, A2,624, S52,036, tide sta., 1; mag. sta., 1.	Ship Lydonia, Jan. 9-June 25, G. C. Mattison, comdg.; Lt. E. W. Eickelberg, exec., to June 6; Lt. Charles Shaw, exec., from June 15; Lt. (J. G.) E. B. Roberts; Lt. (J. G.) E. A. Deily; Lt. (J. G.) H. A. Paton; Lt. (J. G.) E. R. McCarthy; M. G. Ricketts, D. O.; J. H. Fay, D. O., to Jan. 23; M. H. Reese, D. O., from Jan. 24; C. N. Conover, ch. engr.; H. G. Dorsey, sr. elec. engr., May 19-June 2; F. E. Okeson, mate.
Florida, West Palm Beach and Cape Canaveral: Triangulation and traverse, L39, A6, P25; hydrography, M1,262, A144, S18,197; tide sta., 1; mag. sta., 1.	Ship Natoma, Jan. 27-June 26, Lt. J. Senior, comdg.; Lt. (J. G.) J. C. Bose, exec., from Feb. 23; Lt. (J. G.) W. J. Chovan; Lt. (J. G.) W. R. Porter; F. A. Riddell, D. O.; I. R. Rubottom, D. O.; A. Silva, ch. engr.

Between 1 Jan – 30 Jan

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY—Continued

Locality and operations	Persons conducting operations
Florida, Lake Worth-Hillsboro: Triangulation, L45, A60, P28; topography, L38, A10; hydrography, M1,298, A216, S29,463.	Ship Ranger, Jan. 17-June 30, Lt. R. L. Schoppe, comdg.; Lt. (J. G.) B. H. Rigg, exec.; Lt. (J. G.) W. M. Gibson; Ensign G. E. Morris, jr., to Feb. 3; H. F. Garber, D. O., to Feb. 3; M. E. Wennermark, D. O.; J. S. Massey, D. O.; F. L. Chamberlin, ch. engr.; R. C. Overton, mate.
Florida, west coast, San Carlos Bay and Caloosahatchee River to Cape Sable; Triangulation and traverse, L40, A150, P74; topography, L11, A3; hydrography, M1,156, A41, S38,987; tide sta., 4.	Ship Hydrographer, July 1-Dec. 28, Lt. Charles Shaw, comdg.; Lt. O. S. Reading, to Aug. 25; Lt. (J. G.) J. C. Sammons; Lt. (J. G.) E. A. Deily, to Dec. 7; J. N. Hasenfuss, D. O.; K. B. Jeffers, D. O.
Florida, west coast: Air photoreduction, L150, A773.	Office work, Aug. 30-June 30, Lt. O. S. Reading, in charge; Lt. (J. G.) R. J. Sipe, from Apr. 1; Ensign H. J. Oliver, Oct. 24-Mar. 30; Ensign R. C. Bolstad, from Apr. 9; R. A. Marshall, D. O., Oct. 15-Oct. 22; Fred Natella, D. O., Oct. 16-Nov. 12; J. S. Morton, D. O., Oct. 22-Apr. 1; H. C. Walker, D. O., Oct. 30-Apr. 1.
California, La Jolla: Topography, L9, A5; hydrography, M114, A7, S2,261.	Shore party, Aug. 20-Sept. 21, Lt. C. M. Durgin, in charge.
California, San Francisco Bay: Triangulation, L20, A20, P9; topography, L44, A21; hydrography, M15, A1, S1,506; tide sta., 1.	San Francisco field station, Lt. Com. T. J. Maher, inspector.
California, Point Reyes: Triangulation, L34, A109, P37; topography, L24, A61; hydrography, M202, A26, S3,226; tide sta., 1.	Ship Pioneer, May 6-June 30, Lt. O. W. Swainson, comdg.; Lt. R. D. Horne, exec., to June 6; Lt. R. P. Eyman, exec. from June 6; Lt. J. A. Bond; Lt. (J. G.) E. O. Heaton, from May 11; Lt. (J. G.) K. G. Crosby; Lt. (J. G.) R. C. Rowse; Lt. (J. G.) H. J. Healy; Ensign Curtis Le Fever to June 3; J. F. Fay, D. O.; G. C. Mast, D. O.; R. A. Gilmore, D. O.; C. R. Jones, ch. engr.
California, Shelter Cove-Pt. Arena: Triangulation, L14, A18, P18; topography, L74, A21; hydrography, M2,807, A4,133, S16,684; tide sta., 2; base line, 2d order, L1½.	Ship Discoverer, Apr. 29-June 30, Lt. Com. F. G. Engle, comdg.; Lt. L. D. Graham, exec.; Lt. C. M. Durgin; Lt. H. P. Odessey; Lt. (J. G.) R. W. Knox; Lt. (J. G.) G. L. Anderson, from May 9; Lt. (J. G.) A. C. Thorson; Ensign C. Le Fever, from June 5; Ensign G. R. Fish; Ensign C. J. Wagner; J. L. Laskowski, D. O.; J. L. McIver, ch. engr.
California, vicinity of Crescent City: Topography, L52, A72; hydrography, M307, A42, S6,200; tide sta., 2.	Shore party, Apr. 27-June 30, Lt. A. P. Ratti, in charge; Lt. (J. G.) G. R. Shelton; Ensign G. M. Marchand.
California and Oregon, Cape Sebastian-Trinidad Head: Topography, L114, A83; hydrography, M6,837, A5,600, S54,074; tide sta., 2; mag. sta., 3.	Ship Discoverer, July 1-Nov. 30, Lt. Com. F. G. Engle, comdg.; Lt. L. D. Graham, exec.; Lt. C. M. Durgin, Lt. H. P. Odessey; Lt. (J. G.) R. W. Knox, from Aug. 13; Lt. (J. G.) A. C. Thorson; Lt. (J. G.) G. R. Shelton; Ensign G. R. Fish; G. M. Marchand, D. O., from Sept. 1; C. J. Wagner, D. O.; J. L. McIver, ch. engr.
Oregon, Coquille River-Cape Sebastian: Topography, L58, A65; hydrography, M598, A94, S9,738; tide sta., 2; current sta., 1.	Shore party, July 1-Oct. 31, Lt. A. P. Ratti, in charge; Lt. (J. G.) Thos. B. Reed; Ensign Geo. A. Nelson.
Oregon, Cape Foulweather-Cape Arago: Topography, L74, A31; hydrography, M6,978, A4,665, S42,747; tide sta., 3; mag. sta., 8.	Ship Pioneer, July 1-Dec. 1, Lt. O. W. Swainson, comdg.; Lt. R. D. Horne, exec.; Lt. E. H. Bernstein; Lt. J. A. Bond; Lt. (J. G.) H. A. Karo; Lt. (J. G.) K. G. Crosby; Lt. (J. G.) R. C. Rowse; Ensign Curtis Le Fever; C. R. Jones, ch. engr.
Alaska, southeast, Behm Canal: Triangulation, L78, A136, P68.	Shore party, Apr. 17-June 30, Lt. (J. G.) J. M. Smook, in charge; Lt. (J. G.) B. G. Jones.
Alaska, Keku Straits, Wrangell Narrows and Duncan Canal: Triangulation, L30, A28, P87; topography, L48, A17; hydrography, M738, A17, S51,691; tide sta., 1.	Ship Explorer, Mar. 29-June 30, Lt. H. A. Cotton, comdg.; Lt. T. B. Reed, exec.; Lt. (J. G.) P. C. Doran; Lt. (J. G.) J. C. Partington; Lt. (J. G.) L. C. Johnson; Ensign J. N. Jones; W. Weidlich, mate; A. N. Loken, ch. engr.
Southeast Alaska, Taku Inlet: Triangulation, L26, A75, P17.	Shore party, April 27-June 30, Lt. W. M. Scaife, in charge.
Alaska, Kruzof Island and Peril Strait: Triangulation, L68, A615, P21; topography, L110, A130; hydrography, M860, A124, S9,986; wire drag, M32, A18; mag. sta., 5; tide sta., 1.	Ship Explorer, June 1-Oct. 25, Lt. H. A. Cotton, comdg.; Lt. W. D. Patterson, exec.; Lt. (J. G.) W. M. Scaife; Lt. (J. G.) I. T. Sanders; Lt. (J. G.) B. G. Jones; A. N. Stewart, D. O.; D. M. Watt, D. O.; W. Weidlich, mate; K. R. Gile, ch. engr.
Alaska, Montague Island-Nuka Bay and Sitkalidak Straits: Triangulation, L68, A388, P90; topography, L169, A158; hydrography, M4,788, A2,926, S31,466; tide sta., 1; mag. sta., 6.	Ship Surveyor, July 1-Oct. 8, Lt. R. R. Lukens, comdg.; Lt. C. A. Egner, exec.; Lt. (J. G.) L. S. Hubbard; Lt. (J. G.) P. A. Smith; Lt. (J. G.) S. B. Grennell; Lt. (J. G.) F. G. Johnson; Lt. (J. G.) J. C. Partington; Ensign P. L. Bernstein; Ensign F. R. Gosset; Ensign J. C. Mathisson; R. W. Healy, mate; G. Johanson, ch. engr.; W. J. Leary, surgeon.
Alaska, Shelikof Strait: Triangulation, L20, A46, P67; topography, L70, A54; hydrography, M1,069, A626, S10,730; tide sta., 5; mag. sta., 4.	Ship Surveyor, Apr. 30-June 30, Lt. R. R. Lukens, comdg.; Lt. C. A. Egner, exec.; Lt. C. D. Meaney; Lt. (J. G.) L. S. Hubbard; Lt. (J. G.) F. G. Johnson; Lt. (J. G.) P. L. Bernstein; Lt. (J. G.) J. C. Mathisson; Ensign H. F. Garber; Ensign H. J. Oliver; Ensign C. A. George; R. W. Healy, mate; G. Johanson, ch. engr.; W. J. Leary, surgeon.

DIVISION OF HYDROGRAPHY AND TOPOGRAPHY—Continued

Locality and operations	Persons conducting operations
Hawaiian Islands, Hawaii Island-French Frigate Shoals: Triangulation, A260, P44; topography, L36, A4; hydrography, M15,755, A33,795, S85,340.	Ship Guide, June 1-July 30, Lt. K. T. Adams, comdg.; Lt. F. L. Gallen, exec.; Lt. (J. G.) H. C. Warwick; Lt. (J. G.) G. E. Boothe; Lt. (J. G.) L. O. Simmons, to Sept. 24, Lt. (J. G.) W. H. Bainbridge; Lt. (J. G.) F. B. Quinn; Ensign V. M. Gibbens, Ensign G. W. Lovesee; Ensign E. B. Lewey; F. Seymour, ch. engr.; W. R. Scroggs, surgeon.
Philippine Islands, Luzon Strait: Topography, L2; hydrography, M3,188, A2,763, S9,948; tide sta., 4; current sta., 57.	Ship Pathfinder, July 9-July 29, and Apr. 24-June 30, Lt. H. B. Campbell, comdg.; Lt. (J. G.) R. W. Woodworth, exec.; Lt. (J. G.) I. Rittenburg; Ensign E. H. Kirsch; Ensign J. D. Thurmond, to Mar. 30; A. N. Loken, ch. engr., to Mar. 30; K. R. Gile, ch. engr., from Apr. 3; J. V. Tormey, surgeon.
Philippine Islands, Davao Gulf: Triangulation, A1,405, P15; topography, L106, A135; hydrography, M2,838, A4,892, S24,151; tide sta., 2; current sta., 26; mag. sta., 7.	Ship Pathfinder, Sept. 21-Mar. 1, Lt. H. B. Campbell, comdg.; Lt. (J. G.) R. W. Woodworth, exec.; Lt. (J. G.) I. Rittenburg; Ensign E. H. Kirsch; Ensign J. D. Thurmond; A. N. Loken, ch. engr.; J. V. Tormey, surgeon.
Philippine Islands, East Coast of Luzon: Triangulation, L60, A860, P42; topography; L91, A89; hydrography, M3,129, A2,632, S25,565; tide sta., 1; mag. sta., 3.	Ship Fathomer, July 1-Dec. 31, and May 16-June 30, Lt. G. C. Jones, comdg.; Lt. (J. G.) A. J. Hoskinson, exec.; Lt. (J. G.) I. Rittenburg, to July 7; Lt. (J. G.) W. F. Malnate, to Mar. 30; Ensign C. A. Burmister, from July 6; Ensign E. C. Baum; Ensign G. E. Morris, jr., from Apr. 23; G. W. Hutchison, ch. engr.; D. R. Kruger, surgeon, to Apr. 23; W. R. Scroggs, surgeon, from Mar. 14.
Philippine Islands, Dumanguilas Bay: Triangulation, A140, P19; topography, L13, A26; hydrography, M2,281, A601, S19,148; tide sta., 1.	Ship Fathomer, Jan. 7-Mar. 8, Lt. G. C. Jones, comdg.; Lt. (J. G.) A. J. Hoskinson, exec.; Lt. (J. G.) W. F. Malnate; Ensign C. A. Burmister; Ensign E. C. Baum; G. W. Hutchison, ch. engr.; D. R. Kruger, surgeon.
Philippine Islands, Sulu Islands: Topography, L69, A19; hydrography, M5,703, A415, S114,421; tide sta., 7; current sta., 16.	Ship Marinduque, July 1-Dec. 31, Lt. (J. G.) L. O. Wilder, comdg.; Lt. (J. G.) J. A. McCormick, exec.; Lt. (J. G.) C. I. Aslakson; Lt. (J. G.) R. J. Sipe, to Oct 13; Harry Ely, ch. engr.; F. J. Soule, surgeon.
Philippine Islands, Dumanguilas Bay: Triangulation, L27, A75, P17; topography, L91, A56; hydrography, M1,127, A78, S28,964; tide sta., 3; current sta., 4; mag. sta., 5.	Ship Marinduque, Mar. 24-June 30, Lt. (J. G.) L. C. Wilder, comdg., to Apr. 30; Lt. W. D. Patterson, comdg., from May 1; Lt. (J. G.) C. I. Aslakson, exec.; Lt. (J. G.) S. B. Grenell; Ensign F. R. Gossett; Harry Ely, ch. engr.; F. J. Soule, surgeon.

DIVISION OF GEODESY

Locality	Operations	Persons conducting operations
Augusta-International Boundary, Maine.	Triangulation, first-order; 80 mi., 2,700 sq. mi.; 2 Laplace azimuths.	Ensign C. A. Schanck, chief.
Pittsburgh arc, Pennsylvania and Ohio.	Triangulation and base measurement, first-order; 85 mi., 1,100 sq. mi., base line 5.8 mi.; 1 Laplace azimuth.	W. Mussetter, chief; Lt. (J.G.) John Bowie; Lt. (J. G.) E. B. Latham.
Columbus arc, Ohio	Triangulation, first-order; 205 mi., 2,250 sq. mi.; 2 Laplace azimuths.	Do.
Do	Triangulation, first-order; 20 mi., 250 sq. mi.; 1 Laplace and 1 first-order azimuth.	Lt. (J. G.) C. M. Thomas, chief; Lt. (J. G.) E. J. Brown; M. Braden, foreman hand.
Owingsville to Virginia-Tennessee boundary, Kentucky.	Triangulation, first-order; 120 mi., 2,850 sq. mi.; 2 Laplace azimuths.	Lt. H. W. Hemple, chief; Lt. (J. G.) J. M. Smook; E. R. Martin, jr. engr.
Bardstown-Berea, Ky	Triangulation, first-order; 65 mi., 1,000 sq. mi.; 1 first-order azimuth.	W. Mussetter, chief; Lt. (J.G.) John Bowie; Lt. (J. G.) E. B. Latham.
Portsmouth, Ohio-Owingsville, Ky.	Triangulation, first-order; 50 mi., 600 sq. mi.; 1 first-order azimuth.	Do.
Ninety-third meridian arc, Iowa, Missouri, and Arkansas.	Triangulation, first-order, 420 mi., 5,400 sq. mi.; 5 Laplace azimuths.	Lt. (J. G.) E. O. Heaton, chief; Lt. (J. G.) J. M. Smook; Lt. (J. G.) C. M. Thomas; Lt. (J. G.) R. L. Pfau; W. J. Bilby, signalman.
Springfield-Van Buren, Mo	Triangulation, first-order; 95 mi., 1,600 sq. mi.; 1 Laplace azimuth.	Do.
Newport Beach-Bear Lake, Calif.	Triangulation, first-order; 60 mi., 1,100 sq. mi.; 2 Laplace azimuths.	Lt. G. L. Bean, chief; Lt. (J. G.) H. A. Karo; Lt. (J. G.) J. H. Brittain.
Redding-Humboldt Bay, Calif.	Triangulation, second-order; 85 mi., 2,400 sq. mi.; 1 first-order azimuth.	Lt. G. L. Bean, chief.

DIVISION OF GEODESY—Continued

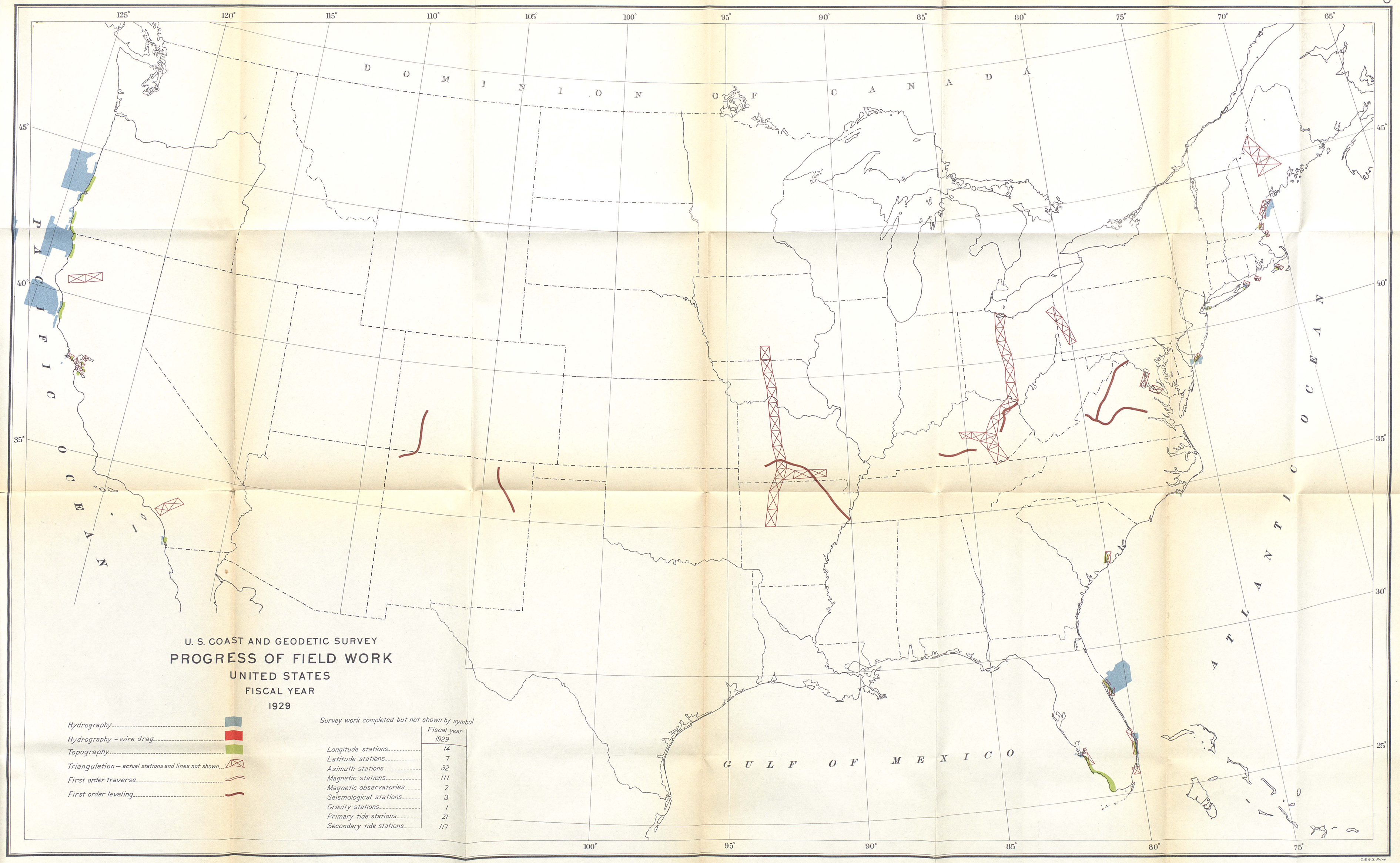
Locality	Operations	Persons conducting operations
Buffalo, N. Y.-Westfield, Pa	Reconnaissance for first-order triangulation; 110 mi., 900 sq. mi.	Ensign C. A. Schanck, chief.
Westfield-Canton, Pa	Reconnaissance for first-order triangulation; 40 mi., 300 sq. mi.	Lt. (J. G.) C. M. Thomas, chief; M. Braden, foreman hand.
Portsmouth, Ohio-Berea, Ky	Reconnaissance for first-order triangulation; 110 mi., 1,600 sq. mi.	Lt. H. W. Hemple, chief; Lt. (J. G.) J. M. Smook.
Danville, Ark.-Missouri boundary.	Reconnaissance for first-order triangulation; 120 mi., 1,800 sq. mi.	J. S. Bilby, chief.
Springfield-Charleston, Mo	Reconnaissance for first-order triangulation; 190 mi., 2,700 sq. mi.	Do.
Ninety-fourth meridian arc, Arkansas, Louisiana, and Texas.	Reconnaissance for first-order triangulation; 310 mi., 3,000 sq. mi.	Signalman W. J. Bilby, chief.
Shreveport-Union base, Louisiana, Mississippi, and Alabama.	Reconnaissance for first-order triangulation; 390 mi., 4,100 sq. mi.	Do.
Atlanta-Montgomery, Georgia, and Alabama.	Reconnaissance for first-order triangulation; 200 mi., 2,200 sq. mi.	W. Mussetter, chief.
Cairo-Memphis, Missouri, Kentucky, Arkansas, and Tennessee.	Reconnaissance for first-order triangulation; 145 mi., 1,600 sq. mi.	W. Mussetter, chief; Lt. (J. G.) John Bowie.
Memphis-Natchez, Arkansas, Mississippi, and Louisiana.	Reconnaissance for first-order triangulation; 270 mi., 1,700 sq. mi.	J. S. Bilby, chief; W. J. Bilby, signalman.
Natchez-New Orleans, Mississippi and Louisiana.	Reconnaissance for first-order triangulation; 180 mi., 1,300 sq. mi.	W. Mussetter, chief; Lt. (J. G.) John Bowie.
Newport Beach-Lucerne Valley, Calif.	Reconnaissance for first-order triangulation; 90 mi., 1,600 sq. mi.	Lt. G. L. Bean, chief; Lt. (J. G.) J. H. Brittain.
Minnesota, Wisconsin, and Iowa	10 Laplace azimuths, 14 longitudes, and 7 latitudes.	Lt. (J. G.) E. J. Brown, chief; Ensign J. P. Lushene.
Montrose, Colo.-Farmington, N. Mex.	Leveling, first-order; 148 mi.	Lt. (J. G.) J. H. Brittain, chief.
Farmington-Shiprock, N. Mex	Leveling, first-order; 30 mi	Do.
Alexandria, Va	Leveling, first-order; 0.3 mi	Associate Mathematician H. S. Rappleye, chief.
Tucumcari-Taylor Springs, N. Mex.	Leveling, first-order; 103 mi	Lt. (J. G.) J. H. Brittain, chief.
Greenup-Jackson, Ky	Leveling, first-order; 128 mi	Ensign H. O. Fortin, chief.
Somerset-Glasgow Junction, Ky	Leveling, first-order; 102 mi	Do.
Monett, Mo.-Memphis, Tenn. (part).	Leveling, first-order; 322 mi	Lt. (J. G.) P. C. Doran, chief.
Covington-Richmond, Va	Leveling, first-order; 257 mi	Ensign H. O. Fortin, chief.
Balcony Falls-Harpers Ferry, W. Va.	Leveling, first-order; 185 mi	Do.
Washington, D. C	Leveling, first-order; 1 mi	Associate Mathematician H. S. Rappleye, chief.
Taylor Springs, N. Mex., to Pueblo, Colo. (part).	Leveling, first-order; 14 mi	Lt. (J. G.) Charles Pierce.

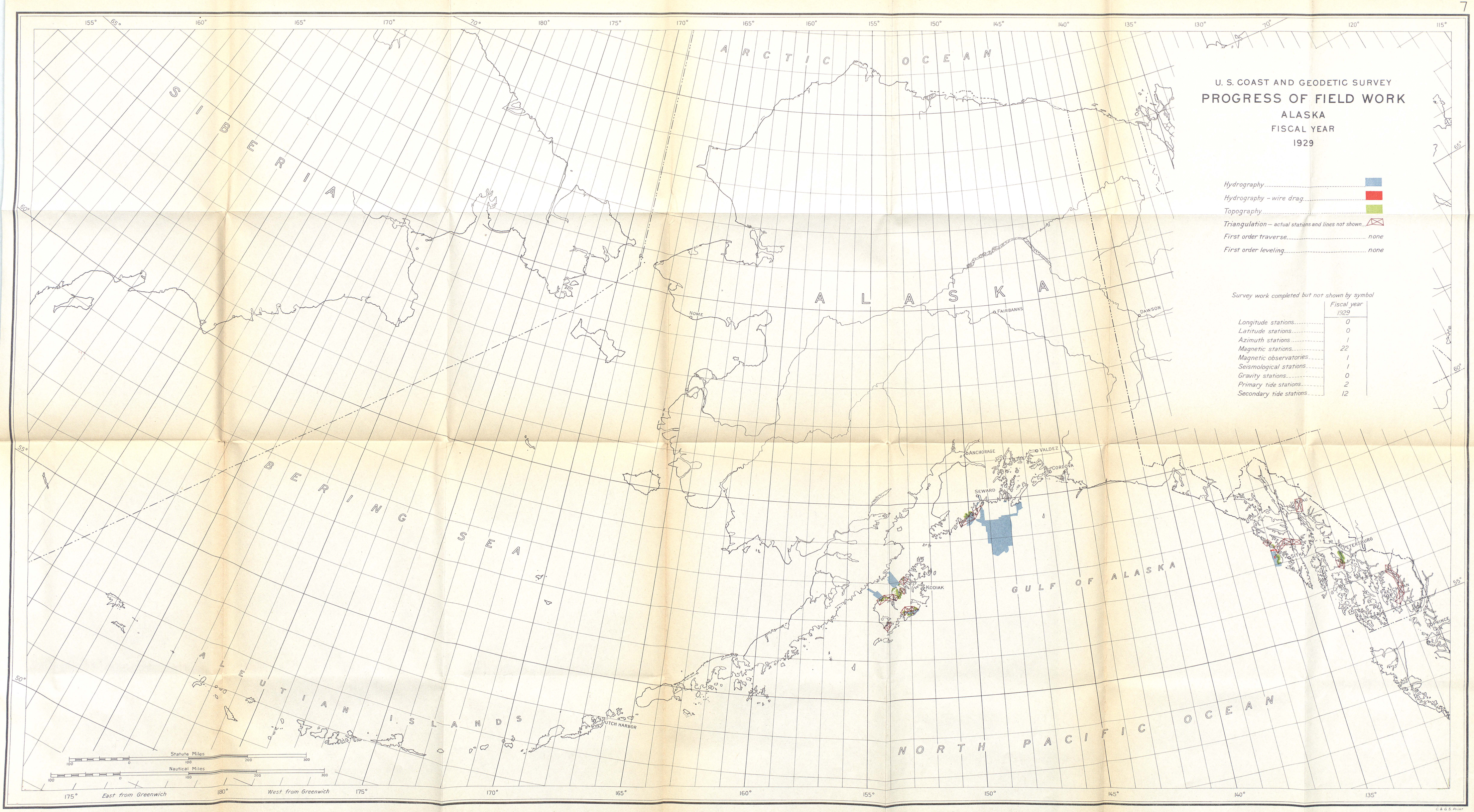
DIVISION OF TIDES AND CURRENTS

Portland, Me	Series of tide observations	C. H. Hudson.
Portsmouth, N. H	do	G. A. Gerry.
Star Island, Isle of Shoals, N. H	do	G. C. Mattison.
Off Isles of Shoals, N. H	Series of current observations	Charles K. Green.
Boston, Mass	Series of tide observations	R. F. Luce; H. F. Russell.
Gloucester Harbor, Mass	do	Raymond P. Eyman.
Annisquam, Mass	do	Do.
Wolf Hill, Mass	do	Do.
Rockport, Mass	do	Do.
Hampton River, N. H	do	Charles K. Green.
Salisbury Beach, Mass	do	Do.
Edgartown, Mass	do	Do.
Oak Bluff, Mass	do	Do.
New York, Whitehall St., N. Y	do	C. L. Garner; T. J. Lyons.
Fort Hamilton, N. Y	do	Mary T. Myers.
Mill Basin, N. Y	do	C. D. Meaney.
Carnarsie, N. Y	do	Do.
Barren Island, N. Y	do	Do.
Broad Creek, N. Y	do	Do.
Survey of Long Island Sound	Series of current observations	H. E. Finnegan.
Atlantic City, N. J	Series of tide observations	S. S. Day.
Cold Spring Inlet, N. Y	do	Jack Senior.
Breakwater Harbor, Del	do	Do.
Philadelphia, Pa	do	W. M. Miller.
Baltimore, Md	do	Fred A. Kummell.
Annapolis, Md	do	R. H. Kiernan.
Dahlgren, Potomac River, Va	do	Navy Department.
Survey of Chesapeake Bay, Md., and Va.	Series of current observations	George L. Anderson.

DIVISION OF TIDES AND CURRENTS—Continued

Locality	Operation	Persons conducting ope
Hampton Roads, Va	Series of tide observations	J. C. Twaddle.
Charleston, S. C	do	L. C. Lockwood.
Little River, S. C	do	United States Engineer
Cainboy, Wando River, S. C	do	R. F. A. Studds.
Red Bank Landing, S. C	do	Do.
Woodville, S. C	do	Do.
Dean Hall, S. C	do	Do.
Wappoo Creek, S. C	do	Do.
Quimby Creek, S. C	do	Do.
Railroad bridge, west branch, Cooper River, S. C.	do	Do.
Mayport, St. Johns River, Fla	do	H. H. Williams.
Jacksonville, Fla	do	W. P. Tisdale.
Daytona Beach, Fla	do	T. J. Wright.
Off Daytona Beach, Fla	Series of current observations	K. T. Adams.
Off Mosquito Inlet, Fla	do	G. C. Mattison.
Port of Lake Mabel, Fla	Series of tide observations	Do.
Miami Beach, Fla	do	United States Engineers.
Key West, Fla	do	S. M. Goldsmith.
Everglades, Fla	do	Fred J. Nebiker.
Punta Rose, Fla	do	Charles Shaw.
Fort Myers, Fla	do	Do.
Iona, Fla	do	Do.
Pensacola, Fla	do	V. D. Holcomb.
Galveston, Tex	do	C. F. Southwick.
San Diego, Calif	do	Floyd C. Bedell, eleventh naval district.
La Jolla, Calif	do	George F. McEwen.
Los Angeles, Calif	do	John T. Gower, harbor department, Los Angeles.
San Francisco, Calif	do	Thomas J. Maher; H. S. Ballard.
San Leandro Bay, San Francisco Bay, Calif.	do	Do.
Humboldt Bay, North Jetty, Calif.	do	H. A. Cotton.
Crescent City, Calif	do	F. G. Engle.
Wedderburn, Oreg	do	J. F. Gillings.
Brookings, Oreg	do	F. G. Engle.
Newport, Oreg	do	O. W. Swainson.
Coos Bay, Oreg	do	Do.
Umpqua River, Oreg	do	Do.
Bandon, Oreg	do	A. P. Ratti.
Port Orford, Oreg	do	Do.
Coos Bay, Oreg	Series of current observations	O. W. Swainson.
Yaquina Bay, Oreg	do	Do.
Bandon, Oreg	do	A. P. Ratti.
Astoria, Oreg	Series of tide observations	A. M. Coleman.
Seattle, Wash	do	F. H. Hardy, E. E. David.
Aberdeen, Wash	do	W. H. Peters, Port Commission, Aberdeen.
Westport, Wash	do	Do.
Cosmopolis, Wash	do	Do.
Montesano, Wash	do	Do.
Port Gamble, Wash	do	G. C. Jones.
Port Ludlow, Wash	do	Do.
Anacortes, Wash	do	Do.
Ketchikan, Alaska	do	Adolph Anderson.
Scraggy Island, Alaska	do	H. A. Cotton.
Fortuna Strait, Alaska	do	Do.
Sitka, Alaska	do	Do.
Salmonberry, Alaska	do	Do.
Kinshan Cove, Alaska	do	Do.
Klag Bay, Alaska	do	Do.
View Cove, Alaska	do	Do.
Craig, Alaska	do	Do.
Kakul Narrows, Alaska	do	Do.
Evans Bay, Alaska	do	R. R. Lukens.
Two Arm Bay, Alaska	do	Do.
Port Hobson, Alaska	do	Do.
Day Harbor, Alaska	do	Do.
Cordova, Alaska	do	Jesse W. Taylor.
Valdez, Alaska	do	Sam Knudson.
Seward, Alaska	do	L. M. High.
Honolulu, Hawaii	do	Walter E. Wall, Territory government, Hawaii.
Hilo, Hawaii	do	R. M. Wilson.
Makaka, Hawaii	do	F. G. Engle.
Waimea, Hawaii	do	Do.
Kailua, Hawaii	do	Thomas J. Maher.
Napoopoo, Hawaii	do	Do.

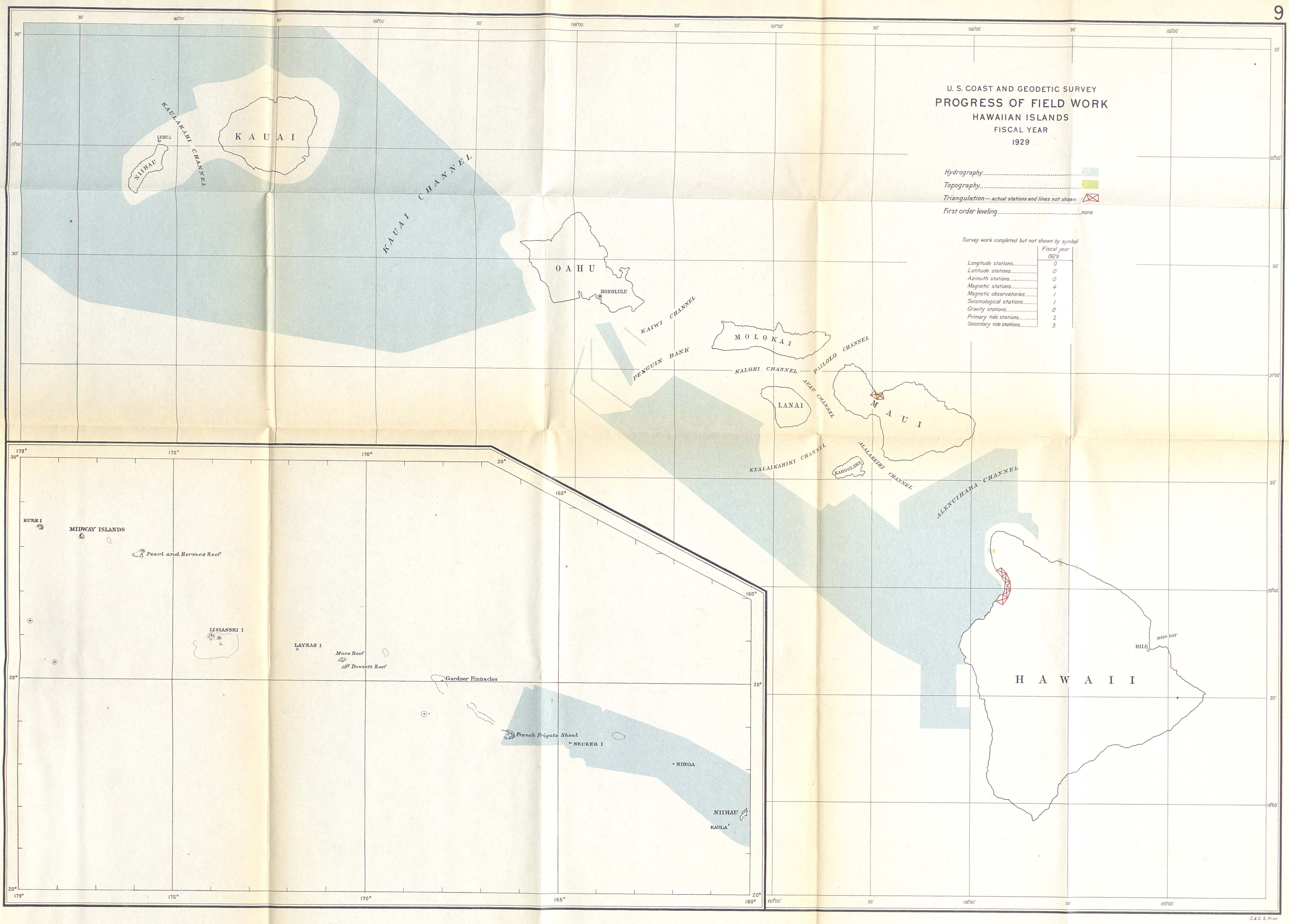

DOMINION OF CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
125° 120° 115° 110° 105° 100° 95° 90° 85° 80° 75° 70° 65°
45° 40° 35° 30° 25°
100° 95° 90° 85° 80° 75°
U. S. COAST AND GEODETIC SURVEY
PROGRESS OF FIELD WORK
UNITED STATES
FISCAL YEAR
1929
Hydrography
Hydrography – wire drag
Topography
Triangulation – actual stations and lines not shown
First order traverse
First order leveling
Survey work completed but not shown by symbol
Fiscal year 1929
Longitude stations 14
Latitude stations 7
Azimuth stations 32
Magnetic stations 111
Magnetic observatories 2
Seismological stations 3
Gravity stations 1
Primary tide stations 21
Secondary tide stations 117
Statute Miles
100 50 0 100 200 300 400
Nautical Miles
100 50 0 100 200 300 400
C.&G.S. Print


U. S. COAST AND GEODETIC SURVEY
PROGRESS OF FIELD WORK
ALASKA
FISCAL YEAR
1929
Hydrography
Hydrography – wire drag
Topography
Triangulation – actual stations and lines not shown
First order traverse ..... none
First order leveling ..... none
Survey work completed but not shown by symbol
Fiscal year 1929
Longitude stations 0
Latitude stations 0
Azimuth stations 1
Magnetic stations 22
Magnetic observatories 1
Seismological stations 1
Gravity stations 0
Primary tide stations 2
Secondary tide stations 12
ARCTIC OCEAN
SIBERIA
ALASKA
BERING SEA
ALEUTIAN ISLANDS
GULF OF ALASKA
NORTH PACIFIC OCEAN
NOME
FAIRBANKS
DAWSON
ANCHORAGE
VALDEZ
CORDOVA
SEWARD
KODIAK
DUTCH HARBOR
PETERSBURG
PRINCE
Statute Miles
Nautical Miles
East from Greenwich
West from Greenwich

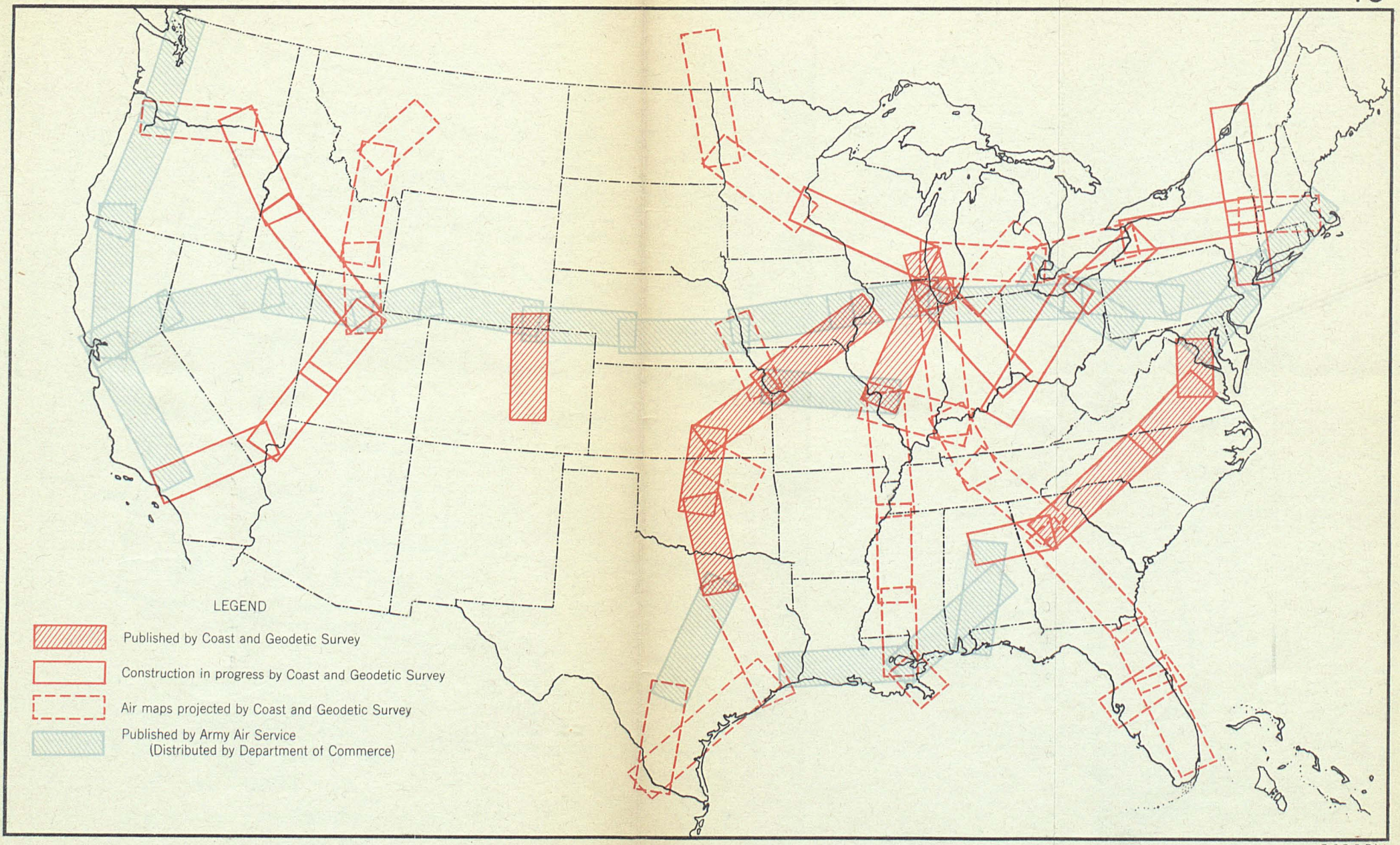
C & G S Print

Survey work completed but not shown by symbol

	Fiscal year 1929
Longitude stations	0
Latitude stations	0
Azimuth stations	0
Magnetic stations	7
Magnetic observatories	0
Seismological stations	0
Gravity stations	0
Primary tide stations	0
Secondary tide stations	17

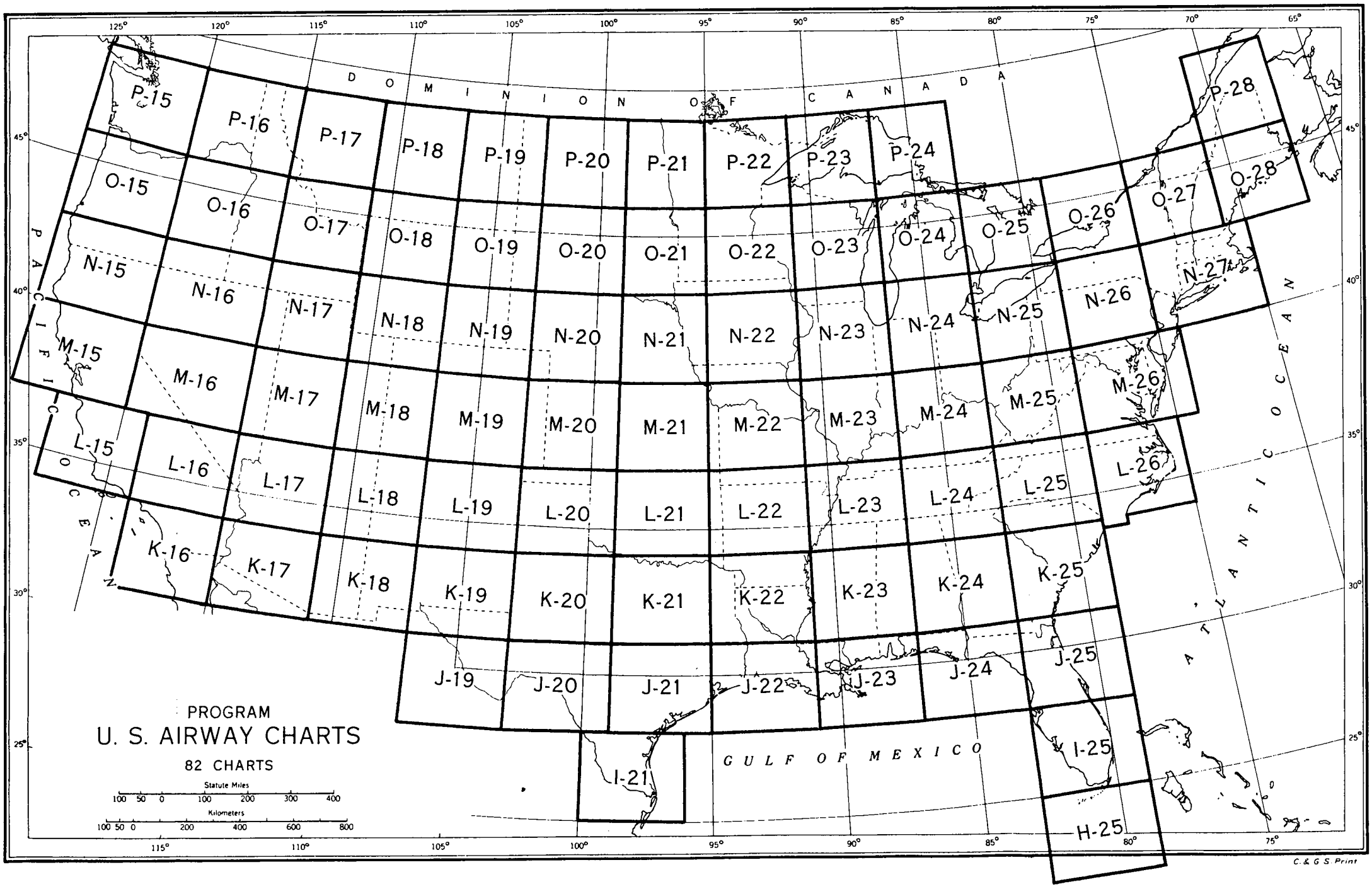

U. S. COAST AND GEODETIC SURVEY
PROGRESS OF FIELD WORK
HAWAIIAN ISLANDS
FISCAL YEAR
1929
Hydrography
Topography
Triangulation — actual stations and lines not shown
First order leveling ... none
Survey work completed but not shown by symbol
Fiscal year 1929
Longitude stations 0
Latitude stations 0
Azimuth stations 0
Magnetic stations 4
Magnetic observatories 1
Seismological stations 1
Gravity stations 0
Primary tide stations 2
Secondary tide stations 5
KAUAI
NIIHAU
LEHUA
KAULAKAHI CHANNEL
KAUAI CHANNEL
OAHU
HONOLULU
KAIWI CHANNEL
PENGUIN BANK
MOLOKAI
KALOHI CHANNEL
PAILOLO CHANNEL
AUAU CHANNEL
LANAI
MAUI
KEALAIKAHIKI CHANNEL
KAHOOLAWE
ALALAKEIKI CHANNEL
ALENUIHAHA CHANNEL
HAWAII
HILO
HILO BAY
KURE I
MIDWAY ISLANDS
Pearl and Hermes Reef
LISIANSKI I
LAYSAN I
Maro Reef
Dowsett Reef
Gardner Pinnacles
French Frigate Shoal
NECKER I
NIHOA
NIIHAU
KAULA

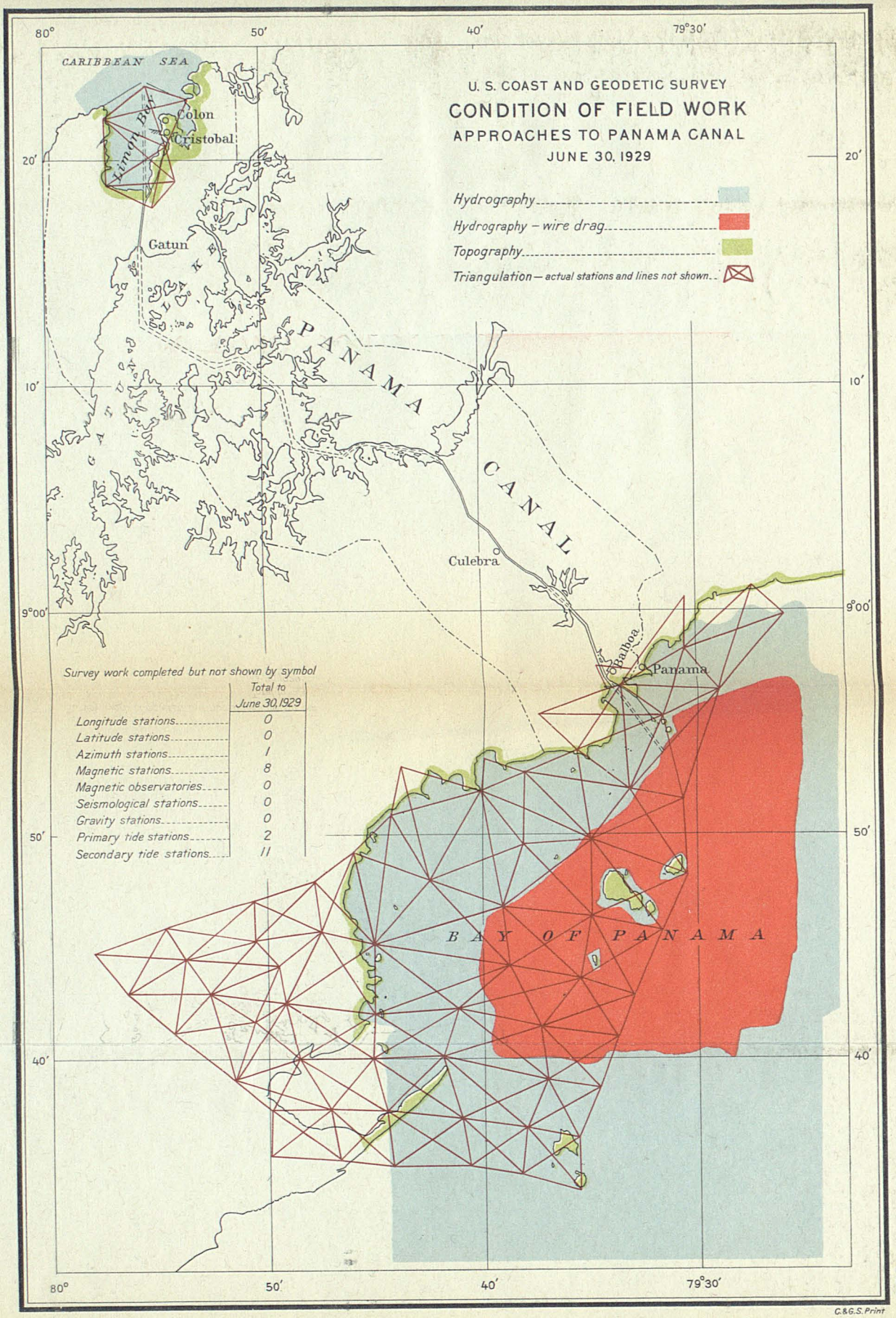
C.&G. S. Print



C. & G. S. Print

PROGRESS OF AIRWAY MAPPING JUNE 30, 1929


PROGRAM
U. S. AIRWAY CHARTS
82 CHARTS
Statute Miles
100 50 0 100 200 300 400
Kilometers
100 50 0 200 400 600 800
DOMINION OF CANADA
PACIFIC OCEAN
ATLANTIC OCEAN
GULF OF MEXICO
P-15
P-16
P-17
P-18
P-19
P-20
P-21
P-22
P-23
P-24
P-28
O-15
O-16
O-17
O-18
O-19
O-20
O-21
O-22
O-23
O-24
O-25
O-26
O-27
O-28
N-15
N-16
N-17
N-18
N-19
N-20
N-21
N-22
N-23
N-24
N-25
N-26
N-27
M-15
M-16
M-17
M-18
M-19
M-20
M-21
M-22
M-23
M-24
M-25
M-26
L-15
L-16
L-17
L-18
L-19
L-20
L-21
L-22
L-23
L-24
L-25
L-26
K-16
K-17
K-18
K-19
K-20
K-21
K-22
K-23
K-24
K-25
J-19
J-20
J-21
J-22
J-23
J-24
J-25
I-21
I-25
H-25
C. & G. S. Print



	Total to June 30, 1929
Longitude stations	0
Latitude stations	0
Azimuth stations	1
Magnetic stations	8
Magnetic observatories	0
Seismological stations	0
Gravity stations	0
Primary tide stations	2
Secondary tide stations	11

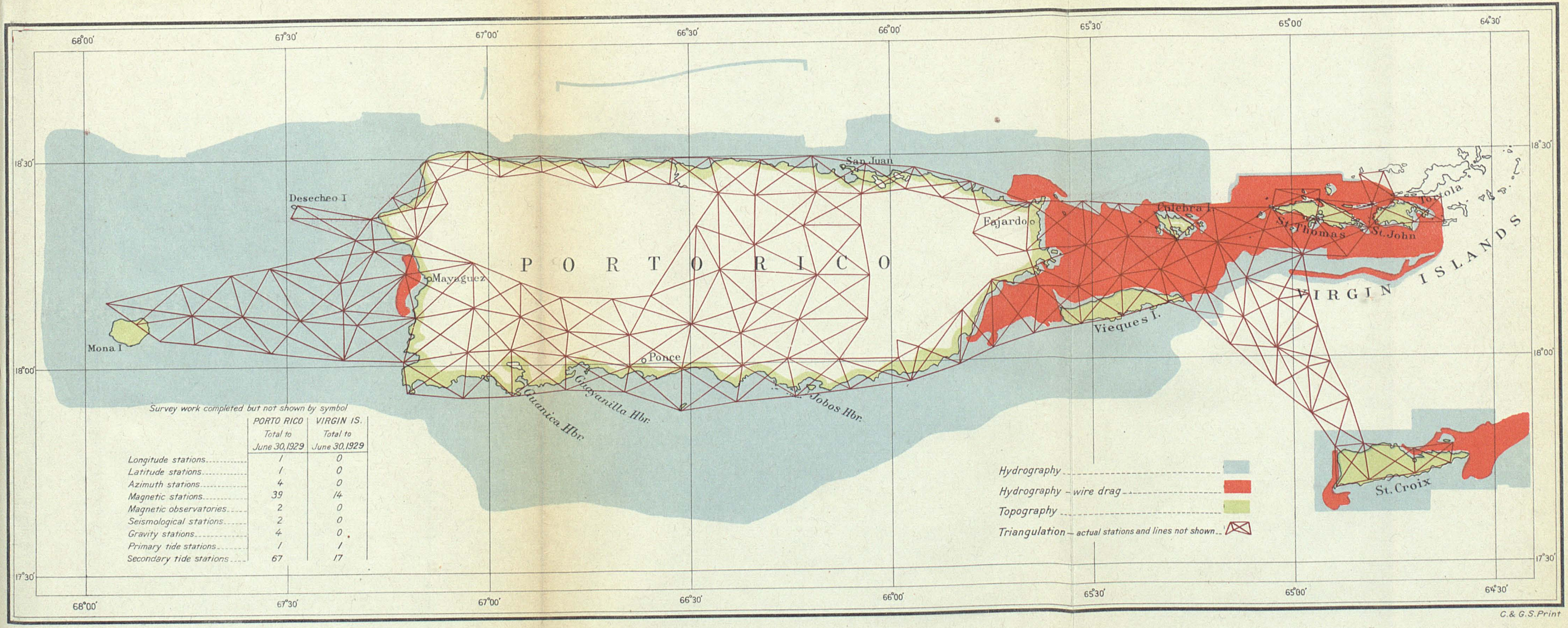
C.&G.S. Print

U. S. COAST AND GEODETIC SURVEY

CONDITION OF FIELD WORK

PORTO RICO AND VIRGIN ISLANDS

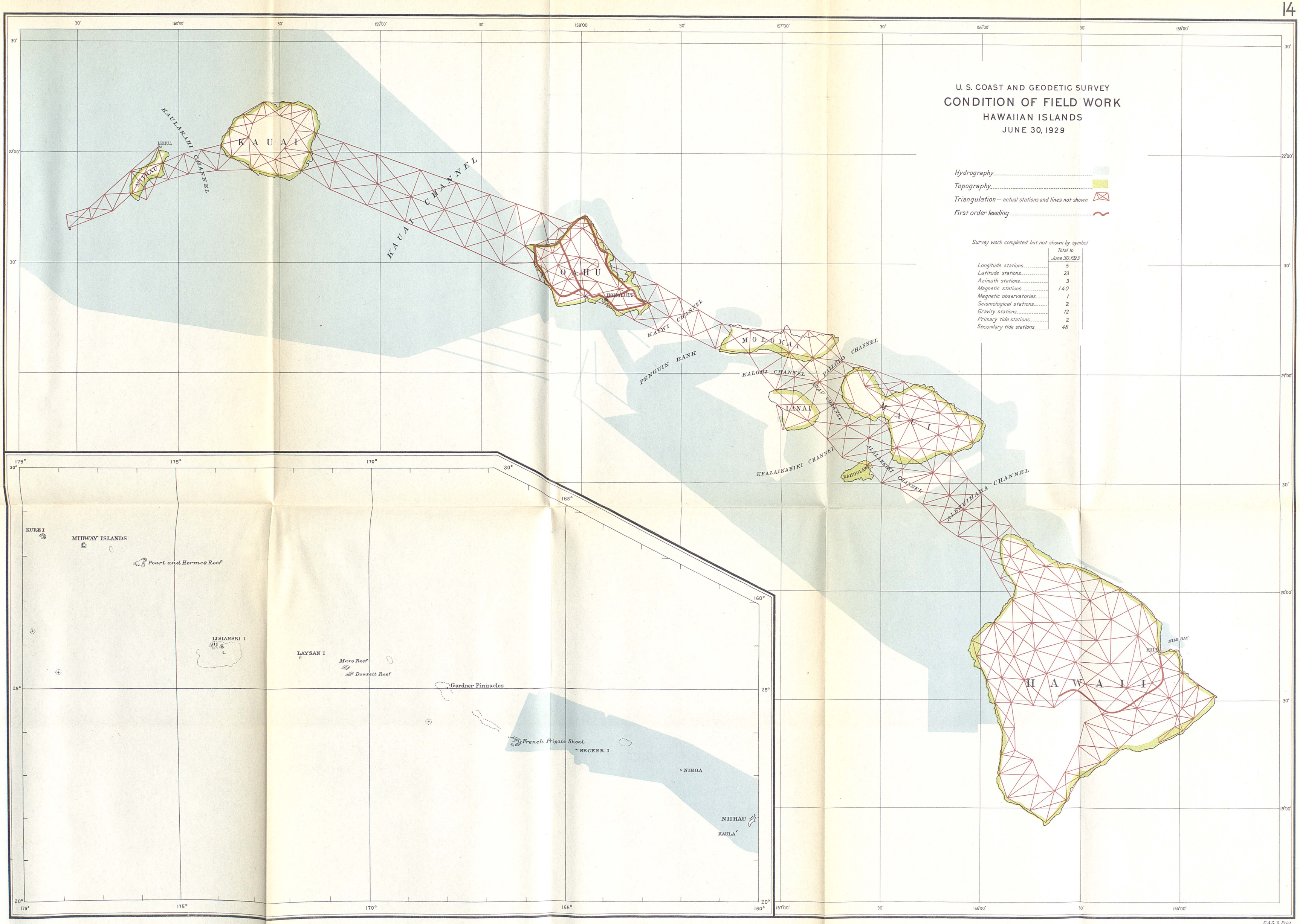
JUNE 30, 1929

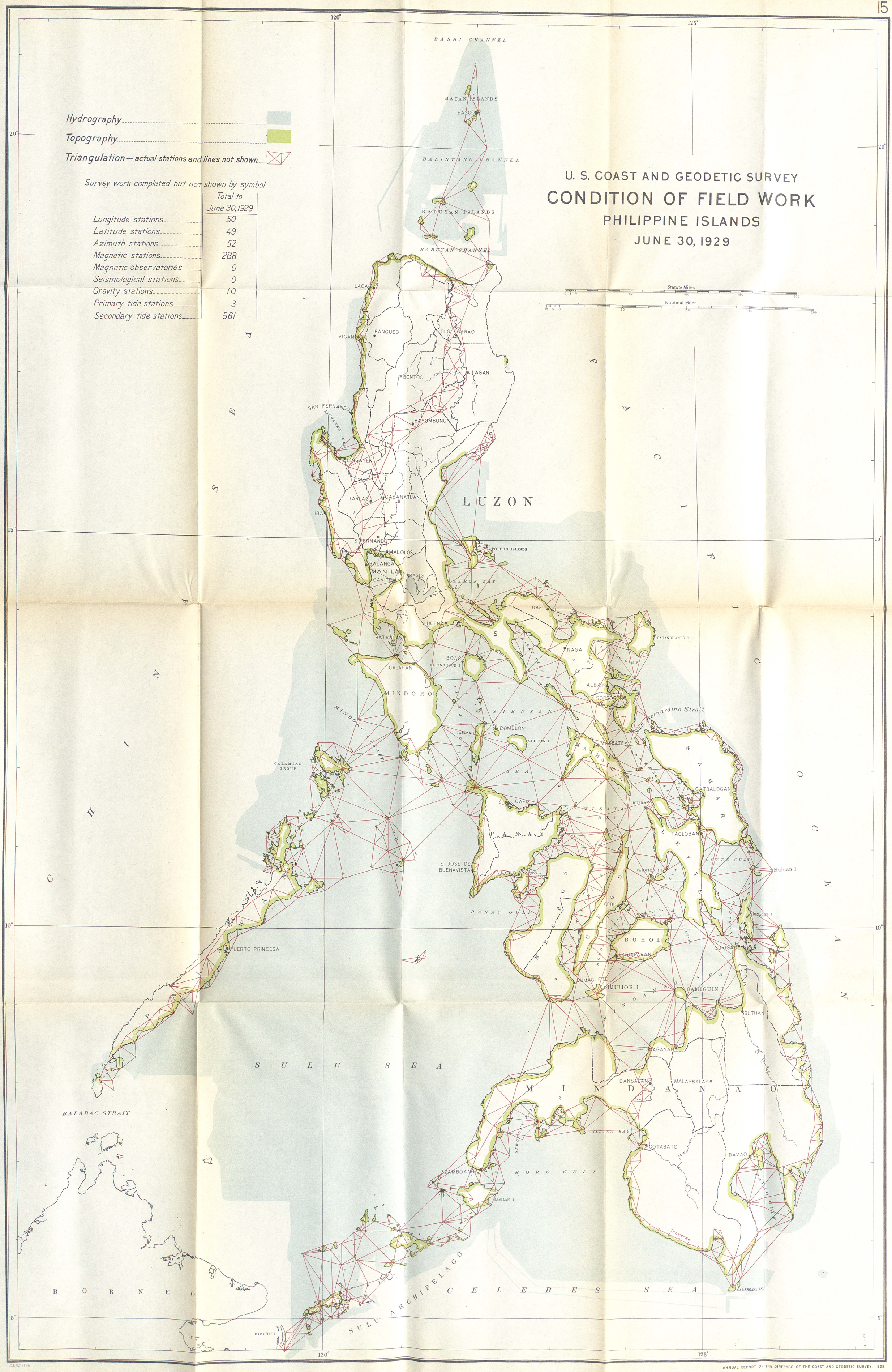


Survey work completed but not shown by symbol

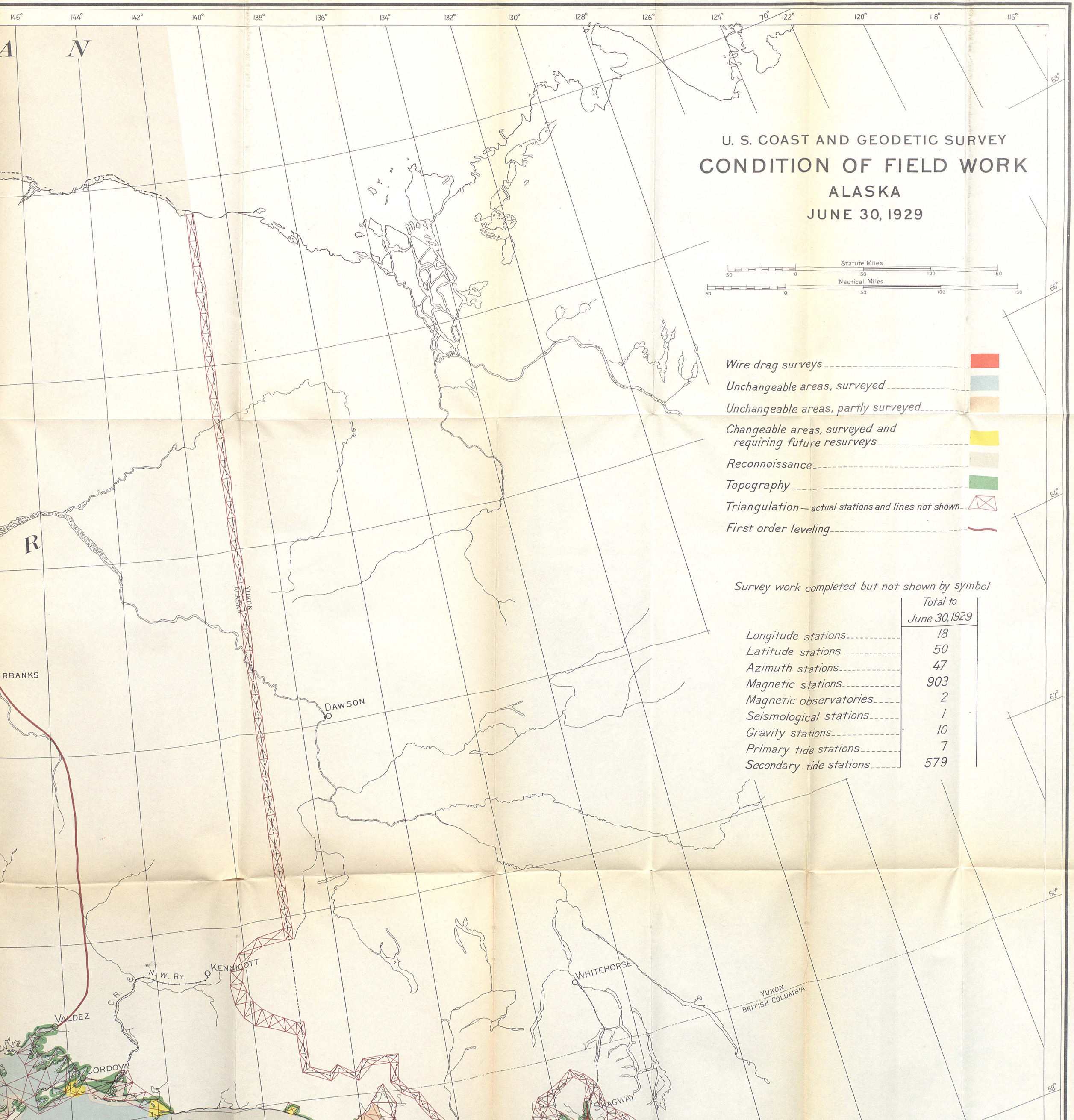
	PORTO RICO Total to June 30, 1929	VIRGIN IS. Total to June 30, 1929
Longitude stations	1	0
Latitude stations	1	0
Azimuth stations	4	0
Magnetic stations	39	14
Magnetic observatories	2	0
Seismological stations	2	0
Gravity stations	4	0
Primary tide stations	1	1
Secondary tide stations	67	17

C. & G. S. Print

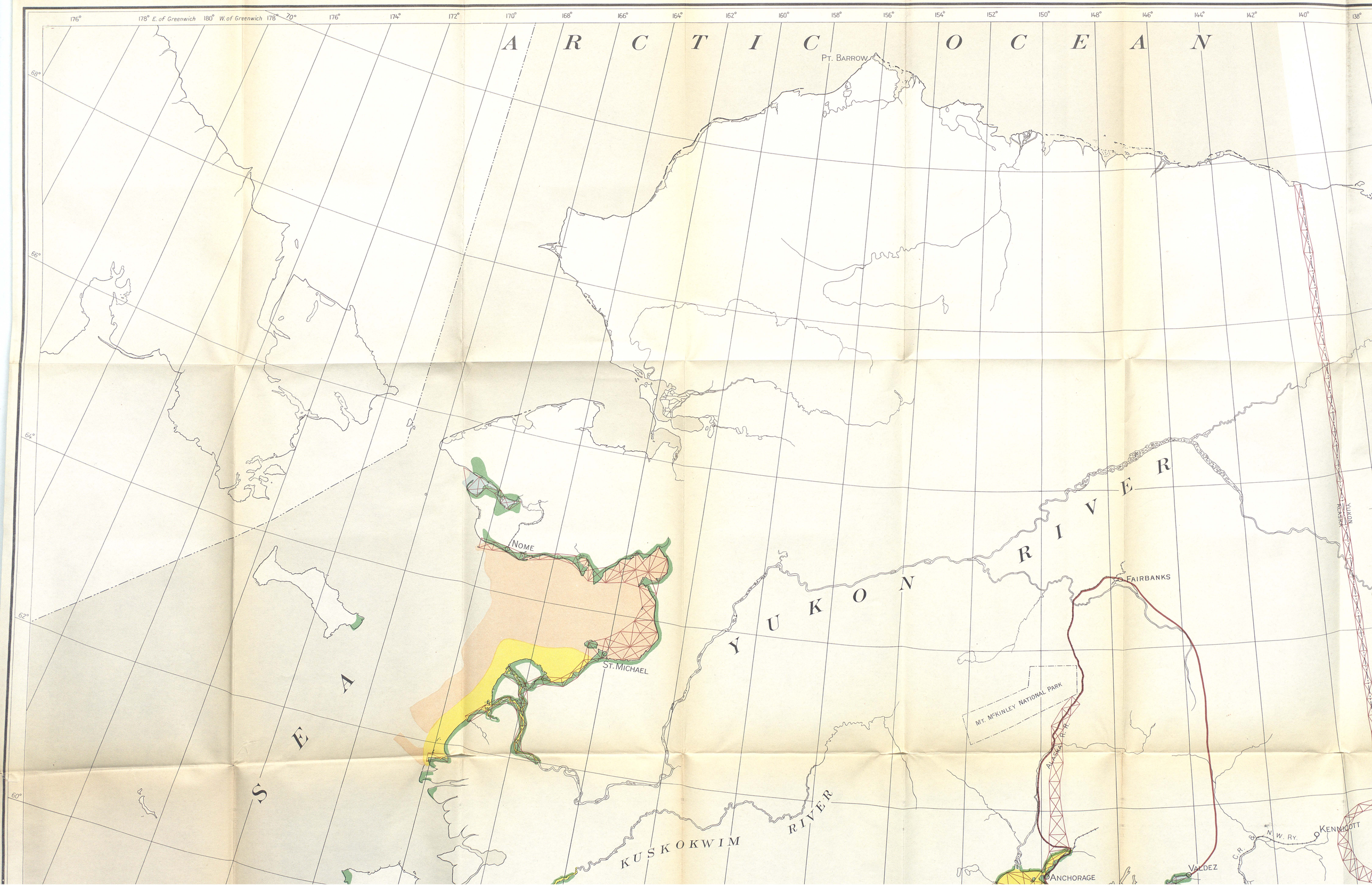

U. S. COAST AND GEODETIC SURVEY
CONDITION OF FIELD WORK
HAWAIIAN ISLANDS
JUNE 30, 1929
Hydrography
Topography
Triangulation — actual stations and lines not shown
First order leveling
Survey work completed but not shown by symbol
Total to June 30, 1929
Longitude stations 5
Latitude stations 23
Azimuth stations 3
Magnetic stations 140
Magnetic observatories 1
Seismological stations 2
Gravity stations 12
Primary tide stations 2
Secondary tide stations 48
KAUAI
NIIHAU
LEHUA
KAULAKAHI CHANNEL
KAUAI CHANNEL
OAHU
HONOLULU
KAIWI CHANNEL
PENGUIN BANK
MOLOKAI
KALOHI CHANNEL
PAILOLO CHANNEL
MAU CHANNEL
LANAI
MAUI
KEALAIKAHIKI CHANNEL
KAHOOLAWE
ALALAKEIKI CHANNEL
ALENUIHAHA CHANNEL
HAWAII
HILO
HILO BAY
KURE I
MIDWAY ISLANDS
Pearl and Hermes Reef
LISIANSKI I
LAYSAN I
Maro Reef
Dowsett Reef
Gardner Pinnacles
French Frigate Shoal
NECKER I
NIHOA
NIIHAU
KAULA I
C.&G.S. Print

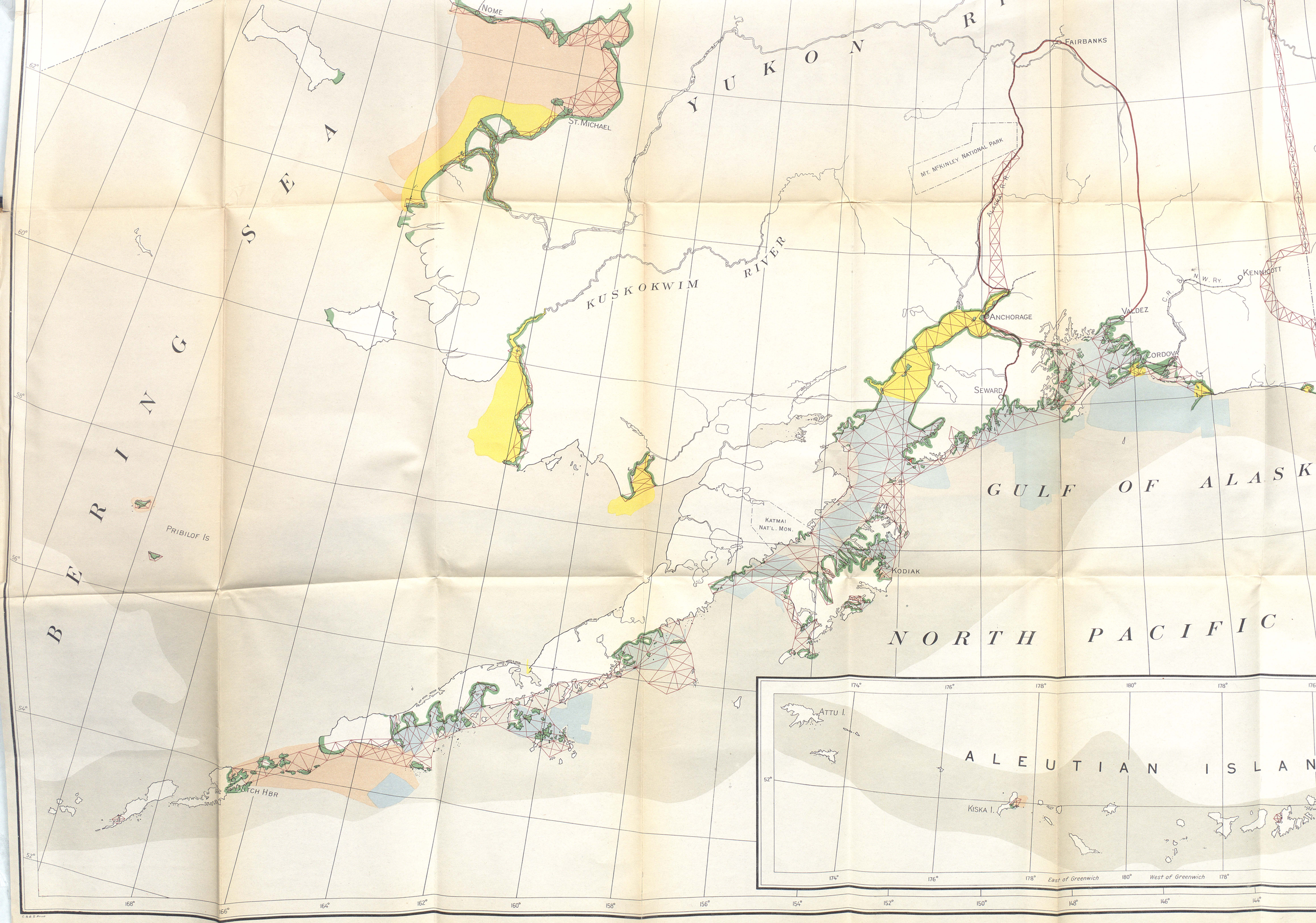

U. S. COAST AND GEODETIC SURVEY
CONDITION OF FIELD WORK
PHILIPPINE ISLANDS
JUNE 30, 1929
Hydrography
Topography
Triangulation — actual stations and lines not shown
Survey work completed but not shown by symbol
Total to June 30, 1929
Longitude stations 50
Latitude stations 49
Azimuth stations 52
Magnetic stations 288
Magnetic observatories 0
Seismological stations 0
Gravity stations 10
Primary tide stations 3
Secondary tide stations 561
Statute Miles
Nautical Miles
BASHI CHANNEL
BATAN ISLANDS
BASCO
BALINTANG CHANNEL
BABUYAN ISLANDS
BABUYAN CHANNEL
LUZON
LAOAG
VIGAN
BANGUED
TUGUEGARAO
ILAGAN
BONTOC
SAN FERNANDO
LINGAYEN GULF
LINGAYEN
BAYOMBONG
TARLAC
CABANATUAN
IBA
S. FERNANDO
MALOLOS
BALANGA
MANILA
CAVITE
PASIG
STA. CRUZ
LAMON BAY
POLILLO ISLANDS
DAET
LUCENA
BATANGAS
CALAPAN
BOAC
MARINDUQUE I
NAGA
CATANDUANES I
LAGONOY GULF
ALBAY
SORSOGON
MINDORO
MINDORO STRAIT
TABLAS STRAIT
TABLAS I
ROMBLON
SIBUYAN I
SIBUYAN SEA
MASBATE
MASBATE I
San Bernardino Strait
SAMAR SEA
SAMAR
CATBALOGAN
CALAMIAN GROUP
CAPIZ
BILIRAN I
VISAYAN SEA
PANAY
TACLOBAN
LEYTE
LEYTE GULF
Suluan I.
S. JOSE DE BUENAVISTA
ILOILO
BACOLOD
CAMOTES IS
CAMOTES SEA
CEBU
PANAY GULF
NEGROS
SURIGAO STRAIT
DINAGAT I
BOHOL
TAGBILARAN
SURIGAO
PUERTO PRINCESA
PALAWAN
DUMAGUETE
SIQUIJOR I
CAMIGUIN I
BUTUAN
SULU SEA
BALABAC STRAIT
AGAYAN
DANSALAN
MALAYBALAY
MINDANAO
ILLANA BAY
COTABATO
DAVAO
DAVAO GULF
ZAMBOANGA
MORO GULF
BASILAN I
Traverse
JOLO
SULU ARCHIPELAGO
BORNEO
CELEBES SEA
SARANGANI IS.
SIBUTU I
PHILIPPINE SEA
120°
125°
20°
15°
10°
5°

Scale $\frac{1}{2500000}$ Lambert Conformal Conic Projection

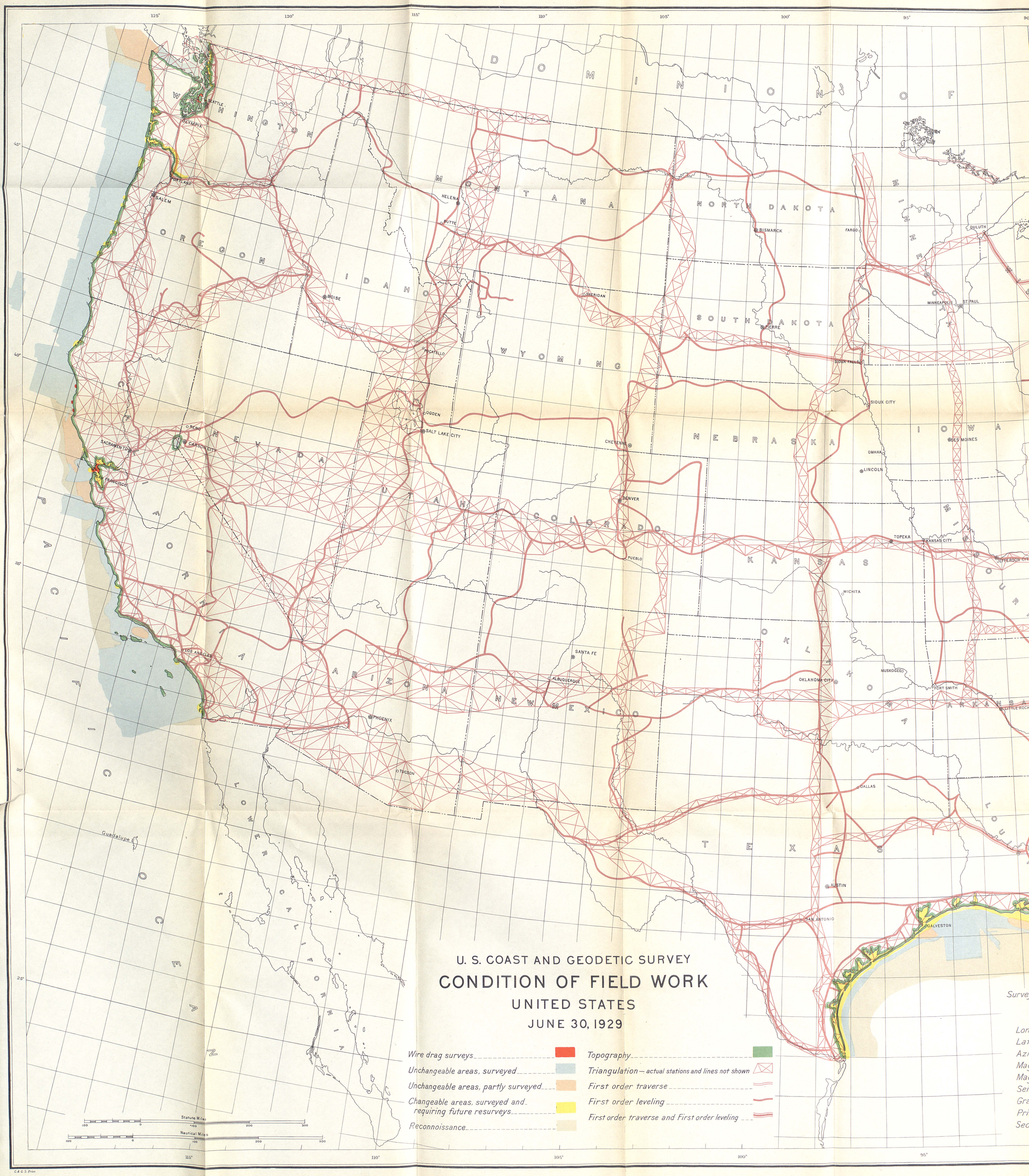


Latitude stations 50
Azimuth stations 47
Magnetic stations 903
Magnetic observatories 2
Seismological stations 1
Gravity stations 10
Primary tide stations 7
Secondary tide stations 579
RBANKS
DAWSON
KENNICOTT
N. W. RY.
C. R.
VALDEZ
CORDOVA
WHITEHORSE
YUKON
BRITISH COLUMBIA
SKAGWAY
JUNEAU
BRITISH COLUMBIA
ALASKA
SITKA
PETERSBURG
WRANGELL
KETCHIKAN
PRINCE RUPERT
OF ALASKA
PACIFIC OCEAN
TIAN ISLANDS
Greenwich
West of Greenwich
180°
178°
176°
174°
172°
170°
62°
60°
58°
56°
54°
52°
148°
146°
144°
142°
140°
138°
136°
134°
132°


176°
178° E. of Greenwich
180° W. of Greenwich
178°
176°
174°
172°
170°
168°
166°
164°
162°
160°
158°
156°
154°
152°
150°
148°
146°
144°
142°
140°
138°
68°
66°
64°
62°
60°
ARCTIC OCEAN
PT. BARROW
NOME
ST. MICHAEL
SEA
YUKON RIVER
FAIRBANKS
MT. MCKINLEY NATIONAL PARK
ALASKA R.R.
YUKON
ALASKA
KUSKOKWIM RIVER
ANCHORAGE
VALDEZ
C.R. & N.W. RY.
KENNICOTT



BERING SEA
YUKON RIVER
KUSKOKWIM RIVER
NOME
ST. MICHAEL
FAIRBANKS
MT. McKINLEY NATIONAL PARK
ALASKA R.R.
ANCHORAGE
VALDEZ
CORDOVA
SEWARD
KENNICOTT
C.R. & N.W. RY.
KATMAI NAT'L. MON.
KODIAK
PRIBILOF IS
DUTCH HBR
GULF OF ALASK
NORTH PACIFIC
ALEUTIAN ISLAN
ATTU I.
KISKA I.
East of Greenwich
West of Greenwich
62°
60°
58°
56°
54°
52°
168°
166°
164°
162°
160°
158°
156°
154°
152°
150°
148°
146°
144°
174°
176°
178°
180°


U. S. COAST AND GEODETIC SURVEY
CONDITION OF FIELD WORK
UNITED STATES
JUNE 30, 1929
Wire drag surveys
Unchangeable areas, surveyed
Unchangeable areas, partly surveyed
Changeable areas, surveyed and requiring future resurveys
Reconnoissance
Topography
Triangulation — actual stations and lines not shown
First order traverse
First order leveling
First order traverse and First order leveling
Statute Miles
Nautical Miles
DOMINION OF
WASHINGTON
OREGON
IDAHO
MONTANA
NORTH DAKOTA
SOUTH DAKOTA
WYOMING
NEBRASKA
IOWA
MINNESOTA
NEVADA
UTAH
COLORADO
KANSAS
MISSOURI
CALIFORNIA
ARIZONA
NEW MEXICO
OKLAHOMA
ARKANSAS
TEXAS
LOUISIANA
LOWER CALIFORNIA
PACIFIC OCEAN
GULF OF MEXICO
SEATTLE
OLYMPIA
PORTLAND
SALEM
HELENA
BUTTE
BISMARCK
FARGO
DULUTH
MINNEAPOLIS
ST. PAUL
BOISE
SHERIDAN
PIERRE
SIOUX FALLS
SIOUX CITY
POCATELLO
OGDEN
SALT LAKE CITY
RENO
CARSON CITY
SACRAMENTO
SAN FRANCISCO
CHEYENNE
DENVER
OMAHA
LINCOLN
DES MOINES
TOPEKA
KANSAS CITY
JEFFERSON CITY
PUEBLO
WICHITA
LOS ANGELES
SANTA FE
ALBUQUERQUE
OKLAHOMA CITY
MUSKOGEE
FORT SMITH
LITTLE ROCK
PHOENIX
TUCSON
DALLAS
AUSTIN
SAN ANTONIO
GALVESTON
Guadalupe I.

C. & G. S. Print

Survey work completed but not shown by symbol

	Total to June 30, 1929
Longitude stations	414
Latitude stations	619
Azimuth stations	826
Magnetic stations	4841
Magnetic observatories	6
Seismological stations	3
Gravity stations	311
Primary tide stations	42
Secondary tide stations	3409

DIVISION OF TIDES AND CURRENTS—Continued

Locality	Operation	Persons conducting operations
Necker Island, Hawaii	Series of tide observations	Thomas J. Maher.
Do	Series of current observations	Do.
Nihaoa Island, Hawaii	do	Do.
Kaumalspan, Hawaii	Series of tide observations	K. T. Adams.
Port Allen, Hawaii	do	Do.
French Frigate Shoals, Hawaii	do	Do.
Batuan Bay, P. I.	do	L. O. Colbert.
Biri Island, P. I.	do	Do.
Basco, Batan Island, P. I.	do	Frank S. Borden.
Jolo, P. I.	do	Do.
Musa Bay, P. I.	do	Do.
Manila, P. I.	do	Fred L. Peacock.

DIVISION OF TERRESTRIAL MAGNETISM AND SEISMOLOGY

Locality	Operations	Persons conducting operations
Cheltenham, Md	Observatory	George Hartnell, S. G. Townshend, magnetic observers.
San Juan, P. R.	do	W. M. Hill, magnetic observer; Lt. E. R. Hand.
Sitka, Alaska	do	Lt. H. A. Cotton; F. P. Ulrich, magnetic observer.
Tucson, Ariz	do	A. K. Ludy, magnetic observer; Lt. L. P. Raynor.
Honolulu, Hawaii	do	Lt. J. H. Peters.
Alabama, Tennessee, Kentucky, Indiana, Ohio, West Virginia, Pennsylvania, Virginia.	Repeat stations and replacements	R. R. Bodle, S. A. Deel, magnetic observers.
Virginia, North Carolina, South Carolina, Georgia.	do	R. R. Bodle, magnetic observer; C. A. George, junior engineer.
Georgia, Florida, Alabama, Mississippi, Louisiana, Texas.	do	W. M. Hill, magnetic observer
Mississippi, Texas	do	Lt. (J. G.) J. A. McCormick.
Kansas, Nebraska, South Dakota	do	S. A. Deel, magnetic observer.
Alaska, interior	Repeat and new stations	F. P. Ulrich, magnetic observer.

Very truly yours,

R. S. Patton, *Director.*

O